National Institute for Health and Care Excellence

Addendum to Clinical Guideline 124, Hip fracture: management

Clinical Guideline Addendum 124.1

Methods, evidence and recommendations

May 2017

Update information
NICE's original guidance on hip fracture was published in 2011 and updated in 2017. Recommendations on surgical procedures have been updated by the 2023 update. See the NICE website for the guideline recommendations and the evidence reviews for the 2023 update. This document preserves evidence reviews and committee discussions for areas of the guideline that were not updated in 2023.

Developed by the National Institute for Health and Care Excellence

Disclaimer
Healthcare professionals are expected to take NICE clinical guidelines fully into account when exercising their clinical judgement. However, the guidance does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of each patient, in consultation with the patient and, where appropriate, their guardian or carer.

Copyright
© National Institute for Health and Care Excellence, 2017. All rights reserved.

Contents

Clinical guidelines update **7**
1 Summary section **8**
1.1 Update information 8
1.2 Recommendations 9
1.3 Patient-centred care 9
1.4 Methods 10
2 Evidence review and recommendations – Displaced intracapsular hip fracture **11**
2.1 Introduction 11
2.2 RQ1: management of displaced intracapsular hip fracture 11
2.2.1 Clinical evidence review 11
2.2.2 Health economic evidence review 23
2.2.3 Economic modelling 28
2.3 Evidence statements 34
2.3.1 Clinical evidence statements 34
2.3.2 Health economic evidence statements 35
2.4 Evidence to recommendations 35
2.5 Recommendations 38
2.6 Research recommendations 39
3 Evidence review and recommendations – Undisplaced intracapsular hip fracture **40**
3.1 RQ2: management of undisplaced intracapsular hip fracture 40
3.1.1 Clinical evidence review 40
3.1.2 Health economic evidence review 45
3.2 Evidence statements 45
3.2.1 Clinical evidence statements 45
3.2.2 Health economic evidence statements 45
3.3 Evidence to recommendations 46
3.4 Recommendations 47
3.5 Research recommendations 47
4 References **49**
4.1 RQ1 – Displaced intracapsular hip fracture 49
4.2 RQ2 – Undisplaced intracapsular hip fracture 51
5 Glossary and abbreviations **53**

Appendices **54**
Appendix A: Standing Committee members and NICE teams 54
A.1 Core members 54
A.2 Topic expert Committee members 54
A.3 NICE project team 54

A.4 Clinical guidelines update team 55
Appendix B: Declarations of interest 56
Appendix C: Review protocol 57
C.1 RQ1 - Displaced intracapsular hip fracture 57
C.2 RQ2 - Undisplaced intracapsular hip fracture 60
Appendix D: Search strategy 64
Appendix E: Review flowchart 67
E.1 RQ1 – Displaced intracapsular hip fracture 67
E.2 RQ2 - Undisplaced intracapsular hip fracture 68
Appendix F: Excluded studies 69
F.1 RQ1 – Displaced intracapsular hip fracture 69
F.2 RQ2 – Undisplaced intracapsular hip fracture 72
Appendix G: Evidence tables 76
G.1 RQ1: Displaced intracapsular hip fracture 76
G.1.1 IF versus HA 76
G.1.2 IF versus THR 123
G.1.3 HA versus THR 149
G.2 RQ2 – Undisplaced intracapsular hip fracture 183
G.2.1 Internal fixation 183
G.2.2 Conservative management 202
Appendix H: GRADE profiles 211
H.1 RQ1 – Displaced intracapsular hip fracture 211
H.1.1 HA versus THR – dichotomous outcomes 211
H.1.2 HA versus THR – continuous outcomes 212
H.1.3 IF versus HA – dichotomous outcomes 214
H.1.4 IF versus HA – continuous outcomes 215
H.1.5 IF versus THR – dichotomous outcomes 216
H.1.6 IF versus THR – continuous outcomes 217
H.2 RQ2 - Undisplaced intracapsular hip fracture 217
H.2.1 IF 217
H.2.2 CM 219
Appendix I: Forest plots 221
I.1 RQ1 – Displaced intracapsular hip fracture 221
I.1.1 HA versus THR 221
I.1.2 IF versus HA 229
I.1.3 IF versus THR 231
Appendix J: Economic evidence review methods 234
Appendix K: Economic search strategy 238
Appendix L: Economic flow chart 244
Appendix M: Excluded economic studies 245

Appendix N: Full economic evidence tables 247
Appendix O: Economic modelling report 257
O.1 Introduction 257
O.2 Methods 257
O.2.1 Type of analysis 257
O.2.2 Target population 257
O.2.3 Interventions 257
O.2.4 Time horizon 257
O.2.5 Perspective 257
O.2.6 Discounting 257
O.2.7 Model structure 257
O.2.8 Mortality rates 258
O.2.9 Revision rates 259
O.2.10 Costs 261
O.2.11 Utilities 262
O.2.12 Sensitivity analysis 262
O.3 Results 264
O.3.1 Deterministic results 264
O.3.2 Sensitivity analysis 265
O.4 Discussion 267
Appendix P: Network meta analysis 269
P.1 Methods 269
P.2 Inputs 269
P.3 Results 271
Appendix Q: WinBUGs code for network meta analysis 273
Q.1 Network 1 – Revision at 1 Year 273
Q.2 Network 2 – Revision at any Endpoint 275
Q.3 Network 3 – Mortality at 1 Year 278

Clinical guidelines update

The NICE clinical guidelines update team update discrete parts of published clinical guidelines as requested by NICE's Guidance Executive.

Suitable topics for update are identified through the surveillance programme (see surveillance programme interim guide). These guidelines are updated using a standing committee of healthcare professionals, research methodologists and lay members from a range of disciplines and localities. For the duration of the update the core members of the committee are joined by up to 5 additional members who are have specific expertise in the topic being updated, hereafter referred to as 'topic expert members'.

In this document where 'the committee' is referred to, this means the entire committee, both the core standing members and topic expert members.

Where 'standing committee members' is referred to, this means the core standing members of the committee only.

Where 'topic expert members' is referred to this means the recruited group of members with topic expertise.

All of the core members and the topic expert members are fully voting members of the committee.

Details of the committee membership and the NICE team can be found in appendix A. The committee members' declarations of interest can be found via appendix B.

1 Summary section

1.1 Update information

The NICE guideline on hip fracture: management (NICE clinical guideline CG124) was reviewed in December 2015 as part of NICE's routine surveillance programme to decide whether it required updating. The surveillance report can be found here.

Displaced intracapsular hip fracture

The surveillance review identified 6 new studies that were consistent with the current NICE recommendation to perform hemiarthroplasty (HA) or total hip replacement (THR) in patients with a displaced intracapsular hip fracture. However, a decision to update this part of the guideline was made after topic experts noted a population based study that reported a low level of compliance (around 30% nationally) with the NICE CG124 recommendation to offer THR to patients who are: (i) able to walk independently, (ii) cognitively unimpaired, and (iii) medically fit to undergo the procedure (Perry et al 2016).

The review question (RQ) considered in this update is:

1. What is the clinical and cost effectiveness of internal fixation compared with hemiarthroplasty compared with total hip replacement in people undergoing repair for a displaced intra-capsular hip fracture?

Undisplaced intracapsular hip fracture

The management of undisplaced intracapsular hip fracture was not included in the original review of evidence for NICE CG124 as the guideline development group had considered the area relatively uncontroversial. However topic experts advising the surveillance review noted that there is currently considerable debate among clinicians as to whether internal fixation (IF) is the most appropriate treatment for all patients with undisplaced fracture. It was agreed that this area should also be included in the update for this guideline. This is therefore a new review question.

The additional review question considered in this update is:

2. What is the clinical and cost effectiveness of conservative management compared with internal fixation compared with hemiarthroplasty compared with total hip replacement in people with an undisplaced intra-capsular hip fracture?

Recommendations

Some recommendations can be made with more certainty than others. The Committee makes a recommendation based on the trade-off between the benefits and harms of an intervention, taking into account the quality of the underpinning evidence. For some interventions, the Committee is confident that, given the information it has looked at, most people would choose the intervention. The wording used in the recommendations in this guideline denotes the certainty with which the recommendation is made (the strength of the recommendation).

For all recommendations, NICE expects that there is discussion with the person about the risks and benefits of the interventions, and their values and preferences. This discussion aims to help them to reach a fully informed decision (see also 'Patient-centred care').

Recommendations that must (or must not) be followed

We usually use 'must' or 'must not' only if there is a legal duty to apply the recommendation. Occasionally we use 'must' (or 'must not') if the consequences of not following the recommendation could be extremely serious or potentially life threatening.

Recommendations that should (or should not) be followed– a 'strong' recommendation

We use 'offer' (and similar words such as 'refer' or 'advise') when we are confident that, for the vast majority of people, following a recommendation will do more good than harm, and be cost effective. We use similar forms of words (for example, 'Do not offer…') when we are confident that actions will not be of benefit for most people.

Recommendations that could be followed

We use 'consider' when we are confident that following a recommendation will do more good than harm for most people, and be cost effective, but other options may be similarly cost effective. The course of action is more likely to depend on the person's values and preferences than for a strong recommendation, and so the healthcare professional should spend more time considering and discussing the options with the person.

1.2 Recommendations

1. **Offer replacement arthroplasty (total hip replacement or hemiarthroplasty) to patients with a displaced intracapsular hip fracture. [2017]**

2. **Offer total hip replacement rather than hemiarthroplasty to patients with a displaced intracapsular hip fracture who:**
    - were able to walk independently out of doors with no more than the use of a stick and
    - are not cognitively impaired and
    - are medically fit for anaesthesia and the procedure. [2017]

3. **Use cemented implants in patients undergoing surgery with arthroplasty[1]. [2011]**

1.3 Patient-centred care

This guideline offers best practice advice on the care of skeletally mature adults (aged 18 years and over) with displaced or undisplaced intracapsular hip fracture.

Patients and healthcare professionals have rights and responsibilities as set out in the NHS Constitution for England – all NICE guidance is written to reflect these. Treatment and care should take into account individual needs and preferences. Patients should have the opportunity to make informed decisions about their care and treatment, in partnership with their healthcare professionals. Healthcare professionals should follow the Department of Health's advice on consent. If someone does not have the capacity to make decisions, healthcare professionals should follow the code of practice that accompanies the Mental Capacity Act and the

[1] The Association of Anaesthetists of Great Britain and Ireland, British Orthopaedic Association and British Geriatric Society have produced a safety guideline on reducing the risk from cemented hemiarthroplasty for hip fracture (2015). This safety guideline is not NICE accredited.

supplementary code of practice on deprivation of liberty safeguards. In Wales, healthcare professionals should follow advice on consent from the Welsh Government.

NICE has produced guidance on the components of good patient experience in adult NHS services. All healthcare professionals should follow the recommendations in Patient experience in adult NHS services.

1.4 Methods

This update was developed based on the process and methods described in Developing NICE guidelines: the manual.

2 Evidence review and recommendations – Displaced intracapsular hip fracture

2.1 Introduction

Decisions regarding management of intracapsular hip fractures are made on consideration of several factors, including the age and overall health of the patient, preceding level of mobility, condition of the bone and joint (for example, whether there is any pre-existing arthritis), and whether the fracture is displaced or undisplaced.

Displaced intracapsular hip fracture

Surgical treatment of a displaced hip fracture is recommended. This is because conservative management (a period of immobilisation and bed rest) can lead to a painful non-union of fracture fragments. NICE CG124 recommends that people with a hip fracture should receive surgery on the day of injury or the following day.

Surgical treatment options include:

- reduction and internal fixation with screws (IF);
- hemiarthroplasty (HA) - partial replacement of one half of the hip joint (a prosthetic replaces the femoral head, leaving the other half of the joint intact), or
- total hip replacement (THR).

2.2 RQ1: management of displaced intracapsular hip fracture

What is the clinical and cost effectiveness of internal fixation compared with hemiarthroplasty compared with total hip replacement (THR) in people undergoing repair for a displaced intracapsular hip fracture?

2.2.1 Clinical evidence review

One systematic search was conducted to cover both review question 1 (RQ1: management of displaced intracapsular hip fracture) and RQ2 (management of undisplaced intracapsular hip fracture) - see Appendix D:. The search identified 11,520 articles. The titles and abstracts were screened and 73 articles were identified as potentially relevant to RQ1 and full-text versions of these were ordered. A further 3 articles were identified from the original guideline CG124 or the reference lists of key studies and full-text versions of these were also requested. A total of 76 articles were obtained in full-text and reviewed against the criteria specified in the review protocol (Appendix C.1). Of these, 37 were excluded as they did not meet the criteria and 39 met the criteria and were included. A review flowchart is provided in appendix E.1, and the excluded studies (with reasons for exclusion) are shown in Appendix F.1.

2.2.1.1 Methods

Deviations from the review protocol

The methods outlined in the review protocol (see Appendix C.1) were used with the following amendments:

- Where data were sparse, as for the outcomes of functional status at 5 years and mortality at 5 years, the topic experts agreed that it would be reasonable to use 'indirect' data in its place and therefore data from 2 years or more was used.
- No information on minimal important differences (MID) was identified in the COMET database. The following MIDs were used in this update.
  - For mortality the line of no effect was used as in the original guideline
  - For functional status, a MID of 10 points for the Harris Hip Score has been reported in the literature (Cadossi 2013, van den Bekerom 2010).
  - For the EQ-5D, a MID of 0.07 points was identified in the literature (Walters & Brazier 2005)
  - GRADE default MIDs were used to assess imprecision for all other outcomes specified in the review protocol (for dichotomous outcomes: RR = 0.8 and 1.25; for continuous outcomes: SMD = -0.5 and 0.5).

Statistical analysis

Where appropriate, effect estimates including risk ratios (95% CIs) and mean differences (95% CIs), or standardised mean differences where different scales were used to measure the outcome of interest, were calculated using Review Manager 5.3. The I^2, chi^2 and tau^2 statistics were calculated to assess heterogeneity. The committee anticipated that there would be difference in effect size for different population subgroup and so a random effect models was used for analyses. The committee then discussed the finding in the committee meeting. For a random effects model, a $tau^2>1.0$ is considered to indicate significant statistical heterogeneity.

Subgroup analysis was only performed where data were available and only for the HA versus THR comparison as IF was not as effective as the other two procedures. When testing for subgroup differences, a p value < 0.05 was used to indicate significant subgroup difference.

2.2.1.2 Results

Overall summary of the evidence

The included studies were reviewed in 3 pairwise comparisons as follows:

- Hemiarthroplasty versus total hip replacement (9 included studies reported in 14 articles)
- Internal fixation versus hemiarthroplasty (15 included studies reported in 22 articles)
- Internal fixation versus total hip replacement (8 included studies reported in 15 articles).

Three RCTs (Keating 2005, Mouzopoulos 2008 and Skinner 1989) compared all 3 surgical treatments (that is, internal fixation versus hemiarthroplasty versus total hip replacement). The relevant treatment group data have been extracted and analysed as a separate study for each pairwise comparison in this review. In the study by Keating (2005), some participating surgeons opted to randomise patients between just 2 of the 3 treatment options: internal fixation or hemiarthroplasty. For the purpose of the comparison of internal fixation versus hemiarthroplasty in this review, this subset of data (Keating 2005b) has been analysed as a separate study from the 3-way randomisation data reported in Keating 2005a because of potential limitations with the 2-way randomisation data in terms of selection or performance bias.

A summary of the quality assessment of the body of evidence for each comparison identified the following:

- Hemiarthroplasty versus total hip replacement – majority of studies had serious limitations due to inadequate or unclear treatment allocation and lack of blinding of outcome assessors

where functioning outcomes were reported. Evidence for relevant outcomes was downgraded for risk of bias where appropriate.

- Internal fixation versus hemiarthroplasty – majority of studies had serious limitations due to inadequate or unclear treatment allocation and lack of blinding of outcome assessors where functioning outcomes were reported. Evidence for relevant outcomes was downgraded for risk of bias where appropriate. There was poor reporting of measures of functional status at 1 year; 4 studies could not be included in analyses because standard deviations were not given alongside mean scores (studies tended to report the range of scores instead; reliable estimates of SD cannot be imputed from the range).
- Internal fixation versus total hip replacement – all included studies had serious limitations due to inadequate or unclear treatment allocation and lack of blinding of outcome assessors where functioning outcomes were reported. Subgroup analyses were carried out for the hemiarthroplasty versus total hip replacement review based on age (aged 80 years and older versus younger than 80 years) and for cognitive impairment (cognitively impaired versus cognitively unimpaired versus not specified or mixed populations). There was insufficient data to perform other subgroup analyses requested in the review protocol (Gender, baseline ASA status, pre-fracture mobility, pre-fracture place of residence and timing of surgery).

For a summary of the studies included for each pairwise comparison, see tables 1 to 3 (for the full evidence tables, GRADE profiles and forest plots please see appendices G.1, H.1 and I.1 respectively).

Summary of included studies for RQ1 (surgical treatment of displaced intracapsular hip fracture)

Table 1: Internal fixation Vs. Hemiarthroplasty - included studies

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Blomfeldt 2005 Sweden (single centre) RCT	N = 60 adults ≥ 70yrs with dementia and with displaced fracture of the femoral neck Mean age: 84yrs 90% female	• Internal fixation with 2 cannulated screws • Hemiarthroplasty – unipolar, uncemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Quality of life • Place of residence at 1 year	Subgroups ○ Cognitively impaired ○ Independently mobile
Davison 2001 England (single centre) RCT	N = 280 adults 65-79yrs and mental test score ≥ 5/13 with displaced intracapsular fracture of the proximal femur Mean age: 75yrs 76% female	• Internal fixation with sliding compression screw and two-hole plate • Hemiarthroplasty – unipolar, cemented • Hemiarthroplasty – bipolar, cemented	• Mortality at 30 days • Mortality at 1 year • Surgical revision • Length of stay	Subgroup ○ Not cognitively impaired
Frihagen 2007 Norway (single centre) RCT	N = 222 adults ≥ 60yrs with displaced intracapsular femoral neck hip fracture Mean age: 83yrs 74% female	• Internal fixation with 2 cannulated screws • Hemiarthroplasty – bipolar, cemented	• Mortality at 30 days • Mortality at 1 year • Surgical revision • Functional status at 1 year • Quality of life • Length of stay • Place of residence at 1 year	Subgroup ○ Independently mobile

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Hedbeck 2013 Sweden RCT	N = 60 adults > 70 years and severe cognitive dysfunction (SMPSQ < 3) with displaced intracapsular hip fracture Mean age : 84.5 years 81.7% female	• Internal fixation –closed reduction with cannulated screws • Hemiarthroplasty - unipolar, cemented	• Mortality at 1 year • Mortality at 5 years • Surgical revision • Quality of life	Subgroup ○ cognitively impaired ○ Independently mobile
Keating 2005a Scotland, UK (11 centres) RCT	N = 138 adults ≥ 60yrs and mental test score > 6/13 with displaced intracapsular hip fracture Mean age: 75yrs 76% female	• Internal fixation – open or closed reduction; sliding or cannulated screws • Hemiarthroplasty - bipolar, cemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Quality of life • Length of stay	Subgroup ○ Not cognitively impaired ○ Independently mobile
Keating 2005b Scotland, UK (11 centres) RCT	N = 91 adults ≥ 60yrs and mental test score > 6/13 with displaced intracapsular hip fracture Mean age: 75yrs 84% female	• Internal fixation – open or closed reduction; sliding or cannulated screws • Hemiarthroplasty - bipolar, cemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Quality of life • Length of stay	Subgroup ○ Not cognitively impaired ○ Independently mobile
Mouzopoulos 2008 Greece (no. centres unspecified) RCT	N = 72 adults with displaced subcapital hip fracture Mean age: 75yrs 70% female	• Internal fixation – plate screw • Hemiarthroplasty – type not specified	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Length of stay	

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Parker 2002 England (single centre) RCT	N = 455 adults > 70yrs with displaced intracapsular hip fracture Mean age: 82yrs 80% female	• Internal fixation – closed reduction, 3 parallel cancellous screws • Hemiarthroplasty - unipolar, uncemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Length of stay • Place of residence at 1 year	Within-study subgroup analysis reported: ○ Age ○ Mobility ○ Cognitive status
Parker 2015 England (single centre) RCT	N = 56 male adults > 50yrs of age with displaced intracapsular hip fracture Mean age: 81yrs 0% female	• Internal fixation with Targon RN locking plate system with telescoping sliding screws • Hemiarthroplasty - cemented, unipolar Exeter trauma stem	• Mortality at 30 days • Mortality at 1 year • Surgical revision • Functional status at 1 year • Length of stay	Subgroup ○ Gender (male)
Puolakka 2001 Finland (single centre) RCT	N = 32 adults > 75yrs with displaced femoral neck fracture Mean age: 81yrs 84% female	• Internal fixation – closed reduction, 3 parallel Ullevaal screws • Hemiarthroplasty - unipolar, cemented	• Surgical revision	Subgroup ○ Independently mobile
Roden 2003 Sweden (single centre) RCT	N = 100 adults > 70yrs with displaced cervical hip fracture Mean age: 81yrs 71% female	• Internal fixation – 2 von Bahr screws • Hemiarthroplasty – bipolar, cemented	• Mortality at 5 years • Surgical revision • Length of stay	Subgroup ○ Independently mobile ○ Not cognitively impaired
Skinner 1989	N = 182 adults > 65yrs with displaced subcapital femoral neck fracture	• Internal fixation – sliding compression screw plate	• Mortality at 1 year • Surgical revision	

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
UK (single centre) RCT	Mean age: 81yrs 90% female	• Hemiarthroplasty – unipolar, uncemented		
Soreide 1979 Norway (single centre) RCT	N = 104 adults > 67yrs with displaced femoral neck fracture Mean age: 78yrs 81% female	• Internal fixation with von Bahr screws • Hemiarthroplasty - bipolar (Christiansen trunnion-bearing prosthesis)	• Mortality at 30 days • Mortality at 1 year • Surgical revision • Functional status at 1 year	
van Dortmont 2000 The Netherlands (single centre) RCT	N = 60 adults > 70yrs with dementia and a displaced intracapsular femoral neck fracture Mean age:84yrs 87% female	• Internal fixation – 3 AO / ASIF screws • Hemiarthroplasty – unipolar, cemented	• Mortality at 30 days • Mortality at 1 year • Surgical revision • Functional status at 1 year	Subgroup ○ Cognitively impaired
van Vugt 1993 The Netherlands (single centre) RCT	N = 43 adults, 71-80yrs with displaced intracapsular hip fracture Mean age: 76yrs 58% female	• Internal fixation with Dynamic HipScrew and 2-hole plate • Hemiarthroplasty –bipolar, cemented	• Mortality at 30 days • Mortality at 1 year • Surgical revision	

Table 2: Internal fixation Vs. Total hip replacement (THR) – included studies

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Chammout, (2012) Sweden (single centre) RCT	N = 100 adults ≥ 65yrs and with a displaced femoral neck fracture Mean age: 82yrs 79% female	• Internal fixation with 2 cannulated screws • Total hip replacement - cemented	• Surgical revision • Functional status at1 year • Functional status at 5 years	Subgroup ○ Not cognitively impaired ○ Independently mobile
Johansson. (2002) Sweden (single centre) RCT	N = 143 adults ≥ 75yrs with an acute displaced femoral neck fractures Mean age: 84yrs 76% female	• Internal fixation with two parallel screws after closed reduction • Total hip replacement - cemented prosthesis	• Mortality at 1 year • Surgical revision	Subgroup ○ Independently mobile Within-study subgroup analysis reported: ○ Cognitive status
Jonsson, (1996) Sweden (single centre) RCT	N = 47 adults with displaced cervical hip fractures Mean age: 79yrs 77% female	• Closed reduction and fixation with hansson hook-pins • Total hip replacement with Charnley prosthesis	• Mortality at 30 days • Surgical revision • Functional status at 1 year • Length of stay	Subgroup ○ Independently mobile
Keating 2005 Scotland, UK (11 centres) RCT	N = 138 adults > 60yrs and mental test score >6/13 with displaced intracapsular hip fracture Mean age: 75yrs 75% female	• Internal fixation - open or closed reduction; sliding or cannulated screws • Total hip replacement - cemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Quality of life • Length of stay	Subgroup ○ Not cognitively impaired ○ Independently mobile

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Liehu (2004) China (single centre) RCT	N = 285 adults ≥ 65yrs with a displaced femoral neck fracture who were independently mobile Mean age: 76yrs 54% female	• Internal fixation – closed reduction, 3 hollow compression screws • Total hip replacement – uncemented	• Surgical revision • Functional status at 1 year • Functional status at 5 years • Length of stay	Subgroup ○ Not cognitively impaired ○ Independently mobile
Mouzopoulos 2008 Greece (no. centres unspecified) RCT	N = 75 adults with displaced subcapital hip fracture Mean age: 74yrs 72% female	• Internal fixation – plate screw • Total hip replacement - cemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Length of stay	
Skinner 1989 UK (single centre) RCT	N = 180 adults > 65 yrs with displaced intracapsular hip fracture Mean age: 80yrs 90% female	• Internal fixation – sliding compression screw plate • Total hip replacement	• Mortality at 1 year • Surgical revision	
Tidermark, (2003) Sweden (single centre) RCT	N = 102 adults ≥ 70yrs with displaced fractures of the neck of the femur Mean age: 80yrs 80% female	• Internal fixation with two cannulated screws • Total hip replacement – type not reported	• Mortality • Surgical revision • Functional status at 1 year • Quality of Life at 1 year	Subgroup ○ Not cognitively impaired ○ Independently mobile

Table 3: Hemiarthroplasty Vs. Total hip replacement – included studies

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Baker 2006 UK (3 centres) RCT	N = 81 adults ≥ 60yrs with displaced intracapsular femoral neck fracture Mean age: 75yrs 79% female	• Hemiarthroplasty – cemented, unipolar • Total hip replacement - cemented	• Mortality at 30 days • Surgical revision • Quality of life • Dislocations	Subgroup ○ Not cognitively impaired ○ Independently mobile
Blomfeldt 2007 Sweden (single centre) RCT	N = 120 adults 70-90yrs with displaced intracapsular femoral neck Mean age: 81yrs 84% female	• Hemiarthroplasty – cemented, bipolar • Total hip replacement – cemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Quality of life • Place of residence • Dislocations	Subgroup ○ Not cognitively impaired ○ Independently mobile
Cadossi 2013 Italy (single centre) RCT	N = 83 adults ≥ 70yrs with displaced femoral neck fracture Mean age: 83yrs 75% female	• Hemiarthroplasty – cemented or uncemented. bipolar • Total hip replacement – uncemented, polycarbonate-urethane acetabular component	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Length of stay • Dislocations	Subgroup ○ Independently mobile
Dorr 1986 USA (single centre) RCT	N = 89 adults > 55yrs with displaced intracapsular femoral neck fracture Mean age: 70yrs 65% female	• Hemiarthroplasty – cemented, bipolar • Hemiarthroplasty – uncemented, bipolar • Total hip replacement - cemented	• Surgical revision • Functional status at 1 year • Dislocations	Subgroup ○ Independently mobile

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
Keating 2005 Scotland, UK (11 centres) RCT	N = 138 adults > 60yrs with displaced intracapsular hip fractures Mean age: 75yrs 77% female	• Hemiarthroplasty – bipolar, cemented • Total hip replacement - cemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Quality of life • Length of stay • Dislocations	Subgroup ○ Independently mobile ○ Within-study subgroup analysis - functional status x age (sample sizes not reported)
Macaulay 2008 USA (5 centres) RCT	N = 40 adults > 50yrs with displaced femoral neck fracture Mean age: 79yrs 53% female	• Hemiarthroplasty – unipolar or bipolar, cemented or uncemented femoral stem • Total hip replacement – cemented or uncemented femoral stem	• Surgical revision • Functional status at 1 year • Quality of life • Length of stay • Dislocations	Subgroup ○ Independently mobile ○ Not cognitively impaired
Mouzopoulos 2008 Greece (no. centres unspecified) RCT	N = 86 adults with displaced subcapital hip fracture Mean age: 74yrs 73% female	• Hemiarthroplasty – type not specified • Total hip replacement - cemented	• Mortality at 1 year • Surgical revision • Functional status at 1 year • Length of stay	Subgroup ○ Not cognitively impaired ○ Independently mobile
Skinner 1989 UK (single centre) RCT	N = 180 adults > 65yrs with displaced subcapital femoral neck fracture, of any cognitive status Mean age: 82yrs 90% female	• Hemiarthroplasty – uncemented, unipolar • Total hip replacement - cemented	• Mortality at 1 year • Surgical revision • Dislocations	

Study reference (including study design)	Study population	Intervention & comparator	Outcomes reported	Comments
van den Bekerom 2010 The Netherlands (8 centres) RCT	N = 252 adults ≥ 70yrs with displaced femoral neck fracture Mean age: 81yrs 82% female	• Hemiarthroplasty – cemented, bipolar • Total hip replacement - cemented	• Mortality at 30 days • Mortality at 1 year • Mortality at 5 years • Surgical revision • Functional status at 1 year • Functional status at 5 years • Length of stay • Dislocations	

2.2.2 Health economic evidence review

2.2.2.1 Methods

Methods of the economic evidence review, including explanation of the structure of the economic evidence profile and cost effectiveness criteria, are detailed in Appendix J:.

2.2.2.2 Undertaking new health economic analysis

As well as reviewing the published economic literature for each review question, a new economic analysis was undertaken by the health economist.

The following general principles were adhered to in developing the cost-effectiveness analysis:

- Methods were consistent with the NICE reference case.
- The Committee was involved in the design of the model, selection of inputs and interpretation of results.
- Model inputs were based on the systematic review of the clinical literature supplemented with other published data sources where possible.
- When published data were not available, Committee expert opinion was used to populate the model.
- Model inputs and assumptions were reported fully and transparently.
- The results were subject to sensitivity analysis and limitations were discussed.
- The model was quality assured by another health economist within NICE's Centre for Guidelines.

Full methods for the cost-effectiveness analysis conducted for this guideline are described in Appendix O:.

2.2.2.3 Results of the economic literature review

The initial search returned a total of 2,176 results, of which 21 were identified for full text review. Of these, 4 were included in the economic evidence review. Table 4 contains the economic evidence profile for this review question summarising the results of the studies included in the systematic review, modelling conducted for the previous guideline and the economic model developed for the present update. Full economic evidence tables are contained in Appendix N:.

The flowchart summarising the number of studies included and excluded at each stage of the review process can be found in Appendix L:. Appendix M: contains a list of excluded studies and the reason for their exclusion.

Of the 4 studies included, 2 were relevant to the NHS perspective. One of these (Keating et al, 2005) consisted of an RCT and economic analysis, which found that total hip replacement dominates both hemiarthroplasty and internal fixation. However, this analysis does not extrapolate beyond the 2 year time horizon of the RCT. Carroll et al (2011) models the cost effectiveness of total hip replacement compared to hemiarthroplasty using data from the Keating study, with extrapolation to a 3- and 5-year time horizon. However, this study makes an error in calculating incremental costs: total hip replacement is reported as being more expensive than hemiarthroplasty while, in the Keating study, the reverse is true. Although this error does not affect the conclusion of the deterministic analysis (that total hip replacement is cost effective) it means that sensitivity analysis results are not reliable.

Of the non-UK-based studies, 1 was a USA-based analysis comparing total hip replacement to hemiarthroplasty using a modelling approach with a 20-year time horizon. This study found total hip replacement to be cost effective, with an ICER of $1,960. Bjornelv et al (2012) was a Norwegian analysis comparing hemiarthroplasty to internal fixation via an in-trial RCT analysis with a 2 year time horizon. This study concludes that hemiarthroplasty dominates internal fixation.

In summary, the economic literature agrees that total hip replacement is cost effective compared to hemiarthroplasty and internal fixation, and that hemiarthroplasty is cost effective compared to internal fixation. However, the lack of probabilistic sensitivity analysis and generally short time horizons makes it difficult to quantify the uncertainty in these results.

Table 4: Economic evidence profile

Study	Applicability	Limitations	Other comments	Incremental			Uncertainty
				Cost	Effect	ICER	
Bjornelv et al. 2012 Hemiarthroplasty versus internal fixation Norway	Partially applicable[1]	Potentially serious limitations[2]	RCT-based analysis with 2-year time horizon	Total cost: -€14,160 Total hospital cost: €-2,474	0.2 QALYs	Hemiarthroplasty dominates internal fixation	Bootstrapping of all cost and effect measures using 1,000 iterations. Mean incremental effect 0.149 QALYs and mean incremental cost -€2,421 (total hospital cost). Hemiarthroplasty was not cost effective in 2% of iterations based on a threshold of €37,500.
Carroll et al. 2011 Total hip replacement versus hemiarthroplasty UK	Directly applicable[3]	Very serious limitations[4]	Trial-based analysis of data from Keating et al. 2005. 2-year time horizon with extrapolation to 3 and 5 years. Analysis has been classified as having very serious limitations due to an apparent error in incremental costs – total hip replacement is reported as being more expensive than hemiarthroplasty, whereas a cost saving is reported in the Keating et al. RCT.	£3,989 (all time horizons)	2 years: 0.147 QALYs 3 years: 0.285 QALYs 5 years: 0.580 QALYs	2 years: £27,023 3 years: £16,146 5 years: £7,952	An exploratory sensitivity analysis conducted using utility data from an alternative RCT yielded the following ICERs: 2 years: £44,997 3 years: £30,511 5 years: £18,932

Study	Applicability	Limitations	Other comments	Incremental			Uncertainty
				Cost	Effect	ICER	
Keating et al. 2005 Total hip replacement versus hemiarthroplasty versus internal fixation UK	Partially applicable[5]	Potentially serious limitations[6]	RCT reporting 2-year costing outcomes and EQ-5D scores at 4, 12 and 24 months.	THR vs. HA: -£3,010 HA vs. IF: £381 THR v. IF: -£2,629	EQ-5D utilities: THR vs. HA: 4 months: 0.08 12 months: 0.04 24 months: 0.16 HA vs. IF: 4 months: 0.03 12 months: 0.08 24 months: -0.05 THR vs. IF: 4 months: 0.11 12 months: 0.12 24 months: 0.11	Total hip replacement dominates both hemiarthroplasty and internal fixation	Results were robust to changes in cost of prosthesis and hip-related admissions – varying values over a range from -50% to +100% did not change outcomes.
Slover et al. 2009 Total hip replacement versus hemiarthroplasty	Partially applicable[7]	Minor limitations[8]	Markov model with a 1 year cycle length. 20 year time horizon.	$3,000	1.53 QALYs	$1,960	At a threshold of $50,000: Setting identical utility values for the two procedures still results in total hip replacement being the more cost-effective option. The lifetime cost associated with treating a patient with total

Study	Applicability	Limitations	Other comments	Incremental			Uncertainty
				Cost	Effect	ICER	
USA							hip replacement must be greater than $78,000, while the lifetime cost associated with using a hemiarthroplasty must be less than $22,000 for hemiarthroplasty to be the more cost-effective option.

Acronyms
ICER: incremental cost-effectiveness ratio; QALY: quality-adjusted life year

[1] *Partially applicable: This study compares two of the relevant outcomes in a relevant patient population, but is only partially applicable due to the non-UK healthcare system perspective.*
[2] *Potentially serious limitations: This study suffers from a relatively short time horizon (2 years). However, this is unlikely to change the outcome, as the higher revision rate for internal fixation means that results are likely to be conservative against hemiarthroplasty.*
[3] *Directly applicable: This analysis is directly applicable, as it compares two of the interventions of interest in the context of the UK healthcare system*
[4] *Potentially serious limitations: In the base case, this analysis uses only a 2-year horizon, which is likely insufficient to capture all relevant costs and health benefits. Although, results are given for 3- and 5-year horizons, health benefits are extrapolated in a simplistic manner (last observation carried forward) and no additional costs are considered. The fact that the analysis does not consider revisions or displacements beyond 2 years means that the cost-effectiveness of total hip replacement is likely underestimated.*
[5] *Partially applicable: While this analysis compares all relevant interventions in an appropriate population, the fact that that costs and health benefits are not combined in the form of ICERs makes it only partially applicable.*
[6] *Potentially serious limitations: Although unlikely to affect outcomes, this analysis suffers from a limited 2-year time horizon.*
[7] *Paritally applicable: This study compares two of the relevant outcomes in a relevant patient population, but is only partially applicable due to the non-UK healthcare system perspective.*
[8] *Minor limitations: The analysis considers most relevant outcomes over a sufficiently long time horizon, though suffers from estimated utility values and lack of consideration of dislocations.*

2.2.3 Economic modelling

2.2.3.1 Introduction

Novel economic modelling was undertaken for review question 1. The full report of the economic model developed for this update is provided in Appendix O:.

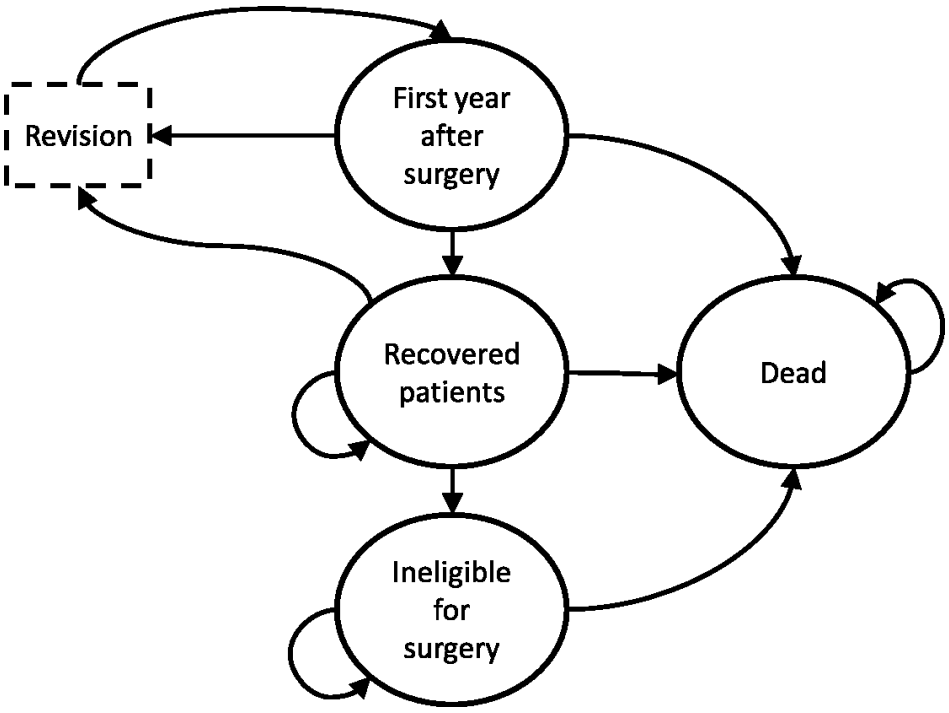
The objective of the model was to investigate the cost effectiveness of total hip replacement (THR), hemiarthroplasty (HA), and reduction and internal fixation (IF) with screws for the management of intracapsular hip fracture in previously healthy patients who are not cognitively impaired and were previously able to walk independently.

The evaluation was a cost utility analysis; costs were measured in GBP, and health outcomes were measured in quality adjusted life years (QALYs).

2.2.3.2 Methods

A Markov model with a cycle length of one year was used to simulate the progression of patients over a lifetime time horizon. The structure of the model is displayed in Figure 1.

Figure 1: Diagram of model structure



At the start of the model, all patients undergo a surgical procedure (THR, HA, or IF) and enter the 'first year after surgery' state. During this year, patients may die or require a revision procedure, which results in those patients returning to the 'first year after surgery' state for the next cycle of the model. The remainder of patients progress to the 'recovered patients' state. Patients in this state also have an annual probability of death and revision. However, it is also assumed that 50% of patients in this state who require revision are deemed too risky for

additional surgery, and progress to 'ineligible for surgery' state, where they remain for the rest of the model.

It is assumed that, in the HA and IF arms of the model, 80% of patients requiring a revision procedure receive THR, while the remaining 20% receive HA. For patients in the THR arm, it is assumed that all patients requiring a revision procedure receive THR.

In order to inform model revision and mortality rates, odds ratios were calculated for each pair of comparators via a network meta-analysis using data sourced from studies identified in the clinical review, the methodology of which is detailed in Appendix P:. These odds ratios were transformed to relative risks, which were applied to baseline revision and mortality rates for HA, in order to calculate probabilities for each intervention. Calculating the annual probability of revision in recovered patients required a multi-step approach, in order to compensate for the fact that baseline long-term revision rates also incorporated revisions in the first year after surgery. This involved calculating both the long- and short- term revision rates for each intervention, subtracting the latter from the former, and recalculating relative risks between interventions. The annual long-term baseline revision rate for HA was then calculated using data from the Swedish Hip Arthroplasty Register, to which the relative risks were applied. Swedish data were used due to a lack of long-term revision rate data with a specific endpoint for the English population.

The assumption was made that once patients entered the 'recovered' state, mortality returned to the baseline rate for individuals of that age.

Costs of each procedure were taken from initial inpatient episode costs reported in Keating et al (2005). These values accounted for resource usage during patients' initial hospital stay, and therefore accounted for all costs accrued during this period. The assumption was made that costs of revision procedures are the same as those of primary procedures.

Utility scores 4 months after each procedure were sourced from Keating et al (2005). The assumption was made that, after the initial four month period following surgery, patients' utility remained at the level of the four month score corresponding to the most recent procedure. For the initial four months after surgery, it was assumed that patients' utility progressed linearly from the utility score immediately following surgery to the utility score at four months. Mean utility for patients ineligible for surgery was assumed to be midway between the score for patients at four months and the score immediately following surgery.

As well as reporting deterministic results, one-way and probabilistic sensitivity analyses were carried out, in order to characterise uncertainty in the results. Additionally, a threshold analysis was carried out, to determine the cost above which THR would not be considered cost effective at a threshold of £20,000 per QALY at a variety of time horizons.

2.2.3.3 Results

Deterministic results of the analysis, in terms of total lifetime costs and QALYs associated with each procedure, are displayed in Table 5. These results show that THR dominates both HA and IF: it is less costly and generates a higher number of QALYs.

Table 5: Deterministic model results

Intervention	Cost	QALYs	ICER
Total hip replacement	£11,083	4.05	-
Hemiarthroplasty	£11,387	3.51	dominated
Internal fixation	£12,134	3.44	dominated

Table 6 displays intermediate outcomes of the analysis. These results show that HA is associated with the fewest surgical revision procedures. However, THR is associated with the fewest deaths in the year following surgery, and is associated with the highest mean utility for living patients. As a result, despite the lower number of revision associated with HA, THR is the procedure resulting in the highest number of QALYs.

While the intermediate results show that HA is associated with the lowest mean revision surgery cost per patient, THR is still the least costly option overall, due to a lower cost of the initial procedure compared to HA. Despite having the lowest cost per procedure, IF is the most costly strategy. The reason for this is demonstrated by the intermediate results: IF is associated with a mean revision surgery cost per patient of £3,031 per patient.

Table 6: Intermediate model outcomes

Outcome	THR	HA	IF
Total number of revision procedures per 1,000 patients	64	50	303
Number of deaths occurring in the year following primary surgery/revision surgery per 1,000 patients	182	204	233
Number of deaths in the year following revision surgery per 1,000 patients	11	9	53
Mean utility for living patients	0.675	0.599	0.592
Average revision surgery cost per patient	£629	£492	£3,031

Results of the one-way sensitivity analysis are shown in Table 7 for a number of scenarios. These results demonstrate that outcomes are generally robust to changes in key model assumptions. Only 2 scenarios result in a change in the order of outcomes: the scenario in which costs of all procedures are set to those of THR, and the scenario in which relative risks of revision are set to the values derived from the network meta-analysis (NMA) without data from Skinner 1989. This latter sensitivity analysis was carried out as the Skinner study causes inconsistency between network meta-analysis and pairwise meta-analysis results: relative risks for revision rates favour THR in the former case and HA in the latter case. In both of these scenarios HA is the least costly option, but THR is still the most cost effective option, due to an ICER well below the £20,000 threshold. Results of scenarios in which the time horizon of the model is reduced to 2, 3, 4, and 5 years show that THR remains the most cost effective option, indicating that THR is likely to be cost effective in patients with a shorter life expectancy.

Table 7: One-way sensitivity analysis results

Utility values for all procedures set to those of THR			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,083	4.07	-
Hemiarthroplasty	£11,387	3.94	dominated

Internal fixation	£12,134	3.90	dominated
Costs of all procedures set to those of THR			
Intervention	**Cost**	**QALYs**	**ICER**
Hemiarthroplasty	£10,941	3.51	-
Total hip replacement	£11,083	4.08	£275
Internal fixation	£13,460	3.45	dominated
Cost of revision twice the cost of primary procedure			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,712	4.08	-
Hemiarthroplasty	£11,879	3.51	dominated
Internal fixation	£15,164	3.45	dominated
All patients eligible for revision			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,083	4.08	-
Hemiarthroplasty	£11,388	3.52	dominated
Internal fixation	£12,141	3.45	dominated
50% of patients requiring revision in the first year after surgery deemed ineligible			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,078	4.05	-
Hemiarthroplasty	£11,382	3.50	dominated
Internal fixation	£12,025	3.38	dominated
80% of patients in HA and IF arms receive hemiarthroplasty as revision procedure			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,083	4.08	-
Hemiarthroplasty	£11,396	3.50	dominated
Internal fixation	£12,185	3.36	dominated
Relative risks for revision calculated from NMA without Skinner 1989			
Intervention	**Cost**	**QALYs**	**ICER**
Hemiarthroplasty	£11,408	3.51	-
Total hip replacement	£11,470	4.07	£112
Internal fixation	£13,488	3.47	dominated
Relative risks from pairwise meta analyses used for revision rate and one year mortality			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£10,782	4.08	-
Hemiarthroplasty	£11,377	3.51	dominated
Internal fixation	£11,400	3.40	dominated
Model time horizon set to 2 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£10,983	1.20	-
Hemiarthroplasty	£11,269	1.05	dominated
Internal fixation	£11,753	1.02	dominated
Model time horizon set to 3 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,020	1.68	-

Hemiarthroplasty	£11,301	1.47	dominated
Internal fixation	£11,915	1.43	dominated
Model time horizon set to 4 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,032	2.11	-
Hemiarthroplasty	£11,316	1.83	dominated
Internal fixation	£11,959	1.79	dominated
Model time horizon set to 5 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,041	2.49	-
Hemiarthroplasty	£11,329	2.15	dominated
Internal fixation	£11,991	2.11	dominated

Results of the threshold analysis investigating the cost above which THR would no longer be cost effective at a threshold of £20,000 are shown in Table 8. These results demonstrate that, with a lifetime time horizon, the cost per THR procedure would have to be above £21,208 for the intervention to no longer be considered cost effective. Threshold values at shorter time horizons are lower, as QALY gains produced by THR are smaller in these scenarios. However, even at a 2 year time horizon, the cost of THR would have to be substantially higher for the procedure to no longer be considered cost effective.

Table 8: Threshold analysis results – cost per procedure above which THR would no longer be cost effective at a £20,000 threshold

Model time horizon	Lifetime	2 years	3 years	4 years	5 years
Cost above which THR would not be cost effective	£21,208	£13,511	£14,807	£15,958	£16,963

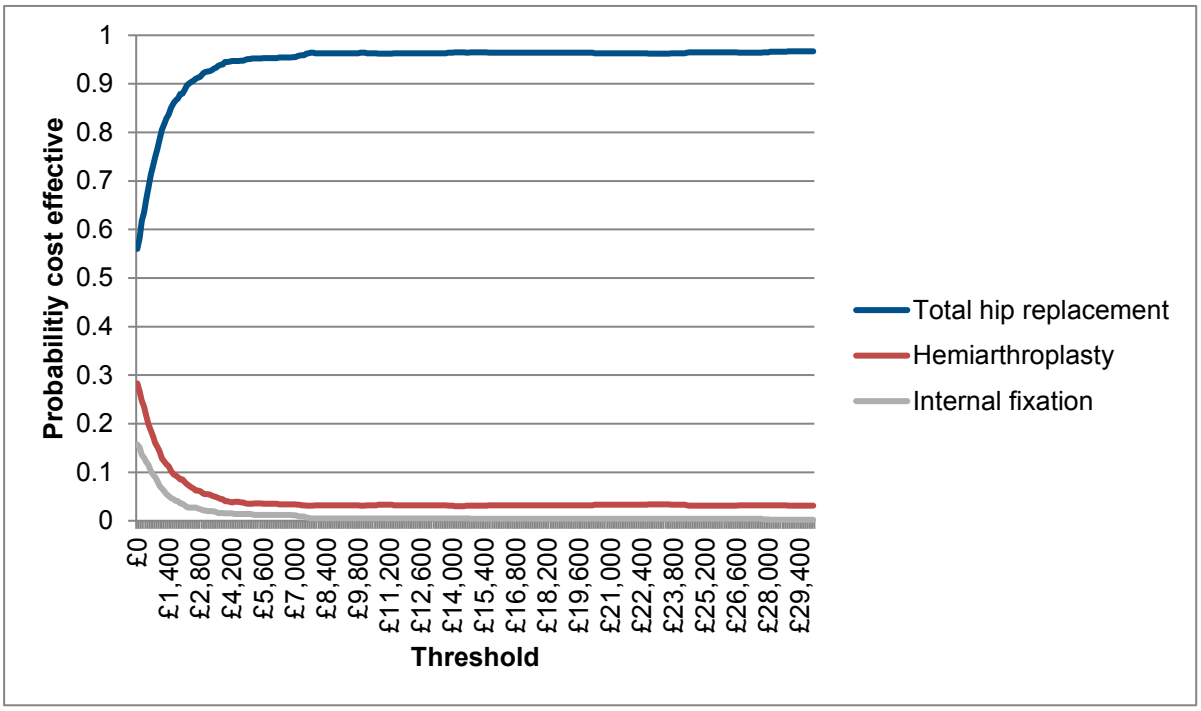
Mean cost effectiveness results of the probabilistic sensitivity analysis are shown in Table 9. These values are generally similar to the results of the deterministic analysis, and produce the same conclusion: THR dominates both HA and IF.

Table 9: Mean probabilistic sensitivity analysis results

Intervention	Cost	QALYs	ICER
Total hip replacement	£11,057	4.05	-
Hemiarthroplasty	£11,372	3.50	Dominated
Internal fixation	£11,856	3.44	Dominated

Figure 2 shows the results of the probabilistic sensitivity analysis as a cost effectiveness acceptability curve. The results show that THR has the highest probability of being the most cost effective intervention at any threshold. At a threshold of £20,000 per QALY THR has a probability of 96% of being the most cost effective intervention.

Figure 2: Cost effectiveness acceptability curve of probabilistic sensitivity analysis results



2.2.3.4 Conclusion

The results of this cost utility analysis show that THR is likely to be the most cost effective strategy for the management of displaced, intracapsular hip fracture in previously healthy patients. Despite a higher revision rate than HA, THR is associated with the highest expected number of QALYs, due to lower mortality rates and higher utility scores following surgery. Due to a lower initial procedure cost than HA, and a lower revision rate than IF, THR is also associated with the lowest expected cost.

Sensitivity analyses have shown that results are robust overall, with one-way sensitivity analyses demonstrating that, even assuming that all procedures are associated with equal costs or equal utility following surgery, THR is the most cost effective option.

2.3 Evidence statements

2.3.1 Clinical evidence statements

Hemiarthroplasty versus total hip replacement

This review found a lower dislocation rate in the hemiarthroplasty group compared to the total hip replacement group (very low level of certainty from eight RCTs with 983 people). However, there was also improved functional status with total hip replacement compared to hemiarthroplasty at 1 year (moderate level of certainty from 4 RCTs with 313 people) and at 5 years (low level of certainty from 5 RCTs with 292 people).

There was no evidence of a difference between the 2 interventions for the outcomes of mortality at 30 days (moderate level of certainty from 2 RCTs with 233 people), mortality at 1 year (low level of certainty from 6 RCTs with 859 people) and 5 years (low level of certainty from 8 RCTs with 980 people); surgical revision rates (very low level of certainty from 9 RCTs with 1069 people); place of residence (1 RCT with 111 people); quality of life (moderate level of certainty from 1 RCT with 164 people) and length of stay (high level of certainty from 3 RCTs 264 people).

There were no subgroup differences for age or cognitive impairment with the exception of functional status at 5 years where, while there was improved functional status with total hip replacement compared to hemiarthroplasty, those aged 80 and older showed a much greater difference between the 2 interventions (Harris Hip Score MD = 13.06 lower [from 18.28 to 7.84 lower] than those younger than 80 years of age (Harris Hip Score MD = 4.46 lower [from 7.33 to 1.59 lower]).

Internal fixation versus Hemiarthroplasty

This review found a lower surgical revision rate in the hemiarthroplasty group compared to the internal fixation (low level of certainty from 15 RCTs with 1968 people). There was also improved functional status with hemiarthroplasty compared to internal fixation at 1 year (moderate level of certainty from 4 RCTs with 394 people) and at 5 years (moderate level of certainty) from 4 RCTs with 329 people).

There was no evidence of a difference between the 2 interventions for the outcomes of mortality at 30 days (moderate level of certainty from 6 RCTs with 765 people), mortality at 1 year (moderate level of certainty from 13 RCTs with 1836 people) and 5 years (low level of certainty from 11 RCTs with 1293 people); quality of life (low level of certainty from 5 RCTs with 450 people) and length of stay (high level of certainty from 5 RCTs with 591 people).

Internal fixation versus total hip replacement

This review found a lower surgical revision rate in the total hip replacement group compared to the internal fixation (low level of certainty from 8 RCTs with 1084 people). There was also improved functional status with total hip replacement compared to internal fixation at 1 year (low level of certainty from 2 RCTs with 174 people) and at 5 years (very low level of certainty) from 2 RCTs with 145 people) and quality of life (moderate level of certainty from 1 RCT with 126 people).

There was no evidence of a difference between the two interventions for the outcomes of mortality at 30 days (moderate level of certainty from 1 RCT with 47 people), mortality at 1 year (moderate level of certainty from 5 RCTs with 650 people) and 5 years (low level of certainty from 6 RCTs with 653 people); and length of stay (high level of certainty from 3 RCTs with 509 people).

2.3.2 Health economic evidence statements

A UK-based RCT reporting data on the quality of life and costs associated with total hip replacement, hemiarthroplasty, and internal fixation (Keating et al. 2005) reported that total hip replacement is associated with a lower total cost and higher EQ-5D scores at all time points compared to other interventions, and therefore dominates both hemiarthroplasty and internal fixation. This study was considered partially applicable, due to considering costs and utilities separately, rather than conducting a full cost utility analysis, and with potentially serious limitations, due to only reporting outcomes over a 2 year horizon.

A simplistic model-based analysis, based on results from Keating et al. (Carroll et al. 2011) reported that total hip total hip replacement is both more costly and more effective than hemiarthroplasty, with ICERs becoming relatively smaller as the time horizon of the model is extended (ICER at 2 years = £27,023, ICER at 5 years = £7,952). However, incremental costs used in this analysis were incorrect - the study used an incremental cost of total hip replacement compared to hemiarthroplasty of £3,989, whereas Keating et al. reported that total hip replacement was less costly than hemiarthroplasty. While this does not change the overall conclusion of the analysis (that total hip replacement is cost effective), the results of the probabilistic sensitivity analysis are unreliable. The analysis is directly applicable to the review question and to the NHS perspective, but is characterised by very serious limitations, due to the aforementioned cost error.

A USA-based analysis (Slover et al. 2009) used a Markov model to predict costs and health benefits of total hip replacement and hemiarthroplasty over a 20 year time horizon. Results demonstrated that total hip replacement is associated with a cost effective ICER of $1,960 (approximately £1,600) – a finding which is robust to one-way sensitivity analyses varying utility values and costs. The analysis is only partially applicable to the review question, due to being conducted in the USA, but is characterised by only minor limitations.

A Norwegian cost utility analysis (Bjornelv et al. 2012) based on the results of an RCT reported that hemiarthroplasty dominates internal fixation over a 2 year time horizon. This result was robust to sensitivity analysis via bootstrapping, with only 2% of iterations giving a cost ineffective ICER for hemiarthroplasty at a threshold of €37,500 (approximately £30,000). This study is partially applicable, due to the non-UK healthcare setting, and suffers from potentially serious limitations, because of the short time horizon.

The novel cost utility analysis conducted for this guideline reported that, for previously healthy patients, THR dominates both HA and IF over a lifetime time horizon. This result was robust to both deterministic and probabilistic sensitivity analysis. This analysis is directly applicable to the review question and to the NHS perspective, with minor limitations.

2.4 Evidence to recommendations

	Committee discussions
Relative value of different outcomes	People have a general understanding that a hip fracture is potentially a life-altering condition. For many patients with hip fracture, the concerns are about recovering and 'getting back to usual activities'. For a highly-active patient a total hip replacement may be preferable even if they have to wait for a day or two whereas in patients who are less active (for example, due to stroke or dementia) early hemiarthroplasty and mobilisation are crucial to avoid dislocation due to non-co-operation or early muscle imbalance. For this reason the committee considered the following outcomes to be critical criteria for people with hip fracture (and their family/carers) in decision making: mortality, quality of life and functional status. Surgical revision rates (resulting from fixation failure) and/or dislocations were considered to be less critical as an outcome. This is because mortality

	Committee discussions
	rates are higher with short-term fixation failure. While the number of revisions and dislocations have significant implications for both the patient and their family/carer and for the wider health and social care services, the committee considered that these outcomes would not have an impact on decision making. This is partially due to the fact that revision surgery may not be offered as those patients who are considered to be in general decline and frail have poorer prospects for surgery. In the case of dislocation, the majority of these are corrected by manipulation and may not require a surgical procedure so have little impact on clinical decision making. Length of stay is considered important as it has major implications for resources as the average length of stay after hip fracture surgery in the UK is around 3 weeks, though the committee did not expect to see large variation in the length of stay associated with each type of surgery. There is also some consideration that this may not accurately represent clinical practice as some hospitals may discharge early to a rehabilitation unit and this may not be included in the 'length of stay' outcome. Place of residence after hip fracture was also considered to be important as returning home is a key concern for patients whose place of residence was their home. However, in clinical practice, there is no reliable way to determine patients' place of residence immediately following care for each procedure as this information is not regularly recorded. There was sparse data on this outcome in the included studies. The topic experts also queried the applicability of 'return to residence' as reported in the included studies due to the differences in how services are organised in different countries. However return to original place of residence could be regarded as a surrogate measurement of functional status.
Quality of evidence	The committee noted that the certainty around the majority of outcomes was low indicating a lack of confidence in the evidence identified. This was driven by several factors based on a full GRADE assessment: • The quality of the included studies was reduced as a result of concerns over bias (lack of blinding of assessor for functional outcomes, poor reporting of methodological considerations around randomisation and allocation concealment). • The certainty around the findings for some of the outcomes was adjusted downwards due to heterogeneity in the meta-analyses for some outcomes. This was not explained by subgroup analyses requested by the committee but may be due to the variation in devices used in the included studies. • While the data for the majority of the outcomes was reported at the time-points specified in the review protocols, some data was reported at other timepoints and this data was downgraded for indirectness. • Several of the findings were imprecise as the confidence intervals crossed the line of no effect or the line of MID making it difficult to determine the clinical significance of effect size estimate. Overall, the committee noted that the new studies were consistent with those included in the original guideline and also that the evidence was consistent with their experiences in clinical practice.
Trade-off between benefits and harms	The benefits of surgical interventions in cases of intracapsular hip fracture are improved functional status, improved quality of life and return to place of residence. These are considered against the harms such as need for surgical revision and increased mortality rates due to the procedure or any re-surgery. Total hip replacement was associated with improved functional status (when compared to hemiarthroplasty and internal fixation) and quality of life (when compared to internal fixation). Internal fixation was associated with an increased need for surgical revisions (when compared to both hemiarthroplasty and total hip

	Committee discussions
	replacement) while there was no difference between the interventions for mortality. The committee were confident that the harm associated with internal fixation (increased risk of surgical revision) was paramount in their decision making especially as this intervention did not convey any benefits in terms of functional status or quality of life when compared to the other two interventions. When hemiarthroplasty was compared with total hip replacement there was no meaningful difference between the two interventions for the majority of the outcomes examined, with the exception of dislocation rate (which favoured hemiarthroplasty) and functional status at both 1 and 5 years (which favoured total hip replacement). The committee noted that functional status at both timepoints would be a key driver in decision making for the reasons outlined above.
Trade-off between net health benefits and resource use	The committee considered the evidence from the economic literature review, and agreed that deterministic results seem to indicate that total hip replacement is cost effective compared to both hemiarthroplasty and internal fixation. However, the committee raised concerns regarding the level of certainty surrounding these results, due to the lack of significance at the 95% level between many parameters associated with the interventions, and the lack of probabilistic sensitivity analysis in the majority of evaluations. The committee also considered evidence from the novel economic analysis conducted for the guideline update, and agreed the results indicate that total hip replacement is likely to be the most cost effective management strategy for displaced intracapsular hip fracture. There was some discussion surrounding the input parameters used for the model – specifically, some committee members raised the concern that total hip replacement may be more expensive in practice. However, sensitivity analyses demonstrated that model results are robust to changes in parameters, and the cost per total hip replacement procedure would need to be more than doubled for it to no longer be cost effective at a threshold of £20,000. The committee also discussed whether the data used from Keating et al (2005) capture all relevant costs. The costs used from the Keating study account for all resource usage during the initial hospital stay (including high dependency and intensive care costs), and patients undergoing a revision procedure incur the cost of the appropriate primary procedure in the model. The committee discussed whether there might be a difference in costs relating to hospital re-admissions which do not result in revision surgery, but it was felt that revisions surgery is the predominant reason for hip-related readmission, and therefore no significant differences between these costs would be expected. Based on this evidence, the committee concluded that total hip replacement should be offered to patients with displaced intracapsular hip fracture who are not cognitively impaired and were previously able to walk independently. However, the committee agreed that it was not possible to fully extrapolate the results of the economic evidence to patients with cognitive impairment or with mobility issues. This was because, in the committee's experience, outcomes for these patients can differ substantially from those of previously healthy patients – for instance patients with cognitive impairment typically experience a higher dislocation rate with total hip replacement. Therefore, the committee agreed that the option to offer either hemiarthroplasty or total hip replacement to these patients should be available. The committee also discussed the potential resource impact of the recommendation, and concluded that, although the broad messages remain the same, the update is likely to increase the proportion of total hip replacement procedures being carried out, due to the availability of more robust clinical and economic evidence.

	Committee discussions
	While the results of economic analyses indicate that total hip replacement is unlikely to be considerably more costly than hemiarthroplasty, the change in practice would necessitate a substantial reorganisation of services as experienced surgeons (consultant level) usually perform total hip replacements and as these are based in regional centres and not all hospitals have access to a consultant surgeon. Therefore, it is likely that the recommendation would incur a significant resource impact in excess of £1 million. However, this additional cost is justified by the results of a robust health economic analysis.
Other considerations	The committee noted that the typical patient with a displaced hip fracture is an 83 year old woman who is living at home and has a 1 in 3 chance of having dementia. Thirty seven of the included studies included a majority of women and 28 of the included studies included participants with a mean age of 80 years of age or more; but only 8 included those with cognitive impairment and only 5 included only participants who were living at home. The committee were therefore concerned that the included studies did not reflect clinical practice in the UK. The committee noted safety concerns in the field regarding cemented implants and risk of bone cement implantation syndrome. The topic experts discussed a 2015 consensus safety guideline developed by the Association of Anaesthetists of Great Britain and Ireland, British Orthopaedic Association, and British Geriatric Society. It was felt that this guideline describes a safe method of practice that should apply to every patient given cemented implants. It was agreed that a footnote should be added to the recommendations on the use of cemented implants to highlight this safety guideline. This safety guideline is not NICE accredited. **Equalities** The committee recognised, however, that a high proportion of this group of patients are elderly and frail and cognitive impairment is also common. This may complicate their assessment and management, and specific steps to ascertain this, especially in the prevention and management of delirium, are required. Such impairment may limit reliability in communicating symptoms, in particular pain.

2.5 Recommendations

1. **Offer replacement arthroplasty (total hip replacement or hemiarthroplasty) to patients with a displaced intracapsular hip fracture. [2017]**

2. **Offer total hip replacement rather than hemiarthroplasty to patients with a displaced intracapsular hip fracture who:**
    - were able to walk independently out of doors with no more than the use of a stick and
    - are not cognitively impaired and
    - are medically fit for anaesthesia and the procedure. [2017]

3. **Use cemented implants in patients undergoing surgery with arthroplasty[b]. [2011]**

[b] The Association of Anaesthetists of Great Britain and Ireland, British Orthopaedic Association and British Geriatric Society have produced a safety guideline on reducing the risk from cemented hemiarthroplasty for hip fracture (2015). This safety guideline is not NICE accredited.

2.6 Research recommendations

No research recommendation was drafted

3 Evidence review and recommendations – Undisplaced intracapsular hip fracture

3.1 RQ2: management of undisplaced intracapsular hip fracture

What is the clinical and cost effectiveness of conservative management compared with internal fixation compared with hemiarthroplasty compared with total hip replacement (THR) in people with an undisplaced intra-capsular hip fracture?

3.1.1 Clinical evidence review

From the literature search conducted (see 2.2.1), 44 studies were identified as potentially relevant to this clinical evidence review. No randomised controlled trials or comparative cohort studies were found and a post-hoc decision was made at committee meeting 1 to extend the protocol to case series. These studies were assessed in full and 10 case series met the criteria specified in the review protocol and were included. A review flowchart is provided in appendix E.2, and the excluded studies (with reasons for exclusion) are shown in Appendix F.2.

3.1.1.1 Methods

The methods outlined in the review protocol (see Appendix C.2) were used. Only studies using both anteroposterior (AP) and lateral radiographs to diagnose undisplaced hip fractures were included. As in review question 1, for outcomes where 5 years data were sparse, the topic experts agreed that it would be reasonable to use 'indirect' data in its place and therefore data from 2 years or more was used where available. As all studies included were case series, risk of bias assessment in GRADE was conducted using the Joanna Briggs Institute (JBI) checklist for case series: http://joannabriggs.org/research/critical-appraisal-tools.html. Due to the non-comparative nature of the studies, no statistical analysis was undertaken. Therefore, imprecision using MID and inconsistency could not be assessed in GRADE. The evidence was summarised by means, medians and ranges.

3.1.1.2 Results

Ten studies of case series design were included. Evidence for the following interventions were found:

- Internal fixation (7 studies: Bjorgul 2007, Lapidus 2013, Lee 2008, Lin 2012, Song Hyung 2013, van Walsum 2016 and Yih-Shiunn 2007)
- Conservative management (3 studies: Buord 2010, Raaymakers 2002 and Tanaka 2002)

No evidence was found which used hemiarthroplasty or total hip replacement.

No evidence was found for the following outcomes:

- Quality of life
- Place of residence at 1 year

Quality appraisal of the case series included showed that there was no serious risk of bias in any of the studies included for internal fixation. Only 1 study included for conservative management (Tanaka 2002) had serious risk of bias and this is because it is unclear from the study if the case series had consecutive inclusion of participants.

For a summary of the studies included for each pairwise comparison, see Table 10 and Table 11 (for the full evidence tables and GRADE profiles please see appendices G.2 and H.2 respectively.

Table 10: Internal fixation for undisplaced fractures

Study reference (including study design)	Study population	Intervention	Outcomes reported	Comments
Bjorgul 2007 Norway Case series	N = 225 adults > 60 years with undisplaced fractures Mean age: 80yrs 72% female	• Internal fixation with 2 cannulated screws	• Mortality at 30 days • Mortality at 1 year • Surgical revision	
Lapidus 2013 Sweden Case series	N = 379 (383 hips) Mean age = 79.3 years 74% female	• Closed reduction and internal fixation or in situ internal fixation was performed with 2 Olmed screws.	• Mortality at 1 year • Surgical revision	
Lee 2008 Taiwan Case series	N = 90 adults > 60 yrs with undisplaced fracture. Mean age: mean age 72.5 years 51% female	• Internal fixation with osteosynthesis by either conventional dynamic hip screw (CDHS) or multiple cannulated screws (MCS).	• Mortality at 5 years • Functional status at 5 years • Length of stay	
Lin 2012 China Case series	N = 12 adults with undisplaced fracture. Mean age: mean age 47 years for all participants with both undisplaced and displaced. 39% female for all participants with both undisplaced and displaced.	• Internal fixation with proximal femoral locking plate with cannulated screws.	• Functional status at 5 years •	○ Functional status reported as dichotomous (11/12 excellent) and therefore could not be included in GRADE.
Song Hyung 2013 Location not reported Case series	N = 78 adults with undisplaced fracture. Mean age: mean age 66.2 years 82% female	• Internal fixation with 3 7.0 mm cannulated screws percutaneously.	• Functional status at 1 year.	

Van Walsum 2016 The Netherlands Case series	N = 149 with undisplaced femoral neck fractures. mean age: 69 years % female not reported.	• Internal fixation by Dynamic Locking Blade Plate (DLBP).	• Surgical revision	
Yih-Shiunn 2007 Location not reported. Case series	N = 84 with acute and intracapsular fractures and > 60 yrs.	Internal fixation with either MCS or a 3-hole DHS	• Functional status at 5 years	○

1

2 **Table 11: Conservative management for undisplaced fractures**

Study reference (including study design)	Study population	Intervention	Outcomes reported	Comments
Buord 2010 Location not reported. Case series	N = 40 adults > 65 years with garden I femoral neck fractures and recent injury. Mean age: 82yrs 92.5% female	• 48 hour period of bed rest and analgesics. • Full mobilisation test supported by a pair of crutches or a walker under strict guidance by a physiotherapist	• Surgical revision • Length of stay	

Raaymakers 2002 The Netherlands Case series	N = 319 with undisplaced fractures Mean age: 72yrs % female not reported.	• Early mobilisation took place within 4 weeks of the date of fracture	• Mortality at 1 year • Mortality at 5 years • Surgical revision	○ Reports age range is 13 to 98.
Tanaka 2002 Japan Case series	N = 38 with fresh Garden stage I femoral neck fractures. Mean age 81 years 92% female.	• Either: • Bed-rest for up to 2 weeks after injury and began bed-to-wheelchair transfer training 3-4 weeks after injury • began bed-to-wheelchair transfer training and ambulation as individually tolerated within 13 days after injury	• Surgical revision • Length of stay	

1

3.1.2 Health economic evidence review

Please see section 2.2.2 for methodology of health economic evidence review. No relevant articles were identified during the health economic review. It was determined that clinical data on the management of undisplaced intracapsular hip fracture were insufficient to allow novel economic modelling.

3.2 Evidence statements

3.2.1 Clinical evidence statements

Internal fixation

Low quality evidence from 1 case series with 225 people reported a mortality rate of 7% at 30 days follow-up. Low quality evidence from 2 case series with 607 undisplaced fractures reported a mortality rate of 21% to 22% at 1 year follow-up. Very low quality evidence from 1 case series with 90 people reported a mortality rate of 8.9% at 25.5 months follow-up and this evidence was indirect for mortality at 5 years follow-up.

Low quality evidence from 3 case series with 607 undisplaced fractures reported a median surgical revision of 11.8% (range = 4% - 19%).

Low quality evidence from 1 case series with 78 people showed that functional status using the Harris Hip Score at 1 year was mean: 85.7 (95% CI: 83.3 – 88). Very low quality evidence from 2 case series with 150 people showed that the mean Harris Hip Score at 5 years was between the ranges of 80.16 to 83.36. Indirect evidence from 25.5 months and 34.6 months follow-up was used for this outcome.

Low quality evidence from 2 case series with 174 people showed that mean length of stay was between the ranges of 7.7 and 8.4 days.

Conservative management

Low quality evidence from 1 case series with 319 people who were treated with early mobilisation reported a mortality rate of 19% at 1 year and 25% at 2 years and this evidence was indirect for mortality at 5 years follow-up.

Very low quality evidence from 3 case series with 397 people treated with early mobilisation and varying lengths of bed rest reported that a median of 9.1% of people (range: 2.5% - 42%) received further treatment, including internal fixation and hemiarthroplasty.

Very low quality evidence from 2 case series with 106 people treated with 48 hours bed rest, mobilisation and no weight bearing reported functional status using the Harris Hip Score at 5 years to range from 82 to 97. Indirect evidence from 20 months and 18.3 years was used for this outcome.

Very low quality evidence from 2 case series with 78 people varying lengths of bed rest and mobilisation reported the mean length of stay to range from 8 to 58.5 days.

3.2.2 Health economic evidence statements

No health economic studies were identified.

3.3 Evidence to recommendations

	Committee discussions
Relative value of different outcomes	People with an undisplaced hip fracture may present some time after the initial injury has been suffered. Some people may be wrongly diagnosed as having an undisplaced intracapsular hip fracture based on a single x-ray view as the dislocation may not be visible on that view. In general the committee considered the outcomes to have the same relative values as those with displaced fractures. That is mortality, quality of life and functional status, are considered critical criteria for people with hip fracture (and their family/carers) in decision making with all other outcomes considered to be important (see section 2.4).
Quality of evidence	The committee noted that the certainty around the majority of outcomes was very low indicating a lack of confidence in the evidence base identified. This was driven primarily by concerns over selection bias in the included studies.
Trade-off between benefits and harms	The committee did not consider the evidence to be sufficient in terms of quality or quantity to allow for a full discussion of the trade-off between benefits and harms of the interventions examined.
Trade-off between net health benefits and resource use	No economic analyses of management of undisplaced intracapsular hip fracture were identified by the economic literature review. The committee determined that the evidence identified by the clinical review was of insufficient quality to populate a novel economic analysis. Therefore economic modelling was not possible for this review question.
Other considerations	The committee agreed to make a post-hoc change to the protocol to include case series study designs as there were no studies comparing the interventions of interest. It was hoped that well-conducted cases series (consecutive enrolment, clear description of baseline demographics and clear reporting of outcomes) would allow some judgement of the benefits and harms of these interventions. However the evidence that was included was not of sufficient quality to allow this and so the committee declined to make a recommendation based on the evidence presented. Given the concerns of the lack of high quality evidence the committee agreed that a research recommendation should be drafted. As the proportion of undisplaced intracapsular hip fractures differ per unit and range from 5% and 15%, the committee requested that any new research examine the characteristics of undisplaced intracapsular hip fractures and the treatment that should follow. This will enable clinicians to understand the clinical characteristics of this population and how this relates to the effectiveness of different treatment startegies. There is also a variation in the UK on how undisplaced intracapsular hip fractures are recognised, resulting in some people not being offered the most appropriate treatment. The committee also noted a paucity of evidence for 2 of the interventions that could potentially be useful in people with undisplaced intracapsular hip fracture therefore a randomised controlled trial comparing these interventions was suggested. Equalities The committee recognised that a high proportion of this group of patients are elderly and frail and cognitive impairment is also common. This may complicate their assessment and management, and specifics steps to ascertain this, especially in the prevention and management of delirium, are

	Committee discussions
	required. Such impairment may limit reliability in communicating symptoms, in particular pain.

3.4 Recommendations

The committee did not draft any recommendations

3.5 Research recommendation

1. **For people with undisplaced (or non-displaced) intracapsular hip fracture, what features should be used to characterise the injury and what are the optimal clinical and cost-effective management strategies?**

Why is this important?

Between 5% and 15% of people with an intracapsular hip fracture will have an undisplaced fracture. There is variation in the UK in how undisplaced intracapsular hip fractures are recognised, resulting in some people not being offered the most appropriate treatment. Research is needed to help healthcare professionals understand the clinical characteristics of people who have undisplaced hip fracture (on anterior-posterior and lateral X-rays) and how this relates to the effectiveness of different treatment strategies.

The committee also noted a paucity of evidence for 2 of the interventions (total hip replacement and hemiarthroplasty) that could potentially be useful for people with undisplaced intracapsular hip fracture. A randomised controlled trial comparing these interventions would be beneficial. **[2017]**

Table 12: Criteria for selecting high-priority research recommendations

PICO	**Population:** People with a traditionally described undisplaced (or non-displaced) intracapsular hip fracture based on anterior-posterior and lateral x-rays. **Intervention:** • Total hip replacement • Hemiarthroplasty **Comparison:** • Internal fixation **Outcomes:** • Mortality • Surgical revision • Re-treatment • Functional status • Quality of life • Return to residence • Pain • Activities of daily living • Mobility
Current evidence base	Only low quality case series are available

Study design	Randomised controlled trial

Other comments	The research will be in two parts
	• An epidemiological assessment of the clinical characteristics of undisplaced intracapsular hip fracture
	• A randomised controlled trial examining the following interventions
	  ○ Total hip replacement
	  ○ Hemiarthroplasty
	  ○ Internal fixation

.

4 References

4.1 RQ1 – Displaced intracapsular hip fracture

Avery P P, Baker R P, Walton M J, et al. (2011). Total hip replacement and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: a seven- to ten-year follow-up report of a prospective randomised controlled trial. The Journal of bone and joint surgery. British volume, 93(8), 1045-8.

Bachrach-Lindström M, Johansson T, Unosson M, et al. (2000). Nutritional status and functional capacity after femoral neck fractures: a prospective randomized one-year follow-up study. Aging (Milan, and Italy), 12(5), 366-74.

Baker R P, Squires B, Gargan M F, et al. (2006). Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: A randomized, controlled trial. Journal of Bone and Joint Surgery - Series A, 88(12), 2583-9.

Bjornelv G M. W, Frihagen F, Madsen J E et al. (2012). Hemiarthroplasty compared to internal fixation with percutaneous cannulated screws as treatment of displaced femoral neck fractures in the elderly: Cost-utility analysis performed alongside a randomized, controlled trial. Osteoporosis international, 23(6), 1711-9.

Blomfeldt R, Tornkvist H, Ponzer S, et al (2005). Comparison of internal fixation with total hip replacement for displaced femoral neck fractures: Randomized, controlled trial performed at four years. Journal of Bone and Joint Surgery - Series A, 87(8), 1680-8.

Blomfeldt R, Tornkvist H, Ponzer S, et al. (2005). Internal fixation versus hemiarthroplasty for displaced fractures of the femoral neck in elderly patients with severe cognitive impairment. Journal of Bone and Joint Surgery - Series B, 87(4), 523-9.

Blomfeldt R, Törnkvist H, Eriksson K, et al. (2007). A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. The Journal of bone and joint surgery. British volume, 89(2), 160-5.

Cadossi M, Chiarello E, Savarino L, et al. (2013). A comparison of hemiarthroplasty with a novel polycarbonate-urethane acetabular component for displaced intracapsular fractures of the femoral neck: a randomised controlled trial in elderly patients. The bone & joint journal, 95-b(5), 609-15.

Chammout G K, Mukka S S, Carlsson T, et al. (2012). Total hip replacement versus open reduction and internal fixation of displaced femoral neck fractures: a randomized long-term follow-up study. The Journal of bone and joint surgery. American volume, 94(21), 1921-8.

Davison J N, Calder S J, Anderson G H, et al (2001). Treatment for displaced intracapsular fracture of the proximal femur. A prospective, randomised trial in patients aged 65 to 79 years. The Journal of bone and joint surgery. British volume, 83(2), 206-12.

Dorr LD, Glousman R, Hoy AL, et al. (1986). Treatment of femoral neck fractures with total hip replacement versus cemented and noncemented hemiarthroplasty.. Journal of Arthroplasty, 1(1), 21-8.

Frihagen F, Nordsletten L, and Madsen J E. (2007). Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: Randomised controlled trial. British Medical Journal, 335(7632), 1251-4.

Frihagen F, Waaler G M, Madsen J E, et al. (2010). The cost of hemiarthroplasty compared to that of internal fixation for femoral neck fractures. 2-year results involving 222 patients based on a randomized controlled trial. Acta orthopaedica, 81(4), 446-52.

Hedbeck C J, Enocson A, Lapidus G, et al (2011). Comparison of bipolar hemiarthroplasty with total hip arthroplasty for displaced femoral neck fractures: A concise four-year follow-up of a randomized trial. Journal of Bone and Joint Surgery - Series A, 93(5), 445-50.

Johansson T, Jacobsson S A, Ivarsson I, et al. (2000). Internal fixation versus total hip arthroplasty in the treatment of displaced femoral neck fractures: a prospective randomized study of 100 hips. Acta orthopaedica Scandinavica, 71(6), 597-602.

Johansson T. (2002). Displaced femoral neck fractures: a prospective study of clinical outcome, nutirtion and costs.. Medical dissertation. Faculty of Health Sciences, Linkoping University, Sweden.

Johansson T, Bachrach-Lindstrom M, Aspenberg P, et al. (2006). The total costs of a displaced femoral neck fracture: Comparison of internal fixation and total hip replacement - A randomised study of 146 hips. International Orthopaedics, 30(1), 1-6.

Johansson T. (2014). Internal fixation compared with total hip replacement for displaced femoral neck fractures: A minimum fifteen-year follow-up study of a previously reported randomized trial. Journal of Bone and Joint Surgery - Series A, 96(6), e46.

Keating J F, Grant A, Masson M, et al. (2005). Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health technology assessment (Winchester, and England), 9(41), iii-65.

Keating J F, Grant A, Masson M, et al. (2006). Randomized comparison of reduction and fixation, bipolar hemiarthroplasty, and total hip arthroplasty: Treatment of displaced intracapsular hip fractures in healthy older patients. Journal of Bone and Joint Surgery - Series A, 88(2), 249-60.

Liehu C, Bin W, Ming L, et al. (2014). Closed reduction and internal fixation versus total hip arthroplasty for displaced femoral neck fracture. Chinese Journal of Traumatology - English Edition, 17(2), 63-8.

Macaulay W, Nellans K W, Garvin K L, et al. (2008). Prospective randomized clinical trial comparing hemiarthroplasty to total hip arthroplasty in the treatment of displaced femoral neck fractures: winner of the Dorr Award. The Journal of arthroplasty, 23(6 Suppl 1), 2-8.

Macaulay W, Nellans KW, Iorio R, et al. (2008). Total hip arthroplasty is less painful at 12 months compared with hemiarthroplasty in treatment of displaced femoral neck fracture. HSS journal : the musculoskeletal journal of Hospital for Special Surgery, 4(1), 48-54.

Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008). The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International orthopaedics, 32(3), 367-73.

Parker M J, and Pryor G A. (2000). Internal fixation or arthroplasty for displaced cervical hip fractures in the elderly: a randomised controlled trial of 208 patients. Acta orthopaedica Scandinavica, 71(5), 440-6.

Parker M J, Khan R J, Crawford J, et al. (2002). Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. A randomised trial of 455 patients. The Journal of bone and joint surgery. British volume, 84(8), 1150-5.

Parker MJ, Pryor G, and Gurusamy K. (2010). Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures: a long-term follow-up of a randomised trial. Injury, 41(4), 370-3.

Parker MJ. (2015). Hemiarthroplasty versus internal fixation for displaced intracapsular fractures of the hip in elderly men: a pilot randomised trial. The bone & joint journal, 97-b(7), 992-6.

Puolakka T J. S, Laine H J, Tarvainen T, et al. (2001). Thompson hemiarthroplasty is superior to Ullevaal screws in treating displaced femoral neck fractures in patients over 75 years. A prospective randomized study with two-year follow-up. Annales chirurgiae et gynaecologiae, 90(3), 225-8.

Ravikumar K J, and Marsh G. (2000). Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur--13 year results of a prospective randomised study. Injury, 31(10), 793-7.

Rödén M, Schön M, and Fredin H. (2003). Treatment of displaced femoral neck fractures: a randomized minimum 5-year follow-up study of screws and bipolar hemiprostheses in 100 patients. Acta orthopaedica Scandinavica, 74(1), 42-4.

Skinner P, Riley D, Ellery J, et al. (1989). Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20(5), 291-3.

Soreide O, Molster A, and Raugstad T S. (1979). Internal fixation versus primary prosthetic replacement in acute femoral neck fractures: a prospective, randomized clinical study. The British journal of surgery, 66(1), 56-60.

Støen RØ, Lofthus C M, Nordsletten L, et al. (2014). Randomized trial of hemiarthroplasty versus internal fixation for femoral neck fractures: no differences at 6 years. Clinical orthopaedics and related research, 472(1), 360-7.

Tidermark J, Ponzer S, Svensson O, et al. (2003). Internal fixation compared with total hip replacement for displaced femoral neck fractures in the elderly. A randomised, controlled trial. Journal of Bone and Joint Surgery - Series B, 85(3), 380-8.

Van Den Bekerom , M P J, Hilverdink EF et al. (2010). A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck: A randomised controlled multicentre trial in patients aged 70 years and over. Journal of Bone and Joint Surgery - Series B, 92(10), 1422-8.

Van Dortmont , L M C, Douw C M, Van Breukelen , A M A, et al. (2000). Cannulated screws versus hemiarthroplasty for displaced intracapsular femoral neck fractures in demented patients. Annales Chirurgiae et Gynaecologiae, 89(2), 132-7.

Van Vugt , A B, Oosterwijk W M, and Goris R J. A. (1993). Osteosynthesis versus endoprosthesis in the treatment of unstable intracapsular hip fractures in the elderly: A randomised clinical trial. Archives of Orthopaedic and Trauma Surgery, 113(1), 39-45

Walters SJ and Brazier JE.(2005) Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. Quality of Life Research.14(6):1523-32

4.2 RQ2 – Undisplaced intracapsular hip fracture

Bjorgul K, and Reikeras O. (2007). Outcome of undisplaced and moderately displaced femoral neck fractures: A prospective study of 466 patients treated by internal fixation. Acta Orthopaedica, 78(4), 498-504.

Buord J M, Flecher X, Parratte S et al. (2010). Garden I femoral neck fractures in patients 65 years old and older: Is conservative functional treatment a viable option?. Orthopaedics and Traumatology: Surgery and Research, 96(3), 228-34.

Lapidus L J, Charalampidis A, Rundgren J et al (2013). Internal fixation of garden I and II femoral neck fractures: posterior tilt did not influence the reoperation rate in 382 consecutive hips followed for a minimum of 5 years. Journal of orthopaedic trauma, 27(7), pp.386-1.

Lee Y S, Chen S H, Tsuang Y H et al. (2008). Internal fixation of undisplaced femoral neck fractures in the elderly: A retrospective comparison of fixation methods. Journal of Trauma - Injury, and Infection and Critical Care, 64(1), 155-62.

Lin Dasheng, Lian Kejian, Ding Zhenqi et al. (2012). Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 35(1), .e1-5.

Pihlajamaki H K, Ruohola J P, Weckstrom M et al. (2006). Long-term outcome of undisplaced fatigue fractures of the femoral neck in young male adults. The Journal of bone and joint surgery. British volume, 88(12), 1574-9.

Raaymakers E L. F. B. (2002). The non-operative treatment of impacted femoral neck fractures. Injury, 33(SUPPL. 3), SC8-SC14.

Song Hyung K, Lee Jae J, Oh Hyun C et al (2013). Clinical implication of subgrouping in valgus femoral neck fractures: comparison of 31-B1.1 with 31-B1.2 fractures using the OTA/AO classification. Journal of orthopaedic trauma, 27(12), pp.677-82.

Tanaka J, Seki N, Tokimura F et al. (2002). Conservative treatment of Garden stage I femoral neck fracture in elderly patients. Archives of orthopaedic and trauma surgery, 122(1), 24-8.

van Walsum , A D, Vroemen J, Janzing H M et al. (2016). Low failure rate by means of DLBP fixation of undisplaced femoral neck fractures. European Journal of Trauma and Emergency Surgery,

Yih-Shiunn Lee, Chien-Rae Huang, and Wen-Yun Liao. (2007). Surgical treatment of undisplaced femoral neck fractures in the elderly. International orthopaedics, 31(5), 677-82.

5 Glossary and abbreviations

Please refer to the NICE glossary.

Anteriolateral approach –surgical approach to the hip in front of the body, and to the side of the midline.

Anteroposterior (x-ray) – describing the direction of projection (from front to back) so that the x-ray image is viewed as if facing the patient.

Arthroplasty - surgery to relieve pain and restore range of motion by realigning or reconstructing a joint after damage.

Avascular necrosis - the death of bone tissue due to a lack of blood supply.

Bipolar hemiarthroplasty - replacement of the femoral head and neck with a prosthetic stem and an acetabular cup that is not attached to the pelvis.

Displaced fracture- where fracture fragments have moved in relation to each other, out of their normal position.

Hemiarthroplasty - replacement of the femoral head with a metal implant, the stem of which is secured in the femoral shaft. The socket half of the hip joint remains intact.

Internal fixation – surgery to hold fracture fragments in position. This is done using special implants made from stainless steel or titanium, such as plates, screws or nails. This should allow healing of the facture fragments in an acceptable position for long term function and also for maintenance of patient function during the healing process.

Intracapsular – a fracture of the head or neck of the femur, which is contained within the capsule of the hip joint.

Lateral (x-ray) - describing the direction of projection (perpendicular to the midsagittal plane which vertically bisects the body) so that the x-ray image is a side-on view of the patient.

Osteosynthesis - the reduction and internal fixation of a bone fracture with implantable devices that are usually made of metal.

Posterior approach – surgical approach from the back of the body

Reduction (of a fracture) – a surgical procedure to restore displaced fracture fragments to their correct alignment. Open reduction involves exposing the fragments surgically by dissecting surrounding tissues. Closed reduction involves manipulation of the bone fragments without surgical exposure of the fragments.

Replacement arthroplasty – surgical removal of part or all of the damaged bone, replacing it with a prosthesis which then functions in place of the removed bone.

Resurfacing hemiarthroplasty - replacement of the surface of the femoral head.

Total hip replacement (THR) / total hip arthroplasty – replacement of both the femoral head and the acetabular (socket) part of the hip joint with a prosthetic metal implant. The acetabulum is reamed out to accept a metal cup that is attached to the pelvis.

Undisplaced (or non-displaced) fracture – where the fracture fragments are still aligned in the position they would have occupied prior to the injury and are inherently relatively stable.

Unipolar hemiarthroplasty - replacement of the femoral head and neck.

Appendices

Appendix A: Standing Committee members and NICE teams

A.1 Core members

Name	Role
Susan Bewley (Chair)	Professor of Complex Obstetrics
John Graham (Vice Chair)	Consultant Oncologist
Gita Bhutani	Associate Director for Psychological Professions
Simon Corbett	Cardiologist
Rachel Churchill	Chair in Evidence Synthesis
Gail Fortes Mayer	Commissioner
Nathan Griffiths	Consultant Nurse - Paediatric Emergency and Ambulatory Medicine
Manoj Mistry	Lay Member
Mark Rodgers	Research Fellow - Methodologist
Sietse Wieringa	General Practitioner

A.2 Topic expert Committee members

Name	Role
Karen Barnard	Advanced Trauma Nurse Practitioner
David Brookfield	Lay member
Tim Chesser	Consultant Trauma Orthopaedic Surgeon
Bob Hanley	Consultant Trauma and Orthopaedic Surgeon
Antony Johansen	Consultant Orthogeriatician
Stuart M White	Consultant Anaesthetist

A.3 NICE project team

Name	Role
Jessica Fielding	PIP Lead
Rupert Franklin	Programme Manager
Andrea Heath	Information Scientist
Annette Mead	Technical Editor
Bhash Naidoo	Health Economist
Gary Shield	Costing lead
Jay Stone	Communications Lead
Sharon Summers-Ma	Guideline Lead
Nichole Taske	Technical Lead
Jeremy Wight	Clinical Adviser
Trudie Willingham	Guidelines Coordinator

A.4 Clinical guidelines update team

Name	Role
Omnia Abdulrazeg	Technical Analyst
Martin Allaby	Clinical Adviser
Emma Banks	Coordinator
Emma Carter	Administrator
Nicole Elliott	Associate Director
Ben Johnson	Health Economist
Hugh McGuire	Technical Adviser
Nicki Mead	Technical Analyst (until September 2016)
Rebecca Parsons	Project Manager

Appendix B: Declarations of interest

The standing committee and topic experts interests have been declared and collated and are available in a separate document.

Appendix C: Review protocol

C.1 RQ1 - Displaced intracapsular hip fracture

	Details
Review Question	What is the clinical and cost effectiveness of internal fixation compared with hemiarthroplasty compared with total hip replacement (THR) in people undergoing repair for a displaced intracapsular hip fracture?
Objectives	The recent surveillance review of NICE CG124 identified 3 studies comparing internal fixation with total hip replacement (THR) and 3 studies comparing hemiarthroplasty with THR. These studies are consistent with the current NICE recommendation to perform hemiarthroplasty or total hip replacement in patients with a displaced intracapsular fracture. However currently only about 30% of eligible patients nationally are receiving a total hip replacement (THR) in accordance with the CG124 recommendation 1.6.3 to offer THR to people with a displaced intracapsular hip fracture who are: ○ able to walk independently, and ○ cognitively unimpaired, and ○ medically fit to undergo THR. Topic experts advised the surveillance process that future functional status might be being considered as a fourth criterion in clinicians' decision-making but was not explicitly considered in the original NICE review of evidence. Also the original evidence-base mainly comprised patients aged less than 80 years so may not be applicable to the whole hip fracture population, only those with better prospects of long-term functional benefit. The review will re-examine the original evidence base plus any new studies eligible for inclusion, paying specific attention to baseline health status and indicators of long-term functional benefit to determine the comparative effectiveness of the different interventions in light of these variables.
Type of Review	Intervention studies
Language	English language only
Study Design	• RCTs • Systematic reviews of RCTs For the long-term outcomes of mortality and functional status, if no RCT data are available, comparative observational studies and cohort studies with a minimum follow-up of 5 years will be included.
Status	Published papers (full text) only
Population	Adults (18+) with a displaced intracapsular hip fracture
Intervention	• Internal fixation • Hemiarthroplasty • Total hip replacement (THR)
Comparator	Any of the above Comparisons within the same type of intervention will not be included. However, it will be noted whether studies of hemiarthroplasty and THR

	Details
	involve cemented, uncemented or hybrid implants, and what type of screw or plate is used in studies of internal fixation.
Outcomes	• Mortality - within 30 days - medium term (1 year) - long term (5 years) • Surgical revision (excluding removal of plates, screws etc.) • Functional status - medium term (1 year) - long term (5 years) • Quality of life • Length of stay • Place of residence (at 1yr +) • Dislocation rate (for hemiarthroplasty vs THR only)
Other criteria for inclusion / exclusion of studies	**Inclusion / Exclusion** The committee will be sent the list of included and excluded studies prior to the committee meeting. The committee will be requested to check whether any studies have been excluded inappropriately, and whether there are any relevant studies they know of which have not been picked up by the searches or have wrongly been sifted out.
Analysis of subgroups or subsets	Where data are available, subgroup analyses will include: • Age • Gender • Baseline ASA physical health status • Mobility assessment / use of walking aids (prior to fracture) • Place of residence (prior to fracture) • Baseline cognitive status / dementia • Operation performed within 36 hrs of admission vs. >36 hrs
Data extraction and quality assessment	<u>Sifting</u> Relevant studies will be identified through sifting the abstracts and excluding studies clearly not relevant to the PICO. In the case of relevant or potentially relevant studies, the full paper will be ordered and reviewed, whereupon studies considered not relevant to the topic will be excluded. *i) Selection based on titles and abstracts* A full double-sifting of titles and abstracts will not be conducted due to the nature of the review question (typical intervention question). However in cases of uncertainty the following mechanisms will be in place: - technical analyst will discuss with a support technical analyst - comparison with included studies of other systematic reviews - recourse to members of the committee. *ii) Selection based on full papers* A full double-selecting of full papers for inclusion/exclusion will not be conducted due to the nature of the review question (as mentioned above). However in cases of uncertainty, the same mechanisms stated in i) above will be followed.

	Details
	Data extraction Information from included studies will be extracted into standardised evidence tables. . Critical appraisal The quality of each included study will be assessed using standardised checklists available in the NICE manual for intervention: • NICE RCT checklist • NICE systematic reviews and meta-analyses checklist • NICE observational studies checklist Quality assessment GRADE methodology will be used to assess the quality of evidence on an outcome basis: • Risk of bias will be assessed using critical appraisal checklists • Inconsistency will be assessed using I2 • Indirectness will be assessed after considering the population, intervention and outcomes of included studies, relative to the target population; • Imprecision will be assessed using whether the confidence intervals around point estimates cross the MIDs for each outcome. COMET and published literature, including related NICE guidelines, will be checked for appropriate minimal important differences (MID) for each outcome. If none are available, the topic experts will be consulted on the appropriateness of using default MIDs as suggested by the GRADE working group. *Reliability of quality assessment:* A full double-scoring quality assessment will not be conducted due to the nature of the review question (typical intervention review) and the studies that are likely to be included. Other quality assurance mechanisms will be in place as follows: • Internal QA (10%) by CGUT technical adviser on the risk of bias and quality assessment that is being conducted. Any disagreement will be resolved through discussion. • The Committee will be sent the evidence synthesis prior to the committee meeting and will be requested to comment on the quality assessment, which will serve as another QA function.
Strategy for data synthesis	• If possible a meta-analysis of available study data will be carried out. A fixed effects model will be used if studies appear to be homogenous in terms of population and we can assume a similar effect size across studies. A random effects model will be used if this assumption does not hold. • A narrative evidence summary outlining volume, applicability and quality of evidence and presenting the key findings from the evidence will be produced.
Searches	Sources to be searched • Clinical searches - Medline, Medline in Process, PubMed, Embase, CINAHL, AMED, Cochrane CDSR, CENTRAL, DARE (legacy records) and HTA • Economic searches - Medline, Medline in Process, Embase, NHS EED (legacy records) and HTA, with economic evaluations and quality of life filters applied.

	Details
	Supplementary search techniques None identified Limits • Studies reported in English • Study design SR, RCT and Observational filters will be applied • Animal studies will be excluded from the search results • Conference abstracts will be excluded from the search results • No date limit will be set.
Post-hoc deviations	Where data were sparse, as for the outcomes of functional status at 5 years and mortality at 5 years, the topic experts agreed that it would be reasonable to use 'indirect' data in its place and therefore data from 2 years or more was used. No information on minimal important differences (MID) was identified in the COMET database. The following MIDs were used in this update. • For mortality the line of no effect was used as in the original guideline • For functional status, a MID of 10 points for the Harris Hip Score has been reported in the literature (Cadossi 2013, van den Bekerom 2010). • For the EQ-5D, a MID of 0.07 points was identified in the literature (Walters & Brazier 2005) • GRADE default MIDs were used to assess imprecision for all other outcomes specified in the review protocol (for dichotomous outcomes: RR = 0.8 and 1.25; for continuous outcomes: SMD = -0.5 and 0.5). The committee anticipated that there would be difference in effect size for different population subgroup and so a random effect models was used for analyses. The committee then discussed the finding in the committee meeting.

C.2 RQ2 - Undisplaced intracapsular hip fracture

	Details
Review Question	What is the clinical and cost effectiveness of conservative management compared with internal fixation compared with hemiarthroplasty compared with total hip replacement (THR) in people with an undisplaced intra-capsular hip fracture?
Objectives	Management of undisplaced intracapsular fracture was not included in the original NICE CG124 guideline due to time constraints and the fact that the GDG considered the area relatively uncontroversial, with internal fixation being common practice. Comparison of internal fixation with other potential management options for undisplaced fractures has therefore not been a focus of subsequent surveillance reviews (new evidence identification has been limited to studies comparing different types of screw fixation only). However topic experts advising the recent surveillance process noted there is much debate among the orthopaedic clinical community as to whether internal fixation is the most appropriate treatment for all patients with undisplaced fracture. It was felt that a comparison of different management options should be included in the update for this guideline, with particular focus on medium-term outcomes due to the possibility that failure rates during the rehabilitation period may differ. This is therefore a new review question.

	Details
Type of Review	Intervention studies
Language	English language only
Study Design	• RCTs • Systematic reviews of RCTs • Observational or cohort studies with a minimum follow-up of 12 months
Status	Published papers (full text) only
Population	Adults (18+) with an undisplaced intracapsular hip fracture (including valgus impacted fractures)
Intervention	• Conservative management • Internal fixation • Hemiarthroplasty • Total hip replacement
Comparator	Any of the above Note: We will not include comparisons within the same type of intervention. However, it will be noted whether studies of hemiarthroplasty and THR involve cemented, uncemented or hybrid implants, and what type of screw or plate is used in studies of internal fixation.
Outcomes	• Mortality - within 30 days - medium term (1 year) - long term (5 years) • Surgical revision (excluding removal of plates, screws etc.) • Functional status - medium term (1 year) - long term (5 years) • Quality of life • Length of stay • Place of residence (at 1yr +) • Dislocation rate (for hemiarthroplasty vs. THR)
Other criteria for inclusion / exclusion of studies	**Inclusion / Exclusion** The committee will be sent the list of included and excluded studies prior to the committee meeting. The committee will be requested to check whether any studies have been excluded inappropriately, and whether there are any relevant studies they know of which have not been picked up by the searches or have wrongly been sifted out.
Analysis of subgroups or subsets	Where data are available, subgroup analyses will include: • Age • Gender • Baseline ASA physical health status • Mobility assessment / use of walking aids (prior to fracture) • Place of residence (prior to fracture) • Baseline cognitive status / dementia • Operation performed within 36 hrs of admission vs. >36 hrs

	Details
Data extraction and quality assessment	Sifting Relevant studies will be identified through sifting the abstracts and excluding studies clearly not relevant to the PICO. In the case of relevant or potentially relevant studies, the full paper will be ordered and reviewed, whereupon studies considered not relevant to the topic will be excluded. *i) Selection based on titles and abstracts* A full double-sifting of titles and abstracts will not be conducted due to the nature of the review question (typical intervention question). However in cases of uncertainty the following mechanisms will be in place: - technical analyst will discuss with a support technical analyst - comparison with included studies of other systematic reviews - recourse to members of the committee. *ii) Selection based on full papers* A full double-selecting of full papers for inclusion/exclusion will not be conducted due to the nature of the review question (as mentioned above). However in cases of uncertainty, the same mechanisms stated in i) above will be followed. Data extraction Information from included studies will be extracted into standardised evidence tables. . Critical appraisal The quality of each included study will be assessed using standardised checklists available in the NICE manual for intervention: • NICE RCT checklist • NICE systematic reviews and meta-analyses checklist • NICE observational studies checklist Quality assessment GRADE methodology will be used to assess the quality of evidence on an outcome basis: • Risk of bias will be assessed using critical appraisal checklists • Inconsistency will be assessed using I^2 • Indirectness will be assessed after considering the population, intervention and outcomes of included studies, relative to the target population; • Imprecision will be assessed using whether the confidence intervals around point estimates cross the MIDs for each outcome. COMET and published literature, including related NICE guidelines, will be checked for appropriate minimal important differences (MID) for each outcome. If none are available, the topic experts will be consulted on the appropriateness of using default MIDs as suggested by the GRADE working group. *Reliability of quality assessment:* A full double-scoring quality assessment will not be conducted due to the nature of the review question (typical intervention review) and the studies that are likely to be included. Other quality assurance mechanisms will be in place as follows: • Internal QA (10%) by CGUT technical adviser on the risk of bias and quality assessment that is being conducted. Any disagreement will be resolved through discussion.

	Details
	• The Committee will be sent the evidence synthesis prior to the committee meeting and will be requested to comment on the quality assessment, which will serve as another QA function.
Strategy for data synthesis	• If possible a meta-analysis of available study data will be carried out. A fixed effects model will be used if studies appear to be homogenous in terms of population and we can assume a similar effect size across studies. A random effects model will be used if this assumption does not hold. • A narrative evidence summary outlining volume, applicability and quality of evidence and presenting the key findings from the evidence will be produced.
Searches	Sources to be searched • Clinical searches - Medline, Medline in Process, PubMed, Embase, CINAHL, AMED, Cochrane CDSR, CENTRAL, DARE (legacy records) and HTA • Economic searches - Medline, Medline in Process, Embase, NHS EED (legacy records) and HTA, with economic evaluations and quality of life filters applied. Supplementary search techniques None identified Limits • Studies reported in English • Study design SR, RCT and Observational filters will be applied • Animal studies will be excluded from the search results • Conference abstracts will be excluded from the search results • No date limit will be set.
Post-hoc deviations	For outcomes where 5 years data were sparse, the topic experts agreed that it would be reasonable to use 'indirect' data in its place and therefore data from 2 years or more was used where available. As all studies included were case series, risk of bias assessment in GRADE was conducted using the Joanna Briggs Institute (JBI) checklist for case series: http://joannabriggs.org/research/critical-appraisal-tools.html. Due to the non-comparative nature of the studies, no statistical analysis was undertaken. Therefore, imprecision using MID and inconsistency could not be assessed in GRADE. The evidence was summarised by means, medians and ranges.

Appendix D: Search strategy

One literature search was employed for both review questions included in this guideline update. Databases that were searched, together with the number of articles retrieved from each database are shown in Table 13. The Medline search strategy is shown in Table 14. The same strategy was translated for the other databases listed.

Table 13: Clinical search summary

Database	Date searched	Number retrieved
Cochrane Central Register of Controlled Trials (CENTRAL)	20/06/16	1436
Cochrane Database of Systematic Reviews (CDSR)	20/06/16	47
Database of Abstracts of Reviews of Effect (DARE)	20/06/16	93
Embase (Ovid)	20/06/16	5278
Health Technology Assessment (HTA Database)	20/06/16	12
MEDLINE (Ovid)	20/06/16	7752
MEDLINE In-Process (Ovid)	20/06/16	1534
PubMed[c]	20/06/16	375

Table 14: Clinical search terms (Medline search strategy)

Line number/Search term/Number retrieved		
Strategy used:		
1	exp Hip Fractures/	20226
2	((femur* or femoral*) adj4 (head or neck or proximal) adj4 fracture*).ti,ab.	8706
3	((hip* or femur* or femoral* or intracapsular* or garden or valgus*) adj4 fracture*).ti,ab.	29131
4	((displace* or undisplace* or non-displace* or non displace*) adj4 fracture*).ti,ab.	6959
5	or/1-4	40507
6	Fracture Fixation, Internal/ or Hemiarthroplasty/ or Arthroplasty/ or Arthroplasty, Replacement, Hip/ or Bed Rest/ or Traction/	66181
7	((internal or reduc*) adj2 fixat*).ti,ab.	14798
8	((surgical or surgery) adj2 reduc*).ti,ab.	9183
9	((total or partial) adj4 (hip replac* or arthroplast*)).ti,ab.	34049
10	((pin*1 or nail* or screw*1 or plate*1 or fix*) adj3 (surgery or surgical or hip* or fixat*)).ti,ab.	116090
11	(arthroplast* or hemiarthroplast* or hemi-arthroplast* or hemi arthroplast* or prosthes* or osteosynthesis or osteo synthesis).ti,ab.	106783
12	(conservat* adj4 (treat* or therap* or manag* or method*)).ti,ab.	61326
13	(bed rest or traction).ti,ab.	17519
14	or/6-13	320811
15	Randomized Controlled Trial.pt.	420779
16	Controlled Clinical Trial.pt.	91003
17	Clinical Trial.pt.	502048
18	exp Clinical Trials as Topic/	294647

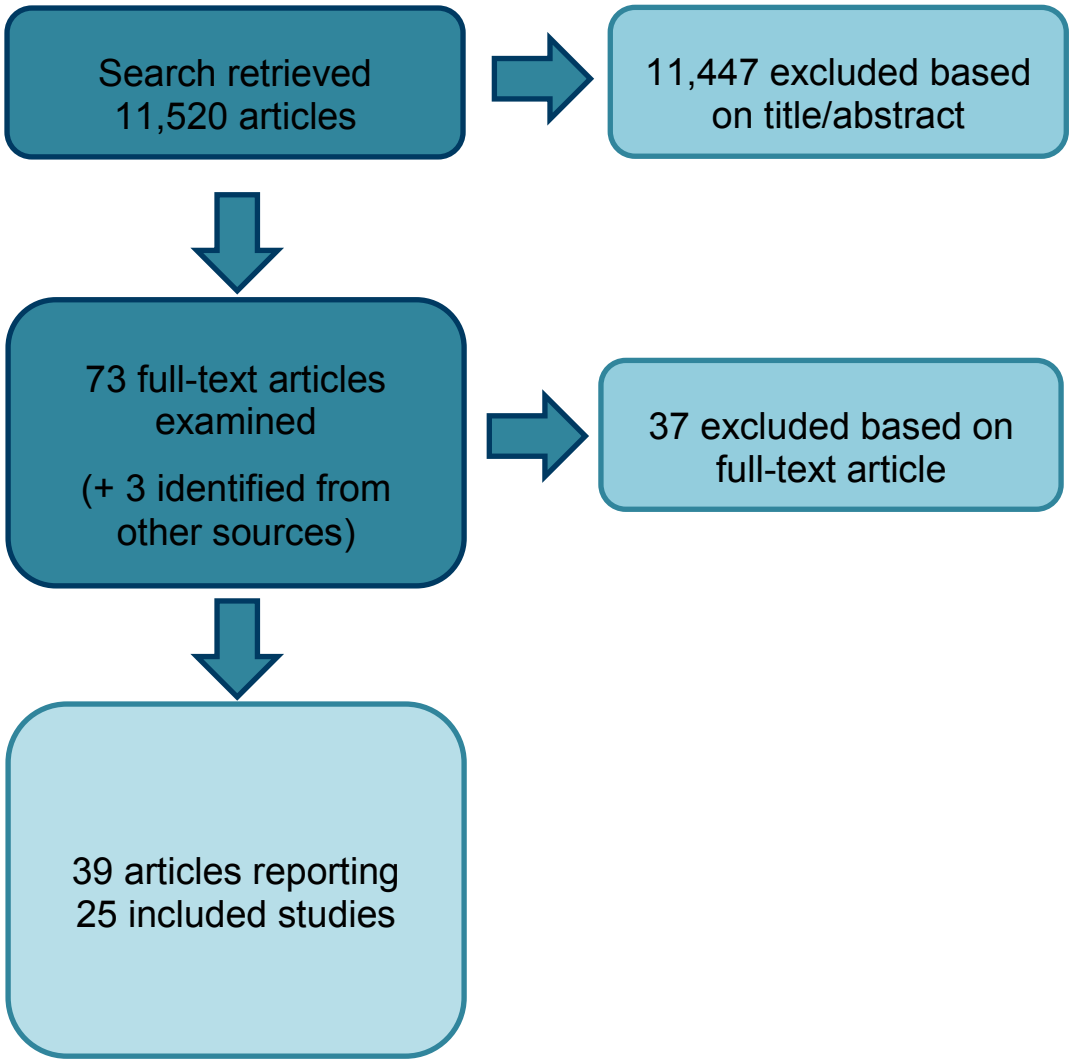
[c] Limit search to publisher[sb] and last 3 days only.

Line number/Search term/Number retrieved	
19 Placebos/	33419
20 Random Allocation/	87452
21 Double-Blind Method/	136790
22 Single-Blind Method/	22158
23 Cross-Over Studies/	38616
24 ((random$ or control$ or clinical$) adj3 (trial$ or stud$)).tw.	833371
25 (random$ adj3 allocat$).tw.	23244
26 placebo$.tw.	165113
27 ((singl$ or doubl$ or trebl$ or tripl$) adj (blind$ or mask$)).tw.	133744
28 (crossover$ or (cross adj over$)).tw.	61595
29 or/15-28	1517541
30 Observational Studies as Topic/	1471
31 Observational Study/	22526
32 Epidemiologic Studies/	7162
33 exp Case-Control Studies/	792572
34 exp Cohort Studies/	1556786
35 Cross-Sectional Studies/	219062
36 Controlled Before-After Studies/	145
37 Historically Controlled Study/	54
38 Interrupted Time Series Analysis/	163
39 Comparative Study.pt.	1752095
40 case control$.tw.	87982
41 case series.tw.	40024
42 (cohort adj (study or studies)).tw.	103214
43 cohort analy$.tw.	4312
44 (follow up adj (study or studies)).tw.	39227
45 (observational adj (study or studies)).tw.	52333
46 longitudinal.tw.	151520
47 prospective.tw.	381252
48 retrospective.tw.	305362
49 cross sectional.tw.	188511
50 or/30-49	3621831
51 Meta-Analysis.pt.	67225
52 Meta-Analysis as Topic/	15058
53 Review.pt.	2068405
54 exp Review Literature as Topic/	8727
55 (metaanaly$ or metanaly$ or (meta adj3 analy$)).tw.	79394
56 (review$ or overview$).ti.	307973
57 (systematic$ adj5 (review$ or overview$)).tw.	74900
58 ((quantitative$ or qualitative$) adj5 (review$ or overview$)).tw.	5342
59 ((studies or trial$) adj2 (review$ or overview$)).tw.	28754
60 (integrat$ adj3 (research or review$ or literature)).tw.	6494

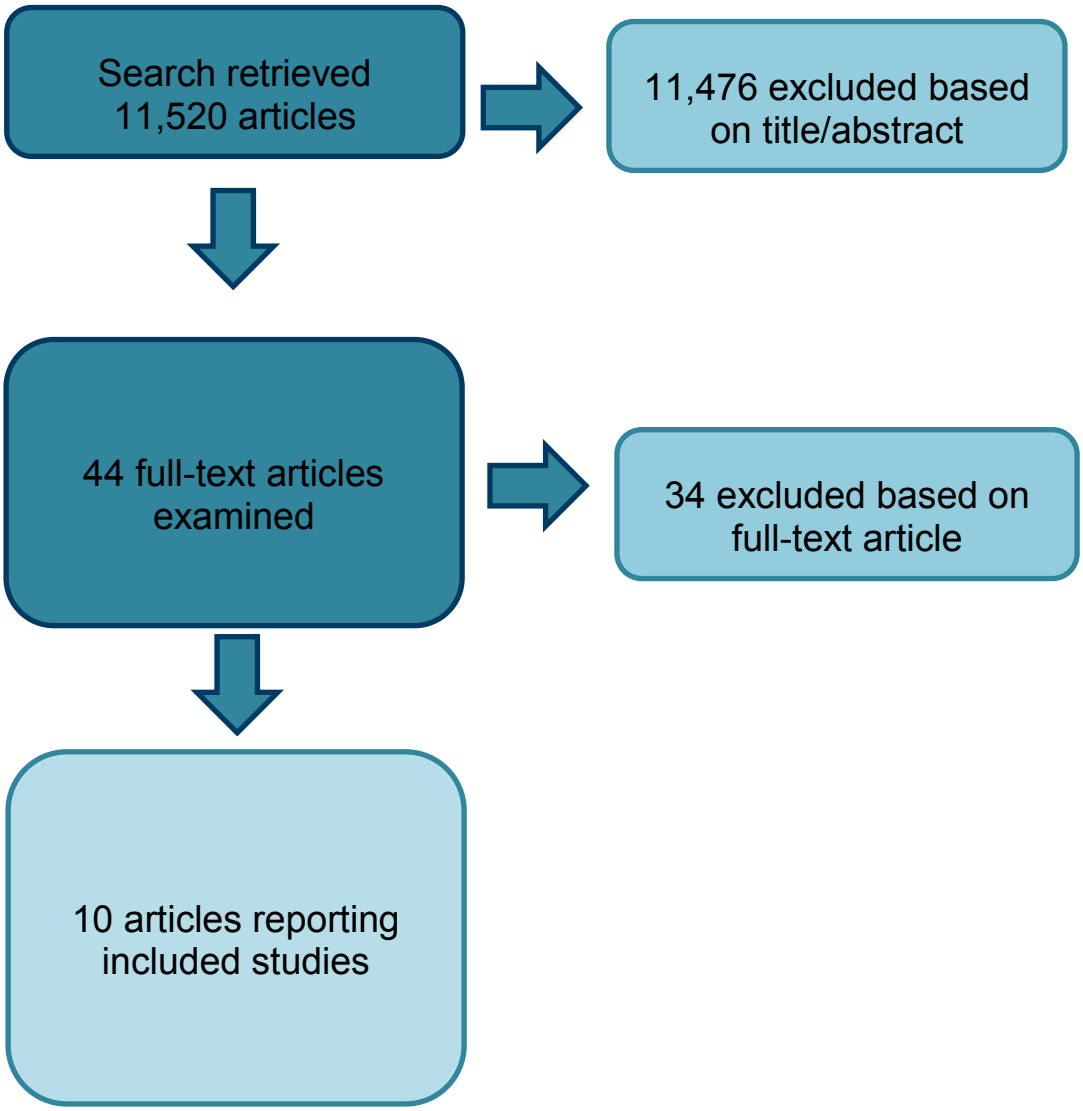
Line number/Search term/Number retrieved	
61 (pool$ adj2 (analy$ or data)).tw.	17248
62 (handsearch$ or (hand adj3 search$)).tw.	6153
63 (manual$ adj3 search$).tw.	3666
64 or/51-63	2248959
65 or/29,50,64	6366873
66 and/5,14,65	9664
67 animals/ not humans/	4230831
68 66 not 67	9516
69 limit 68 to english language	7750

Appendix E: Review flowchart

E.1 RQ1 – Displaced intracapsular hip fracture



E.2 RQ2 - Undisplaced intracapsular hip fracture



Appendix F:Excluded studies

F.1 RQ1 – Displaced intracapsular hip fracture

Reference	Reason for exclusion
Bhandari M, Devereaux P, Swiontkowski M, et al. (2003). Internal fixation compared with arthroplasty for displaced fractures of the femoral neck: a meta-analysis. Journal of Bone and Joint Surgery - Series A 85(9):1673-81.	Publication type: meta analysis. Used for cross-checking. No additional studies identified.
Bhandari M, Tornetta I, Ellis T, et al. (2004). Hierarchy of evidence: Differences in results between non-randomized studies and randomized trials in patients with femoral neck fractures. Archives of Orthopaedic and Trauma Surgery 124(1):10-6.	Publication type: review of non-randomised or observational vs. randomised studies. Used for cross-checking.
Bhandari M, Devereaux P, Einhorn T, et al. (2015). Hip fracture evaluation with alternatives of total hip arthroplasty versus hemiarthroplasty (HEALTH): Protocol for a multicentre randomised trial. BMJ Open 5(2)	Publication type: review protocol paper (trial on-going).
Bonke H, Schnater J, Kleijnen J, et al. (1999) Hemiarthroplasty or total hip replacement for femoral neck fractures. A preliminary report of a randomized trial. Hefte zur der Unfallchirurg 272:176-7.	Publication type: study abstract only.
Bray T, Smith H, Hooper A, et al. (1988). The displaced femoral neck fracture. Internal fixation versus bipolar endoprosthesis. Results of a prospective, randomized comparison. Clinical Orthopaedics and Related Research (230):127-40.	Study design/reporting: inadequate randomisation (preference of attending surgeon on day of admission).
Burgers P, Hoogendoorn M, van Woensel E, et al. (2016). Total medical costs of treating femoral neck fracture patients with hemi- or total hip arthroplasty: a cost analysis of a multicenter prospective study. Osteoporosis International 27(6):1999-2008.	Publication type: cohort study cost analysis (Netherlands)
Calder S, Anderson G, Harper W, et al. (1995). A subjective health indicator for follow-up. A randomised trial after treatment of displaced intracapsular hip fractures. The Journal of Bone and Joint Surgery. British volume 77(3):494-6.	Incorrect comparator and outcome: compares two types of hemiarthroplasty; outcome not specified in review protocol
Carroll C, Stevenson M, Scope A, et al.. (2011.). Hemiarthroplasty and total hip arthroplasty for treating primary intracapsular fracture of the hip: a systematic review and cost-effectiveness analysis". Health Technology Assessment 15(36):i-74.	Publication type: systematic review. Used for cross-checking. No additional relevant studies identified.
Chesser T, Budnar V, Acharya M. (2012). The role of total hip replacement in the treatment of displaced intracapsular hip fractures in the elderly. Injury 43(10):1621-2.	Publication type: non-systematic review

Reference	Reason for exclusion
Collaborative Orthopaedic Research Network (2016). The provision of total hip replacement for displaced intracapsular hip fractures. Annals of the Royal College of Surgeons of England 98(2):96-101.	Publication type: audit study
Giannini S, Chiarello E, Cadossi M, et al. (2011). Prosthetic surgery in fragility osteopathy. Aging Clinical and Experimental Research 23: (2 Suppl):40-2.	Study design/reporting: unclear sample denominators.
Healy W, and Iorio R. (2004). Total hip arthroplasty: optimal treatment for displaced femoral neck fractures in elderly patients. Clinical Orthopaedics and Related Research (429):43-8.	Publication type: non-randomised comparative study
Heetveld M, Rogmark C, Frihagen F, et al (2009). Internal fixation versus arthroplasty for displaced femoral neck fractures: what is the evidence?. Journal of Orthopaedic Trauma 23(6):395-402.	Publication type: systematic review. Used for cross-checking.
Hopley C, Stengel D, Ekkernkamp A, et al. (2010). Primary total hip arthroplasty versus hemiarthroplasty for displaced intracapsular hip fractures in older patients: systematic review. BMJ (Online) 340(7761):1397.	Publication type: systematic review. Used for cross-checking.
Horriat S, Hamilton P, Sott A. (2015). Financial aspects of arthroplasty options for intra-capsular neck of femur fractures: a cost analysis study to review the financial impacts of implementing NICE guidelines in the NHS organisations. Injury 46(2):363-5.	Publication type: cost analysis study of implementing NICE CG124
Jensen J, Rasmussen T, Christensen S, et al. (1984). Internal fixation or prosthetic replacement in fresh femoral neck fractures. Acta Orthopaedica Scandinavica 55(6):712.	Publication type: conference abstract only.
Jiang J, Yang C, Lin Q, et al. (2015). Does arthroplasty provide better outcomes than internal fixation at mid- and long-term follow-up? A meta-analysis. Clinical Orthopaedics and Related Research 473(8):2672-9.	Publication type: systematic review. Used for cross-checking.
Johansson T, Risto O, Knutsson A, et al. (2001). Heterotopic ossification following internal fixation or arthroplasty for displaced femoral neck fractures: a prospective randomized study. International Orthopaedics 25(4):223-5.	Incorrect outcome - not specified in review protocol. (Secondary publication to Johansson 2002).
Kavcic G, Hudoklin P, Mikek M, et al. (2006). Hemiarthroplasty versus total arthroplasty for treatment of femoral neck fractures. European Journal of Trauma 32(Supplement 1):24.	Publication type: conference abstract.
Kirschenbaum I. (1989). The displaced femoral neck fracture: internal fixation versus bipolar endoprosthesis. Results of a prospective, randomized comparison. Clinical Orthopaedics and Related Research (240):311-2.	Publication type: letter.
Leonardsson O, Sernbo I, Carlsson A, et al. (2010). Long-term follow-up of replacement compared with internal fixation for displaced	Study design/reporting: patient allocation to THR or

Reference	Reason for exclusion
femoral neck fractures: results at ten years in a randomised study of 450 patients. The Journal of Bone and Joint Surgery. British volume 92(3):406-12.	hemiarthroplasty treatment groups was non-random (based on patient criteria).
Neander G, Adolphson P, von Sivers K, et al. (1997). Bone and muscle mass after femoral neck fracture. A controlled quantitative computed tomography study of osteosynthesis versus primary total hip arthroplasty. Archives of Orthopaedic and Trauma Surgery 116(8):470-4.	Study design/reporting: unclear denominators
Neander G. (2000). Reduction and fixation versus total hip arthroplasty in the treatment of displaced femoral neck fractures. Results after four years of a prospective randomised study in 100 patients. *Displaced femoral neck fractures. Studies on osteosynthesis and total hip arthroplasty.* Edited by Stockholm: Division of Orthopaedics, Karolinska Institutet and Danderyds Hospital, Stockholm.	Unavailable (Swedish thesis)
Parker M, Gurusamy K, Selvan (2006). Internal fixation versus arthroplasty for intracapsular proximal femoral fractures in adults. Cochrane Database of Systematic Reviews (4)	Publication type: Cochrane systematic review. Used for cross-checking.
Parker M, Gurusamy K, Selvan, et al. (2010) Arthroplasties (with and without bone cement) for proximal femoral fractures in adults. Cochrane Database of Systematic Reviews (6)	Publication type: Cochrane systematic review. Used for cross-checking.
Rogmark C, Carlsson A, Johnell O, et al. (2002). A prospective randomised trial of internal fixation versus arthroplasty for displaced fractures of the neck of the femur. Journal of Bone and Joint Surgery. British volume 84(2):183-8.	Study design/reporting: patient allocation to THR or hemiarthroplasty treatment groups was non-random (based on patient criteria).
Rogmark C, Carlsson A, Johnell O, al. (2003). Costs of internal fixation and arthroplasty for displaced femoral neck fractures: A randomized study of 68 patients. Acta Orthopaedica Scandinavica 74(3):293-8.	Publication type: cost analysis study
Rogmark C. (2014). CORR insights: Randomized trial of hemiarthroplasty versus internal fixation for femoral neck fractures: No differences at 6 years. Clinical Orthopaedics and Related Research 472(1):368-9.	Publication type: editorial.
Rogmark C, Leonardsson O. (2016). Hip arthroplasty for the treatment of displaced fractures of the femoral neck in elderly patients. Bone and Joint Journal 98B(3):291-7.	Publication type: non-systematic review.
Sikorski J, Barrington R. (1981). Internal fixation versus hemiarthroplasty for the displaced subcapital fracture of the femur. A prospective randomised study. The Journal of Bone and Joint Surgery: British volume 63-B(3):357-61.	Study design/reporting: baseline and outcome data not clearly reported by treatment group.

Reference	Reason for exclusion
Skoldenberg O, Chammout G, Mukka S, et al. (2015). HOPE-trial: hemiarthroplasty compared to total hip arthroplasty for displaced femoral neck fractures in the elderly-elderly, a randomized controlled trial. BMC musculoskeletal disorders 16(1) 307	Publication type: review protocol paper (trial on-going).
Soreide O, Molster A, Raugstad T, et al. (1979). Internal fixation of fractures of the neck of the femur using von Bahr screws and allowing immediate weight bearing: A prospective clinical study. Injury 10(3):239-44.	Publication type: non-comparative prospective study of internal fixation only.
Soreide O, Alho A, Rietti D. (1980). Internal fixation versus endoprosthesis in the treatment of femoral neck fractures in the elderly. A prospective analysis of the comparative costs and the consumption of hospital resources. Acta Orthopaedica Scandinavica 51(5):827-31.	Incorrect publication type: Cost analysis of included study (Soreide 1979)
Soreide O, Molster A, Raugstad T. (1980). Replacement with the Christiansen endoprosthesis in acute femoral neck fractures. A 5 year follow-up study. Acta Orthopaedica Scandinavica 51(1):137-44.	Study design/reporting: secondary publication of included study (Soreide 1979). Reports follow-up for only one treatment group
Svenningsen S, Benum P, Nesse O, et al. (1985). Dislocated femoral neck fractures in the elderly. A comparison of three methods of treatment. Tidsskr-nor-Laegeforen 105(7):492-495+537.	Language: Norwegian (only the abstract is in English)
Wang F, Zhang H, Zhang Z, et al. (2015). Comparison of bipolar hemiarthroplasty and total hip arthroplasty for displaced femoral neck fractures in the healthy elderly: a meta-analysis. BMC Musculoskeletal Disorders 16:229.	Publication type: meta-analysis. Used for cross-checking
Yu L, Wang Y, Chen J. (2012). Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fractures: meta-analysis of randomized trials. Clinical Orthopaedics and Related Research 470(8):2235-43.	Publication type: systematic review. Used for cross-checking.

F.2 RQ2 – Undisplaced intracapsular hip fracture

Reference	Reason for exclusion
Asnis S F, and Wanek-Sgaglione L. (1994). Intracapsular fractures of the femoral neck. Results of cannulated screw fixation. Journal of Bone and Joint Surgery - Series A, 76(12), pp.1793-1803.	Type of radiographs used to diagnose fracture not specified.
Chen W C, Yu S W, Tseng I C, Su J Y, Tu Y K, and Chen W J. (2005). Treatment of undisplaced femoral neck fractures in the elderly. Journal of Trauma - Injury, and Infection and Critical Care, 58(5), pp.1035-1039.	Full article not retrieved.
Chiu F Y, and Lo W H. (1996). Undisplaced femoral neck fracture in the elderly. Archives of orthopaedic and trauma surgery, 115(2), pp.90-3.	Type of radiographs used to diagnose fracture not specified.

Reference	Reason for exclusion
Clement N D, Green K, Murray N, Duckworth A D, McQueen M M, and Court-Brown C M. (2013). Undisplaced intracapsular hip fractures in the elderly: Predicting fixation failure and mortality. A prospective study of 162 patients. Journal of Orthopaedic Science, 18(4), pp.578-585.	Type of radiographs used to diagnose fracture not specified.
Conn Kevin S, and Parker Martyn J. (2004). Undisplaced intracapsular hip fractures: results of internal fixation in 375 patients. Clinical orthopaedics and related research, (421), pp.249-54.	Only AP used for diagnosis (AP and lateral in follow-up)
Di Muria , G V, Marcucci M, Pitto R P, and Troiani M. (1991). Verified causes of failure in the treatment of femoral neck fractures with multiple Knowles pins. Italian journal of orthopaedics and traumatology, 17(1), pp.107-16.	No outcomes from the protocol reported.
Dolatowski Filip C, Adampour Mina, Frihagen Frede, Stavem Knut, Erik Utvag, Stein , and Hoelsbrekken Sigurd Erik. (2016). Preoperative posterior tilt of at least 20degree increased the risk of fixation failure in Garden-I and -II femoral neck fractures. Acta orthopaedica, 87(3), pp.252-6.	No outcomes from the protocol reported.
Gjertsen J E, Fevang J M, Matre K, Vinje T, and Engesaeter L B. (2011). Clinical outcome after undisplaced femoral neck fractures. Acta Orthopaedica, 82(3), pp.268-274.	Type of radiographs used to diagnose fracture not specified.
Hui A C, Anderson G H, Choudhry R, Boyle J, and Gregg P J. (1994). Internal fixation or hemiarthroplasty for undisplaced fractures of the femoral neck in octogenarians. The Journal of bone and joint surgery. British volume, 76(6), pp.891-4.	Type of radiographs used to diagnose fracture not specified.
Jensen J, and Hogh J. (1983). Fractures of the femoral neck. A follow-up study after non-operative treatment of Garden's stage 1 and 2 fractures. Injury, 14(4), pp.339-342.	Type of radiographs used to diagnose fracture not specified.
Kim J W, Byun S E, and Chang J S. (2014). The clinical outcomes of early internal fixation for undisplaced femoral neck fractures and early full weight-bearing in elderly patients. Archives of Orthopaedic and Trauma Surgery, 134(7), pp.941-946.	Type of radiographs used to diagnose fracture not specified.
Kuokkanen H, Korkala O, Antti-Poika I, Tolonen J, Lehtimäki M Y, and Silvennoinen T. (1991). Three cancellous bone screws versus a screw-angle plate in the treatment of Garden I and II fractures of the femoral neck. Acta orthopaedica Belgica, 57(1), pp.53-7.	Type of radiographs used to diagnose fracture not specified.
Levi N. (1998). Dynamic hip screw versus 3 parallel Ullevaal screws versus 3 parallel AO screws in the treatment of Garden 1+2 and Garden 3+4 femoral neck fractures. Minerva Ortopedica e Traumatologica, 49(1-2), pp.19-25.	Type of radiographs used to diagnose fracture not specified.
Levi N. (1999). Dynamic hip screw versus 3 parallel screws in the treatment of garden 1 + 2 and garden 3 + 4 cervical hip fractures. Panminerva medica, 41(3), pp.233-7.	Type of radiographs used to diagnose fracture not specified.
Lin J C. F, and Liang W M. (2015). Outcomes after fixation for undisplaced femoral neck fracture compared to hemiarthroplasty for displaced femoral neck fracture among the elderly. BMC Musculoskeletal Disorders, 16(1), pp.no pagination.	Type of radiographs used to diagnose fracture not specified.
Manohara Ruben, Liang Shen, Huang Deborah, and Krishna Lingaraj. (2014). Cancellous screw fixation for undisplaced femoral neck fractures in the elderly. Journal of orthopaedic surgery (Hong Kong), 22(3), pp.282-6.	Type of radiographs used to diagnose fracture not specified.

Reference	Reason for exclusion
Moulton L S, Green N L, Sudahar T, Makwana N K, and Whittaker J P. (2015). Outcome after conservatively managed intracapsular fractures of the femoral neck. Annals of the Royal College of Surgeons of England, 97(4), pp.279-82.	Type of radiographs used to diagnose fracture not specified.
Nikolopoulos K E, Papadakis S A, Kateros K T, Themistocleous G S, Vlamis J A, Papagelopoulos P J, and Nikiforidis P A. (2003). Long-term outcome of patients with avascular necrosis, after internal fixation of femoral neck fractures. Injury, 34(7), pp.525-8.	Type of radiographs used to diagnose fracture not specified.
Papanastassiou Ioannis D, Mavrogenis Andreas F, Kokkalis Zinon T, Nikolopoulos Konstantinos, Skourtas Konstantinos, and Papagelopoulos Panayiotis J. (2011). Fixation of femoral neck fractures using divergent versus parallel cannulated screws. Journal of long-term effects of medical implants, 21(1), pp.63-9.	No outcomes from the protocol reported.
Parker Martyn J, White Andrew, and Boyle Adrian. (2008). Fixation versus hemiarthroplasty for undisplaced intracapsular hip fractures. Injury, 39(7), pp.791-5.	Type of radiographs used to diagnose fracture not specified.
Pihlajamaki HK, Ruohola JP, Weckstrom M et al. (2006). Long-term outcome of undisplaced fatigue fractures of the femoral neck in young male adults. The Journal of bone and joint surgery. British volume, 88(12), 1574-9.	Population with stress fractures
Rajan D T, and Parker M J. (2001). Does the level of an intracapsular femoral fracture influence fracture healing after internal fixation? A study of 411 patients. Injury, 32(1), pp.53-6.	Only anterio-posterior radiograph used to diagnose HF and no outcomes from protocol reported.
Schep N W. L, Heintjes R J, Martens E P, van Dortmont , L M C, van Vugt , and A B. (2004). Retrospective analysis of factors influencing the operative result after percutaneous osteosynthesis of intracapsular femoral neck fractures. Injury, 35(10), pp.1003-9.	No outcomes from the protocol reported.
Shih C H, and Wang K C. (1991). Femoral neck fractures. 121 cases treated by Knowles pinning. Clinical orthopaedics and related research, (271), pp.195-200.	No outcomes from the protocol reported.
Shimizu Takashi, Miyamoto Kei, Masuda Kazuaki, Miyata Yoshio, Hori Hirohiko, Shimizu Katsuji, and Maeda Masato. (2007). The clinical significance of impaction at the femoral neck fracture site in the elderly. Archives of orthopaedic and trauma surgery, 127(7), pp.515-21.	Type of radiographs used to diagnose fracture not specified.
Shuqiang Ma, Kunzheng Wang, Zhichao Tong, Mingyu Zhang, and Wei Wang. (2006). Outcome of non-operative management in Garden I femoral neck fractures. Injury, 37(10), pp.974-8.	Type of radiographs used to diagnose fracture not specified.
Sikand M, Wenn R, and Moran C G. (2004). Mortality following surgery for undisplaced intracapsular hip fractures. Injury, 35(10), pp.1015-9.	Type of radiographs used to diagnose fracture not specified.
Svenningsen S, Benum P, Nesse O, and Furset O I. (1984). Internal fixation of femoral neck fractures. Compression screw compared with nail plate fixation. Acta orthopaedica Scandinavica, 55(4), pp.423-9.	Type of radiographs used to diagnose fracture not specified.
Talboys Rupert, Pickup Luke, and Chojnowski Adrian. (2012). The management of intracapsular hip fractures in the 'young elderly' internal fixation or total hip replacement?. Acta orthopaedica Belgica, 78(1), pp.41-8.	Type of radiographs used to diagnose fracture not specified.

Reference	Reason for exclusion
Tidermark Jan, Zethraeus Niklas, Svensson Olle, Tornkvist Hans, and Ponzer Sari. (2002). Quality of life related to fracture displacement among elderly patients with femoral neck fractures treated with internal fixation. Journal of orthopaedic trauma, 16(1), pp.34-8.	Type of radiographs used to diagnose fracture not specified.
Tidermark J, Zethraeus N, Svensson O, Tornkvist H, and Ponzer S. (2003). Quality of life related to fracture displacement among elderly patients with femoral neck fractures treated with internal fixation. Journal of Orthopaedic Trauma, 17(8 SUPPL.), pp.S17-S21.	Duplicate.
Verheyen Cees C. P. M, Smulders Tom C, van Walsum , and Ariaan D P. (2005). High secondary displacement rate in the conservative treatment of impacted femoral neck fractures in 105 patients. Archives of orthopaedic and trauma surgery, 125(3), pp.166-8.	Type of radiographs used to diagnose fracture not specified.
Warschawski Yaniv, Sharfman Zachary T, Berger Omri, Steinberg Ely L, Amar Eyal, and Snir Nimrod. (2016). Dynamic locking plate vs. simple cannulated screws for nondisplaced intracapsular hip fracture: A comparative study. Injury, 47(2), pp.424-7.	Type of radiographs used to diagnose fracture not specified.
Watson A, Zhang Y, Beattie S, and Page R S. (2013). Prospective randomized controlled trial comparing dynamic hip screw and screw fixation for undisplaced subcapital hip fractures. ANZ journal of surgery, 83(9), pp.679-83.	Type of radiographs used to diagnose fracture not specified.

Appendix G: Evidence tables

G.1 RQ1: Displaced intracapsular hip fracture

G.1.1 IF versus HA

G.1.1.1 Blomfeldt 2005

Bibliographic reference	**Blomfeldt R, Tornkvist H, Ponzer S, et al (2005) - Internal fixation *versus* hemiarthroplasty for displaced fractures of the femoral neck in elderly patients with severe cognitive impairment. Journal of bone and joint surgery British volume. 2005. 87(4):523-9. Erratum in: Journal of bone and joint surgery British volume. 2005 87(8):1166**
Study type	RCT
Aim	To compare the outcome in patients with severe cognitive impairment and a displaced fracture of the femoral neck, who were randomly allocated to receive either internal fixation or hemiarthroplasty.
Patient characteristics	**Inclusion criteria** - ≥70 years - Diagnosed with dementia and/or severe cognitive dysfunction (according to the Short Portable Mental Status Questionnaire (SPMSQ) - Independent walking capability with or without a walking aid **Exclusion criteria** - Patients with fractures not suitable for internal fixation, such as pathological fractures - Patients with displaced fractures of a duration more than 24 hours - Patients with rheumatoid arthritis or osteoarthritis **Baseline characteristics**

	Internal Fixation (N = 30)	**Hemiarthroplasty (N = 30)**
Age – Mean (SD)	83.6 (6.3)	84.0 (5.9)
Gender – F (%)	28 (93.3)	26 (86.7)
ASA status	N/R	N/R

Bibliographic reference	**Blomfeldt R, Tornkvist H, Ponzer S, et al (2005) - Internal fixation *versus* hemiarthroplasty for displaced fractures of the femoral neck in elderly patients with severe cognitive impairment. Journal of bone and joint surgery British volume. 2005. 87(4):523-9. Erratum in: Journal of bone and joint surgery British volume. 2005 87(8):1166**
	<table><tr><td>Mobility assessment (‘no walking aids or just one stick’) - n (%)</td><td>18 (60)</td><td>19 (63.3)</td></tr><tr><td>Place of residence – n (%) • Home (independent living’ • Residential care • Other</td><td> 14 (46.7) 16 (53.3)</td><td> 15 (50) 15 (50)</td></tr><tr><td>Cognitive status** / dementia – n (%)</td><td>30 (100)</td><td>30 (100)</td></tr><tr><td>Time since admission</td><td>N/R</td><td>N/R</td></tr></table> *reported as ‘severely cognitively impaired’ **Other baseline characteristics reported were:** ○ cognitive function using SPMSQ, ○ Quality of life using EQ5D, ○ ADL A to B, ○ Comorbidity
Number of Patients	N = 60
Intervention	Internal fixation – fracture reduced by closed methods and internally fixed using two cannulated screws (DePuy/Johnson-Johnson, Solle-tuna, Sweden) Mean operating time: 19 minutes (range: 10 to 40)
Comparison	Hemiarthroplasty using anterolateral modified Hardinge approach. An uncemented Austin Moore implant was used (DePuy/Johnson-Johnson) Mean operating time: 43 minutes (range: 29 to 60).
Length of follow up	2 years

<table>
<tr><td>Bibliographic reference</td><td>Blomfeldt R, Tornkvist H, Ponzer S, et al (2005) - Internal fixation versus hemiarthroplasty for displaced fractures of the femoral neck in elderly patients with severe cognitive impairment. Journal of bone and joint surgery British volume. 2005. 87(4):523-9. Erratum in: Journal of bone and joint surgery British volume. 2005 87(8):1166</td></tr>
<tr><td>Location</td><td>Sweden (single centre)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal Fixation (N = 30)</th><th>Hemiarthroplasty (N = 30)</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years *2 year data used)</td><td>
N/R
10 (33%)
13 (43%)</td><td>
N/R
7 (23%)
12 (40%)</td></tr>
<tr><td>Surgical revision (at 2 years)* – n (%)</td><td>8 (26.7%)</td><td>2 (6.7%)</td></tr>
<tr><td>Functional status (reported as ADL) – mean, n
• 1 year
• 5 years</td><td>
4.4 (no SD), n = 19
N/R</td><td>
4.7 (no SD), n = 23
N/R</td></tr>
<tr><td>Quality of life ($EQ5D_{index}$) at 4 months – Mean score, n</td><td>0.2 (no SD), n = 25</td><td>0.2 (no SD), n = 26</td></tr>
<tr><td>Length of stay – Mean (SD)</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence at 1 year** n/N
• Home
• Residential care
• Other</td><td>6/17</td><td>2/18</td></tr>
</table>
*reported as surgical revisions for non-union in the Internal fixation group within 2 year follow-up and in the Hemiarthroplasty group, one patient had a type-II fracture causing some instability and requiring revision to a cemented bipolar arthroplasty and one patient had an infection treated primarily by wound debridement and lavage but a further operation was required to remove the prosthesis following which the infection healed.
**reported as 'retaining independent living status at 2 years'
Standard deviation for EQ5D not reported at 4 months so standard deviation from study population at baseline (0.17) used in meta-analyses

Other outcomes / timepoints reported were
○ Mortality at 4 months</td></tr>
</table>

Bibliographic reference	**Blomfeldt R, Tornkvist H, Ponzer S, et al (2005) - Internal fixation *versus* hemiarthroplasty for displaced fractures of the femoral neck in elderly patients with severe cognitive impairment. Journal of bone and joint surgery British volume. 2005. 87(4):523-9. Erratum in: Journal of bone and joint surgery British volume. 2005 87(8):1166**
	○ Mortality at 24 months ○ Complications ○ ADL at 4 month ○ ADL at 24 months ○ ADL = 6 (totally dependent) at 4 months ○ ADL = 6 (totally dependent) at 4 months ○ Charnley score at 4 ○ Charnley score at 12 months ○ Charnley score at 24 months ○ Blood loss ○ Blood transfusion
Source of funding	This study was supported in part by grants from the Trygg-Hansa Insurance Company, the Swedish Society for Medical Research, the Swedish Orthopaedic Association and the Stockholm County Council (EXPO-95, proj. no. 2002-7929).
Comments	Data on EQ5D using in analysis calculated by technical team as follows: • Mean at endpoint for each group imputed from mean baseline score plus change score at endpoint • SD at endpoint for both groups imputed from largest SD at baseline (0.2) <u>Methodology checklist</u> **Selection bias: Inadequate -** 'sealed envelopes' (no further details). **Performance bias:** The two arms received the same care apart from the intervention being studied. Study participants and individuals administering care not blinded. **Attrition bias:** <2% loss to follow-up. All groups followed up for an equal period of time and completed treatment, ITT analysis used. Groups comparable at treatment completion. **Detection bias: No indication of blinding of outcome assessors.** Outcomes defined and valid and reliable measures used.

G.1.1.2 Davison 2001

Bibliographic reference	**Davison JN, Calder SJ, Anderson GH et al. (2001) Treatment for displaced intracapsular fracture of the proximal femur. A prospective, randomised trial in patients aged 65 to 79 years. Journal of bone and joint surgery British volume.. 83(2):206-12**
Study type	RCT
Aim	To compare the outcome after internal fixation, unipolar hemiarthroplasty and bipolar hemiarthroplasty, with reference to mortality, surgical morbidity, the rate of re-intervention, functional recovery, level of dependency and subjective outcome.
Patient characteristics	**Inclusion criteria:** - Displaced intracapsular fracture of the proximal femur - Aged between 65 and 79 years **Exclusion criteria:** - Mental test score of less than 5/13 - Uncontrolled Parkinson's disease - A pathological fracture or disseminated malignancy - Paget's disease - Rheumatoid arthritis - Long-term steroid therapy **Baseline characteristics:**

	Internal Fixation (N = 93)	**Hemiarthroplasty – cemented unipolar (N = 90)**	**Hemiarthroplasty – cemented bipolar (n = 97)**
Age (years) – Median (IQR)	73 (70 to 77)	76 (72 to 77)	75 (71 to 78)
Gender – F (%)	70 (75.3)	71 (78.9)	72 (74.2)
ASA status	N/R	N/R	N/R
Mobility assessment* / use of waking aids – n (%)	79 (84.9)	69 (76.7)	74 (76.3)
Place of residence – n (%) • Home** • Residential care	 87 (93.5) 6 (6.5)	 83 (89.2) 7 (10.8)	 91 (93.8) 6 (6.2)

Bibliographic reference	**Davison JN, Calder SJ, Anderson GH et al. (2001) Treatment for displaced intracapsular fracture of the proximal femur. A prospective, randomised trial in patients aged 65 to 79 years. Journal of bone and joint surgery British volume.. 83(2):206-12**
	• Other Cognitive status / dementia – mental test score – Median (IQR): 13 (13 to 13) / 13 (13 to 13) / 13 (12 to 13) Time since admission (days) – Mean (SD) / range / Median (IQR): 2 (1 to 2) / 2 (1 to 3) / 2 (1 to 3) *reported as independent of mobility ** reported as living independently in the community **Other baseline characteristics reported were:** o marital status, o previous fracture status, o delay between fracture and admission,
Number of Patients	N = 280
Intervention	Reduction and internal fixation using an 'Ambi' compression hip screw (AHS) and a two-hole plate
Comparison	Hemiarthroplasty using lateral (Hardinge) approach using two devices • a cemented Thompson unipolar hemiarthroplasty • a cemented Monk (hard-top) bipolar hemiarthroplasty Methylmethacrylate cement of normal viscosity was inserted using a orthograde technique, with a vent and no cement restrictor.
Length of follow up	5 years
Location	England
Outcomes measures and effect size	**Results** **Internal Fixation (N = 93) / Hemiarthroplasty – cemented unipolar (N = 90) / Hemiarthroplasty – cemented bipolar (N = 97)** Mortality – n (%) • 30 days: 2 (2%) / 2 (2%) / 6 (6%) • 1 year: 5 (5%) / 10 (11%) / 11 (11%) • 5 years: 17 (19%) / 31 (34%) / 29 (30%)

Bibliographic reference	**Davison JN, Calder SJ, Anderson GH et al. (2001) Treatment for displaced intracapsular fracture of the proximal femur. A prospective, randomised trial in patients aged 65 to 79 years. Journal of bone and joint surgery British volume.. 83(2):206-12**
	<table><tr><td></td><td></td><td></td><td></td></tr><tr><td>Surgical revision* at 6 years – n (%)</td><td>26 (28%)</td><td>2 (2%)</td><td>1 (1%)</td></tr><tr><td>Functional status – Harris Hip score – mean (SD), n • 1 year • 5 years</td><td> 70.8 (no SD or N) 70.0 (no SD or N)</td><td> 71.1 (no SD or N) 71.8 (no SD or N)</td><td> 73.2 (no SD or N) 73.6 (no SD or N)</td></tr><tr><td>Quality of life – Mean (SD)</td><td>N/R</td><td>N/R</td><td>N/R</td></tr><tr><td>Length of stay (days) – Median (IQR)</td><td>14 (10 to 21)</td><td>15 (11 to 22)</td><td>15 (13 to 21)</td></tr><tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td><td>N/R</td></tr></table> *32 patients in the internal fixation group had complication but four did not have another surgery and 2 had screw removal only,
Source of funding	N/R
Comments	Methodology checklist **Selection bias: Adequate** randomisation and allocation concealment by computer generation of random numbers. Blinding: not reported. Groups comparable at baseline. **Performance bias:** All groups received the same care apart from the intervention received. **Attrition bias:** Loss to follow-up not reported. All arms were followed up for an equal length of time. All participants received treatment. ITT analysis used. Outcome data was recorded for all participants, but until the 2 year follow up. The 2 arms were comparable at treatment completion. **Detection bias: Outcome assessor blinded**. Outcomes defined and valid and reliable measures used.

G.1.1.3 Frihagen 2007

Bibliographic reference	**Frihagen F, Nordsletten L, Madsen JE. (2007) Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: randomised controlled trial BMJ 335 :1251**
Study type	RCT

<table>
<tr><td>Bibliographic reference</td><td>Frihagen F, Nordsletten L, Madsen JE. (2007) Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: randomised controlled trial BMJ 335 :1251</td></tr>
<tr><td>Aim</td><td>To compare the functional results after displaced fractures of the femoral neck treated with internal fixation or hemiarthroplasty.</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion
- patients aged ≥60 years
- intracapsular femoral neck fracture with angular displacement in either radiographic plane
- previously ambulant
Exclusion
- being unfit for arthroplasty according to an anaesthetist
- previous symptomatic hip pathology (such as arthritis)
- pathological fracture
- delay of more than 96 hours from injury to treatment
- living outside the hospitals designated area

Baseline characteristics
<table>
<tr><th></th><th>Internal Fixation (N = 112)</th><th>Hemiarthroplasty (N = 110)</th></tr>
<tr><td>Age (years) – Mean (SD)</td><td>83.2 (7.65)</td><td>82.5 (7.32)</td></tr>
<tr><td>Gender – Female n (%)</td><td>87 (78%)</td><td>78 (71%)</td></tr>
<tr><td>ASA status – n (%)
• I or II
• III or IV</td><td>
59 (53%)
53 (47%)</td><td>
52 (47%)
58 (53%)</td></tr>
<tr><td>Mobility assessment* / use of waking aids – n/N</td><td>45 (40%)</td><td>50 (45%)</td></tr>
<tr><td>Place of residence*** – n (%)
• Home
• Residential care
• Other</td><td>
80 (71%)
N/R
N/R</td><td>
83 (75%)
N/R
N/R</td></tr>
<tr><td>Cognitive status** / dementia</td><td>40/112</td><td>29/110</td></tr>
<tr><td>Time since admission (hours) – Mean (SD), n</td><td>25.3 (15.34), n = 111</td><td>31.4 (22.32), n = 107</td></tr>
</table>
*reported as ‘ability to walk without any aid’</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Frihagen F, Nordsletten L, Madsen JE. (2007) Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: randomised controlled trial BMJ 335 :1251</td></tr>
<tr><td></td><td>**reported as ‘previously recognised cognitive failure’
***reported as living in own home

Other baseline characteristics reported were:
○ not able to give informed consent
○ fall from standing height or lower
○ time from injury to admission
○ place where injury occurred
○ retrospective Harris Hip score
○ concurrent symptomatic medical disease
○ concurrent condition or impairment likely to affect rehabilitation</td></tr>
<tr><td>Number of Patients</td><td>N = 222</td></tr>
<tr><td>Intervention</td><td>Closed reduction and internal fixation with two parallel cannulated screws
Mean (SD) duration of surgery in minutes: 26 (20.18) (n = 110)</td></tr>
<tr><td>Comparison</td><td>Charnley-Hastings bipolar cemented hemiarthroplasty
Mean (SD) duration of surgery in minutes: 76 (19.01) (n = 107)</td></tr>
<tr><td>Length of follow up</td><td>6 years</td></tr>
<tr><td>Location</td><td>Norway</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results

<table>
<tr><th></th><th>Internal Fixation (N = 112)</th><th>Hemiarthroplasty (N = 110)</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>
7 (6%)
24 (21%)
79 (71%)</td><td>
10 (9%)
29 (26%)
73 (67%)</td></tr>
<tr><td>Surgical revision* at 2 years – n (%)</td><td>40 (36%)</td><td>3 (2%)</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Frihagen F, Nordsletten L, Madsen JE. (2007) Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: randomised controlled trial BMJ 335 :1251**

Functional status – Harris Hip score - mean (SD, n • 1 year • 5 years (reported at 2 years)	 65.8 (15.9), n = 87 67.3 (15.5), n = 71	 72.6 (17.5), n = 74 70.6 (19.1), n = 68
Quality of life ($EQ5D_{index}$ score at 4 months) – Mean (SD), n	0.53 (0.29), n = 79	0.61 (0.30), n = 70
Length of stay – Mean (SD), n	8.2 (7.35), n = 111)	10.2 (11.95), n = 109
Place of residence at 1 year – n/N (%) • Change from pre-fracture home status to post surgery residential care	 34 (62%), n = 55	 28 (57%), n = 49

*reported as 'mechanical failure of internal fixation/non-union

Other outcomes / timepoints reported were:

- mortality at 4 months; 2 years; 6 years
- number with Barthel Index score of 95 or 100 (higher scores are better) at 4 months; 1 year; 2 years; 6 years
- EQ-5D visual analogue scale score at 4 months, 1 year, 2 years
- complications
- blood transfusion
- any medical complications
- postoperative confusion
- time in theatre
- blood loss
- spinal anaesthesia

Source of funding	Norwegian Foundation for Health and Rehabilitation through the Norwegian Osteoporosis Society and the Norwegian Research Council, Nycomed, Smith and Nephew, and OrtoMedic.
Comments	**Secondary publications from this trial:**

Bibliographic reference	Frihagen F, Nordsletten L, Madsen JE. (2007) Hemiarthroplasty or internal fixation for intracapsular displaced femoral neck fractures: randomised controlled trial BMJ 335 :1251
	• Frihagen F, Waaler GM, Madsen JE et al. (2010) The cost of hemiarthroplasty compared to that of internal fixation for femoral neck fractures. 2-year results involving 222 patients based on a randomized controlled trial. Acta Orthopaedica. 2010 81(4):446-52 • Waaler Bjørnelv GM, Frihagen F, Madsen JE et al. (2012) Hemiarthroplasty compared to internal fixation with percutaneous cannulated screws as treatment of displaced femoral neck fractures in the elderly: cost-utility analysis performed alongside a randomized, controlled trial. Osteoporosis International. 2012 23(6):1711-9 • Støen RØ, Lofthus CM, Nordsletten L et al. (2014) Randomized trial of hemiarthroplasty versus internal fixation for femoral neck fractures: no differences at 6 years. Clinical orthopaedics and related research ;472(1):360-7 <u>Methodology checklist</u> **Selection bias: Adequate** (sealed, opaque, numbered envelopes kept in the emergency admissions area). On recruiting the patient, the surgeon opened the envelope with the lowest number. Blinding: not reported, but the surgeons carrying out the operation were unblinded. The two groups were comparable at baseline. **Performance bias:** Groups received same care apart from the intervention received. **Attrition bias:** <1% loss to follow-up. All groups followed up for an equal length of time. All patients completed treatment in each arm. ITT analysis used. Groups comparable at treatment completion. **Detection bias: Outcome assessors blinded**. The study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

G.1.1.4 Hedbeck 2013

Bibliographic reference	Hedbeck CJ, Inngul C, Blomfeldt R et al. (2013) Internal fixation versus cemented hemiarthroplasty for displaced femoral neck fractures in patients with severe cognitive dysfunction: a randomized controlled trial. Journal of Orthopaedic Trauma. 27(12):690-5
Study type	RCT
Aim	To estimate if hemiarthroplasy is associated with less reoperations and better health related quality of life

<table>
<tr><td>Bibliographic reference</td><td>Hedbeck CJ, Inngul C, Blomfeldt R et al. (2013) Internal fixation versus cemented hemiarthroplasty for displaced femoral neck fractures in patients with severe cognitive dysfunction: a randomized controlled trial. Journal of Orthopaedic Trauma. 27(12):690-5</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion:
- Acute displaced femoral neck fracture (Garden III or IV)
- >70 years of age
- Severe cognitive dysfunction (SPMSQ < 3)
- Able to walk
Exclusion:
- pathological fracture
- patients with osteroarthritis
- patients with previous hip disorder
- fractures > 24 hours old on admission,

Baseline characteristics[1]
<table>
<tr><th></th><th>Internal fixation (N = 30)</th><th>Hemiarthroplasty (N = 30)</th></tr>
<tr><td>Age in years – mean</td><td>83.8 ± 5.4</td><td>85.2 ± 5.5</td></tr>
<tr><td>Gender – Female n (%)</td><td>25 (83%)</td><td>24 (83%)</td></tr>
<tr><td>ASA status (1-2) – n (%)</td><td>10 (33.3%)</td><td>8 (28%)</td></tr>
<tr><td>Mobility assessment* / use of walking aids – n (%)</td><td>30 (100%)</td><td>30 (100%)</td></tr>
<tr><td>Place of residence</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Cognitive status / dementia** - n (%)</td><td>30 (100%)</td><td>30 (100%)</td></tr>
<tr><td>Time since admission</td><td>Not reported</td><td>Not reported</td></tr>
</table>
*reported as ‘able to walk with or without aids’
**reported as Short Portable Mental Status Questionnaire (SPMSQ) < 3</td></tr>
<tr><td>Number of Patients</td><td>N = 60</td></tr>
<tr><td>Intervention</td><td>Internal fixation (N = 30)
Closed reduction on hip traction table using 2 cannulated 7.3 mm Olmed screws (DePuy / Johnson & Johnson, Warsaw, IN)</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Hedbeck CJ, Inngul C, Blomfeldt R et al. (2013) Internal fixation versus cemented hemiarthroplasty for displaced femoral neck fractures in patients with severe cognitive dysfunction: a randomized controlled trial. Journal of Orthopaedic Trauma. 27(12):690-5</td></tr>
<tr><td>Comparison</td><td>Hemiarthroplasty (N = 30)
Cemented Exeter HA with a unipolar Universal Head Replacement (Stryker Howmedica, Kalamazoo, MI)

Both procedure performed under spin al anaesthesia</td></tr>
<tr><td>Length of follow up</td><td>2 years</td></tr>
<tr><td>Location</td><td>Sweden</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal fixation (N = 30)</th><th>Hemiarthroplasty (N = 29)</th></tr>
<tr><td>Mortality – n/N
• 30 days
• 1 year
• 5 years (2 year data used)</td><td>
Not reported
14/30 (46.7%)
19/30 (63.3%)</td><td>
Not reported
12/29 (41.4%)
18/29 (62.1%)</td></tr>
<tr><td>Surgical revision* at 2 years – n (%)</td><td>7/30 (23.3%)</td><td>1/29 (3.4%)</td></tr>
<tr><td>Functional status</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Quality of life at 4 months – mean (SD)</td><td>0.14 (0.20), n = 20</td><td>0.24 (0.27), n = 19</td></tr>
<tr><td>Length of stay in days – mean</td><td>Not reported</td><td>Not reported</td></tr>
<tr><td>Place of residence at 1 year</td><td>Not reported</td><td>Not reported</td></tr>
</table>
Other outcomes / timepoints reported were:
○ Mortality at 4 months
○ Charnley score (Pain Walking Range of Motions scores) at 4 months 12 months and 24 months</td></tr>
<tr><td>Source of funding</td><td>None</td></tr>
<tr><td>Comments</td><td><u>Methodology checklist</u>
Selection bias: None
Performance bias: All groups received the same care apart from the interventions. No indication participants / care providers were blinded to treatment.</td></tr>
</table>

Bibliographic reference	**Hedbeck CJ, Inngul C, Blomfeldt R et al. (2013) Internal fixation versus cemented hemiarthroplasty for displaced femoral neck fractures in patients with severe cognitive dysfunction: a randomized controlled trial. Journal of Orthopaedic Trauma. 27(12):690-5**
	Attrition bias: <2% loss to follow-up. **Detection bias: Outcome assessors blinded.** Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

G.1.1.5 Keating 2005a

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
Study type	RCT
Aim	To compare the impact on functional outcome, clinical parameters and resource utilisation, more than two years after surgery, of treatment using internal fixation and bipolar hemiarthroplasty for displaced intracapsular hip fractures in previously healthy, mobile patients as 2nd part of a randomized trial if participating surgeon did not want to randomise to total hip replacement
Patient characteristics	**Inclusion:** - Aged > 60yrs - Normal cognitive function (Mini Mental Test score >6) - Independently mobile prior to fracture - No serious concomitant disease (e.g. malignancy) or other clinical reason for exclusion **Exclusion:** - Undisplaced or valgus impacted fracture **Baseline characteristics**[1]

	Internal fixation (N = 69)	**Hemiarthroplasty (N = 69)**
Age in years – mean (SD)	74.3 (7)	75.0 (6)
Gender – Female n (%)	51 (74%)	54 (78%)
ASA status	N/R	N/R

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**

Mobility assessment / use of walking aids	N/R	N/R
Place of residence	N/R	N/R
Cognitive status / dementia*	N/R	N/R
Time since admission*	N/R	N/R

* inclusion required Mini Mental Test score >6

**reports that all operations were conducted within 48 hours of entry to the trial and that surgery was usually undertaken the day following patient's admission to hospital.

Other baseline data reported:

No (%) with left / right-sided fracture

No (%) taking regular medication prior to trial entry

No (%) of operations performed by a consultant

Number of Patients	N = 138
Intervention	Internal fixation - Choice of reduction (open / closed) and fixings (e.g. cannulated screws or sliding hip screw) was at surgeon discretion. 67% had closed approach; 64% had multiple screws. - 39% had general anaesthetic; 61% had regional anaesthetic - Operating time in mins – mean (SD): 49.7 mins (22) - 22% of operations undertaken by Consultant grade surgeon
Comparison	Hemiarthroplasty - Bipolar with cement (however 2 patients (3%) received unipolar) - Choice of approach (lateral / posterior) was at surgeon discretion. 90% used lateral approach - 38% had general anaesthetic; 62% had regional anaesthetic - Operating time in mins – mean (SD): 58.5 mins (21) - 25% of operations undertaken by Consultant grade surgeon

<table>
<tr><td>Bibliographic reference</td><td>Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.</td></tr>
<tr><td>Length of follow up</td><td>2 years</td></tr>
<tr><td>Location</td><td>UK</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal fixation (N = 69)</th><th>Hemiarthroplasty (N = 69)</th></tr>
<tr><td>Mortality – n (%)
• 30 days*
• 1 year
• 5 years</td><td>
2 (2.9%)
6 (9%)
9 (13.4%)</td><td>
0 (0%)
6 (9%)
9 (13.4%)</td></tr>
<tr><td>Surgical revision (at 2 years)** – n/N</td><td>26 (38%)</td><td>0 (0%)</td></tr>
<tr><td>Functional status - Hip Rating Questionnaire (HRQ)*** – mean (SD)
• 1 year
• 5 years (2 year data used)</td><td>
71.8 (17), n = 55
75.2 (19), n = 47</td><td>
76.5 (13), n = 51
73.8 (16), n = 50</td></tr>
<tr><td>Quality of life (EQ5D utility score at 4 months)**** – Mean (SD)</td><td>0.57 (0.29), n = 64</td><td>0.60 (0.31), n = 64</td></tr>
<tr><td>Length of stay (days)***** – Mean (SD)</td><td>10.6 (6)</td><td>11.5 (8)</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
</table>
*reported as death during index admission
** reported as cumulative no. with fixation failure
*** HRQ: higher score = better functioning (max. 100)
****reported as EQ-5D utility score (numbers (%’s) in each EQ-5D subscale category, self-reported change in overall health score and ‘thermometer’ score also reported but not extracted)
***** reported as length of post-operative stay</td></tr>
</table>

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**

	Internal fixation (max N = 65)	**Hemiarthroplasty (max N = 65)**
Functional status* (AGE) - mean HRQ score (SD)		
12 months		
• 60 to 74yrs	69.8 (21)	76.3 (14)
• ≥75yrs	73.5 (13)	75.8 (14)
24 months		
• 60 to 74yrs	73.9 (19)	74.4 (15)
≥75yrs	75.0 (12)	72.8 (17)

*HRQ: higher score = better functioning (max. 100)

Other outcomes / timepoints reported were:

- Mortality during index admission
- Mortality at 4 months
- Mortality at 2 years
- Blood transfusion
- Surgical revision at 4 months
- Surgical revision at 12 months

Source of funding	Funded by grant from the NHS Health Technology Assessment programme.

Comments	**Secondary publication** • Keating J, Grant A, Masson M et al. (2006) Randomized comparison of reduction and fixation, bipolar hemiarthroplasty, and total hip arthroplasty. Treatment of displaced intracapsular hip fractures in healthy older patients. Journal of bone and joint Surgery American volume. 88(2):249-60 Methodology checklist

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
	Selection bias: Adequate - centralised, independent computerised randomisation via telephone. Allocation stratified by surgeon code and minimised on age category (60-74, 75yrs+) and gender. Treatment groups were comparable at baseline. **Performance bias:** All groups received the same care apart from the intervention received. Not possible to blind patients or care providers as post-operative management (including types of complication) differ between treatments and patients needed to consent to actual allocated operation. **Attrition bias:** <5% loss to follow-up. All groups were followed up for an equal length of time. All patients randomised completed treatment. ITT analysis used. Groups were comparable at treatment completion. **Detection bias: Outcome assessor not blinded** – self-report measures of functioning and QoL were used; research nurses co-ordinated data collection, but states: "when recording further surgery or operative complications it would usually be apparent to which group a patient was originally allocated". Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

1. Data extracted for two treatment arms (internal fixation and hemiarthroplasty) of the 3-way randomisation reported in this study comparing internal fixation vs. hemiarthroplasty vs. total hip replacement. Data from the separate 2-way randomisation between internal fixation and hemiarthroplasty only are extracted below as Keating 2005b.

G.1.1.6 Keating 2005b

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
Study type	RCT
Aim	To compare the impact on functional outcome, clinical parameters and resource utilisation, more than two years after surgery, of treatment using internal fixation and bipolar hemiarthroplasty for displaced intracapsular hip fractures in previously healthy, mobile patients as 2nd part of a randomized trial if participating surgeon did not want to randomise to total hip replacement
Patient characteristics	**Inclusion:** - Aged > 60yrs - Normal cognitive function (Mini Mental Test score >6) - Independently mobile prior to fracture - No serious concomitant disease (e.g. malignancy) or other clinical reason for exclusion

<table>
<tr><td>Bibliographic reference</td><td>Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.</td></tr>
<tr><td></td><td>Exclusion:
- Undisplaced or valgus impacted fracture

Baseline characteristics[1]
<table>
<tr><th></th><th>Internal fixation (N = 49)</th><th>Hemiarthroplasty (N = 42)</th></tr>
<tr><td>Age in years – mean (SD)</td><td>74.7 (7)</td><td>76.1 (7.9)</td></tr>
<tr><td>Gender – Female n (%)</td><td>38 (77.6)</td><td>38 (90.5)</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment / use of walking aids</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Cognitive status / dementia*</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Time since admission*</td><td>N/R</td><td>N/R</td></tr>
</table>
* inclusion required Mini Mental Test score >6
**reports that all operations were conducted within 48 hours of entry to the trial and that surgery was usually undertaken the day following patient’s admission to hospital.

Other baseline data reported:
o No (%) with left / right-sided fracture
o No (%) taking regular medication prior to trial entry
o No (%) of operations performed by a consultant</td></tr>
<tr><td>Number of Patients</td><td>N = 91</td></tr>
<tr><td>Intervention</td><td>Internal fixation
- Choice of reduction (open / closed) and fixings (e.g. cannulated screws or sliding hip screw) was at surgeon discretion. 63% had closed approach; 14% had multiple screws.
- 82% had general anaesthetic; 18% had regional anaesthetic</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.</td></tr>
<tr><td></td><td>- Operating time in mins – mean (SD): 57.4 mins (24)
- 20% of operations undertaken by Consultant grade surgeon</td></tr>
<tr><td>Comparison</td><td>Hemiarthroplasty
- Bipolar with cement (however 2 patients (5%) received unipolar)
- Choice of approach (lateral / posterior) was at surgeon discretion. 83% used lateral approach
- 67% had general anaesthetic; 33% had regional anaesthetic
- Operating time in mins – mean (SD): 67.2 mins (20)
- 10% of operations undertaken by Consultant grade surgeon</td></tr>
<tr><td>Length of follow up</td><td>2 years</td></tr>
<tr><td>Location</td><td>UK</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results[1]
<table>
<tr><th></th><th>Internal fixation (N = 49)</th><th>Hemiarthroplasty (N = 42)</th></tr>
<tr><td>Mortality – n (%)
• 30 days*
• 1 year
• 5 years 2 year data used)</td><td>
0 (0%)
4 (8%)
9 (18.4%)</td><td>
1 (2%)
5 (12%)
9 (21.4%)</td></tr>
<tr><td>Surgical revision (at 2 years)** – n/N</td><td>18 (31%)</td><td>0 (0%)</td></tr>
<tr><td>Functional status - Hip Rating Questionnaire (HRQ)*** – mean (SD)
• 1 year
• 5 years</td><td>
66.7 (14.9), n = 34
75.2(19), n = 47</td><td>
78.1 (14.9), n = 31
73.8 (16), n = 50</td></tr>
<tr><td>Quality of life (EQ5D utility score at 4 months)**** – Mean (SD)</td><td>0.5 (0.3), n = 45</td><td>0.6 (0.3), n = 38</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**

Length of stay (days)***** – Mean (SD)	10.8 (7.9)	9.7 (5.8)
Place of residence at 1 year	N/R	N/R

*reported as death during index admission

** reported as cumulative no. fixation failure

*** HRQ: higher score = better functioning (max. 100)

****reported as EQ-5D utility score (numbers (%'s) in each EQ-5D subscale category, self-reported change in overall health score and 'thermometer' score also reported but not extracted)

***** reported as length of post-operative stay

Other outcomes / timepoints reported were:

- Mortality during index admission
- Mortality at 4 months
- Mortality at 2 years
- Blood transfusion
- Surgical revision at 4 months
- Surgical revision at 12 months

Source of funding	Funded by grant from the NHS Health Technology Assessment programme.
Comments	**Secondary publication** • Keating J, Grant A, Masson M et al. (2006) Randomized comparison of reduction and fixation, bipolar hemiarthroplasty, and total hip arthroplasty. Treatment of displaced intracapsular hip fractures in healthy older patients. Journal of bone and joint Surgery American volume. 88(2):249-60 <u>Methodology checklist</u> **Selection bias: Inadequate - c**entralised, independent computerised randomisation via telephone. Treatment allocation stratified by surgeon code and minimised on age category (60-74, 75yrs+) and gender. Randomisation broken at and of trial when final 3 patients randomised between fixation and hemiarthroplasty were forced into hemiarthroplasty arm to balance numbers. Treatment groups were comparable at baseline.

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
	Performance bias: All groups received the same care apart from the intervention received. Not possible to blind patients or care providers as post-operative management (including types of complication) differ between treatments and patients needed to consent to actual allocated operation. **Attrition bias:** <5% loss to follow-up. All groups were followed up for an equal length of time. All patients randomised completed treatment. ITT analysis used. Groups were comparable at treatment completion. **Detection bias: Outcome assessor not blinded** – self-report measures of functioning and QoL were used; research nurses co-ordinated data collection, but states: "when recording further surgery or operative complications it would usually be apparent to which group a patient was originally allocated". Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

1 Data calculated by reviewer- correspond only to the subset of patients who were randomised to a 2-way treatment comparison (internal fixation or hemiarthroplasty) separate from those patients included in the 3-way randomisation part of this trial (the latter are reported as Keating 2005a)

G.1.1.7 Mouzopoulos 2008

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**
Study type	RCT
Aim	To estimate the functional restitution of patients up to 4 years after the surgical treatment of a displaced subcapital hip fracture, comparing three surgical options: internal fixation, hemiarthroplasty and total hip replacement.
Patient characteristics	**Inclusion:** - displaced subcapital hip fracture (Garden III or IV) after a fall **Exclusion:** - previous hip fracture - history of cancer or Paget's disease, - rheumatic arthritis **Baseline characteristics[1]**

	Internal fixation (N = 38)	**Hemiarthroplasty (N = 34)**
Age in years – mean	75.4 ± 4.6	74.2 ± 3.8

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**

Gender – Female n (%)	26 (68%)	24 (71%)
ASA status (1-4) - mean	2.0 ±1.1	2.2 ±1.9
Mobility assessment* / use of walking aids – n (%)	38 (100%)	34 (100%)
Place of residence – n (%) • Home** • Residential care	 38 (100%) 0	 34 (100%) 0
Cognitive status / dementia*** - mean	7.8 ± 2.8	7.5 ± 3.1
Time since admission**** - mean	44.2 ± 5.2	45.8 ± 2.4

*reported as 'ambulatory'

**reported as 'own home or living with relatives' (all but 2 patients were living with relatives)

***measured using Short Portable Mental Status Questionnaire (SPMSQ, score 0-10)

****reported as mean pre-operative waiting time (presumably in hours)

Number of Patients	N = 86 across two of the three treatment groups compared (data not extracted for total hip replacement group), but states that 7 patients were subsequently excluded due to prior history of hip fracture. Baseline data are given for N = 109 participants in the three treatment groups; outcome data reported for N = 129 across 3 groups – unclear which other patients are excluded from baseline information. Participants recruited between April 1999 to April 2002.
Intervention	Internal fixation (N = 43 randomised) - Richards plate-screw; (Smith & Nephew, Memphis, TN, USA). No further details. Postoperatively in the hospital and after discharge, all patients received the same rehabilitation programme
Comparison	Hemiarthroplasty (N = 43 randomised) - Merete (Berlin, Germany). No further details. Postoperatively in the hospital and after discharge, all patients received the same rehabilitation programme

<table>
<tr><td>Bibliographic reference</td><td>Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Length of follow up</td><td>4 years</td></tr>
<tr><td>Location</td><td>Greece (number of study centres unclear).</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal fixation (N = 43)</th><th>Hemiarthroplasty (N = 43)</th></tr>
<tr><td>Mortality – n/N
• 30 days
• 1 year
• 5 years (4 year data used)</td><td>
N/R
5
11 (26%)</td><td>
N/R
6
13 (30%)</td></tr>
<tr><td>Surgical revision* at 4 years – n (%)</td><td>12 (28%)</td><td>5 (12%)</td></tr>
<tr><td>Functional status** - mean, n
• 1 year
• 5 years (4 year data used)</td><td>
71.3 (5.3), n = 32
73.6 (6.7), n = 19</td><td>
77.8 (9.6), n = 30
79.5 (6.5), n = 20</td></tr>
<tr><td>Quality of life</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Length of stay in days – mean</td><td>13 (2.8)</td><td>9.1 (3.4)</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Dislocation rate</td><td>N/R</td><td>N/R</td></tr>
</table>
*Cumulative revisions throughout follow-up period
**reported as Harris Hip Score (overall score)

Other outcomes / timepoints reported were:
○ Mortality at 4 years
○ Functional status (Harris Hip Score) at discharge; at 4 years
○ Bartel (activities of daily living) Index Score at discharge; 1 year; 4 years</td></tr>
<tr><td>Source of funding</td><td>Not reported.</td></tr>
<tr><td>Comments</td><td>Methodology checklist</td></tr>
</table>

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**
	Selection bias: Inadequate - one patient selected for entry to study every third admission; the 129 participants were randomly divided by two orthopaedic surgeons into three groups in following order: hemi-arthroplasty, total arthroplasty, internal fixation. Unclear reporting of baseline data: sample sizes do not correspond with study flowchart. **Performance bias:** All groups received the same care apart from the interventions. No indication participants / care providers were blinded to treatment. **Attrition bias:** <2% loss to follow-up. No intention-to-treat analysis: patients who subsequently underwent revision surgery were excluded from follow-up analyses (5 INF and 2 HEMI patients by 12 months; 12 INF and 5 HEMI by 4 years). **Detection bias: Outcome assessors blinded.** Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

[1] *Only data corresponding to two treatment arms (internal fixation and hemiarthroplasty) are extracted.*
[2] *Sample sizes do not correspond with flowchart reported in study re: exclusions due to prior history of hip fracture, mortality or missing data.*

G.1.1.8 Parker 2002

Bibliographic reference	**Parker MJ, Khan RJ, Crawford J et al (2002) Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. A randomised trial of 455 patients. Journal of Bone and Joint Surgery - British Volume 84(8):1150-5.**
Study type	RCT
Aim	To see if there were advantage of one methods over another and for what subgroups

<table>
<tr><td>Bibliographic reference</td><td>Parker MJ, Khan RJ, Crawford J et al (2002) Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. A randomised trial of 455 patients. Journal of Bone and Joint Surgery - British Volume 84(8):1150-5.</td></tr>
<tr><td>Patient characteristics</td><td>All patients presenting to one hospital with a displaced intracapsular fracture of the hip between July 1991 and February 2001 were considered for inclusion in the study.

Inclusion criteria
- clearly displaced on both the anteroposterior and lateral radiographs
- over 70 years old
- fit for either surgical procedure.

Exclusion criteria
- Undisplaced or minimally displaced fractures
- age less than 71 years
- rheumatoid arthritis
- chronic renal failure
- significant arthritis of the hip
- a delay from the fracture to surgery of more than 48 hours
- fractures secondary to tumour, Paget’s disease or metabolic bone disease

Baseline characteristics
<table>
<tr><th></th><th>Internal Fixation (N = 226)</th><th>Hemiarthroplasty (N = 229)</th></tr>
<tr><td>Age – Mean (range)</td><td>82.2 (71 to 103)</td><td>82.4 (71 to 101)</td></tr>
<tr><td>Gender – F (%)</td><td>183 (79.9)</td><td>181 (80.1)</td></tr>
<tr><td>ASA status – mean</td><td>2.7 (no SD)</td><td>2.7 (no SD)</td></tr>
<tr><td>Mobility assessment* / use of waking aids – n (%)</td><td>139 (61.5)</td><td>141 (61.6)</td></tr>
<tr><td>Place of residence – n (%)
• Home
• Residential care
• Other</td><td>
151 (66.8)
N/R
75 (33.2)</td><td>
164 (71.6)
N/R
65 (28.4)</td></tr>
<tr><td>Cognitive status** / dementia</td><td>5.4 (no SD)</td><td>5.5 (no SD)</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Parker MJ, Khan RJ, Crawford J et al (2002) Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. A randomised trial of 455 patients. Journal of Bone and Joint Surgery - British Volume 84(8):1150-5.**
	<table><tr><td>Time since admission (hours)</td><td>20.1 (no SD)</td><td>22.7 (no SD)</td></tr></table> *reported as 'pre-fracture use of walking aids = none' **reported as 'mean mental test score' **Other baseline characteristics reported were:** ○ Mean mobility score ○ Pre-existing cardiovascular disease ○ Pre-existing respiratory ○ Mean preoperative haemoglobin ○ Garden7 grade 3 ○ Garden7 grade 4 ○ Mean time from injury to admission ○ Operation with spinal anaesthesia
Number of Patients	N = 455
Intervention	Internal fixation was undertaken percutaneously after closed reduction of the fracture using three parallel cannulated AO cancellous screws (Stratec Ltd).
Comparison	Hemiarthroplasty an uncemented Austin Moore (Stryker Howmedica Osteonics Ltd, Newbury, UK) implant was inserted by an anterolateral surgical approach with preservation of the joint capsule.
Length of follow up	9 - 15 years
Location	England
Outcomes measures and effect size	**Results** <table><tr><th></th><th>Internal Fixation (N = 226)</th><th>Hemiarthroplasty (N = 229)</th></tr><tr><td>Mortality – n (%)</td><td></td><td></td></tr></table>

Bibliographic reference	Parker MJ, Khan RJ, Crawford J et al (2002) Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. A randomised trial of 455 patients. Journal of Bone and Joint Surgery - British Volume 84(8):1150-5.

• 30 days • 1 year • 5 years	N/R 61 (27%) N/R	N/R 63 (27%) N/R
Surgical revision* at 11 years– n (%)	86 (38%)	15 (7%)
Functional status – change in mobility score)** – mean (SD) • 1 year • 5 years	 -1.71 (no SD), n = 160 N/R	 -1.92 (no SD), n = 163 N/R
Quality of life	N/R	N/R
Length of stay – Mean (SD)	20.5 (no SD)	20.8 (no SD)
Place of residence at 1 year***	134/164	135/162

*reported as implant survival rate, revision to hemiarthroplasty or internal fixation by 11 year follow-up (Parker et al. 2010)

**mobility score (score 0 to 9 and high scores are better) - see Parker MJ, Palmer CR. A new mobility score for predicting mortality after hip fracture. Journal of Bone and Joint Surgery British volume 1993;75-B:797-98.

***reported as number 'at same residential status'

Subgroups

	Internal Fixation (N = 226)	Hemiarthroplasty (N = 229)
Mortality at 1 year (AGE) – n/N, (%) • 71 to 79 • 80 to 89 • 90 and above	 17/85 (20%) 35/117 (30%) 8/24 (33%)	 12/83 (14%) 36/110 (33%) 15/36 (42%)
Mortality at 1 year (MOBILITY) – n/N, (%) • 0 to 3 • 4 to 6	 35/81 (43%) 19/64 (30%)	 38/72 (53%) 20/79 (25%)

Bibliographic reference	**Parker MJ, Khan RJ, Crawford J et al (2002) Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. A randomised trial of 455 patients. Journal of Bone and Joint Surgery - British Volume 84(8):1150-5.**

• 7 to 9	7/81 (9%)	5/78 (6%)
Mortality at 1 year (MENTAL TEST SCORE) – n/N		
• 0 to 3	35/67 (52%)	31/64 (48%)
• 4 to 6	8/21 (38%)	13/26 (50%)
• 7 to 10	20/137 (15%)	13/125 (10%)

Other outcomes / timepoints reported were:

- Pain,
- complications,
- blood loss,
- blood transfusions,
- operative fall in blood pressure,
- mobility score at 3 years,
- length of operation in minutes,
- length of anaesthesia in minutes,
- units of blood transfused

Source of funding	None reported

Comments	**Secondary publications** • Parker MJ, Pryor GA. Internal fixation or arthroplasty for displaced cervical hip fractures in the elderly: a randomised controlled trial of 208 patients. Acta Orthopaedica Scandinavica 2000 71:440-6. • Parker MJ, Pryor G, Gurusamy K. Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures: a long-term follow-up of a randomised trial. Injury 2010 41: 370-3. <u>Methodology checklist</u> **Selection bias: Adequate** - sealed opaque identical envelopes. One surgeon completed or supervised all operations, so was not blind to treatment allocation. Both groups comparable at baseline. **Performance bias:** Groups received the same care apart from the interventions received. No indication participants / care providers were blinded to treatment.

Bibliographic reference	**Parker MJ, Khan RJ, Crawford J et al (2002) Hemiarthroplasty versus internal fixation for displaced intracapsular hip fractures in the elderly. A randomised trial of 455 patients. Journal of Bone and Joint Surgery - British Volume 84(8):1150-5.**
	Attrition bias: No loss to follow-up. ITT analysis used. All patients followed up for the same period of time. Both arms were comparable at treatment completion. **Detection bias: Outcome assessor not blinded** (surgeon who completed / supervised all operations). Study had an appropriate follow up time. Outcomes defined and valid and reliable measures used.

G.1.1.9 Parker 2015

Bibliographic reference	**Parker MJ. (2015) Hemiarthroplasty versus internal fixation for displaced intracapsular fractures of the hip in elderly men: a pilot randomised trial. Bone & Joint Journal. 97-B(7):992-6**
Study type	RCT
Aim	To compare cemented hemiarthroplasty with a newer implant
Patient characteristics	**Inclusion criteria** - displaced intracapsular fracture of the hip - over 50 years old **Exclusion criteria** - life expectancy of > 10 years based on patient assessment - age less than 50 years - very frail patients considered to be high risk for surgery - comorbidity that would affect choice of surgery - a delay from the fracture to surgery of more than 48 hours **Baseline characteristics**

	Internal Fixation (N = 30)	**Hemiarthroplasty (N = 26)**
Age – Mean (range)	81.5 (62 to 94)	81.2 (65 to 91)
Gender – F (%)	0 (0)	0 (0)
ASA status – n (%) • I or II • III or more	 6 (20%) 24(80%)	 7 (27%) 19 (73%)
Mobility assessment* mean	3.5 (no SD)	3.2 (no SD)

<table>
<tr><td>Bibliographic reference</td><td colspan="2">Parker MJ. (2015) Hemiarthroplasty versus internal fixation for displaced intracapsular fractures of the hip in elderly men: a pilot randomised trial. Bone & Joint Journal. 97-B(7):992-6</td></tr>
<tr><td></td><td colspan="2">
<table>
<tr><td>Place of residence – n/N
• Home
• Residential care
• Other</td><td>24 (80%)
N/R
6 (20%)</td><td>22 (85%)
N/R
4 (15%)</td></tr>
<tr><td>Cognitive status / dementia</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Time since admission</td><td>N/R</td><td>N/R</td></tr>
</table>
*reported as ‘mean mobility score’

Other baseline characteristics reported were:
o Social dependency score</td></tr>
<tr><td>Number of Patients</td><td colspan="2">N = 56</td></tr>
<tr><td>Intervention</td><td colspan="2">Internal fixation was undertaken using fracture table and image intensification, with closed reduction and fixation with a Targon FN</td></tr>
<tr><td>Comparison</td><td colspan="2">Hemiarthroplasty using a cemented Exeter trauma stem inserted via a antero-lateral approach</td></tr>
<tr><td>Length of follow up</td><td colspan="2">1 year</td></tr>
<tr><td>Location</td><td colspan="2">England</td></tr>
<tr><td>Outcomes measures and effect size</td><td colspan="2">Results
<table>
<tr><th></th><th>Internal Fixation (N = 30)</th><th>Hemiarthroplasty (N = 26)</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>
3 (10%)
10 (33%)
N/R</td><td>
1 (4%)
7 (27%)
N/R</td></tr>
<tr><td>Surgical revision – n (%)</td><td>8 (27%)</td><td>0 (0%)</td></tr>
<tr><td>Functional status (mobility score*) – mean (SD), n
• 1 year</td><td></td><td>
2.6 (no SD), n = 19</td></tr>
</table></td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Parker MJ. (2015) Hemiarthroplasty versus internal fixation for displaced intracapsular fractures of the hip in elderly men: a pilot randomised trial. Bone & Joint Journal. 97-B(7):992-6</td></tr>
<tr><td></td><td>
<table>
<tr><td>• 5 years</td><td>1.5 (no SD), n = 20
Not reported</td><td>Not reported</td></tr>
<tr><td>Quality of life – Mean (SD)</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Length of stay (days) – Mean (SD)</td><td>15.9 (12.1)</td><td>24.2 (22.5)</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
</table>
* Mobility score (score 0 to 9 and high scores are better) see Parker MJ, Palmer CR. A new mobility score for predicting mortality after hip fracture. Journal of Bone and Joint Surgery British volume 1993;75-B:797-98.

Other outcomes reported were:
○ Pain (modified Charnley pain score)
○ Social dependency</td></tr>
<tr><td>Source of funding</td><td>No external source of funding. Internal funding from the Peterborough Hospital Hip Fracture Fund.</td></tr>
<tr><td>Comments</td><td><u>Methodology checklist</u>
Selection bias: Adequate - sealed opaque identical envelopes prepared by individual independent of study. One surgeon completed or supervised all operations, so was not blind to treatment allocation. Both groups comparable at baseline.
Performance bias: Groups received the same care apart from the interventions received. No indication participants / care providers were blinded to treatment.
Attrition bias: No loss to follow-up. ITT analysis used. All patients followed up for the same period of time.
Both arms were comparable at treatment completion.
Detection bias: Outcome assessor blinded (research nurse assessing mobility, pain and docial dependency).
Short follow up of 1 year. Outcomes defined and valid and reliable measures used.</td></tr>
</table>

G.1.1.10 Puolakka 2001

Bibliographic reference	**Puolakka TJ, Laine HJ, Tarvainen T et al (2001) Thompson hemiarthroplasty is superior to Ullevaal screws in treating displaced femoral neck fractures in patients over 75 years. A prospective randomized study with two-year follow-up. Annales Chirurgiae et Gynaecologiae 90(3):225–8.**
Study type	RCT
Aim	To study if internal fixation would prove superior to hemiarthroplasty even in displaced femoral neck fractures in patients over 75 years old
Patient characteristics	**Inclusion criteria** - femoral neck fracture, - Garden 3-4 - aged > 75 years **Exclusion criteria** - unable to walk independently (without other person's help) - rheumatoid arthritis **Baseline characteristics**

	Internal Fixation (N = 17)	**Hemiarthroplasty (N = 15)**
Age – Mean (range)	81 (76 to 88)	82 (77 to 90)
Gender – F (%)	13 (76.5)	14 (93.3)
ASA status	N/R	N/R
Mobility assessment* / use of waking aids – n/N	13 (76.5)	10 (66.7)
Place of residence – n/N		
• Home	13 (76.5)	9 (60.0)
• Residential care – home for the aged	4 (23.5)	4 (26.7)
• Other - hospital	0	1 (6.6)
Cognitive status / dementia	N/R	N/R
Time since admission	N/R	N/R

*reported as walking ability > 100 m

<table>
<tr><td>Bibliographic reference</td><td>Puolakka TJ, Laine HJ, Tarvainen T et al (2001) Thompson hemiarthroplasty is superior to Ullevaal screws in treating displaced femoral neck fractures in patients over 75 years. A prospective randomized study with two-year follow-up. Annales Chirurgiae et Gynaecologiae 90(3):225–8.</td></tr>
<tr><td>Number of Patients</td><td>N = 32 randomised but one patient randomised to INF was excluded from analyses because acceptable reduction could not be achieved and arthroplasty was undertaken instead.</td></tr>
<tr><td>Intervention</td><td>Reduction and fixation with 3 Ulleval screws
- Operating time in minutes – mean (range): 41 mins (25 to 60)</td></tr>
<tr><td>Comparison</td><td>Cemented Thompson unipolar hemiarthroplasty (posterior approach)
- Operating time in minutes – mean (range): 65 mins (45 to 90)</td></tr>
<tr><td>Length of follow up</td><td>2 years</td></tr>
<tr><td>Location</td><td>Finland</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal Fixation (N = 17)</th><th>Hemiarthroplasty (N = 15)</th></tr>
<tr><td>Mortality – n/N
• 30 days
• 1 year
• 5 years (2 year data used)</td><td>
N/R
N/R
8/17 (47.1%)</td><td>
N/R
N/R
7/15 (46.7%)</td></tr>
<tr><td>Surgical revision – n/N</td><td>7 (41.2%)</td><td>1(6.6%)</td></tr>
<tr><td>Functional status
• 1 year
• 5 years</td><td>
N/R
N/R</td><td>
N/R
N/R</td></tr>
<tr><td>Quality of life – Mean (SD)</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Length of stay – Mean (SD)</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
</table>
Other outcomes / timepoints reported were:
○ Mortality at 3 months
○ Mortality at 2 years
○ Operative blood loss</td></tr>
</table>

Bibliographic reference	**Puolakka TJ, Laine HJ, Tarvainen T et al (2001) Thompson hemiarthroplasty is superior to Ullevaal screws in treating displaced femoral neck fractures in patients over 75 years. A prospective randomized study with two-year follow-up. Annales Chirurgiae et Gynaecologiae 90(3):225–8.**
Source of funding	None reported
Comments	Methodology checklist **Selection bias: Inadequate** – 'sealed envelope method' (no further details). Groups comparable at baseline, but very small numbers. **Performance bias:** Both arms received the same care apart from the intervention. Blinding not reported. **Attrition bias:** 3% loss to follow-up. Study stopped early, but same follow up was planned for all participants. No ITT analysis: one patient randomised to INF received arthroplasty after acceptable reduction could not be achieved and was excluded from analyses. **Detection bias: Blinding of outcome assessor not reported** however study reports only hard outcomes (mortality and surgical reoperations), so unlikely to be source of bias. Study was stopped early so final follow up timepoints would not have been met (unclear for what timepoint data are reported). Outcomes defined.

G.1.1.11 Roden 2003

Bibliographic reference	**Roden M, Schon M, Fredin H. (2003) Treatment of displaced femoral neck fractures: a randomised minimum 5-year follow-up study of screws and bipolar hemiarthroplasty in 100 patients. Acta Orthopedica Scandinavica 74(1): 42–4.**
Study type	RCT
Aim	To compare clinical outcomes of bipolar prosthesis with screw osteosynthesis in non-senile patients of 70 years of age ro more, who had displaced hip fractures (garden 3 or 4)
Patient characteristics	**Inclusion criteria:** - displaced cervical hip fracture, - aged > 70 years - walking before fracture **Exclusion criteria** - senile dementia, - immobility, - unable to consent, - refusal, - delay > 12 hours fracture to surgery, - irreducible fracture

<table>
<tr><td>Bibliographic reference</td><td>Roden M, Schon M, Fredin H. (2003) Treatment of displaced femoral neck fractures: a randomised minimum 5-year follow-up study of screws and bipolar hemiarthroplasty in 100 patients. Acta Orthopedica Scandinavica 74(1): 42–4.</td></tr>
<tr><td></td><td>Baseline characteristics
<table>
<tr><th></th><th>Internal Fixation (N = 53)</th><th>Hemiarthroplasty (N = 47)</th></tr>
<tr><td>Age – Mean (range)</td><td>81 (70 to 96)</td><td>81 (70 to 96)</td></tr>
<tr><td>Gender – F (%)</td><td>37 (69.8)</td><td>34 (42.3)</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment / use of waking aids</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Cognitive status / dementia*</td><td>0(0)</td><td>0 (0)</td></tr>
<tr><td>Time since admission – Mean (SD) / range / Median (IQR)</td><td>N/R</td><td>N/R</td></tr>
</table>
*reported as ‘able to remember date of birth and home address’</td></tr>
<tr><td>Number of Patients</td><td>N = 100</td></tr>
<tr><td>Intervention</td><td>Reduction and fixation with 2 von Bahr screws versus</td></tr>
<tr><td>Comparison</td><td>Cemented Variokopf bipolar hemiarthroplasty (posterior approach)</td></tr>
<tr><td>Length of follow up</td><td>5 years</td></tr>
<tr><td>Location</td><td>Sweden</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal Fixation (N = 53)</th><th>Hemiarthroplasty (N = 47)</th></tr>
<tr><td>Mortality – n/N
• 30 days
• 1 year
• 5 years</td><td>
N/R
N/R
28/53</td><td>
N/R
N/R
20/47</td></tr>
<tr><td>Surgical revision** at 5-6 years – n (%)</td><td>25 (45%)</td><td>1 (2%)</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Roden M, Schon M, Fredin H. (2003) Treatment of displaced femoral neck fractures: a randomised minimum 5-year follow-up study of screws and bipolar hemiarthroplasty in 100 patients. Acta Orthopedica Scandinavica 74(1): 42–4.**

Functional status • 1 year • 5 years	 N/R N/R	 N/R N/R
Quality of life – Mean (SD)	N/R	N/R
Length of stay (days) – Mean (range)	15 (2 to 49)	15 (3 to 51)
Place of residence at 1 year: n/N	N/R	N/R

* reported as return to place of residence but timepoint not reported

**only those re-operations reported as revisions to a prosthesis are extracted(excludes screw extraction in INF group and open/closed reduction of dislocations in HEMI group).

Other outcomes / timepoints reported were:

- Mortality at 2 years
- Return to original residence(no timepoint reported)
- Pain
- Analgesia use
- Function status (able to walk as before fracture at 4 months)
- Blood loss
- Bloods transfusion (units)
- Duration of surgery

Source of funding	N/R
Comments	Methodology checklist **Selection bias: Inadequate –** 'sealed envelopes opened in the operating theatre'. Unclear if opaque or numbered. Groups comparable at baseline. **Performance bias:** Comparison groups received same care apart from the intervention received. Blinding not reported. **Attrition bias:** Loss to follow-up not reported. Poor reporting of outcomes **–** gives description of complications in each group but proportions / sample sizes not specified. All patients were followed up for the same amount of time. Unclear whether the groups were comparable at treatment completion or with regard to availability of outcome data. **Detection bias: Outcome assessor blinding not reported.** Study had an appropriate length follow up. Outcomes not clearly defined.

G.1.1.12 Skinner 1989

<table>
<tr><td>Bibliographic reference</td><td>Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.</td></tr>
<tr><td>Study type</td><td>RCT</td></tr>
<tr><td>Aim</td><td>To determine the relative mortality, morbidity and eventual mobility of patients following three methods of treatment of subcapital fracture of the femur: internal fixation, hemiarthroplasty and total hip replacement.</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion:
- patients over the age of 65 years
- admitted with a displaced subcapital femoral neck fracture (Garden grades III and IV)
Exclusion:
- old fractures or pathological fractures
- rheumatoid arthritis
- doubt regarding the displacement or grading of the fracture

Baseline characteristics[1]
<table>
<tr><th></th><th>Internal fixation (N = 91)</th><th>Hemiarthroplasty (N = 91)</th></tr>
<tr><td>Age in years – mean*</td><td>79.7</td><td>82.1</td></tr>
<tr><td>Gender**</td><td>N/R</td><td>N/R</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment / use of walking aids</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Cognitive status / dementia</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Time since admission</td><td>N/R</td><td>N/R</td></tr>
</table>
*SD not reported
**90% female (reported for full sample only)</td></tr>
<tr><td>Number of Patients</td><td>N = 182 patients across 2 treatment groups
Recruitment period: December 1984 to December 1986</td></tr>
<tr><td>Intervention</td><td>Internal fixation (N = 91)</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.</td></tr>
<tr><td></td><td>- closed reduction and internal fixation with a Richards sliding compression screw/plate;
- mean operation time not reported.
Operations performed as soon as practicable – usually within 24h of admission. Most surgeons were registrar grade, but some were consultants or senior house officers.

All patients were mobilized, fully weight bearing, usually within 48h, and discharged or transferred as soon as practicable.</td></tr>
<tr><td>Comparison</td><td>Hemiartroplasty (N = 91)
- uncemented Austin Moore prosthesis
- posterolateral approach
- mean operation time not reported
Operations performed as soon as practicable – usually within 24h of admission. Most surgeons were registrar grade, but some were consultants or senior house officers.

All patients were mobilized, fully weight bearing, usually within 48h, and discharged or transferred as soon as practicable.</td></tr>
<tr><td>Length of follow up</td><td>1 year (Skinner 1989)
13 years (Ravikumar 2000)</td></tr>
<tr><td>Location</td><td>UK (single centre)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results[1]
<table>
<tr><th></th><th>Internal fixation (N = 91)</th><th>Hemiarthroplasty (N = 91)</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years (13 year data used)</td><td>
N/R
23 (25%)
82 (90%)</td><td>
N/R
25 (27%)
78 (86%)</td></tr>
<tr><td>Surgical revision* at 13 years – n (%)</td><td>30 (33%)</td><td>22 (24%)</td></tr>
<tr><td>Functional status**</td><td>N/R</td><td>N/R</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.**

Quality of life	N/R	N/R
Length of stay	N/R	N/R
Place of residence at 1 year	N/R	N/R

*cumulative revisions within time period (data from medical records of survivors and dead patients). Only percentages are given; raw numbers calculated by reviewer.

**Harris Hip Score (overall mean score) reported for survivors at 13 years only (Ravikumar 2000)

Other outcomes / timepoints reported were:

- % mortality at 2 months (Skinner 1989); at 13 years (Ravikumar 2000)
- % requirement for second anaesthetic for local complication within 12 months (Skinner 1989)
- % with infection (superficial and deep) at 13 years (Ravikumar 2000)
- Mean Harris Hip score (survivors) at 13 years (Ravikumar 2000)
- Mean time to revision (months) (Ravikumar 2000)

Source of funding	Funding support for research staff from Johnson & Johnson plc.
Comments	**Secondary publication:** • Ravikumar K, Marsh G. (2000) Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur — 13 year results of a prospective randomised study. Injury, 31: 793-7. Methodology checklist **Selection bias: Inadequate** – patients were randomly allocated to the three methods of treatment according to the day of the week on which they were admitted. States groups were matched on baseline criteria (fitness, ability, accommodation), but insufficient detail presented to verify. **Performance bias:** Both arms received the same care apart from the intervention. Blinding not reported. **Attrition bias:** Loss to follow-up unclear. Poor reporting – outcomes presented as percentages with no sample sizes - no indication of intention-to-treat analysis. Pain and mobility data assumed to correspond only to survivors. **Detection bias: Outcome assessor not blinded.** Outcomes defined and valid and reliable measures used.

[1] *Only data corresponding to two treatment arms of this 3-arm study (internal fixation and hemiarthroplasty) are extracted.*

G.1.1.13 Soreide 1979

Bibliographic reference	**Soreide O, Molster A, Raugstad TS. (1979) Internal fixation versus primary prosthetic replacement in acute femoral neck fractures: a prospective, randomized clinical study. British Journal of Surgery 66(1):56–60.**
Study type	Randomised controlled trial
Aim	To solve disputed problems in the treatment of femoral neck fractures in the elderly
Patient characteristics	**Inclusion criteria** - acute femoral neck fracture (Garden II-IV), - aged over 67 **Exclusion criteria:** - pathological fractures, - metastatic carcinoma **Baseline characteristics**
Number of Patients	N = 104
Intervention	Reduction and fixation with von Bahr screws versus
Comparison	Bipolar hemiarthroplasty, Christiansen
Length of follow up	1 year
Location	Norway
Outcomes measures and effect size	**Results**

	Internal Fixation (N = 51)	Hemiarthroplasty (N = 53)
Age – Mean (SD)	77.9 (no SD)	78.3 (no SD)
Gender – Female, n (%)	38 (75%)	46 (87%)
ASA status	N/R	N/R
Mobility assessment / use of waking aids	N/R	N/R
Place of residence	N/R	N/R
Cognitive status / dementia	N/R	N/R
Time since admission	N/R	N/R

	Internal Fixation (N = 51)	Hemiarthroplasty (N = 53)

Bibliographic reference	**Soreide O, Molster A, Raugstad TS. (1979) Internal fixation versus primary prosthetic replacement in acute femoral neck fractures: a prospective, randomized clinical study. British Journal of Surgery 66(1):56–60.**

Mortality – n/N • 30 days • 1 year • 5 years	 3/51 9/51 N/R	 3/53 11/53 N/R
Surgical revision at 2 years– n/N	9/51	3/53
Functional status* - n/N (%)	N/R	N/R
Quality of life – Mean (SD)	N/R	N/R
Length of stay in days** – Mean (SD), n	7.2 (no SD), n = 51	11.0 (no SD), n = 53
Place of residence at 1 year	N/R	N/R

*reported as Stinchfield's objective hip assessment classification scoring system: 16 points+ = excellent; 12-15 points = good; 9-11 points = fair; ≤8 points = poor

**reported as 'necessary hospitalisation' = until the patient is walking with/without help, no pyrexia, all post-operative complications treated.

Other outcomes / timepoints reported were:

- Mortality at 6 months
- Walking ability at 1 year follow-up (self-report)
- Infections
- Haematoma
- Complications

Source of funding	N/R
Comments	Methodology checklist **Selection bias: Inadequate** – randomise/allocated to treatment according to the patients date of birth. Groups comparable at baseline. **Performance bias:** Comparison groups received the same care apart from the intervention received. Blinding not reported. **Attrition bias:** 7% loss to follow-up. ITT analysis not reported. All patients received the same care apart from the intervention received. All participants randomised completed treatment Groups comparable at treatment completion. **Detection bias: Outcome assessor unblinded.** Short follow up – 1 year. Outcomes defined and valid and reliable measures used.

G.1.1.14 von Dortmont 2000

<table>
<tr><td>Bibliographic reference</td><td>van Dortmont LM, Douw CM, van Breukelen AM et al. (2000) Cannulated screws versus hemiarthroplasty for displaced intracapsular femoral neck fractures in demented patients. Annales Chirurgiae et Gynaecologiae 89(2):132–7.</td></tr>
<tr><td>Study type</td><td>Randomised controlled trial</td></tr>
<tr><td>Aim</td><td>To determine if internal fixation or hemiarthroplasty should be the treatment of first choice in the elderly patient with dementia and with a displaced intracapsular femoral neck fracture.</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion criteria
- displaced intracapsular femoral neck fracture (Garden III-IV),
- aged over 70,
- diagnosis of ’senile dementia’ before admission
Exclusion criteria
- None reported

Baseline characteristics
<table>
<tr><th></th><th>Internal Fixation (N = 31)</th><th>Hemiarthroplasty (N = 29)</th></tr>
<tr><td>Age – Mean (range)</td><td>84 (72 to 92)</td><td>84 (71 to 96)</td></tr>
<tr><td>Gender – Female n (%)</td><td>30 (96.8)</td><td>22 (75.9)</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment / use of waking aids</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence
• Home
• Residential care – old peoples home
• Other – psychogeriatric institution</td><td>
3 (.7)
11 (35.5)
17 (54.8)</td><td>
2 (6.9)
6 (20.7)
21 (72.3)</td></tr>
<tr><td>Cognitive status / dementia**</td><td>31 (100.0)</td><td>29 (100.0)</td></tr>
<tr><td>Time since admission (days) – median (range)</td><td>1 (0 to 2)</td><td>1 (0 to 2)</td></tr>
</table>
*reported as ‘senile dementia (DSM-III-R)

Other baseline characteristics reported were:
○ Side of fracture
○ Surgeon experience</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>van Dortmont LM, Douw CM, van Breukelen AM et al. (2000) Cannulated screws versus hemiarthroplasty for displaced intracapsular femoral neck fractures in demented patients. Annales Chirurgiae et Gynaecologiae 89(2):132–7.</td></tr>
<tr><td></td><td>○ Co-existing conditions
○ Cognitive Screening Test-14</td></tr>
<tr><td>Number of Patients</td><td>N = 60</td></tr>
<tr><td>Intervention</td><td>Reduction and fixation with 3 AO/ASIF screws versus</td></tr>
<tr><td>Comparison</td><td>Unipolar Thompson hemiarthroplasty (cemented, anterior approach)</td></tr>
<tr><td>Length of follow up</td><td>2 years</td></tr>
<tr><td>Location</td><td>The Netherlands</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal Fixation (N = 31)</th><th>Hemiarthroplasty (N = 29)</th></tr>
<tr><td>Mortality – n/N
• 30 days
• 1 year
• 5 years</td><td>
3 (10%)
20 (65%)
N/R</td><td>
4 (14%)
14 (48%)
N/R</td></tr>
<tr><td>Surgical revision – n/N</td><td>7/31</td><td>0/29</td></tr>
<tr><td>Functional status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Quality of life – Mean (SD)</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Length of stay – Mean (SD)</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
</table>
Other outcomes / timepoints reported were:
○ Mortality at 4 months
○ Blood loss
○ Length of surgery
○ Complications
○ Wound complications
○ Mobility at 4 months
○ Activities of daily Living at 4 months
○ Duration of surgery</td></tr>
</table>

Bibliographic reference	**van Dortmont LM, Douw CM, van Breukelen AM et al. (2000) Cannulated screws versus hemiarthroplasty for displaced intracapsular femoral neck fractures in demented patients. Annales Chirurgiae et Gynaecologiae 89(2):132–7.**
Source of funding	N/R
Comments	Methodology checklist **Selection bias: Inadequate** – randomisation/allocation procedures not described. **Performance bias:** Comparison groups received the same care apart from the intervention received. Blinding not reported. **Attrition bias:** Loss to follow-up not reported. ITT analysis undertaken. All groups were followed up for an equal length of time. Groups were comparable at treatment completion. 3 patients died before the 30 day follow up, meaning outcome data was available for 31 patients in the INTF group at 30 days and only 26 in hemi group. **Detection bias: Outcome assessor not blinded.** Appropriate length of follow up. Outcomes not clearly defined.

G.1.1.15 van Vugt 1993

Bibliographic reference	**van Vugt AB, Oosterwijk WM, Goris RJ. (1993) Osteosynthesis versus endoprosthesis in the treatment of unstable intracapsular hip fractures in the elderly. A randomised clinical trial. Archives of Orthopaedic and Trauma Surgery. 113(1):39-45**
Study type	Randomised controlled trial
Aim	To determine if osteosynthesis or endoprosthesis should be first choice
Patient characteristics	**Inclusion criteria** - Intracapsular hip fracture - Aged between 71 and 80 - Garden III or IV fracture - Very good degree of independence **Exclusion criteria** - None reported **Baseline characteristics**

	Internal Fixation (N = 21)	Hemiarthroplasty (N = 22)
Age – Mean (SD)	75.3 (3)	76.0 (3)

<table>
<tr><td>Bibliographic reference</td><td colspan="3">van Vugt AB, Oosterwijk WM, Goris RJ. (1993) Osteosynthesis versus endoprosthesis in the treatment of unstable intracapsular hip fractures in the elderly. A randomised clinical trial. Archives of Orthopaedic and Trauma Surgery. 113(1):39-45</td></tr>
<tr><td></td><td colspan="3">
<table>
<tr><td>Gender – Female n (%)</td><td>11 (52.4)</td><td>14 (63.6)</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment / use of waking aids – n/N</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Cognitive status / dementia</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Time since admission
• ≤24 hrs
• >24 hours</td><td>
15 (71%)
6 (29%)</td><td>
12 (55%)
10 (45%)</td></tr>
</table>

Other baseline characteristics reported were
○ Associated ailments</td></tr>
<tr><td>Number of Patients</td><td colspan="3">N = 43</td></tr>
<tr><td>Intervention</td><td colspan="3">Internal fixation (Osteosynthesis) – a closed reduction was performed and internal fixation using Dynamic HipScrew was carried out according to standard technique using the 135° device with a two hole plate.</td></tr>
<tr><td>Comparison</td><td colspan="3">Bipolar hemiarthroplasty (endoprosthesis) was implanted using Stanmore variocup and placed in neutral in slight anteversion and valgus position. Fixation of the prosthesis in the femoral shaft was carried out using femoral shaft plugging and insertion of bone-cement under pressure. The stability was tested perioperatively,</td></tr>
<tr><td>Length of follow up</td><td colspan="3">36 months</td></tr>
<tr><td>Location</td><td colspan="3">The Netherlands</td></tr>
<tr><td>Outcomes measures and effect size</td><td colspan="3">Results
<table>
<tr><th></th><th>Internal Fixation (N = 21)</th><th>Hemiarthroplasty (N = 22)</th></tr>
<tr><td>Mortality – n/N
• 30 days
• 1 year
• 5 years</td><td>
0 (0%)
2 (10%)
N/R</td><td>
1 (5%)
5 (23%)
N/R</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**van Vugt AB, Oosterwijk WM, Goris RJ. (1993) Osteosynthesis versus endoprosthesis in the treatment of unstable intracapsular hip fractures in the elderly. A randomised clinical trial. Archives of Orthopaedic and Trauma Surgery. 113(1):39-45**

Surgical revision* at 3 years– n/N	6 (29%)	5 (23%)
Functional status	N/R	N/R
Quality of life	N/R	N/R
Length of stay in days** – Median (range)	32.0 (11 to 326)	30.0 (5 to 324)
Place of residence at 1 year	N/R	N/R

*reported as fracture-related re-intervention (excluding removal of implant after internal fixation) by 3 year follow-up
**reported as 'admission time'. No means presented, though significance testing showed no difference between groups.

Other outcomes / timepoints reported were:

- Mortality at 3 months
- Mortality at 6 months
- Mortality at 2 years
- Mortality at 3 years
- Complications
- Duration of surgery
- Blood loss
- Return to pre-fracture place residence (timeframe not reported)

Source of funding	N/R
Comments	Methodology checklist **Selection bias: Inadequate** – randomisation/allocation procedure not described. Blinding not reported. Both groups comparable at baseline. **Performance bias:** Patients received different care dependent on the fracture repair: (i) INTF: full weight bearing in patients with an optimal reduction and fixation and those in whom Garden's angle exceeded 180°. In all other cases, none weight bearing mobilisation using an ambulatory or crutches was started under the guidance of a physiotherapist. In these cases, partial weight bearing was allowed at 6 weeks and full weight bearing at 12 weeks after the operation. (ii) HEMI: full weight bearing was allowed except in patients with a luxable prosthesis. In these cases immobilisation was carried out for 3 weeks with foam traction, avoiding external rotation and extension of the hip.

Bibliographic reference	**van Vugt AB, Oosterwijk WM, Goris RJ. (1993) Osteosynthesis versus endoprosthesis in the treatment of unstable intracapsular hip fractures in the elderly. A randomised clinical trial. Archives of Orthopaedic and Trauma Surgery. 113(1):39-45**
	Attrition bias: Loss to follow-up <5%. Both groups followed up for the same period. All patients completed treatment in each arm and groups were comparable at treatment completion. **Detection bias: Blinding of outcome assessor not reported** – but only clinical outcomes presented (mortality, complications, revisions), so unlikely to be a source of bias. Trial had an appropriate length of follow up. Outcomes defined and valid / reliable measures used.

G.1.2 IF versus THR

G.1.2.1 Chammout 2012

Bibliographic reference	**Chammout, GK, Mukka, SS, Carlsson, T et al. (2012) Total Hip Replacement versus Open Reduction and Internal Fixation of Displaced Femoral Neck Fractures. A randomised long-term follow-up study. The Journal of Joint and Bone Surgery. 94, 1921-8**
Study type	RCT
Aim	To compare the results of total hip replacement with those of internal fixation over a long-term follow up period of 17 years.
Patient characteristics	**Inclusion:** - Acute displaced femoral neck fracture (Garden stage 3 or 4), that were sustained within the previous 36 hours - ≥ 65 years - Admitted from home - No concurrent joint disease (osteoarthritis of the hip) - No previous fracture involving the lower extremities - Healthy status or mild systemic disease (ASA, [American Society of Anaesthesiology] grade 1 or 2) - Intact cognitive function (no diagnosis of dementia, with patients being lucid and fully orientated) - Ability to carry out all activities of daily living - Intact hip function prior to injury **Exclusion:** - Patients with a pathological hip fracture - Deemed not suitable for a total hip replacement by the anesthesiologist - Not suitable for the trial for any other reason

Baseline characteristics

	Internal Fixation (N = 57)	Total hip replacement (N = 43)
Age – Mean (range)	79 (66-90)	78 (65-90)
Gender – n (%) Female	41 (72)	38 (88)
ASA status*	NR	NR
Mobility assessment / use of waking aids – n/N (%)	NR	NR
Place of residence	NR	NR
Cognitive status / dementia**	NR	NR
Time since admission	NR	NR

*ASA Grade 1 or 2 was inclusion criterion

**All patients were cognitively unimpaired (trial inclusion criterion)

Other baseline characteristics reported were:

- Which hip was fractured

Number of Patients

N = 100 randomised

Intervention

Total Hip replacement – performed using a cemented femoral stem, manufactured from a titanium alloy and a 28mm chromium-cobalt head. A posterolateral approach without repair of the capsule or external rotators was used.

Comparison

Internal Fixation – carried out with the patient on a fracture table. The fracture was reduced closed, with the aid of an image intensifier, and was fixed with two cannulated screws.

Length of follow up

Total follow up period: 17 years.

- 3 months
- 1 year
- 2 years
- 4 years
- 11 years

<table>
<tr><td></td><td>• 17 years</td></tr>
<tr><td>Location</td><td>Sweden</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal Fixation (N = 57)</th><th>Total hip replacement (N = 43)</th></tr>
<tr><td>Mortality – n/N (%)*
• At 30 days
• At 1 year
• At 5 years (4 year data used)</td><td>
NR
3 (5.2%)
15 (2.6%)</td><td>
NR
2 (4.7%)
8 (18.6%)</td></tr>
<tr><td>Surgical revision – n/N (%)</td><td>26/57 (70%)</td><td>13/43 (30%)</td></tr>
<tr><td>Functional status – Mean Harris Hip Score**
• 1 year
• 5 years</td><td>

84 (no SD)
79 (no SD)</td><td>

88 (no SD)
87.5 (no SD)</td></tr>
<tr><td>Quality of life</td><td>NR</td><td>NR</td></tr>
<tr><td>Length of stay</td><td>NR</td><td>NR</td></tr>
<tr><td>Place of residence at 1 year</td><td>NR</td><td>NR</td></tr>
</table>
* Mortality was reported as high regardless of treatment allocation. At the 11 year follow up 25% of the sample were still living. At the 17 year follow up 13% of the sample were still living.
** Data estimated from graph by reviewer.

Other outcomes / time points reported were:
○ Hip complications across the entire 17 year follow ups
○ Gait velocity reported 3 months
○ Pain reported throughout the entire follow up period
○ Functional status was also assessed at 4, 11 and 17 years</td></tr>
<tr><td>Source of funding</td><td>No outside funding was received for this research.</td></tr>
<tr><td>Comments</td><td><u>Methodology checklist</u>
Selection bias: Inadequate randomisation / allocation - first 20 patients randomised using sealed opaque envelopes, but following 80 patients allocated to treatment according to which weekday they were admitted (THR =</td></tr>
</table>

	admitted on Monday to Thursday; INTF = admitted Friday to Sunday). Group imbalance in numbers; comparability similar otherwise. **Performance bias:** Groups received the same care apart from the intervention. No blinding. **Attrition bias:** 9% loss to follow up - greater in the THR group. Both groups planned to be followed up for the same period of time **Detection bias: Outcome assessor not blinded.** The study had an appropriate length follow up. Outcomes defined and valid and reliable measures used.

G.1.2.2 Johansson 2002

Bibliographic reference	**Johansson, T (2002) Displaced femoral neck fractures. A prospective randomised study of clinical outcome, nutrition and costs. Linköping University Medical Dissertation. 71 – no additional data added as is based on a 2 year follow up.**
Study type	RCT
Aim	To compare the clinical outcome of displaced femoral neck fractures treated with internal fixation versus total hip replacement when performed as routine procedures.
Patient characteristics	**Inclusion:** - ≥ 75 years - admitted with displaced and acute femoral neck fractures - ability to walk before the fracture - no contraindications to major surgery - no malignancy of significance - no signs of rheumatic joint disease **Exclusion** - None reported **Baseline characteristics**

	Internal Fixation (N = 78)	Total hip replacement (N = 68)
Age – median (IQR)	84 (74-96)	84 (75-101)
Gender – n (%) Female	57 (73)	54 (79)

	ASA status	NR	NR
	Mobility assessment / use of waking aids	NR	NR
	Place of residence	NR	NR
	Cognitive status / dementia*	NR	NR
	Time since admission – n (%) within 24 hours*	78 (100)	68 (100)

* cognitive status not reported until the first follow up time point
**all patients received surgery within 24 hours after admission.

Number of Patients	N = 143
Intervention	Osteosynthesis (internal fixation) – performed with two parallel and percutaneously-inserted screws after closed reduction and with the aid of a 2-plane fluoroscopy
Comparison	Total hip replacement – performed using a cemented prosthesis, using a dorsolateral approach
Length of follow up	2 years
Location	Sweden
Outcomes measures and effect size	**Results**

	Internal Fixation (N = 78)	**Total hip replacement (N = 68)**
Mortality – n/N (%) reported as accumulated mortality		
• 30 days	NR	NR
• 1 year*	17/78 (22)	16/68 (24)
• 5 years	NR	NR
Surgical revision – n/N (%)**	26/78 (45)	7/68 (18)
Functional status***		
• 1 year	NR	NR
• 5 years	NR	NR
Quality of life – Mean (SD)	NR	NR

Length of stay – Mean (SD)	NR	NR
Place of residence at 1 year	NR	NR

* Accumulated mortality reported at 3 months, 2 and 3 years.

** reported at 2 year time point; includes dislocations (for THR). *** Assessed using Harris Hip Score, results presented as subscale scores without an overall score.

Subgroups

	Internal Fixation (N = 78)	**Total hip replacement (N = 68)**
Surgical revision (COGNITIVE STATUS) – n/N (%)*		
• Lucid	30/53 (57%)	3/37 (8%)
• Impaired	5/25 (20%)	9/31 (29%)

* reported at 2 year time point; includes dislocations (for THR).

Other outcomes / time points reported were:

- Local complications after internal fixation
- Local complications after THR
- Mental function In relation to local complications
- Radiographic findings
- Heterotopic ossification
- Pain
- Hospital costs

Source of funding

Not reported

Comments

Secondary publications:

- Bachrach-Lindström M ; Johansson T ; Unosson M ; Ek A C; Wahlström O (2000) Nutritional status and functional capacity after femoral neck fractures: a prospective randomized one-year follow-up study. Aging. 12: 366-74
- Johansson, T, Jacobsson, SA, Ivarsson, I et al (2000) Internal fixation versus total hip arthroplasty in the treatment of displaced femoral neck fractures. A prospective randomised study of 100 hips. Acta Orthopaedica Scandinavica. 71(6): 597-602

	• Johansson, T, Bachrach-Lindström, M, Aspenberg, P et al (2006). The total costs of a displaced femoral neck fracture: comparison of internal fixation and total hip replacement. A randomised study of 146 hips. International Orthopaedics 30: 1-6 • Johansson, T (2014) Internal fixation compared with total hip replacement for displaced femoral neck fractures. A minimum fifteen-year follow-up study of a previously reported randomised trial. 96(46): 1-6 Methodology checklist **Selection bias: Inadequate** – randomisation / allocation using sequentially numbered sealed envelopes. No details how the envelopes were prepared. Only those allocated to THR were consented, and it is unclear if patients who refused consent were then excluded (breaking randomisation). Group imbalance in numbers. Groups appear comparable at baseline but minimal information provided. At 2 year follow-up more THR patients were cognitively impaired (46% vs 32%) but no data on cognitive status to assess if this was a difference between groups at baseline. **Performance bias:** Patients received the same care apart from the intervention. No indication of blinding. **Attrition bias:** 10% loss to follow-up. **Detection bias: Outcome assessor blinding not reported.** Appropriate length of follow-up. Outcomes defined and valid and reliable measures used.

G.1.2.3 Jonsson 1996

Bibliographic reference	**Jonsson, B, Sernbo, I, Carlsson, A (1996). Social function after cervical hip fracture. A comparison of hook-pins and total hip replacement in 47 patients. Acta Orthopaedica Scandinavica. 67(5): 431-44**
Study type	RCT
Aim	To identify the level of social function in people who have been treated with hook pins or hip replacement following a cervical hip fracture.
Patient characteristics	**Inclusion:** - Displaced cervical hip fracture - Living in their own home - Be fully ambulatory before fracture - Fracture < 48 hours old at the time of admission - Healthy enough to receive anaesthesia (determined by assessment from an anaesthesiologist) **Exclusion:** - None specified

	Baseline characteristics <table><tr><th></th><th>Internal Fixation (N = 24)</th><th>Total hip replacement (N = 23)</th></tr><tr><td>Age – median (IQR)</td><td>79 (70-89)</td><td>80 (67-89)</td></tr><tr><td>Gender – n (%) Female</td><td>18 (75)</td><td>18 (78)</td></tr><tr><td>ASA status</td><td>NR</td><td>NR</td></tr><tr><td>Mobility assessment / use of waking aids – n (%)</td><td>23 (96)</td><td>19 (83)</td></tr><tr><td>Place of residence – n (%) Home</td><td> 24 (100)</td><td> 23 (100)</td></tr><tr><td>Cognitive status / dementia</td><td>NR</td><td>NR</td></tr><tr><td>Time since admission*</td><td>NR</td><td>NR</td></tr></table>* no specific time-points reported, states that patients had 'usually undergone surgery the following day' from admission. **Other baseline characteristics reported were:** ○ Able to do own shopping ○ Walking distance 1km or more
Number of Patients	N = 47
Intervention	Closed reduction and fixation with hansson hook-pins
Comparison	Primary replacement with the Charnley prosthesis using trochanteric osteotomy
Length of follow up	Total 24 month follow up period • 1 month • 4 month • 12 month • 24 month
Location	Sweden

Outcomes measures and effect size

Results

	Internal Fixation (N = 24)	Total hip replacement (N = 23)
Mortality – n/N (%) • 30 days* • 1 year • 5 years (2 year data reported)	 0/24 N/R 2/24	 1/23 (4) N/R 3/23
Surgical revision – n/N (%)	7/24	1/23 (4)
Functional status • 1 year*** • 5 years	 10 NR	 13 NR
Quality of life – Mean (SD)	NR	NR
Length of stay – Median (range)	12 (7 to 47)	15 (8 to 73)
Place of residence at 1 year	NR	NR

* Paper reported 5 deaths taking place in the 'observation period', the time-point of the death was not clear, so not included in any of the above time points.

** paper reported there were no deaths within the first month postoperatively, but 1 patient died 1 month postoperatively. As the time points were not clear, the reviewer added this data to the 30 day time point.

*** functional status evaluated by ability to walk 1km or more. Paper also reported the CI (95% CI) for this time point – 1.8 (0.4 - 78)

Other outcomes / time points reported were:

- Walking aids – 1 cane or less outdoors
- Able to do own shopping
- No pain at rest
- No pain when walking
- No use of analgesics
- Home assistance less than 4 hours weekly
- Postoperative morbidity

Source of funding	Financial support was obtained from the Swedish Medical Society and the Herman Jarnhardt and Greta and Johan Kock foundations
Comments	Methodology checklist **Selection bias: Inadequate** – 'sealed envelopes' no details of whether numbered and opaque. Both arms comparable at baseline. No blinding reported. **Performance bias:** Both treatment groups received the same care apart from the interventions. No blinding reported. **Attrition bias:** 4% loss to follow-up. 3 patients excluded following randomisation due to deterioration in health or misclassification of the fracture. Insufficient detail to assess whether the 2 arms were comparable or had same data available at treatment completion and follow-up. **Detection bias: Outcome assessor blinding not reported.** Length of follow up was appropriate.

G.1.2.4 Keating 2005a

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
Study type	RCT
Aim	To compare the impact on functional outcome, clinical parameters and resource utilisation, more than two years after surgery, of treatment using internal fixation and bipolar hemiarthroplasty for displaced intracapsular hip fractures in previously healthy, mobile patients as 2nd part of a randomized trial if participating surgeon did not want to randomise to total hip replacement
Patient characteristics	**Inclusion:** - Aged > 60yrs - Normal cognitive function (Mini Mental Test score >6) - Independently mobile prior to fracture - No serious concomitant disease (e.g. malignancy) or other clinical reason for exclusion **Exclusion:** - Undisplaced or valgus impacted fracture **Baseline characteristics[1]**

	Internal fixation (N = 69)	**Total hip replacement**

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**

		(N = 69)
Age in years – mean (SD)	74.3 (7)	75.2 (6)
Gender – Female n (%)	51 (74)	52 (75)
ASA status	N/R	N/R
Mobility assessment / use of walking aids	N/R	N/R
Place of residence	N/R	N/R
Cognitive status / dementia*	N/R	N/R
Time since admission*	N/R	N/R

* inclusion required Mini Mental Test score >6

**reports that all operations were conducted within 48 hours of entry to the trial and that surgery was usually undertaken the day following patient's admission to hospital.

Other baseline data reported:

No (%) with left / right-sided fracture

No (%) taking regular medication prior to trial entry

No (%) of operations performed by a consultant

Number of Patients	N = 138
Intervention	Internal fixation (n = 69) - Choice of reduction (open / closed) and fixings (e.g. cannulated screws or sliding hip screw) was at surgeon discretion. 67% had closed approach; 64% had multiple screws. - 39% had general anaesthetic; 61% had regional anaesthetic - Operating time in mins – mean (SD): 49.7 mins (22) - 22% of operations undertaken by Consultant grade surgeon
Comparison	Total hip replacement (n = 69) - With cement - Choice of approach (lateral / posterior) was at surgeon discretion. 88% used lateral approach

<table>
<tr><td>Bibliographic reference</td><td>Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.</td></tr>
<tr><td></td><td>- 30% had general anaesthetic; 70% had regional anaesthetic
- Operating time in mins – mean (SD): 79.7 mins (26)
- 42% of operations undertaken by Consultant grade surgeon</td></tr>
<tr><td>Length of follow up</td><td>2 years</td></tr>
<tr><td>Location</td><td>UK</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal fixation (N = 69)</th><th>Total hip replacement (N = 69)</th></tr>
<tr><td>Mortality – n (%)
• 30 days*
• 1 year
• 5 years (2 days data used)</td><td>
2 (2.9%)
6 (9%)
9 (13%)</td><td>
1 (1.4%)
4 (6%)
6 (9%)</td></tr>
<tr><td>Surgical revision (at 2 years)** – n/N</td><td>27 (39%)</td><td>6 (9%)</td></tr>
<tr><td>Functional status - Hip Rating Questionnaire (HRQ)*** – mean (SD), n
• 1 year
• 5 years (2 year data used)</td><td>
71.8 (17), n = 55
75.2 (19), n = 47</td><td>
79.4 (17), n = 54
79.9 (17), n = 56</td></tr>
<tr><td>Quality of life (EQ5D utility score at 4 months)**** – Mean (SD)</td><td>0.57 (0.29), n = 64</td><td>0.68 (0.24), n = 66</td></tr>
<tr><td>Length of stay (days)***** – Mean (SD)</td><td>10.6 (6)</td><td>12.3 (10)</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
</table>
*reported as death during index admission
** reported as cumulative no. requiring further surgery from operation date
*** HRQ: higher score = better functioning (max. 100)</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.</td></tr>
<tr><td></td><td>****reported as EQ-5D utility score (numbers (%'s) in each EQ-5D subscale category, self-reported change in overall health score and 'thermometer' score also reported but not extracted)
***** reported as length of post-operative stay

Subgroups
<table>
<tr><th></th><th>Internal fixation (max N = 65)</th><th>Total hip replacement (max N = 66)</th></tr>
<tr><td>Functional status* (AGE) - mean HRQ score (SD)
<u>12 months</u>
• 60 to 74yrs
• ≥75yrs

<u>24 months</u>
• 60 to 74yrs
• ≥75yrs</td><td>

69.8 (21)
73.5 (13)

73.9 (19)
75.0 (12)</td><td>

85.3 (13)
73.7 (18)

87.2 (14)
74.5 (17)</td></tr>
</table>
*HRQ: higher score = better functioning (max. 100)

Other outcomes / timepoints reported were:
○ Mortality during index admission
○ Mortality at 4 months
○ Mortality at 2 years
○ Blood transfusion
○ Surgical revision at 4 months
○ Surgical revision at 12 months</td></tr>
<tr><td>Source of funding</td><td>Funded by grant from the NHS Health Technology Assessment programme.</td></tr>
<tr><td>Comments</td><td>Secondary publication</td></tr>
</table>

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
	• Keating J, Grant A, Masson M et al. (2006) Randomized comparison of reduction and fixation, bipolar hemiarthroplasty, and total hip arthroplasty. Treatment of displaced intracapsular hip fractures in healthy older patients. Journal of bone and joint Surgery American volume. 88(2):249-60 Methodology checklist **Selection bias: Adequate -** centralised, independent computerised randomisation via telephone. Allocation stratified by surgeon code and minimised on age category (60-74, 75yrs+) and gender. Treatment groups were comparable at baseline. **Performance bias:** All groups received the same care apart from the intervention received. Not possible to blind patients or care providers as post-operative management (including types of complication) differ between treatments and patients needed to consent to actual allocated operation. **Attrition bias:** <5% loss to follow-up. All groups were followed up for an equal length of time. All patients randomised completed treatment. ITT analysis used. Groups were comparable at treatment completion. **Detection bias: Outcome assessor not blinded** – self-report measures of functioning and QoL were used; research nurses co-ordinated data collection, but states: "when recording further surgery or operative complications it would usually be apparent to which group a patient was originally allocated". Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

1. Data extracted for two treatment arms (internal fixation and total hip replacement) of the 3-way randomisation reported in this study comparing internal fixation vs. hemiarthroplasty vs. total hip replacement.

G.1.2.5 Liehu 2014

Bibliographic reference	**Liehu, C., Bin, W., Ming., et al (2014). Closed reduction and internal fixation versus total hip arthroplasty for displaced femoral neck fracture. Chinese Journal of Traumatolgy. 17(2): 63-8**
Study type	RCT
Aim	To compare the clinical effects between closed reduction and internal fixation (CRIF) and total hip replacement (THR) for displaced femoral neck fracture.
Patient characteristics	**Inclusion:** - Femoral neck fracture (classified as Garden 3 or 4)

- Patients aged ≥ 65 years
- Admitted to hospital 1-3 days after bone fracture
- In a normal mental state
- Independent living ability

Exclusion:

- Patients living with pathological fractures (e.g. bone tumours, metabolic bone disease)
- Preoperative avascular necrosis of the femoral head
- Osteoarthritis or rheumatoid arthritis
- Hemiplegia or bedridden for various reasons
- Other complications affecting hip function

Baseline characteristics

	Internal Fixation (N = 128)	**Total hip replacement (N = 157)**
Age – Mean (range)	76.8 (65 to 93)	75.9 (65 to 94)
Gender – n (%) Female	69 (54%)	84 (54%)
ASA status	NR	NR
Mobility assessment / use of waking aids – n/N (%)	NR	NR
Place of residence – n/N (%) Home Residential care Other	NR	NR
Cognitive status / dementia*		
Time since admission – Mean (SD) / range / Median (IQR)	NR	NR

* normal mental state as per inclusion criteria

Other baseline characteristics reported were:

- Fracture type (per garden score)
- Hypertension
- Diabetes

<table>
<tr><td></td><td>○ Coronary heart disease
○ Chronic obstructive lung disease</td></tr>
<tr><td>Number of Patients</td><td>N = 285</td></tr>
<tr><td>Intervention</td><td>Closed reduction internal fixation – carried out under C arm X-ray, with small incision in the lateral femur. Internally fixed using 3 hollow compression screws.</td></tr>
<tr><td>Comparison</td><td>Total hip arthroscopy – carried out with an uncemented prosthesis via posterior approach to the hip joint, with the patient in a lateral position.</td></tr>
<tr><td>Length of follow up</td><td>Total follow up 5 years
• 1 year
• 2 year
• 3 year
• 4 year
• 5 year</td></tr>
<tr><td>Location</td><td>China</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal Fixation (N = 128)</th><th>Total hip replacement (N = 157)</th></tr>
<tr><td>Mortality*</td><td>NR</td><td>NR</td></tr>
<tr><td>Surgical revision – n/N (%)</td><td>41/128 (33)</td><td>20/157 (13)</td></tr>
<tr><td>Functional status Harris hip score - % with a score ≥80
• 1 year
• 5 years</td><td>
72.6%
58%</td><td>
92.3%
89%</td></tr>
<tr><td>Quality of life</td><td>NR</td><td>NR</td></tr>
<tr><td>Length of stay (days) – Mean (SD)</td><td>17.3 (9.6)</td><td>24.3 (11.5)</td></tr>
<tr><td>Place of residence at 1 year</td><td>NR</td><td>NR</td></tr>
</table>
* Mortality per arm presented as total percentages for each time point, not by treatment group – 7.0%, 15.5%, 24.2%, 27.0%, 30.5%</td></tr>
</table>

	** Data also provided for functional status and mortality at 2, 3, 4 years **Other outcomes / timepoints reported were:** ○ Postoperative complication including decubitus ulcer, pneumonia, deep vein thrombosis, stroke, urinary infection, deep infection.
Source of funding	Not stated
Comments	**Selection bias: Adequate** - identical sealed, opaque and numbered envelopes used. Blinding not reported. States that groups were comparable at baseline (only age and details of health conditions presented). **Performance bias:** Comparison groups received the same care apart from the intervention. Blinding not reported. **Attrition bias:** 5.3% loss to follow-up. ITT analysis used. Both groups followed up for an equal length of time. Groups were comparable at treatment completion and follow-up with regards to availability of data. **Detection bias: Outcome assessor blinding not reported**. Study had an appropriate length follow up. Poor reporting of outcomes: percentages and p values without sample sizes. Outcomes defined and valid and reliable measure used. .

G.1.2.6 Mouzopoulos 2008

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**
Study type	RCT
Aim	To estimate the functional restitution of patients up to 4 years after the surgical treatment of a displaced subcapital hip fracture, comparing three surgical options: internal fixation, hemiarthroplasty and total hip replacement.
Patient characteristics	**Inclusion:** - displaced subcapital hip fracture (Garden III or IV) after a fall **Exclusion:** - previous hip fracture - history of cancer or Paget's disease, - rheumatic arthritis **Baseline characteristics[1]**

	Internal fixation (N = 38)	**Total hip replacement (N = 37)**

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**

Age in years – mean	75.4 ± 4.6	73.1 ± 4.9
Gender – Female n (%)	26 (68%)	28 (76%)
ASA status (1-4) - mean	2.0 ±1.1	2.0 ± 2.0
Mobility assessment* / use of walking aids – n (%)	38 (100%)	37 (100%)
Place of residence – n (%) • Home** • Residential care	 38 (100%) 0	 37 (100%) 0
Cognitive status / dementia*** - mean	7.8 ± 2.8	7.9 ± 2.6
Time since admission**** - mean	44.2 ± 5.2	45.2 ± 7.3

*reported as 'ambulatory'
**reported as 'own home or living with relatives' (all but 2 patients were living with relatives)
***measured using Short Portable Mental Status Questionnaire (SPMSQ, score 0-10)
****reported as mean pre-operative waiting time (presumably in hours)

Number of Patients	N = 86 across two of the three treatment groups compared (data not extracted for hemiarthroplasty group), but states that 7 patients were subsequently excluded due to prior history of hip fracture. Baseline data are given for N = 109 participants in the three treatment groups; outcome data reported for N = 129 across 3 groups – unclear which other patients are excluded from baseline information. Participants recruited between April 1999 to April 2002.
Intervention	Internal fixation (N = 43 randomised) - Richards plate-screw; (Smith & Nephew, Memphis, TN, USA). No further details. Postoperatively in the hospital and after discharge, all patients received the same rehabilitation programme
Comparison	Total hip replacement (THR; N = 43 randomised) - Plus; De Puy (Warsaw, IN, USA). No further details.

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**
	Postoperatively in the hospital and after discharge, all patients received the same rehabilitation programme
Length of follow up	4 years
Location	Greece (number of study centres unclear).
Outcomes measures and effect size	**Results**

	Internal fixation (N = 43)	**Total hip replacement (N = 43)**
Mortality – n/N • 30 days • 1 year • 5 years (4 year data used)	 N/R 5 (12%) 11 (26%)	 N/R 6 (14%) 15 (35%)
Surgical revision* – n (%) • by 1 year • by 4 years	 5 (12%) 12 (28%)	 0 (0%) 1 (2%)
Functional status** - mean, n • 1 year • 5 years (4 year data used)	 71.3 (5.3), n = 32 73.6 (6.7), n = 19	 81.6 (4.9), n = 33 83.7 (4.8), n = 23
Quality of life	N/R	N/R
Length of stay in days – mean	13 ± 2.8	8.3 ± 6.2
Place of residence at 1 year	N/R	N/R

*Cumulative revisions throughout follow-up period
**reported as Harris Hip Score (overall score)

Other outcomes / timepoints reported were:

- Mortality at 4 years
- Functional status (Harris Hip Score) at discharge; at 4 years
- Bartel (activities of daily living) Index Score at discharge; 1 year; 4 years

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**
Source of funding	Not reported.
Comments	Methodology checklist **Selection bias: Inadequate** - one patient selected for entry to study every third admission; the 129 participants were randomly divided by two orthopaedic surgeons into three groups in following order: hemi-arthroplasty, total arthroplasty, internal fixation. Unclear reporting of baseline data: sample sizes do not correspond with study flowchart. **Performance bias:** All groups received the same care apart from the interventions. No indication participants / care providers were blinded to treatment. **Attrition bias:** <2% loss to follow-up. No intention-to-treat analysis: patients who subsequently underwent revision surgery were excluded from follow-up analyses (5 INF and 2 HEMI patients by 12 months; 12 INF and 5 HEMI by 4 years). **Detection bias: Outcome assessors blinded.** Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

[3] *Only data corresponding to two treatment arms (internal fixation and THR) are extracted.*
[4] *Sample sizes do not correspond with flowchart reported in study re: exclusions due to prior history of hip fracture, mortality or missing data.*

G.1.2.7 Skinner 1989

Bibliographic reference	**Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.**
Study type	RCT
Aim	To determine the relative mortality, morbidity and eventual mobility of patients following three methods of treatment of subcapital fracture of the femur: internal fixation, hemiarthroplasty and total hip replacement[1].
Patient characteristics	**Inclusion:** - patients over the age of 65 years - admitted with a displaced subcapital femoral neck fracture (Garden grades III and IV) - any cognitive status **Exclusion:** - old fractures or pathological fractures - rheumatoid arthritis - doubt regarding the displacement or grading of the fracture

<table>
<tr><td>Bibliographic reference</td><td>Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.</td></tr>
<tr><td></td><td>Baseline characteristics[1]
<table>
<tr><th></th><th>Internal fixation (N = 91)</th><th>Total hip replacement (N = 89)</th></tr>
<tr><td>Age in years – mean*</td><td>79.7</td><td>81.0</td></tr>
<tr><td>Gender**</td><td>N/R</td><td>N/R</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment / use of walking aids</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Cognitive status / dementia</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Time since admission</td><td>N/R</td><td>N/R</td></tr>
</table>
*SD not reported
**90% female (reported for full sample only)</td></tr>
<tr><td>Number of Patients</td><td>N = 180 patients across 2 of the 3 treatment groups compared (data for hemiarthroplasty group not extracted)
Recruitment period: December 1984 to December 1986</td></tr>
<tr><td>Intervention</td><td>Internal fixation (N = 91)
- closed reduction and internal fixation with a Richards sliding compression screwplate;
- mean operation time not reported.
Operations performed as soon as practicable – usually within 24 h of admission. Most surgeons were registrar grade, but some were consultants or senior house officers.

All patients were mobilized, fully weight bearing, usually within 48 h, and discharged or transferred as soon as practicable.</td></tr>
<tr><td>Comparison</td><td>Total Hip Replacement (N = 89)
- cemented Howse II prosthesis using a semicaptive cup and a 32 mm head
- posterolateral approach
- mean operation time not reported</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.</td></tr>
<tr><td></td><td>Operations performed as soon as practicable – usually within 24 h of admission. Most surgeons were registrar grade, but some were consultants or senior house officers.

All patients were mobilized, fully weight bearing, usually within 48 h, and discharged or transferred as soon as practicable.</td></tr>
<tr><td>Length of follow up</td><td>1 year (Skinner 1989)
13 years (Ravikumar 2000)</td></tr>
<tr><td>Location</td><td>UK (single centre)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal fixation (N = 91)</th><th>Total hip replacement (N = 89)</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>
N/R
23 (25%)
N/R</td><td>
N/R
20 (23%)
N/R</td></tr>
<tr><td>Surgical revision* – n (%)
• by 1 year
• by 13 years</td><td>
23 (25%)
30 (33%)</td><td>
4 (4%)
6 (7%)</td></tr>
<tr><td>Functional status**</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Quality of life</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Length of stay</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
</table>
*cumulative revisions within time period (data from medical records of survivors and dead patients). Only percentages are given; raw numbers calculated by reviewer.
**Harris Hip Score (overall mean score) reported for survivors at 13 years only (Ravikumar 2000).

Other outcomes / timepoints reported were:</td></tr>
</table>

Bibliographic reference	**Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.**
	○ % mortality at 2 months (Skinner 1989); at 13 years (Ravikumar 2000) ○ % requirement for second anaesthetic for local complication within 12 months (Skinner 1989) ○ % with infection (superficial and deep) at 13 years (Ravikumar 2000) ○ Mean Harris Hip score (survivors) at 13 years (Ravikumar 2000) ○ Mean time to revision (months) (Ravikumar 2000)
Source of funding	Funding support for research staff from Johnson & Johnson plc.
Comments	**Secondary publication:** • Ravikumar K, Marsh G. (2000) Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur — 13 year results of a prospective randomised study. Injury, 31: 793-7. <u>Methodology checklist</u> **Selection bias: Inadequate** – patients were randomly allocated to the three methods of treatment according to the day of the week on which they were admitted. States groups were matched on baseline criteria (fitness, ability, accommodation), but insufficient detail presented to verify. **Performance bias:** Both arms received the same care apart from the intervention. Blinding not reported. **Attrition bias:** Loss to follow-up unclear. Poor reporting – outcomes presented as percentages with no sample sizes - no indication of intention-to-treat analysis. Pain and mobility data assumed to correspond only to survivors. **Detection bias: Outcome assessor not blinded.** Outcomes defined and valid and reliable measures used.

[1] *Only data corresponding to two treatment arms (internal fixation and THR) are extracted.*

G.1.2.8 Tidermark 2003

Bibliographic reference	**Tidermark, J, Ponzer, O, Svensson, A et al (2003) – Internal fixation compared with total hip replacement for displaced femoral neck fractures in the elderly. A randomised controlled trial. The journal of bone and joint surgery. 85: 380-8**
Study type	RCT

Bibliographic reference	**Tidermark, J, Ponzer, O, Svensson, A et al (2003) – Internal fixation compared with total hip replacement for displaced femoral neck fractures in the elderly. A randomised controlled trial. The journal of bone and joint surgery. 85: 380-8**
Aim	To identify the outcomes of individuals after displaced fractures of the femoral neck in elderly patients treated either by Internal fixation or Total Hip Replacement.
Patient characteristics	**Inclusion:** - Acute displaced fractures of the neck of the femur (Garden 3 and 4) - Aged ≥ 70 years - No evidence of severe cognitive dysfunction - Domestic independence - Ability to walk with or without walking aids **Exclusion:** - Patients with fractures not suitable for internal fixation (e.g. pathological fractures, displaced fractures more than 24 hours old - Patients with chronic arthritis, either rheumatoid or osteoarthritis **Baseline characteristics**

	Internal Fixation (N = 53)	**Total hip replacement (N = 49)**
Age – Mean (SD)	81.4 (6.6)	79.2 (5.0)
Gender –n (%) female	42 (79)	40 (82)
ASA status	NR	NR
Mobility assessment / use of walking aids (reported number with no walking aid or just one stick) – n/N (%)	46/53 (87)	45/49 (92)
Place of residence	NR	NR
Cognitive status / dementia (reported cognitive function SPMSQ4) – mean (SD)	8.7 (1.6)	9.0 (1.1)

[4] Short Portable mental Status Questionnaire

<table>
<tr><td>Bibliographic reference</td><td>Tidermark, J, Ponzer, O, Svensson, A et al (2003) – Internal fixation compared with total hip replacement for displaced femoral neck fractures in the elderly. A randomised controlled trial. The journal of bone and joint surgery. 85: 380-8</td></tr>
<tr><td></td><td>
<table>
<tr><td>Time since admission</td><td>NR</td><td>NR</td></tr>
</table>

Other baseline characteristics reported were:
○ EQ-5Dindex score pre-fracture
○ Number with ADL with index A or B
○ Number with co-morbidity A or B (* A = full health B = another illness not affecting rehabilitation)
</td></tr>
<tr><td>Number of Patients</td><td>N = 102 (110 recruited; 8 patients excluded following randomisation)</td></tr>
<tr><td>Intervention</td><td>Internal fixation with two cannulated screws</td></tr>
<tr><td>Comparison</td><td>Primary total hip replacement – anterolateral approach</td></tr>
<tr><td>Length of follow up</td><td>Total follow up period: 24 months
• 4 months
• 12 months
• 24 months</td></tr>
<tr><td>Location</td><td>Sweden</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Internal Fixation
(N = 53)</th><th>Total hip replacement
(N = 49)</th></tr>
<tr><td>Mortality – n/N (%)
• 30 days
• 1 year
• 5 years (4 year data reported)</td><td>
N/R
N/R
13/53</td><td>
N/R
N/R
12/49</td></tr>
<tr><td>Surgical revision – n/N (%)</td><td>18/53 (26)</td><td>2/49 (2)</td></tr>
<tr><td>Functional status*
1 year (mean score)</td><td></td><td></td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Tidermark, J, Ponzer, O, Svensson, A et al (2003) – Internal fixation compared with total hip replacement for displaced femoral neck fractures in the elderly. A randomised controlled trial. The journal of bone and joint surgery. 85: 380-8**

- Movement - Walking 5 years	4.6 (no SD) 3.9 (no SD) NR	5.0 (no SD) 4.6 (no SD) NR
Quality of life – Mean change score from baseline (SD)** at 4 months	0.60 (0.22), n = NR	0.73 (0.20), n = NR
Length of stay – Mean (SD)	NR	NR
Place of residence at 1 year	NR	NR

*Reported as Charnley score (1 = total disability; 6 = normal state). No treatment group sample sizes given.

** reported using EQ-5D$_{index}$ score. Paper also reported EQ-5D$_{index}$ scores for patients without hip complications.

*** number of surviving patients in each arm at this follow up time point not reported.

Other outcomes / time points reported were:

- Mortality by 4 months; by 24 months
- Charnley mean pain score at 4 and 24 months.
- Operative data - mean operating time, operative blood loss for each arm and the position of the stem
- General complications for each arm – by 4 months
- Surgical outcomes – reported across all study follow-up time points

See note in comments section about secondary publication (Blomfeldt et al (2005) reporting all outcomes at 4 years.

Source of funding	Study supported in parts by grants from the Trugg-Hansa Insurance company, Swedish Society for Medical Research, the Swedish Orthopaedic Association and the Stockholm County Council
Comments	**Secondary publication:** • Blomfeldt R, Tornkvist H, Ponzer S et al (2005) Comparison of internal fixation with total hip replacement for displaced femoral neck fractures. Randomised Controlled Trial performed at 4 years. The Journal of Bone and Joint Surgery 87 (8) 1680-8. Reports outcomes at 48 months

Bibliographic reference	**Tidermark, J, Ponzer, O, Svensson, A et al (2003) – Internal fixation compared with total hip replacement for displaced femoral neck fractures in the elderly. A randomised controlled trial. The journal of bone and joint surgery. 85: 380-8**
	Methodology checklist **Selection bias: Inadequate** – 'sealed envelope technique', no details of whether numbered or opaque or who did allocation to treatment. Groups comparable at baseline. Blinding not reported. **Performance bias:** Groups received the same care apart from the intervention. Blinding not reported. **Attrition bias:** 3% loss to follow-up. No ITT analysis. Groups followed up for an equal length of time. Actual follow up sample sizes for each group not clearly reported. **Detection bias: Outcome assessor blinding not reported.** Length of the follow up was appropriate. Outcomes defined and valid and reliable measures used.

G.1.3 HA versus THR

G.1.3.1 Baker 2006

Bibliographic reference	**Baker RP; Squires B ; Gargan MF; et al (2006) Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: A randomized, controlled trial. Journal of Bone and Joint Surgery, 88: 2583-9**
Study type	RCT
Aim	To determine whether total hip replacement is superior to hemiarthroplasty for the management of mobile, independent patients who have sustained a displaced intracapsular fracture of the femoral neck, isolating the bearing surface of the acetabulum as the sole independent variable.
Patient characteristics	**Inclusion:** - aged ≥60yrs; - cognitively unimpaired (normal Abbreviated Mini Mental Test score); - living independently (without reliance on caregiver); - able to walk ≥0.5 miles (≥0.8km) prior to fracture; - non-pathological fracture; - hip with no or minimal osteoarthritic changes **Exclusion:** - aged <60yrs;

<table>
<tr><td>Bibliographic reference</td><td>Baker RP; Squires B ; Gargan MF; et al (2006) Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: A randomized, controlled trial. Journal of Bone and Joint Surgery, 88: 2583-9</td></tr>
<tr><td></td><td>
- medical or physical comorbidities limiting walking distance to <0.5 miles (≥0.8km);
- pre-existing hip condition requiring THR;
- pathological fracture secondary to malignancy

Baseline characteristics
<table>
<tr><th></th><th>Hemiarthroplasty (N = 41)</th><th>Total hip replacement (N = 40)</th></tr>
<tr><td>Age (years) – mean (range)</td><td>75.8 (66 to 86)</td><td>74.2 (63 to 86)</td></tr>
<tr><td>Gender – n (%) Female</td><td>32 (78%)</td><td>32 (80%)</td></tr>
<tr><td>Median ASA grade (range)</td><td>2 (1 to 3)</td><td>2 (1 to 3)</td></tr>
<tr><td>Mobility assessment* / use of walking aids
- mean (range)</td><td>2.2 (0.5 to 6.0)</td><td>2.2 (0.5 to 5.0)</td></tr>
<tr><td>Cognitive status** – mean (range)</td><td>9.98 (9 to 10)</td><td>9.83 (7 to 10)</td></tr>
<tr><td>Time from fracture to surgery (days) – mean</td><td>1.95</td><td>1.75</td></tr>
</table>
*reported as ‘walking distance in miles’
** Abbreviated Mini Mental test score

Other baseline characteristics reported were:
○ baseline hip disability (Oxford Hip score)
○ baseline QoL (SF-36 physical & mental component scores)
</td></tr>
<tr><td>Number of Patients</td><td>N = 81
(N = 47 at 7-10 year follow-up; Avery 2011)</td></tr>
<tr><td>Intervention</td><td><u>Hemiarthroplasty (N = 41)</u>
- Endo femoral head (Zimmer) – head size available in 2mm increments allowing accurate reproduction of patient’s femoral head (measured intraoperatively)</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Baker RP; Squires B ; Gargan MF; et al (2006) Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: A randomized, controlled trial. Journal of Bone and Joint Surgery, 88: 2583-9</td></tr>
<tr><td></td><td>- Mean femoral head size = 48mm (range: 43 to 59mm)
- Mean operative time: 78 mins (range: 45 to 120 mins)
All patients received standardised femoral component - cemented CPT collarless polished tapered stem (Zimmer).
All operations performed through lateral approach.
All patients mobilised with full weight-bearing on second post-operative day, graduating from walker to cane before discharge.</td></tr>
<tr><td>Comparison</td><td><u>Total hip replacement (N = 40)</u>
- 28mm femoral head articulating with all-polythene cemented acetabular cup without long posterior wall (Zimmer)
- Mean outer diameter of acetabular component: 47mm (range 44 to 55mm)
- Mean operative time: 93 mins (range: 60 to 135 mins).
All patients received standardised femoral component - cemented CPT collarless polished tapered stem (Zimmer).
All operations performed through lateral approach.
All patients mobilised with full weight-bearing on second post-operative day, graduating from walker to cane before discharge.</td></tr>
<tr><td>Length of follow up</td><td>Mean follow-up: 39 months (range: 30 to 66 months) (Baker 2006)
Mean follow-up: 9 years (range 7.2 to 10.3 years) (Avery 2011)</td></tr>
<tr><td>Location</td><td>UK (3 centres)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Hemiarthroplasty (N = 41)</th><th>Total hip replacement (N = 40)</th></tr>
<tr><td>Mortality – n/N (%)
• 30 days*
• 1 year
• 5 years</td><td>
2/41 (5%)
N/R
21/41 (51.2%)</td><td>
0/40 (0%)
N/R
13/40 (32.5%)</td></tr>
<tr><td>Surgical revision** at 39 months – n (%), n</td><td>6 (15%)</td><td>1 (2.5%)</td></tr>
<tr><td>Functional status
• 1 year</td><td>
N/R</td><td>
N/R</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Baker RP; Squires B ; Gargan MF; et al (2006) Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: A randomized, controlled trial. Journal of Bone and Joint Surgery, 88: 2583-9**

• 5 years (at 3 years)	22.3 (No SD), n = 33	18.8 (No SD), n = 36
Quality of life	NR	NR
Length of stay – Mean (SD)	N/R	N/R
Place of residence at 1 year	N/R	N/R
Dislocation rate – n (%), n • Within 30 days	0 (0%), n = 41	3 (8%), n = 40

*reported as immediate postoperative deaths (both from pulmonary embolism)

**reported as overall rate of revision or planned revision at time of study follow-up (mean: 39 months); actual rate at 9 year follow-up (2 patients did not have planned surgery due to ill health)

***treated with closed reduction

Other outcomes / timepoints reported were:

- Mortality by 39 months
- Mortality by 9 years (Avery 2011)
- Surgical revision by 9 years (Avery 2011)
- Hip disability (Oxford hip score) at 39 months
- Hip disability (Oxford hip score) at 9 years (Avery 2011)
- Self-reported walking distance at 39 months
- Self-reported walking distance at 9 years (Avery 2011)
- Other perioperative complications (within 30 days)
- Acetabular erosion (hemiarthroplasty) – prevalence and severity at 39 months; 9 years
- Femoral subsidence (in mm) at stem-cement interface (mean) at 39 months; 9 years

Source of funding	No outside or commercial funding or support.
Comments	**Secondary publication:** • Avery P P, Baker R P, Walton M J, et al (2011) Total hip replacement and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: a seven- to ten-year follow-up report of a prospective randomised controlled trial. The Journal of Bone and Joint surgery. British volume 93: 1045-8. Methodology checklist

Bibliographic reference	**Baker RP; Squires B ; Gargan MF; et al (2006) Total hip arthroplasty and hemiarthroplasty in mobile, independent patients with a displaced intracapsular fracture of the femoral neck: A randomized, controlled trial. Journal of Bone and Joint Surgery, 88: 2583-9**
	Selection bias: Inadequate – 'sealed envelopes opened before surgery'. No further information e.g. whether envelopes were opaque and numbered. Treatment groups comparable at baseline. **Performance bias:** Both arms received the same care apart from the intervention. Blinding not reported. **Attrition bias:** 3% loss to follow-up. Unclear if both groups were followed up for same duration. **Detection bias: Outcome assessor blinding not reported.** Outcomes defined and valid and reliable measures used.

G.1.3.2 Blomfeldt 2007

Bibliographic reference	**Blomfeldt R, Törnkvist H, Eriksson K, et al. (2007) A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. Journal of Bone and Joint Surgery (British volume) 89: 160-5.**
Study type	RCT
Aim	To analyse outcome, with hip function as the primary end-point, and health-related quality of life, after a displaced intracapsular fracture of the femoral neck in a relatively healthy, active and alert elderly patients randomised to receive either a bipolar hemiarthroplasty or a THR.
Patient characteristics	**Inclusion:** - aged 70 to 90 years; - absence of severe cognitive dysfunction(n demonstrated by three or more correct answers on the ten-item Short Portable Mental Status Questionnaire, SPMSQ); - non-institutionalised independent living status; - pre-injury independent walking capability with or without aids. **Exclusion:** - pathological fractures; - displaced fractures present for more than 48 hours before presentation; - rheumatoid arthritis or osteoarthritis. **Baseline characteristics**

	Hemiarthroplasty (N = 60)	**Total hip replacement**

Bibliographic reference	**Blomfeldt R, Törnkvist H, Eriksson K, et al. (2007) A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. Journal of Bone and Joint Surgery (British volume) 89: 160-5.**

		(N = 60)
Age (years) – mean (range)	80.7 (70 to 89)	80.5 (70 to 89)
Gender – n (%) Female	54 (90%)	47 (78%)
ASA status	N/R	N/R
Mobility assessment* / use of walking aids – n (%)	55 (92%)	56 (93%)
Cognitive status** mean score (range)	9.0 (6 to 10)	9.1 (7 to 10)
Time since admission	N/R	N/R

*reported as walking unaided or with the aid of only one stick

**reported as Short Portable Mental Status Questionnaire (SPMSQ) score

Other baseline data reported:

- Ceder rating of comorbidity
- Activities of Daily Living (ADL)
- Pre-fracture EQ-5D$_{index}$ score

Number of Patients	N = 120
Intervention	<u>Hemiarthroplasty (N = 60)</u> - Cemented bipolar head (Bicentric, Howmedica or Universal Head replacement, Howmedica) - Mean operative time: 78 mins (range: 43 to 131 mins) All patients received modular Exeter femoral component (Howmedica, Sweden) with 28mm head. All operations performed using a modified Hardinge anterolateral approach. Patients allowed to sit on high chair immediately post-surgery; mobilised with full weight-bearing with the aid of two crutches as soon as tolerated, and mobilise without restriction after 6 weeks.
Comparison	<u>Total hip replacement (THR) (N = 60)</u> - Cemented OGEE (DePuy Johnson & Johnson, Sweden) acetabular component - Mean operative time: 102 mins (range: 70 to 151 mins)

<table>
<tr><td>Bibliographic reference</td><td>Blomfeldt R, Törnkvist H, Eriksson K, et al. (2007) A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. Journal of Bone and Joint Surgery (British volume) 89: 160-5.</td></tr>
<tr><td></td><td>All patients received modular Exeter femoral component (Howmedica, Sweden) with 28mm head.
All operations performed using a modified Hardinge anterolateral approach.
Patients allowed to sit on high chair immediately post-surgery; mobilised with full weight-bearing with the aid of two crutches as soon as tolerated, and mobilise without restriction after 6 weeks.</td></tr>
<tr><td>Length of follow up</td><td>12 months</td></tr>
<tr><td>Location</td><td>Sweden (single centre)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Hemiarthroplasty (N = 60)</th><th>Total hip replacement (N = 60)</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>
N/R
3 (5%)
14 (23.3%)</td><td>
N/R
4 (7%)
17 (28.3%)</td></tr>
<tr><td>Surgical revision by 1 year follow-up – n (%)</td><td>0 (0%)</td><td>2 (3%)</td></tr>
<tr><td>Functional status* - mean score (SD), n
• 1 year
• 5 years (reported at 4 years)</td><td>

79.4 (12.3), n = 55
75.2 (15.4), n = 41</td><td>

87.2 (9.4), n = 56
89.0 (8.1), n = 42</td></tr>
<tr><td>Quality of life - EQ-5D$_{index}$ score (mean) at 4 months</td><td>0.62 (No SD), n = 56</td><td>0.67 (No SD), n = 57</td></tr>
<tr><td>Length of stay</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence at 1 year
• Home**
• Residential care</td><td>
53/55
2/55</td><td>
54/56
2/56</td></tr>
<tr><td>Dislocation rate – n (%)</td><td>0 (0%)</td><td>0 (0%)</td></tr>
</table>
*reported as total Harris Hip Score (HHS) – note: standard deviations of mean scores are reported in secondary publication (Hedbeck 2011); primary publication reports score range (not extracted)
**reported as living in own home or housing for the elderly; residential = nursing home</td></tr>
</table>

Bibliographic reference	**Blomfeldt R, Törnkvist H, Eriksson K, et al. (2007) A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. Journal of Bone and Joint Surgery (British volume) 89: 160-5.**
	Other outcomes / timepoints reported were: ○ Mortality at 2 yrs; 4 yrs (Hedbeck 2011) ○ Intra-operative blood loss ○ Transfused blood volume ○ Complications relating to the hip (including dislocation, wound infection, acetablular erosion, post-operative fractures, loosening of prosthetic components) – at 4 months; 12 months ○ General post-operative complications – at 4 months ○ ADL status – at 4 months; 12 months ○ Place of residence – at 4 months ○ Hip function (total Harris hip score) at 4 months; 2yrs; 4 yrs (Hedbeck 2011) ○ Harris hip score subscale scores (Pain, Function, Absence of deformity, Range of movement) – 4 months; 2yrs; 4yrs (Hedbeck 2011)
Source of funding	Supported in part by a grant from the Trygg-Hansa Insurance Company and the Stockholm County Council. No commercial support/funding.
Comments	**Secondary publication:** • Hedbeck C, Enocson A, Lapidus G, Blomfeldt R, Tornkvist H, Ponzer S, and Tidermark J. (2011) Comparison of bipolar hemiarthroplasty with total hip replacement for displaced femoral neck fractures: A concise four-year follow-up of a randomised trial. Journal of Bone and Joint Surgery (American volume), 93: 445-50. Reports outcomes at 4 years. Baseline population SD (0.19) for EQ5D used for 4 month SD Methodology checklist **Selection bias: Adequate** – reported in Hedbeck (2011) that randomisation / treatment allocation was by opaque, sealed envelopes prepared independently, performed after assessment of fitness for surgery. **Performance bias:** Both arms received the same care apart from the intervention. No blinding. **Attrition bias:** No loss to follow-up. Groups were followed up for an equal length of time. All patients randomised completed treatment. ITT analysis used (regardless of secondary procedures). Groups were comparable at treatment completion.

Bibliographic reference	**Blomfeldt R, Törnkvist H, Eriksson K, et al. (2007) A randomised controlled trial comparing bipolar hemiarthroplasty with total hip replacement for displaced intracapsular fractures of the femoral neck in elderly patients. Journal of Bone and Joint Surgery (British volume) 89: 160-5.**
	Detection bias: Outcome assessor (research nurse) was unblinded to treatment group. Outcomes defined and valid and reliable measures used.

G.1.3.3 Cadossi 2013

Bibliographic reference	**Cadossi M, Chiarello E, Savarino L, et al. (2013) A comparison of hemiarthroplasty with a novel polycarbonate-urethane acetabular component for displaced intracapsular fractures of the femoral neck: a randomised controlled trial in elderly patients. The Bone & Joint Journal 95-B: 609-15**
Study type	RCT
Aim	To evaluate the functional outcome of displaced femoral neck fractures in elderly patients randomised to recive either a bipolar hemiarthroplasty or a total hip replacement using a polycarbonate-urethane (PCU) acetabular component (PCU-THR).
Patient characteristics	**Inclusion**: - displaced intracapcsular hip fracture / Garden III or IV - age ≥ 70 years - pre-injury independent walking without any aids **Exclusion:** - advanced osteoarthritis / rheumatoid arthritis in the fractured hip - suspected pathological fracture - senile dementia **Baseline characteristics**

	Hemiarthroplasty (N = 41)	PCU-THR (N = 42)
Age in years – mean (range)	84.2 (73 to 98)	82.3 (71 to 96)
Gender – n (%) Female	28 (68%)	34 (81%)
ASA status – n (%) • I • II • III	 1 (2.4%) 10 (24.4%) 22 (53.7%)	 2 (4.8%) 15 (35.7%) 16 (38.1%)

Bibliographic reference	**Cadossi M, Chiarello E, Savarino L, et al. (2013) A comparison of hemiarthroplasty with a novel polycarbonate-urethane acetabular component for displaced intracapsular fractures of the femoral neck: a randomised controlled trial in elderly patients. The Bone & Joint Journal 95-B: 609-15**
	• IV: 8 (19.5%); 9 (21.4%) Mobility assessment* / use of walking aids – n (%): 41 (100%); 42 (100%) Place of residence – n/N: N/R; N/R • Home • Residential care • Other Cognitive status / dementia: N/R; N/R Time to surgery** in days – mean (range): 3.6 (1 to 7); 2.9 (1 to 8) *patient inclusion criterion was 'pre-injury independent walking without any aids' **reported as time from trauma to surgery
Number of Patients	N = 83 (recruited between March 2008 and April 2010)
Intervention	Hemiarthroplasty (n = 41) - Bipolar femoral head (Centrax; Howmedica Stryker) + stem - Patients received either a cemented stem (n = 33, 80.5%) (Exeter; Howmedica Stryker) or uncemented stem (n = 8, 19.5%) (Conus; Zimmer), according to surgeon preference - Mean operating time (range): 81 mins (30 to 125) All operations performed by two experienced surgeons using straight lateral approach. Patients allowed to sit on high chair immediately post-surgery, mobilised to full weight-bearing using two crutches as tolerated and abandoned crutches at own convenience.
Comparison	PCU-THR (n = 42) - All patients received an uncemented stem (Conus; Zimmer) and large-diameter femoral head (Biomet) - Pliable 2.7mm thick hydrophilic polycarbonate-urethane (PCU) acetabular component (TriboFit Hip System) coupled with a 6mm smaller-diameter metal head. - Mean operating time (range): 75 mins (45 to 114) All operations performed by two experienced surgeons using straight lateral approach.

<table>
<tr><td>Bibliographic reference</td><td>Cadossi M, Chiarello E, Savarino L, et al. (2013) A comparison of hemiarthroplasty with a novel polycarbonate-urethane acetabular component for displaced intracapsular fractures of the femoral neck: a randomised controlled trial in elderly patients. The Bone & Joint Journal 95-B: 609-15</td></tr>
<tr><td></td><td>Patients allowed to sit on high chair immediately post-surgery, mobilised to full weight-bearing using two crutches as tolerated and abandoned crutches at own convenience.</td></tr>
<tr><td>Length of follow up</td><td>3 years</td></tr>
<tr><td>Location</td><td>Italy (single centre)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Hemiarthroplasty (N = 41)</th><th>PCU-THR (N = 42)</th></tr>
<tr><td>Mortality – n, (%)
• 30 days
• 1 year
• 5 years (3 years data used)</td><td>
N/R
8 (20%)
14 (34%)</td><td>
N/R
3 (7%)
9 (21%)</td></tr>
<tr><td>Surgical revision* – n, (%)
• 1 year
• 2 years
• 3 years</td><td>
0
0
0</td><td>
3 (7%)
6 (14%)
7 (17%)</td></tr>
<tr><td>Functional status** - mean score (range)
• 1 year
• 5 years (3 years data used)</td><td>
74.7 (No SD), n = 33
78.7 (No SD), n = 16</td><td>
73.1 (No SD), n = 36
71.3 (No SD), n = 16</td></tr>
<tr><td>Quality of life – Mean (SD)</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Length of stay** in days – mean (range)</td><td>8.7 (4 to 21)</td><td>9.9 (5 to 21)</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Dislocation rate by 3 years – n (%)</td><td>0</td><td>5 (12%)</td></tr>
</table>
*cumulative revisions (including 1 awaiting revision at 3 year follow-up)
**reported as Harris Hip Score (total score)
***reported as post-operative hospital stay</td></tr>
</table>

Bibliographic reference	**Cadossi M, Chiarello E, Savarino L, et al. (2013) A comparison of hemiarthroplasty with a novel polycarbonate-urethane acetabular component for displaced intracapsular fractures of the femoral neck: a randomised controlled trial in elderly patients. The Bone & Joint Journal 95-B: 609-15**
	Other outcomes / timepoints reported were: ○ Perioperative blood loss ○ Mortality – 2 years; 3 years ○ Survival rate over 3 years ○ Functional status (total Harris Hip score) – 3 months; 2 years; 3 years ○ Functional status (Pain subscale of Harris Hip score) – 3 months, 1 year; 2 years; 3 years ○ Functional status (Function subscale of Harris Hip score) - 3 months, 1 year; 2 years; 3 years ○ Heteroptopic ossification (Brooker score) at longest available follow-up
Source of funding	No outside or commercial funding or support.
Comments	Methodology checklist **Selection bias: Inadequate** – 'sealed envelopes opened before surgery'. No further information e.g. whether envelopes were opaque and numbered. Treatment groups comparable at baseline. **Performance bias:** Both arms received the same care apart from the intervention. Blinding not reported. **Attrition bias:** Unclear loss to follow-up. **Detection bias: Outcome assessor blinding not reported.** Outcomes defined and valid and reliable measures used.

G.1.3.4 Dorr 1989

Bibliographic reference	**Dorr L, Glousman R, Sew Hoy A, et al. (1986) Treatment of femoral neck fractures with total hip replacement versus cemented and noncemented hemiarthroplasty. Journal of Arthroplasty, 1: 21-28.**
Study type	RCT
Aim	To determine advantages or disadvantages of total hip replacement versus hemiarthroplasty and cemented or uncemented hemiarthroplasty.

<table>
<tr><td>Bibliographic reference</td><td>Dorr L, Glousman R, Sew Hoy A, et al. (1986) Treatment of femoral neck fractures with total hip replacement versus cemented and noncemented hemiarthroplasty. Journal of Arthroplasty, 1: 21-28.</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion:
- Displaced intracapsular femoral neck fracture (Garden III or IV)
- Aged >55 years
- Ambulatory
- Mental status I - alert and oriented, or Mental status II - experiences periods of confusion but oriented to time, place and person

Baseline characteristics
<table>
<tr><th></th><th>Cemented hemiarthroplasty (N = 37)</th><th>Uncemented hemiarthroplasty (N = 13)</th><th>Cemented and uncemented hemiarthroplasty combined[1] (N = 50)</th><th>Total hip replacement (N = 39)</th></tr>
<tr><td>Age – Mean (range)</td><td>72 (53 to 89)</td><td>66 (41 to 85)</td><td>70 (41 to 89)</td><td>69 (51 to 87)</td></tr>
<tr><td>Gender – female n (%)</td><td>26 (70%)</td><td>9 (69%)</td><td>35 (70%)</td><td>23 (59%)</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment* / use of walking aids – n (%)</td><td>37 (100%)</td><td>13 (100%)</td><td>50 (100%)</td><td>39 (100%)</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td>N/R</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Cognitive status* / dementia – n (%)
• Mental status I
• Mental status II</td><td>
27 (73%)
10 (27%)</td><td>
11 (85%)
2 (15%)</td><td>
38 (76%)
12 (24%)</td><td>
32 (82%)
7 (18%)</td></tr>
<tr><td>Time since admission</td><td>N/R</td><td>N/R</td><td>N/R</td><td>N/R</td></tr>
</table>
*’ambulatory’ was an inclusion criterion for this study

Other baseline characteristics reported were: ethnicity, left or right hip fracture.</td></tr>
<tr><td>Number of Patients</td><td>N = 89, recruited between March 1980 and July 1982.</td></tr>
<tr><td>Intervention</td><td>(i) Hemiarthroplasty – cemented (N = 37)</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Dorr L, Glousman R, Sew Hoy A, et al. (1986) Treatment of femoral neck fractures with total hip replacement versus cemented and noncemented hemiarthroplasty. Journal of Arthroplasty, 1: 21-28.</td></tr>
<tr><td></td><td>- Bipolar hip replacement with smooth stem
- Ball size matched anatomically (no further details re: prosthesis)

(ii) Hemiarthroplasty – uncemented (N = 13)[1]
- Bipolar hip replacement with smooth stem
- Full complement of femoral stems available (no further details re: prosthesis)

All surgeries performed through posterior approach to hip.
All patients progressively ambulated from second postoperative day.</td></tr>
<tr><td>Comparison</td><td>Total hip replacement (THR) (N = 39)
- 28mm head used (no further details re: prosthesis)

All surgeries performed through posterior approach to hip.
All patients progressively ambulated from second postoperative day.</td></tr>
<tr><td>Length of follow up</td><td>Mean: 24 months (range 2-4 years)</td></tr>
<tr><td>Location</td><td>USA (single centre)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Cemented hemiarthroplasty (N = 37)</th><th>Uncemented hemiarthroplasty (N = 13)</th><th>Cemented and uncemented hemiarthroplasty combined[1] (N = 50)</th><th>Total hip replacement (N = 39)</th></tr>
<tr><td>Mortality*</td><td>N/R</td><td>N/R</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Surgical revision** – n/N</td><td>3 (8%)</td><td>1 (8%)</td><td>4 (8%)</td><td>2 (5%)</td></tr>
<tr><td>Functional status
Ambulation*** - mean score (6 point scale)
• 1 year</td><td>4.2</td><td>3.0</td><td>3.9</td><td>4.1</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Dorr L, Glousman R, Sew Hoy A, et al. (1986) Treatment of femoral neck fractures with total hip replacement versus cemented and noncemented hemiarthroplasty. Journal of Arthroplasty, 1: 21-28.**

• 5 years	N/R	N/R	N/R	N/R
Using walker / crutches – n (%)				
• 1 year	6 (16%)	9 (70%)	15 (56%)	7 (18%)
• 5 years	N/R	N/R	N/R	N/R
Quality of life – Mean (SD)	N/R	N/R	N/R	N/R
Length of stay – Mean (SD)	N/R	N/R	N/R	N/R
Place of residence at 1 year	N/R	N/R	N/R	N/R
Dislocation rate – n (%)	1 (2%)	1 (2%)	2 (4%)	7 (18%)

*only reports overall mortality rates (not by treatment group)
**reported as reoperations within follow-up period
*** reported as Ambulation subscale score of modified scale described by Charnley (1972)

Other outcomes / timepoints reported were:

- Pain subscale score of modified scale described by Charnley - 3 months; 24 months
- Ambulation subscale score of modified scale described by Charnley – 3 months; 12 months; 24 months
- No (%) of patients remaining ambulatory until death / final follow-up
- Heterotopic ossification
- Stem subsidence

Source of funding	Not reported
Comments	Methodology checklist **Selection bias: Inadequate** – sequence generation based on patient hospital number (odd / even). Fewer females in THR group (59% vs. 70%).

Bibliographic reference	**Dorr L, Glousman R, Sew Hoy A, et al. (1986) Treatment of femoral neck fractures with total hip replacement versus cemented and noncemented hemiarthroplasty. Journal of Arthroplasty, 1: 21-28.**
	Performance bias: Post-operative treatment protocol same for all groups. Note: during first year THR and cemented hemiarthroplasty were performed; during 2nd year THR and uncemented hemiarthroplasty were done until decision was made to stop uncemented hemiarthroplasty due to poor outcomes. Blinding not reported. **Attrition bias:** Loss to follow-up is unclear. Unclear if both groups were followed up for same duration. **Detection bias: Outcome assessor not blinded.** Outcomes defined but poorly reported – no indication of follow-up sample sizes as mortality rates are not given per treatment group.

1 Outcome data have been combined for analysis purposes for the two hemiarthroplasty groups because the use of uncemented arthroplasty was discontinued early in this trial and the review protocol specified that within-group comparisons were not the focus of this review.

G.1.3.5 Keating 2005a

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
Study type	RCT
Aim	To compare the impact on functional outcome, clinical parameters and resource utilisation, more than two years after surgery, of treatment using internal fixation, bipolar hemiarthroplasty or total hip replacement for displaced intracapsular hip fractures in previously healthy, mobile patients[1].
Patient characteristics	**Inclusion:** - Aged > 60yrs - Normal cognitive function (Mini Mental Test score >6) - Independently mobile prior to fracture - No serious concomitant disease (e.g. malignancy) or other clinical reason for exclusion **Exclusion:** - Undisplaced or valgus impacted fracture **Baseline characteristics[1]**

	Hemiarthroplasty (N = 69)	Total hip replacement (N = 69)

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**

Age in years – mean (SD)	75.0 (6)	75.2 (6)
Gender – Female n (%)	54 (78)	52 (75)
ASA status	N/R	N/R
Mobility assessment / use of walking aids	N/R	N/R
Place of residence	N/R	N/R
Cognitive status / dementia*	N/R	N/R
Time since admission*	N/R	N/R

* inclusion required Mini Mental Test score >6

**reports that all operations were conducted within 48 hours of entry to the trial and that surgery was usually undertaken the day following patient's admission to hospital.

Other baseline data reported:

- No (%) with left / right-sided fracture
- No (%) taking regular medication prior to trial entry
- No (%) of operations performed by a consultant

Number of Patients	N = 138 patients recruited June 1996 – May 2000, randomised to either hemiarthroplasty or THR (as part of 3-way comparison element of this study). Data not extracted for internal fixation treatment group(n = 69)
Intervention	Hemiarthroplasty (n = 69) - Bipolar with cement (however 2 patients (3%) received unipolar) - Choice of approach (lateral / posterior) was at surgeon discretion. 93% used lateral approach - 38% had general anaesthetic; 62% had regional anaesthetic - Operating time in mins – mean (SD): 58.5 mins (21) - 25% of operations undertaken by Consultant grade surgeon
Comparison	Total hip replacement (n = 69)

<table>
<tr><td>Bibliographic reference</td><td>Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.</td></tr>
<tr><td></td><td>- With cement
- Choice of approach (lateral / posterior) was at surgeon discretion. 88% used lateral approach
- 30% had general anaesthetic; 70% had regional anaesthetic
- Operating time in mins – mean (SD): 79.7 mins (26)
- 42% of operations undertaken by Consultant grade surgeon</td></tr>
<tr><td>Length of follow up</td><td>2 years</td></tr>
<tr><td>Location</td><td>Scotland, UK (11 centres)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results[1]
<table>
<tr><th></th><th>Hemiarthroplasty (N = 69)</th><th>Total hip replacement (N = 69)</th></tr>
<tr><td>Mortality – n (%)
• 30 days*
• 1 year
• 5 years (2 year data used)</td><td>
NR
6 (9%)
9 (13%)</td><td>
NR
4 (6%)
6 (9%)</td></tr>
<tr><td>Surgical revision** at 2 years- n (%)</td><td>5 (7%)</td><td>6 (9%)</td></tr>
<tr><td>Functional status*** mean (SD), n
• 1 year
• 5 years (2 year data used)</td><td>
76.5 (13), n = 51
73.8 (16), n = 50</td><td>
79.4 (17), n = 54
79.9 (17), n = 56</td></tr>
<tr><td>Quality of life**** (EQ5D at 4 months) – mean (SD), n</td><td>0.60 (0.31), n = 64</td><td>0.68 (0.24), n = 66</td></tr>
<tr><td>Length of stay in days – mean (SD)</td><td>11.5 (8)</td><td>12.3 (10)</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Dislocation rate***** at 2 years n (%)</td><td>2</td><td>3</td></tr>
</table>
*reported as death during index admission</td></tr>
</table>

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**

**reported as cumulative no. requiring further surgery from operation date

***reported as overall Hip Rating Questionnaire (HRQ) score (max = 100). Individual subscale scores for global, pain, walking and function reported but not extracted.

****reported as EQ-5D utility score (numbers (%s) in each EQ-5D subscale category, self-reported change in overall health score and 'thermometer' score also reported but not extracted).

*****reported as cumulative dislocations from operation date

Subgroups

	Hemiarthroplasty (max N = 65)	Total hip replacement (max N = 66)
Functional status* (AGE) - mean score (SD)		
12 months		
• 60 to 74yrs	76.3 (14)	85.3 (13)
• ≥75yrs	75.8 (14)	73.7 (18)
24 months		
• 60 to 74yrs	74.4 (15)	87.2 (14)
• ≥75yrs	72.8 (17)	74.5 (17)

* reported as overall Hip Rating Questionnaire (HRQ) score (max score = 100).

Other outcomes / timepoints reported were:

- Mortality - at 4 months; 24 months
- Hip Rating Questionnaire (HRQ) - at 4 months; 24 months
- EQ-5D - at 4 months
- Serious morbidity – at 4 months; 12 months; 24 months
- Hospital admission for serious hip-related problems - at 4 months; 12 months; 24 months
- Discharge destination (home / nursing home / rehabilitation unit / other)
- No (%) requiring intensive / HDU care post-operatively

Bibliographic reference	**Keating J, Grant A, Masson M, et al. (2005) Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technology Assessment Vol 9: 41.**
	○ Intraoperative blood transfusion rate
Source of funding	Funded by grant from the NHS Health Technology Assessment programme.
Comments	**Secondary publication:** • Keating J, Grant A, Masson M, Scott N, and Forbes J on behalf of Scottish Orthopaedic Trials Network (2006) Randomized comparison of reduction and fixation, bipolar hemiarthroplasty, and total hip replacement.The Journal of Bone and Joint Surgery, 88: 249-260. <u>Methodology checklist</u> **Selection bias: Adequate -** centralised, independent computerised randomisation via telephone. Allocation stratified by surgeon code and minimised on age category (60-74, 75yrs+) and gender. Treatment groups were comparable at baseline. **Performance bias:** All groups received the same care apart from the intervention received. Not possible to blind patients or care providers as post-operative management (including types of complication) differ between treatments and patients needed to consent to actual allocated operation. **Attrition bias:** <5% loss to follow-up. All groups were followed up for an equal length of time. All patients randomised completed treatment. ITT analysis used. Groups were comparable at treatment completion. **Detection bias: Outcome assessor not blinded** – self-report measures of functioning and QoL were used; research nurses co-ordinated data collection, but states: “when recording further surgery or operative complications it would usually be apparent to which group a patient was originally allocated”. Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

[1] *Data extracted for two treatment arms (hemiarthroplasty and total hip replacement) of the 3-group randomised comparison reported in this study (i.e. internal fixation vs. hemiarthroplasty vs. total hip replacement)*

G.1.3.6 Macaulay 2008

Bibliographic reference	**Macaulay W, Nellans K, Garvin K, et al. (2008a) Prospective randomized clinical trial comparing hemiarthroplasty to total hip arthroplasty in the treatment of displaced femoral neck fractures. Journal of Arthroplasty, 23 (6), Suppl 1: 2-8.**
Study type	RCT
Aim	To compare hemiarthroplasty to total hip replacement in the treatment of displaced femoral neck fractures in active, independent elderly patients.
Patient characteristics	**Inclusion:** - Displaced femoral neck fracture (Garden II or IV) which the surgeon considered not amenable to treatemtn with internal fixation - Aged >50yrs - Ability for independent ambulation prior to fracture - Able to understand and read English or Spanish - Cognitively unimpaired **Exclusion:** - Cognitive impairment (defined as <23 of 30 on Folstein Mini Mental State examination (MMMSE)) - Pathological fracture - Other concomitant long bone fractures or fractures requiring surgical repair - Pre-existing arthritis of the ipsilateral hip **Baseline characteristics**

	Hemiarthroplasty (N = 23)	**Total hip replacement (N = 17)**
Age in years – mean (SD)	77 (9)	82 (7)
Gender – female n (%)	14 (61%)	7 (41%)
ASA status	N/R	
Mobility assessment* – n (%)	23 (100%)	17 (100%)
Place of residence	N/R	N/R
Cognitive status / dementia**	0	0
Time since admission	N/R	N/R

*capable of pre-fracture independent ambulation was a criterion for inclusion to the study

<table>
<tr><td>Bibliographic reference</td><td>Macaulay W, Nellans K, Garvin K, et al. (2008a) Prospective randomized clinical trial comparing hemiarthroplasty to total hip arthroplasty in the
treatment of displaced femoral neck fractures. Journal of Arthroplasty, 23 (6), Suppl 1: 2-8.</td></tr>
<tr><td></td><td>**all patients scored >23 on Folstein Mini Mental State examination (MMMSE) indicating absence of dementia (see inclusion/exclusion criteria)

Other baseline characteristics reported:
○ ethnicity
○ average no. of comorbid conditions</td></tr>
<tr><td>Number of Patients</td><td>N = 40</td></tr>
<tr><td>Intervention</td><td>Hemiarthroplasty (N = 23)
- Unipolar or bipolar prosthesis (surgeon choice) – 18 (78%) had unipolar
- Cemented or uncemented femoral stem (surgeon choice)
- Mean operating time (SD): 82 mins (35)
Types of implants used were down to participating surgeon / hospital choice</td></tr>
<tr><td>Comparison</td><td>Total hip replacement (n = 17)
- Protocol stipulated use of femoral head of 28mm or more
- Cemented or uncemented femoral stem (surgeon choice)
- Mean operating time (SD): 89 mins (36)
Types of implants used were down to participating surgeon / hospital choice</td></tr>
<tr><td>Length of follow up</td><td>24 months</td></tr>
<tr><td>Location</td><td>USA (5 centres)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Hemiarthroplasty (N = 23)</th><th>Total hip replacement (N = 17)</th></tr>
<tr><td>Mortality* – n (%)
• 30 days</td><td>
NR</td><td>
NR</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Macaulay W, Nellans K, Garvin K, et al. (2008a) Prospective randomized clinical trial comparing hemiarthroplasty to total hip arthroplasty in the treatment of displaced femoral neck fractures. Journal of Arthroplasty, 23 (6), Suppl 1: 2-8.**

• 1 year • 5 years (34 month data used)	NR 9 (39.1%)	NR 5 (29.4%)
Surgical revision** – n (%)	0 (0%)	1 (16%)
Functional status*** - mean (SD), n • 1 year • 5 years (2 year data used)	 80.6 (14.3), n = 18 81.1 (11.7), n = 14	 84.2 (12.0), n = 16 84.0 (12.2), n = 14
Quality of life**** – mean (SD)	NR	NR
Length of stay in days – mean (SD)	5.4 (2.8)	7.7 (5.5)
Place of residence at 1 year	N/R	N/R
Dislocation rate** - n (%)	0 (0%)	1 (6%)

*reported as deaths within 6 months of index surgery

**surgical revisions and dislocations reported within 6 months of surgery

***measured as Harris Hip Score (1-100, injured side)

Other outcomes / timepoints reported were:

- Mortality at mean follow-up of 19 months (range: 13-33 months; Macaulay 2008); at mean follow-up of 34 months (range: 29-42 months; Macaulay 2008a)
- Other adverse events within 6 months of surgery (Macaulay 2008a)
- Timed 'up and go' functional mobility assessment at 6 months (Macaulay 2008b); 12 months and 24 months (Macaulay 2008a)
- WOMAC (osteoarthritic) scores for pain, stiffness and function at 6 months (Macaulay 2008b); 12 months and 24 months (Macaulay 2008a)
- SF-36 subscales scores at 6 months (Macaulay 2008b) and 24 months (Macaulay 2008a)
- Harris Hip Score at 6 months (Macaulay 2008b) and 24 months (Macaulay 2008a)

Source of funding	Funded with grants from Orthopaedic Research and Education Foundatin and American Association of Hip and Knee Surgeons.
Comments	**Secondary publication:**

Bibliographic reference	**Macaulay W, Nellans K, Garvin K, et al. (2008a) Prospective randomized clinical trial comparing hemiarthroplasty to total hip arthroplasty in the treatment of displaced femoral neck fractures. Journal of Arthroplasty, 23 (6), Suppl 1: 2-8.**
	• Macaulay W, Nellans K, Iorio R, Garvin K, Healy W, Rosenwasser M, and the DEFACTO Consortium. (2008b) Total hip arthroplasty is less painful after 12 months compared with hemiarthroplasty in treatment of displaced femoral neck fracture. HSSJ: Hospital for Special Surgery, 4: 48-54. Originally aimed for 200 patients but enrolment capped at 40 (due to recruitment difficulties – majority of patients did not meet criteria for cognitive score ≥23). Study powered to detect an effect of 11 points on three SF-36 subscales with α = 0.05 and 80% power. Methodology checklist **Selection bias: Adequate** - sealed opaque envelopes containing blocked randomisation scheme, opened prior to operation (to allow appropriate set-up). Block randomisation scheme verified for compliance at each study centre by coordinating centre. Treatment groups comparable at baseline. **Performance bias:** Both arms received the same care apart from the intervention. No blinding. **Attrition bias:** Loss to follow-up not reported. ITT analysis used. Groups were followed up for an equal length of time. **Detection bias: Outcome assessor not blinded.** Outcomes defined and valid and reliable measures used.

G.1.3.7 Mouzopoulos 2008

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**
Study type	RCT
Aim	To estimate the functional restitution of patients up to 4 years after the surgical treatment of a displaced subcapital hip fracture, comparing three surgical options: internal fixation, hemiarthroplasty and total hip replacement (THR).[1]
Patient characteristics	**Inclusion:** - displaced subcapital hip fracture (Garden III or IV) after a fall **Exclusion:** - previous hip fracture - history of cancer or Paget's disease,

Bibliographic reference	Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.

- rheumatic arthritis

Baseline characteristics[2]

	Hemiarthroplasty (N = 34)	Total hip replacement (N = 37)
Age in years – mean	74.2 ± 3.8	73.1 ± 4.9
Gender – Female n (%)	24 (71%)	28 (76%)
ASA status (1-4) - mean	2.2 ±1.9	2.0 ± 2.0
Mobility assessment* / use of walking aids – n (%)	34 (100%)	37 (100%)
Place of residence – n (%) • Home** • Residential care	 34 (100%) 0	 37 (100%) 0
Cognitive status / dementia*** - mean	7.5 ± 3.1	7.9 ± 2.6
Time since admission**** - mean	45.8 ± 2.4	45.2 ± 7.3

*reported as 'ambulatory'

**reported as 'own home or living with relatives' (all but 2 patients were living with relatives)

***measured using Short Portable Mental Status Questionnaire (SPMSQ, score 0-10)

****reported as mean pre-operative waiting time (presumably in hours)

Number of Patients	N = 86 across two of the three treatment groups compared (data not extracted for internal fixation group), but states that 7 patients were subsequently excluded due to prior history of hip fracture. Baseline data are given for N = 109 participants in the three treatment groups; outcome data reported for N = 129 – unclear which other patients are excluded from baseline information. Participants recruited between April 1999 to April 2002.

<table>
<tr><td>Bibliographic reference</td><td>Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.</td></tr>
<tr><td>Intervention</td><td>Hemiarthroplasty (N = 43 randomised)
- Merete (Berlin, Germany). No further details.

Postoperatively in the hospital and after discharge, all patients received the same rehabilitation programme</td></tr>
<tr><td>Comparison</td><td>Total hip replacement (THR; N = 43 randomised)
- Plus; De Puy (Warsaw, IN, USA). No further details.

Postoperatively in the hospital and after discharge, all patients received the same rehabilitation programme</td></tr>
<tr><td>Length of follow up</td><td>4 years</td></tr>
<tr><td>Location</td><td>Greece (number of study centres unclear).</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Hemiarthroplasty (N = 43)</th><th>Total hip replacement (N = 43)</th></tr>
<tr><td>Mortality – n/N
• 30 days
• 1 year
• 5 years (4 year data used)</td><td>
N/R
6 (14%)
13 (30%)</td><td>
N/R
6 (14%)
15 (35%)</td></tr>
<tr><td>Surgical revision* – n (%)
• by 1 year
• by 4 years</td><td>
2 (5%)
5 (12%)</td><td>
0
1 (2%)</td></tr>
<tr><td>Functional status** - mean, n
• 1 year
• 5 years (4 year data used)</td><td>
77.8 (9.6), n = 30
79.5 (6.5), n = 20</td><td>
81.6 (4.9), n = 33
83.7 (4.8), n = 23</td></tr>
<tr><td>Quality of life</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Length of stay in days – mean</td><td>9.1 (3.4)</td><td>8.3 (6.2)</td></tr>
<tr><td>Place of residence at 1 year</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Dislocation rate</td><td>N/R</td><td>N/R</td></tr>
</table>
*Cumulative revisions throughout follow-up period</td></tr>
</table>

Bibliographic reference	**Mouzopoulos G, Stamatakos M, Arabatzi H, et al. (2008) The four-year functional result after a displaced subcapital hip fracture treated with three different surgical options. International Orthopaedics, 32: 367-73.**
	reported as Harris Hip Score (overall score) **Other outcomes / timepoints reported were: ○ Mortality at 4 years ○ Functional status (Harris Hip Score) at discharge; at 4 years ○ Bartel (activities of daily living) Index Score at discharge; 1 year; 4 years
Source of funding	Not reported.
Comments	Methodology checklist **Selection bias: Inadequate** - one patient selected for entry to study every third admission; the 129 participants were randomly divided by two orthopaedic surgeons into three groups in following order: hemi-arthroplasty, total arthroplasty, internal fixation. Unclear reporting of baseline data: sample sizes do not correspond with study flowchart. **Performance bias:** All groups received the same care apart from the interventions. No indication participants / care providers were blinded to treatment. **Attrition bias:** <2% loss to follow-up. No intention-to-treat analysis: patients who subsequently underwent revision surgery were excluded from follow-up analyses (5 INF and 2 HEMI patients by 12 months; 12 INF and 5 HEMI by 4 years). **Detection bias: Outcome assessors blinded.** Study had an appropriate length of follow up. Outcomes defined and valid and reliable measures used.

[5] *Only data corresponding to two treatment arms (hemiarthroplasty and THR) are extracted.*
[6] *Sample sizes do not correspond with study flowchart re: exclusions due to prior history of hip fracture, mortality or missing data.*

G.1.3.8 Skinner 1989

Bibliographic reference	**Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.**
Study type	RCT
Aim	To determine the relative mortality, morbidity and eventual mobility of patients following three methods of treatment of subcapital fracture of the femur: internal fixation, hemiarthroplasty and total hip replacement[1].

<table>
<tr><td>Bibliographic reference</td><td>Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion:
- patients over the age of 65 years
- admitted with a displaced subcapital femoral neck fracture (Garden grades III and IV)
- any cognitive status
Exclusion:
- old fractures or pathological fractures
- rheumatoid arthritis
- doubt regarding the displacement or grading of the fracture

Baseline characteristics
<table>
<tr><th></th><th>Hemiarthroplasty (N = 91)</th><th>Total hip replacement (N = 89)</th></tr>
<tr><td>Age in years – mean*</td><td>82.1</td><td>81.0</td></tr>
<tr><td>Gender**</td><td>N/R</td><td>N/R</td></tr>
<tr><td>ASA status</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Mobility assessment / use of walking aids</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Cognitive status / dementia</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Time since admission</td><td>N/R</td><td>N/R</td></tr>
</table>
*SD not reported
**90% female (reported for full sample only)</td></tr>
<tr><td>Number of Patients</td><td>N = 180 patients across 2 of the 3 treatment groups compared (data for internal fixation group not extracted)
Recruitment period: December 1984 to December 1986</td></tr>
<tr><td>Intervention</td><td>Hemiarthroplasty (N = 91)
- uncemented Austin Moore prosthesis
- posterolateral approach
- mean operation time not reported</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.</td></tr>
<tr><td></td><td>Operations performed as soon as practicable – usually within 24 h of admission. Most surgeons were registrar grade, but some were consultants or senior house officers.

All patients were mobilized, fully weight bearing, usually within 48 h, and discharged or transferred as soon as practicable.</td></tr>
<tr><td>Comparison</td><td>Total Hip Replacement (N = 89)
- cemented Howse II prosthesis using a semicaptive cup and a 32 mm head
- posterolateral approach
- mean operation time not reported

Operations performed as soon as practicable – usually within 24 h of admission. Most surgeons were registrar grade, but some were consultants or senior house officers.

All patients were mobilized, fully weight bearing, usually within 48 h, and discharged or transferred as soon as practicable.</td></tr>
<tr><td>Length of follow up</td><td>1 year (Skinner 1989)
13 years (Ravikumar 2000)</td></tr>
<tr><td>Location</td><td>UK (single centre)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Hemiarthroplasty (N = 91)</th><th>Total hip replacement (N = 89)</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>
N/R
25 (27%)
78</td><td>
N/R
20 (23%)
72</td></tr>
<tr><td>Surgical revision* – n (%)
• by 1 year</td><td>
12 (13%)</td><td>
4 (4%)</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.**

• by 13 years	22 (24%)	6 (7%)
Functional status**	N/R	N/R
Quality of life	N/R	N/R
Length of stay	N/R	N/R
Place of residence at 1 year	N/R	N/R
Dislocation rate – n (%)		
• by 1 year	10 (11%)	11 (12%)
• by 13 years	12 (13%)	18 (20%)

*cumulative revisions within time period (data from medical records of survivors and dead patients). Only percentages are given; raw numbers calculated by reviewer (13 year data from Ravikumar 2000).
**Harris Hip Score (overall mean score) reported for survivors at 13 years only (Ravikumar 2000)
***used grading of pain and mobility scale devised by Sikorski & Barrington, 1981. Assumed 1 and 13-year data based on clinical review or questionnaire responses of survivors. Only percentages are given so raw numbers (including sample sizes) were calculated by reviewer.

Other outcomes / timepoints reported were:

- % mortality at 2 months (Skinner 1989); at 13 years (Ravikumar 2000)
- % requirement for second anaesthetic for local complication within 12 months (Skinner 1989)
- % with infection (superficial and deep) at 13 years (Ravikumar 2000)
- Mean Harris Hip score (survivors) at 13 years (Ravikumar 2000)
- Mean time to revision (months) (Ravikumar 2000)

Source of funding	Funding support for research staff from Johnson & Johnson plc.
Comments	**Secondary publication:** • Ravikumar K, Marsh G. (2000) Internal fixation versus hemiarthroplasty versus total hip arthroplasty for displaced subcapital fractures of femur — 13 year results of a prospective randomised study. Injury, 31: 793-7. Methodology checklist

Bibliographic reference	**Skinner P, Riley D, Ellery J, et al. (1989) Displaced subcapital fractures of the femur: a prospective randomized comparison of internal fixation, hemiarthroplasty and total hip replacement. Injury, 20: 291-3.**
	Selection bias: Inadequate – patients were randomly allocated to the three methods of treatment according to the day of the week on which they were admitted. States groups were matched on baseline criteria (fitness, ability, accommodation), but insufficient detail presented to verify. **Performance bias:** Both arms received the same care apart from the intervention. Blinding not reported. **Attrition bias:** Loss to follow-up unclear. Poor reporting – outcomes presented as percentages with no sample sizes - no indication of intention-to-treat analysis. Pain and mobility data assumed to correspond only to survivors. **Detection bias: Outcome assessor not blinded.** Outcomes defined and valid and reliable measures used.

[2] *Only data corresponding to two treatment arms (hemiarthroplasty and THR) are extracted.*

G.1.3.9 van den Bekerom 2010

Bibliographic reference	**van den Bekerom M, Hilverdink E, Sierevelt I, et al. (2010) A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck. Journal of Bone and Joint Surgery (British volume) 92-B: 1422-8.**
Study type	RCT
Aim	To analyse the functional outcome of displaced femoral neck fractures in patients aged 70 years or over, who were physically and mentally healthy, and randomised to receive either a bipolar hemiarthroplasty or a total hip replacement (THR).
Patient characteristics	**Inclusion:** - patients admitted with a displaced intracapsular femoral neck fracture - age ≥ 70 years - no known metastatic disease - no contraindication to anaesthesia - able to understand written Dutch **Exclusion:** - advanced radiological osteoarthritis or rheumatoid arthritis in the fractured hip - suspected pathological fracture - bedridden or barely mobile bed to chair - significant senile dementia. **Baseline characteristics**

<table>
<tr><td>Bibliographic reference</td><td>van den Bekerom M, Hilverdink E, Sierevelt I, et al. (2010) A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck. Journal of Bone and Joint Surgery (British volume) 92-B: 1422-8.</td></tr>
<tr><td></td><td>
<table>
<tr><th></th><th>Hemiarthroplasty (N = 137)</th><th>Total hip replacement (N = 113)</th></tr>
<tr><td>Age in years – mean (range)</td><td>80.3 (70.2 to 93.9)</td><td>82.1 (70.1 to 95.6)</td></tr>
<tr><td>Gender – Female n (%)</td><td>115 (84%)</td><td>90 (78%)</td></tr>
<tr><td>ASA status – n (%)
• I
• II
• III
• IV
Unknown</td><td>
19 (14%)
77 (56%)
33 (24%)
5 (4%)
3 (2%)</td><td>
11 (10%)
48 (42%)
44 (38%)
10 (9)
0</td></tr>
<tr><td>Mobility assessment* - n (%)</td><td>85 (62%)</td><td>64 (56%)</td></tr>
<tr><td>Place of residence</td><td>N/R</td><td></td></tr>
<tr><td>Cognitive status / dementia</td><td>N/R</td><td>N/R</td></tr>
<tr><td>Time since admission** – mean (range)</td><td>1.0 (0 to 10)</td><td>1.0 (0 to 9)</td></tr>
</table>
*reported as mobility without use of a stick
**reported as mean interval between trauma and surgery in days

Other baseline data reported:
○ No. (%) with right / left sided fracture
○ No.% with pre-fracture ability to climb stairs normally / using rail
○ No. (%) with specified comorbidities
○ No. (%) never using analgesic medication</td></tr>
<tr><td>Number of Patients</td><td>N = 252</td></tr>
<tr><td>Intervention</td><td><u>Hemiarthroplasty</u> (N = 137)
○ Bipolar. One of two types of cemented femoral prostheses were implanted - Weber Rotationsprosthese (Sulzer AG, Winterthur, Switzerland) or a Müller Geradschaftprothese (Protek AG, Münsingen, Switzerland)
○ Femoral component was available in 2 mm increments</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>van den Bekerom M, Hilverdink E, Sierevelt I, et al. (2010) A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck. Journal of Bone and Joint Surgery (British volume) 92-B: 1422-8.</td></tr>
<tr><td></td><td>○ Surgeons used own judgement re: surgical approach – 96% were anterolateral, 4% posterolateral
○ 25% of operations undertaken by consultant; 75% resident (under direct supervision of experienced surgeon)
○ Duration of operation - n (%):
• < 1 hour 44 (35)
• 1 to 1.5 hours 66 (53)
• > 1.5 hours 15 (12)
• Unknown 22 (16)
Patients in both groups were mobilised bearing full weight as tolerated with aid of crutches; allowed to sit on a high chair immediately after surgery; abandoned crutches at their convenience. After six weeks patients were allowed to mobilise without further restriction.</td></tr>
<tr><td>Comparison</td><td><u>Total hip replacement</u> (N = 115)
○ One of two types of cemented femoral prostheses were implanted - Weber Rotationsprosthese (Sulzer AG, Winterthur, Switzerland) or a Müller Geradschaftprothese (Protek AG, Münsingen, Switzerland)
○ Used a 32 mm diameter modular head.
○ Surgeons used own judgement re: surgical approach – 81% were anterolateral, 19% posterolateral
○ 57% of operations undertaken by consultant; 43% resident (under direct supervision of experienced surgeon)
○ Duration of operation (%)
• < 1 hour 10 (10)
• 1 to 1.5 hours 65 (57)
• > 1.5 hours 30 (20)
• Unknown 10 (9)</td></tr>
<tr><td>Length of follow up</td><td>5 years</td></tr>
<tr><td>Location</td><td>The Netherlands (eight centres)</td></tr>
<tr><td>Outcomes measures and effect size</td><td>Results
<table>
<tr><th></th><th>Hemiarthroplasty (N = 137)</th><th>Total hip replacement (N = 115)</th></tr>
<tr><td>Mortality – n/N</td><td></td><td></td></tr>
</table></td></tr>
</table>

Bibliographic reference	van den Bekerom M, Hilverdink E, Sierevelt I, et al. (2010) A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck. Journal of Bone and Joint Surgery (British volume) 92-B: 1422-8.

• 30 days* • 1 year • 5 years	7 (5%) 18 (13%) 61 (45%)	5 (4%) 16 (14%) 71 (62%)
Surgical revision** – n (%) • 1 year • 5 years	 1 (0.7%) 6 (4.4%)	 0 (0%) 2 (1.7%)
Functional status*** • 1 year – mean (range), n • 5 years – mean (SD), n	 73.9 (23 to 100), n = 119 71.9 (33 to 99), n = 76	 76.0 (44 to 100), n = 99 75.2 (45 to 96), n = 44
Quality of life	N/R	N/R
Length of stay in days – mean (range)	17.1 (2 to 89)	18.4 (4 to 86)
Place of residence at 1 year	N/R	N/R
Dislocation rate – n (%) • 5 years	 0 (0%)	 8 (7%)

*reported as mortality during hospital stay

**cumulative total over follow-up period

***reported as modified Harris Hip Score (HHS; max score = 100). Subscale scores for pain and function not extracted. Note:mean score (range) reported in paper but a published meta-analysis by Burgers et al. (2012) gives SD for 5-year HHS data (van den Bekerom was co-author, so assume SD was obtained from primary data source)

Other outcomes / timepoints reported were:

- Perioperative blood loss
- HHS Pain score at 1 year; 5 years
- HHS Function score at 1 year; 5 years
- Radiological findings (inc. femoral component loosening; acetabulum fracture/fissure; heterotopic ossification) at 1 year; 5 years:

Source of funding	No external or commercial funding or support.

Bibliographic reference	**van den Bekerom M, Hilverdink E, Sierevelt I, et al. (2010) A comparison of hemiarthroplasty with total hip replacement for displaced intracapsular fracture of the femoral neck. Journal of Bone and Joint Surgery (British volume) 92-B: 1422-8.**
Comments	Methodology checklist **Selection bias: Adequate** – Centralised computer-generated randomisation and treatment allocation, following eligibility assessment. Treatment groups comparable at baseline. **Performance bias:** Both arms received the same care apart from the intervention. No blinding. **Attrition bias:** No loss to follow-up. Per protocol analysis - includes only those patients who completed the treatment originally allocated.. **Detection bias: Outcome assessor was not blinded.** Outcomes defined and valid and reliable measures used.

G.2 RQ2 – Undisplaced intracapsular hip fracture

G.2.1 Internal fixation

G.2.1.1 Bjorgul 2007

Bibliographic reference	**Bjorgul K, and Reikeras O. (2007). Outcome of undisplaced and moderately displaced femoral neck fractures: A prospective study of 466 patients treated by internal fixation. Acta Orthopaedica, 78(4), pp.498-504.**
Study type	Case series
Aim	To compare the outcome of displaced fractures with good healing potential (moderately displaced fractures) to the outcome of undisplaced fractures treated by internal fixation with 2 parallel screws.

<table>
<tr><td>Bibliographic reference</td><td>Bjorgul K, and Reikeras O. (2007). Outcome of undisplaced and moderately displaced femoral neck fractures: A prospective study of 466 patients treated by internal fixation. Acta Orthopaedica, 78(4), pp.498-504.</td></tr>
<tr><td>Patient characteristics</td><td>
Inclusion criteria
- > 60 years

Exclusion criteria
- Pathological fractures
- Patients who sustained > 1 femoral neck fractures during the study period

Baseline characteristics
<table>
<tr><th></th><th>Internal Fixation (N = 225 undisplaced)</th></tr>
<tr><td>Age (years) – Mean (range)</td><td>Men: 79 (77 – 81)
Women: 81 (79 – 82)</td></tr>
<tr><td>Gender – F (%)</td><td>72%</td></tr>
<tr><td>ASA status</td><td>1 – 2: 56% (95% CI: 50 – 62)
3 – 4: 44% (95% CI: 38 – 50)</td></tr>
<tr><td>Mobility assessment / use of waking aids – n (95% CI)</td><td>11 (7 – 16)</td></tr>
<tr><td>Place of residence – % (95% CI)
• Home**
• Residential care
• Other</td><td>
70 (64 – 76)
16 (11 – 21)
sheltered living: 14 (9 – 18)</td></tr>
<tr><td>Cognitive status / dementia – mental test score</td><td>NR</td></tr>
<tr><td>Time since admission (days) – Mean (SD) / range / Median (IQR)</td><td>NR</td></tr>
</table>
</td></tr>
<tr><td>Number of Patients</td><td>225 with undisplaced fractures</td></tr>
<tr><td>Intervention</td><td>Internal fixation with 2 parallel cannulated screws.
- Undisplaced fractures had either complete or incomplete fracture line with no dislocation on AP radiographs. Fractures with impaction and slight posterior tilting (< 30 degrees) of the femoral head seen on lateral radiographs were also included.</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Bjorgul K, and Reikeras O. (2007). Outcome of undisplaced and moderately displaced femoral neck fractures: A prospective study of 466 patients treated by internal fixation. Acta Orthopaedica, 78(4), pp.498-504.</td></tr>
<tr><td></td><td>- Residents operated 96% of undisplaced fractures
- Decision to reoperate was made by orthopaedic surgeon based on clinical evaluation of patient and assessment of the radiographs.

The radiographs were assessed preoperatively by the attending physician. The undisplaced fractures were those with a complete or incomplete fracture line with no dislocation on AP radiographs. Also included those with impaction and slight posterior tilting (< 30 degrees) of the femoral head seen on the lateral radiographs.</td></tr>
<tr><td>Comparison</td><td>N/A</td></tr>
<tr><td>Length of follow up</td><td>38 months (95% CI: 34 - 43)</td></tr>
<tr><td>Location</td><td>Norway</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th></th><th>Internal Fixation (N = 225 undisplaced)</th></tr>
<tr><td>Mortality – %
• 30 days
• 1 year
• 5 years</td><td>
7%
22%
N/R</td></tr>
<tr><td>Surgical revision – n (%)</td><td>42 (19%)</td></tr>
<tr><td>Functional status
• 1 year
• 5 years</td><td>N/R</td></tr>
<tr><td>Quality of life</td><td>N/R</td></tr>
<tr><td>Length of stay – Mean (SD)</td><td>N/R</td></tr>
<tr><td>Place of residence at 1 year
• Home
• Residential care
• Other</td><td>N/R</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>Stiftelsen Sofies Minde, The Norwegian Medical Association, The Norwegian Orthopaedic Association and Gjensidige Nor.</td></tr>
<tr><td>Comments</td><td>JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)
<table>
<tr><td>Were there clear criteria for inclusion in the case series?</td><td>YES</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Bjorgul K, and Reikeras O. (2007). Outcome of undisplaced and moderately displaced femoral neck fractures: A prospective study of 466 patients treated by internal fixation. Acta Orthopaedica, 78(4), pp.498-504.**

Was the condition measured in a standard, reliable way for all participants included in the case series?	YES
Were valid methods used for identification of the condition for all participants included in the case series?	YES
Did the case series have consecutive inclusion of participants?	YES
Did the case series have complete inclusion of participants?	YES
Was there clear reporting of the demographics of the participants in the study?	YES
Was there clear reporting of clinical information of the participants?	YES
Were the outcomes or follow up results of cases clearly reported?	YES
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
Was statistical analysis appropriate?	YES

G.2.1.2 Lapidus 2013

Bibliographic reference	**Lapidus L J, Charalampidis A, Rundgren J et al (2013). Internal fixation of garden I and II femoral neck fractures: posterior tilt did not influence the reoperation rate in 382 consecutive hips followed for a minimum of 5 years. Journal of orthopaedic trauma, 27(7), pp.386-1.**
Study type	Case series
Aim	To analyse factors influencing the reoperation rate due to fracture healing complications after internal fixation of Garden I and II femoral neck fractures with special reference to a new validated method assessing the preoperative posterior tilt on lateral radiographs.
Patient characteristics	**Inclusion criteria** - Patients operated between April 1 2002 and December 31 2005. **Exclusion criteria** - Stress fracture in the femoral neck - Hips operated with Asmis II screws **Baseline characteristics**

	Internal fixation = 382 Hips (379 people)

<table>
<tr><td>Bibliographic reference</td><td colspan="2">Lapidus L J, Charalampidis A, Rundgren J et al (2013). Internal fixation of garden I and II femoral neck fractures: posterior tilt did not influence the reoperation rate in 382 consecutive hips followed for a minimum of 5 years. Journal of orthopaedic trauma, 27(7), pp.386-1.</td></tr>
<tr><td></td><td colspan="2"><table>
<tr><td>Age (years) – Mean</td><td>79.3 (11.5)</td></tr>
<tr><td>Gender – F (%)</td><td>74%</td></tr>
<tr><td>ASA status</td><td>61% class 3 - 4</td></tr>
<tr><td>Mobility assessment / use of waking aids – n (%)</td><td>NR</td></tr>
<tr><td>Place of residence – n (%)
• Home**
• Residential care
• Other</td><td>NR</td></tr>
<tr><td>Cognitive status / dementia – ‘cognitive dysfunction’</td><td>23%</td></tr>
<tr><td>Time since admission (days)</td><td>NR</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td colspan="2">379 (382 hips)</td></tr>
<tr><td>Intervention</td><td colspan="2">Closed reduction and internal fixation or in situ internal fixation was performed with 2 Olmed screws.

Digital preoperative anteriopsterior radiographs were available and assessedand fractures were classified as either Garden I or II fracture. Posterior tilt was determined in the pre-operative and the first postoperative lateral radiographs.</td></tr>
<tr><td>Comparison</td><td colspan="2">N/A</td></tr>
<tr><td>Length of follow up</td><td colspan="2">Median: 3.5 (0 – 8.7) years</td></tr>
<tr><td>Location</td><td colspan="2">Sweden</td></tr>
<tr><td>Outcomes measures and effect size</td><td colspan="2"><table>
<tr><td></td><td>Internal fixation</td></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>
NR
21% (82/382)*
NR</td></tr>
<tr><td>Surgical revision</td><td>45/382 (11.8%)</td></tr>
<tr><td>Functional status – HHS mean (SD)
• 1 year
• 5 years</td><td>NR</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Lapidus L J, Charalampidis A, Rundgren J et al (2013). Internal fixation of garden I and II femoral neck fractures: posterior tilt did not influence the reoperation rate in 382 consecutive hips followed for a minimum of 5 years. Journal of orthopaedic trauma, 27(7), pp.386-1.**

Quality of life	NR
Length of stay – Mean (range) days	NR
Place of residence at 1 year • Home • Residential care • Other	NR

*study also reports 90 days mortality of 9% (33/382)

Source of funding	NR

Comments

JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)

Were there clear criteria for inclusion in the case series?	YES
Was the condition measured in a standard, reliable way for all participants included in the case series?	YES
Were valid methods used for identification of the condition for all participants included in the case series?	YES
Did the case series have consecutive inclusion of participants?	YES
Did the case series have complete inclusion of participants?	YES
Was there clear reporting of the demographics of the participants in the study?	YES
Was there clear reporting of clinical information of the participants?	YES
Were the outcomes or follow up results of cases clearly reported?	NO – results presented as per displaced hip rather than per person.
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
Was statistical analysis appropriate?	YES

G.2.1.3 Lee 2008

Bibliographic reference	**Lee Y S, Chen S H, Tsuang Y H, Huang H L, Lo T Y, and Huang C R. (2008). Internal fixation of undisplaced femoral neck fractures in the elderly: A retrospective comparison of fixation methods. Journal of Trauma - Injury, and Infection and Critical Care, 64(1), pp.155-162.**
Study type	Case series
Aim	To present the minimally invasive technique and to compare the clinical outcomes of undisplaced femoral neck fractures that were treated with the minimally invasive dynamic hip screws (MIDHS), conventional dynamic hip screws (CDHS) and multiple cannulated screws (MCS) fixation methods.
Patient characteristics	**Inclusion criteria** - Acute and undisplaced intracapsular fractures - > 60 yrs - Internal fixation with either MCS or a 3-hole plate of DHS - Patients with the ability for walking without any assistance before injury **Exclusion criteria** - Basicervical fractures - Bilateral hip fractures - Pathological fractures - Patients who required intensive care or treatment in other departments - Previous ipsilateral hip fracture or surgery. **Baseline characteristics**

	Internal fixation n = 90
Age (years) – Mean	72.5
Gender – F (%)	51%
ASA status	NR
Mobility assessment / use of waking aids – n (%)	NR
Place of residence – n (%) • Home** • Residential care • Other	NR
Cognitive status / dementia – mental test score	NR
Time since admission (days) –	NR

<table>
<tr><td>Bibliographic reference</td><td>Lee Y S, Chen S H, Tsuang Y H, Huang H L, Lo T Y, and Huang C R. (2008). Internal fixation of undisplaced femoral neck fractures in the elderly: A retrospective comparison of fixation methods. Journal of Trauma - Injury, and Infection and Critical Care, 64(1), pp.155-162.</td></tr>
<tr><td>Number of Patients</td><td>90</td></tr>
<tr><td>Intervention</td><td>Distinction between undisplaced and displaced neck fractres was made according to anteroposterior (AP0, lateral and frog views of radtiographs or computed tomography evaluation. Pauwels' classification was used to evaluate fracture vertically.

Internal fixation with osteosynthesis by either conventional dynamic hip screw (CDHS) or multiple cannulated screws (MCS). The MCS technique was standard and followed the 3-point principle, with the insertion of 6.5mm cannulated screws.</td></tr>
<tr><td>Comparison</td><td>N/A</td></tr>
<tr><td>Length of follow up</td><td>Mean (range) = 25.5 months (13 – 41)</td></tr>
<tr><td>Location</td><td>Taiwan</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th></th><th>Internal fixation n = 90</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>Within follow-up (~2yrs): 8/90* (8.9%)</td></tr>
<tr><td>Surgical revision</td><td>NR</td></tr>
<tr><td>Functional status – HHS mean (SD)
• 1 year
• 5 years</td><td>~ 2 yrs follow-up:
80.16 (6.85)</td></tr>
<tr><td>Quality of life</td><td>NR</td></tr>
<tr><td>Length of stay – Mean (range) days</td><td>7.7 (3 – 15)</td></tr>
<tr><td>Place of residence at 1 year
• Home
• Residential care
• Other</td><td>NR</td></tr>
</table>
*not directly relating to hip fracture, causes include cancer, stroke and heart disease.
</td></tr>
<tr><td>Source of funding</td><td>NR</td></tr>
</table>

Bibliographic reference	**Lee Y S, Chen S H, Tsuang Y H, Huang H L, Lo T Y, and Huang C R. (2008). Internal fixation of undisplaced femoral neck fractures in the elderly: A retrospective comparison of fixation methods. Journal of Trauma - Injury, and Infection and Critical Care, 64(1), pp.155-162.**
Comments	**JBI critical appraisal checklist for case series** (http://joannabriggs.org/research/critical-appraisal-tools.html)

Were there clear criteria for inclusion in the case series?	YES
Was the condition measured in a standard, reliable way for all participants included in the case series?	YES
Were valid methods used for identification of the condition for all participants included in the case series?	YES
Did the case series have consecutive inclusion of participants?	YES
Did the case series have complete inclusion of participants?	YES
Was there clear reporting of the demographics of the participants in the study?	NO
Was there clear reporting of clinical information of the participants?	NO
Were the outcomes or follow up results of cases clearly reported?	YES
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
Was statistical analysis appropriate?	YES

G.2.1.4 Lin 2012

Bibliographic reference	**Lin Dasheng, Lian Kejian, Ding Zhenqi, Zhai Wenliang, and Hong Jiayuan. (2012). Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 35(1), pp.e1-5.**
Study type	Case series
Aim	To use proximal femoral locking plate with cannulated screws to evaluate its efficacy and safety in femoral neck fracture fixation.
Patient characteristics	**Inclusion criteria** - Femoral neck fracture. **Exclusion criteria** - Pathological fractures - Autoimmune diseases - Blood disorders

<table>
<tr><td>Bibliographic reference</td><td>Lin Dasheng, Lian Kejian, Ding Zhenqi, Zhai Wenliang, and Hong Jiayuan. (2012). Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 35(1), pp.e1-5.</td></tr>
<tr><td></td><td>- Severe multiple trauma
- Surgical contraindications

Baseline characteristics
<table>
<tr><th></th><th>Internal fixation (n = 12 undisplaced)</th></tr>
<tr><td>Age (years) – Mean (95% CI)</td><td>Unclear for undisplaced only, 47 yrs (21 – 65) for all displaced and nondisplaced</td></tr>
<tr><td>Gender – F (%)</td><td>Unclear for undisplaced only, 39% for all</td></tr>
<tr><td>ASA status</td><td>NR</td></tr>
<tr><td>Mobility assessment / use of waking aids – n (%)</td><td>NR</td></tr>
<tr><td>Place of residence – n (%)
• Home
• Residential care
• Other</td><td>NR</td></tr>
<tr><td>Cognitive status / dementia – mental test score</td><td>NR</td></tr>
<tr><td>Time since admission (days)</td><td>NR</td></tr>
</table>
Time from injury to surgery ranged from 2 hours to 7 days.</td></tr>
<tr><td>Number of Patients</td><td>12</td></tr>
<tr><td>Intervention</td><td>Anteropospterior (AP) and lateral radiographs of the hip joint were taken in all patients and CT scans were obtained if necessary. Garden classification was used for fracture classification.

Internal fixation:
The proximal femoral locking plate used in this study was designed to configure the proximal femur. After positioning of the patient on the fracture table, the hip was exposed through an anterolateral approach in the supine position, and a longitudinal capsular incision was made to the anterior aspect of the fracture.
Patients with no other problems were discharged 1 week postoperatively and returned for follow-up at 6 weeks, 3 and 6 months, and 1 and 2 years postoperatively. Patients were rapidly mobilized and instructed to use toe-touch weight bearing</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Lin Dasheng, Lian Kejian, Ding Zhenqi, Zhai Wenliang, and Hong Jiayuan. (2012). Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 35(1), pp.e1-5.</td></tr>
<tr><td></td><td>with crutches or a walker for 12 weeks. Patients progressed to full weight bearing when they had the strength and balance to do so.</td></tr>
<tr><td>Comparison</td><td>N/A</td></tr>
<tr><td>Length of follow up</td><td>43 months (range 24 – 69 months) between Jan 2005 – Dec 2008</td></tr>
<tr><td>Location</td><td>China</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th></th><th>Internal Fixation (N = 12 undisplaced)</th></tr>
<tr><td>Mortality – n (%)
30 days
1 year
5 years</td><td>NR</td></tr>
<tr><td>Surgical revision</td><td>NR</td></tr>
<tr><td>Functional status
1 year
5 years</td><td>At follow-up: 11/12 excellent, 1/12 good.</td></tr>
<tr><td>Quality of life</td><td>N/R</td></tr>
<tr><td>Length of stay – Mean (SD)</td><td>N/R</td></tr>
<tr><td>Place of residence at 1 year
Home
Residential care
Other</td><td>N/R</td></tr>
</table>
Other outcomes: time to heal, complications.
</td></tr>
<tr><td>Source of funding</td><td>NR</td></tr>
<tr><td>Comments</td><td>JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)
<table>
<tr><td>Were there clear criteria for inclusion in the case series?</td><td>YES</td></tr>
<tr><td>Was the condition measured in a standard, reliable way for all participants included in the case series?</td><td>YES</td></tr>
<tr><td>Were valid methods used for identification of the condition for all participants included in the case series?</td><td>YES</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Lin Dasheng, Lian Kejian, Ding Zhenqi, Zhai Wenliang, and Hong Jiayuan. (2012). Proximal femoral locking plate with cannulated screws for the treatment of femoral neck fractures. Orthopedics, 35(1), pp.e1-5.**	
	Did the case series have consecutive inclusion of participants?	UNCLEAR – does not state that all participants with femoral neck fractures between 2005 – 2008 were included
	Did the case series have complete inclusion of participants?	UNCLEAR – does not state that all participants with femoral neck fractures between 2005 – 2008 were included
	Was there clear reporting of the demographics of the participants in the study?	NO
	Was there clear reporting of clinical information of the participants?	YES
	Were the outcomes or follow up results of cases clearly reported?	YES
	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
	Was statistical analysis appropriate?	Unclear – not reported.

G.2.1.5 Song Hyung 2013

Bibliographic reference	**Song Hyung K, Lee Jae J, Oh Hyun C, and Yang Kyu H. (2013). Clinical implication of subgrouping in valgus femoral neck fractures: comparison of 31-B1.1 with 31-B1.2 fractures using the OTA/AO classification. Journal of orthopaedic trauma, 27(12), pp.677-82.**
Study type	Case series
Aim	To identify the clinical implications of valgus impacted femoral neck fractures and to compare fractures with > 15 degree angle of impaction.
Patient characteristics	**Inclusion criteria** - Femoral neck fractures with valgus deformities. **Exclusion criteria** - Patients who were followed up for less than 12 months. **Baseline characteristics**

	Internal fixation n = 78

<table>
<tr><td>Bibliographic reference</td><td colspan="2">Song Hyung K, Lee Jae J, Oh Hyun C, and Yang Kyu H. (2013). Clinical implication of subgrouping in valgus femoral neck fractures: comparison of 31-B1.1 with 31-B1.2 fractures using the OTA/AO classification. Journal of orthopaedic trauma, 27(12), pp.677-82.</td></tr>
<tr><td></td><td colspan="2">
<table>
<tr><td>Age (years) – Mean (range)</td><td>66.2 yrs (35 – 90)</td></tr>
<tr><td>Gender – F (%)</td><td>82%</td></tr>
<tr><td>ASA status</td><td>NR</td></tr>
<tr><td>Mobility assessment / use of waking aids – n (%)</td><td>NR</td></tr>
<tr><td>Place of residence – n (%)
Home**
Residential care
Other</td><td>NR</td></tr>
<tr><td>Cognitive status / dementia – mental test score</td><td>NR</td></tr>
<tr><td>Time since admission (days) – Mean (SD) / range / Median (IQR)</td><td>NR</td></tr>
</table>
</td></tr>
<tr><td>Number of Patients</td><td colspan="2">78</td></tr>
<tr><td>Intervention</td><td colspan="2">Standard anteroposterior (SP) radiographs of the hip were obtained with both legs positioned to an internal rotation of 15 degree angle. Lateral radiographs were taken with the opposite hip being flexed and abducted.

Evaluation: Fracture types were classified according to the OTA/AO classification. The 31-B1.1 and 31-B1.2 fractures were divided into 2 subgroups according to the degree of posterior tilt.

Fixation:
Each fracture was fixed with 3 7.0 mm cannulated screws percutaneously in an inverted triangle configuration. Rehabilitation started on the first postoperative day with sitting and continuous passive motion of the knee and hip joints. Standing and ambulation with walking aids were usually allowed within 3 days of the surgery.</td></tr>
<tr><td>Comparison</td><td colspan="2">N/A</td></tr>
<tr><td>Length of follow up</td><td colspan="2">Mean: 15 months (range: 12 – 41 months)</td></tr>
<tr><td>Location</td><td colspan="2">NR (author location Korea)</td></tr>
<tr><td>Outcomes measures and effect size</td><td colspan="2">
<table>
<tr><th></th><th>Internal fixation n = 78</th></tr>
<tr><td>Mortality
30 days
1 year
5 years</td><td>NR</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	**Song Hyung K, Lee Jae J, Oh Hyun C, and Yang Kyu H. (2013). Clinical implication of subgrouping in valgus femoral neck fractures: comparison of 31-B1.1 with 31-B1.2 fractures using the OTA/AO classification. Journal of orthopaedic trauma, 27(12), pp.677-82.**

Surgical revision	NR
Functional status - HHS • 1 year - mean (SD) • 5 years	 85.7 (10.56) NR
Quality of life	NR
Length of stay	NR
Place of residence at 1 year • Home • Residential care • Other	NR

Source of funding	NR
Comments	**JBI critical appraisal checklist for case series** (http://joannabriggs.org/research/critical-appraisal-tools.html)

Were there clear criteria for inclusion in the case series?	YES
Was the condition measured in a standard, reliable way for all participants included in the case series?	YES
Were valid methods used for identification of the condition for all participants included in the case series?	YES
Did the case series have consecutive inclusion of participants?	YES
Did the case series have complete inclusion of participants?	YES
Was there clear reporting of the demographics of the participants in the study?	NO
Was there clear reporting of clinical information of the participants?	YES
Were the outcomes or follow up results of cases clearly reported?	YES
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
Was statistical analysis appropriate?	YES

G.2.1.6 van Walsum 2016

Bibliographic reference	**van Walsum , A D, Vroemen J, Janzing H M, Winkelhorst T, Kalsbeek J, and Roerdink W H. (2016). Low failure rate by means of DLBP fixation of undisplaced femoral neck fractures. Eur J Trauma Emerg Surg, , pp..**
Study type	Case series
Aim	To register the results the results in the internal fixation of undisplaced femoral neck fractures by means of Dynamic Locking Blade Plate (DLBP).
Patient characteristics	**Inclusion criteria** - Undisplaced femoral neck fractures **Exclusion criteria** - Pathological fractures - Concomitant fractures of the lower extremity - Symptomatic arthritis - Local infection or inflammation - Inadequate local tissue coverage - Morbid obesity - Any mental or neuromuscular disorder which would create an unacceptable risk of fixation failure or complications in postoperative care. **Baseline characteristics**
Number of Patients	149 undisplaced

	Internal fixation n = 149
Age (years) – Mean (range)	69 (35–101)
Gender – F (%)	NR
ASA status	NR
Mobility assessment / use of waking aids – n (%)	NR
Place of residence – n (%) • Home** • Residential care • Other	NR
Cognitive status / dementia – mental test score	NR
Time since admission (days) –	NR

<table>
<tr><td>Bibliographic reference</td><td>van Walsum , A D, Vroemen J, Janzing H M, Winkelhorst T, Kalsbeek J, and Roerdink W H. (2016). Low failure rate by means of DLBP fixation of undisplaced femoral neck fractures. Eur J Trauma Emerg Surg, , pp..</td></tr>
<tr><td>Intervention</td><td>The Garden classification is based on the pre-operative AP radiograph of the hip. The anterior angulation of the fracture is assessed on the lateral pre-operative radiograph of the hip. Postoperative AP and lateral radiographs were used

Internal fixation by Dynamic Locking Blade Plate (DLBP):
By a ±7 cm lateral approach a 3.0-mm 135° guide wire is placed in the centre/centre position in femoral head. Cannulated reaming is performed up to 5 mm subchondrally in the femoral head. the locking blade together with a two-hole side plate is mounted on the introducer.</td></tr>
<tr><td>Comparison</td><td>N/A</td></tr>
<tr><td>Length of follow up</td><td>At least 1 year</td></tr>
<tr><td>Location</td><td>The Netherlands</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th></th><th>Internal fixation n = 149</th></tr>
<tr><td>Mortality – n (%)
30 days
1 year
5 years</td><td>NR</td></tr>
<tr><td>Surgical revision</td><td>6/149</td></tr>
<tr><td>Functional status
1 year
5 years</td><td>NR</td></tr>
<tr><td>Quality of life</td><td>NR</td></tr>
<tr><td>Length of stay – Mean (SD)</td><td>NR</td></tr>
<tr><td>Place of residence at 1 year
Home
Residential care
Other</td><td>NR</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>No financial support received.</td></tr>
<tr><td>Comments</td><td>JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)</td></tr>
</table>

Bibliographic reference	van Walsum , A D, Vroemen J, Janzing H M, Winkelhorst T, Kalsbeek J, and Roerdink W H. (2016). Low failure rate by means of DLBP fixation of undisplaced femoral neck fractures. Eur J Trauma Emerg Surg, , pp..	
	Were there clear criteria for inclusion in the case series?	YES
	Was the condition measured in a standard, reliable way for all participants included in the case series?	YES
	Were valid methods used for identification of the condition for all participants included in the case series?	YES
	Did the case series have consecutive inclusion of participants?	YES
	Did the case series have complete inclusion of participants?	YES
	Was there clear reporting of the demographics of the participants in the study?	YES
	Was there clear reporting of clinical information of the participants?	NO
	Were the outcomes or follow up results of cases clearly reported?	YES
	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
	Was statistical analysis appropriate?	UNCLEAR – not reported.

G.2.1.7 Yih Shiunn 2006

Bibliographic reference	Yih-Shiunn Lee, Chien-Rae Huang, and Wen-Yun Liao. (2007). Surgical treatment of undisplaced femoral neck fractures in the elderly. International orthopaedics, 31(5), pp.677-82.
Study type	Case series
Aim	To retrospectively follow up and compare the clinical outcome of undisplaced femoral neck fractures that were treated with dynamic hip screws (DHS) or multiple cannulated screws (MCS).
Patient characteristics	**Inclusion criteria** - Acute and intracapsular fractures - All patients older than 60 yrs - Internal fixation with either MCS or a 3-hole DHS - Patients able to walk without any assistance before injury. **Exclusion criteria** - Basicervical fractures - Bilateral hip fractures

<table>
<tr><td>Bibliographic reference</td><td>Yih-Shiunn Lee, Chien-Rae Huang, and Wen-Yun Liao. (2007). Surgical treatment of undisplaced femoral neck fractures in the elderly. International orthopaedics, 31(5), pp.677-82.</td></tr>
<tr><td></td><td>- Pathological fractures
- Patients who required intensive care or treatment in other departments
- Previous ipsilateral hip fracture or surgery.

Baseline characteristics
<table>
<tr><th></th><th>Internal fixation n = 84</th></tr>
<tr><td>Age (years) – Mean</td><td>71.6</td></tr>
<tr><td>Gender – F (%)</td><td>58%</td></tr>
<tr><td>ASA status</td><td>NR</td></tr>
<tr><td>Mobility assessment / use of waking aids – n (%)</td><td>NR</td></tr>
<tr><td>Place of residence – n (%)
• Home**
• Residential care
• Other</td><td>NR</td></tr>
<tr><td>Cognitive status / dementia – mental test score</td><td>NR</td></tr>
<tr><td>Time since admission (days) – hours</td><td>35.4</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>84</td></tr>
<tr><td>Intervention</td><td>Distinction between undisplaced and displaced femoral neck fractures was made according to anteroposterior (AP), lateral and frog view radiographs.

Osteosynthesis with either dynamic hip screws (DHS) or multiple cannulated screws (MCS).
DHS: Standard operating procedure was followed. A guide wire was inserted approximately 2 cm below the vastus lateralis ridge and a 135° guide plate was laced close to the femoral shaft in a parallel position.
MCS: Standard operating procedure and followed. The three point principle, with the insertion on 3 6.5 mm (AO) cannulated screws.

Partial weight bearing with crutches or walker assistance was routine for all patients for at least four weeks after discharge, and full weight bearing was permitted after six weeks, depending on individual clinical condition.</td></tr>
<tr><td>Comparison</td><td>N/A</td></tr>
<tr><td>Length of follow up</td><td>At least 12 months, mean = 34.6 months</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Yih-Shiunn Lee, Chien-Rae Huang, and Wen-Yun Liao. (2007). Surgical treatment of undisplaced femoral neck fractures in the elderly. International orthopaedics, 31(5), pp.677-82.</td></tr>
<tr><td>Location</td><td>Not reported.</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th></th><th>Internal fixation n = 84</th></tr>
<tr><td>Mortality – n (%)
30 days
1 year
5 years</td><td>NR</td></tr>
<tr><td>Surgical revision</td><td>NR</td></tr>
<tr><td>Functional status - HHS mean (sd)
1 year
5 years</td><td>At end of follow-up = 83.36 (5.18)</td></tr>
<tr><td>Quality of life</td><td>NR</td></tr>
<tr><td>Length of stay – Mean (range) (sd) days</td><td>8.4 (3 – 16) (sd = 2.8)</td></tr>
<tr><td>Place of residence at 1 year
Home
Residential care
Other</td><td>NR</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>NR</td></tr>
<tr><td>Comments</td><td>JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)
<table>
<tr><td>Were there clear criteria for inclusion in the case series?</td><td>YES</td></tr>
<tr><td>Was the condition measured in a standard, reliable way for all participants included in the case series?</td><td>YES</td></tr>
<tr><td>Were valid methods used for identification of the condition for all participants included in the case series?</td><td>YES</td></tr>
<tr><td>Did the case series have consecutive inclusion of participants?</td><td>YES</td></tr>
<tr><td>Did the case series have complete inclusion of participants?</td><td>YES</td></tr>
<tr><td>Was there clear reporting of the demographics of the participants in the study?</td><td>NO</td></tr>
<tr><td>Was there clear reporting of clinical information of the participants?</td><td>YES</td></tr>
<tr><td>Were the outcomes or follow up results of cases clearly reported?</td><td>YES</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	Yih-Shiunn Lee, Chien-Rae Huang, and Wen-Yun Liao. (2007). Surgical treatment of undisplaced femoral neck fractures in the elderly. International orthopaedics, 31(5), pp.677-82.	
	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
	Was statistical analysis appropriate?	YES

G.2.2 Conservative management

G.2.2.1 Buord 2010

Bibliographic reference	Buord J M, Flecher X, Parratte S, Boyer L, Aubaniac J M, and Argenson J N. (2010). Garden I femoral neck fractures in patients 65 years old and older: Is conservative functional treatment a viable option?. Orthopaedics and Traumatology: Surgery and Research, 96(3), pp.228-234.
Study type	Case series
Aim	- To evaluate the results of managing Garden I femoral neck fractures in subjects over age 65 years with a minimum 1-year follow-up; - To investigate predictive factors of secondary displacement.
Patient characteristics	**Inclusion criteria** - Garden I femoral neck fracture [7]; - Recent injury (< 24 hours); - Age 65 years or over; - Follow-up longer than 12 months. **Exclusion criteria** - Age under 65 years; - Pathological fracture; - A history of fracture in the studied hip. **Baseline characteristics**

	Conservative management n = 40 nondisplaced

Bibliographic reference	**Buord J M, Flecher X, Parratte S, Boyer L, Aubaniac J M, and Argenson J N. (2010). Garden I femoral neck fractures in patients 65 years old and older: Is conservative functional treatment a viable option?. Orthopaedics and Traumatology: Surgery and Research, 96(3), pp.228-234.**
	<table><tr><td></td><td></td></tr><tr><td>Age (years)</td><td>82 ± 8.5</td></tr><tr><td>Gender – F (%)</td><td>92.5%</td></tr><tr><td>ASA status - n</td><td>Not reported separately for undisplaced only</td></tr><tr><td>Mobility assessment / use of waking aids – n (%)</td><td>NR</td></tr><tr><td>Place of residence – n (%) • Home** • Residential care • Other</td><td>NR</td></tr><tr><td>Cognitive status / dementia</td><td>NR</td></tr><tr><td>Time since admission</td><td>NR</td></tr></table>
Number of Patients	40
Intervention	Conservative management: - 48 hour period of bed rest during which patients received analgesics without any additional immobilisation device (e.g. traction, splits etc). - Full mobilisation test supported by a pair of crutches or a walker under strict guidance by a physiotherapist, followed with routine anterior and lateral x-rays. - In the absence of displacement: a second test was performed under similar conditions within less than 48 hours Initial x-rays were analysed by 2 different observers noting fracture type; subcapital or transcervical location; inclination angle of the fracture line based on Pauwels classification; valgisation degree (anterior hip x-ray) and inclination angle on lateral x-rays.
Comparison	N/A
Length of follow up	Average: 20 ± 8 months (12 to 28 months)
Location	Not reported

Bibliographic reference	**Buord J M, Flecher X, Parratte S, Boyer L, Aubaniac J M, and Argenson J N. (2010). Garden I femoral neck fractures in patients 65 years old and older: Is conservative functional treatment a viable option?. Orthopaedics and Traumatology: Surgery and Research, 96(3), pp.228-234.**

Outcomes measures and effect size

	Conservative management n = 40 nondisplaced
Mortality – n (%) • 30 days • 1 year • 5 years	NR
Surgical revision	1/40 (2.5%) required total arthroplasty due to aseptic osteonecrosis
Functional status - HHS • 1 year • 5 years	At follow-up, average 20 ± 8 months: 82 points
Quality of life	NR
Length of stay – Mean (SD) (range)	8 ± 4 days (4 to 21 days)
Place of residence at 1 year • Home • Residential care • Other	NR

Source of funding	Not reported

Comments

JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)

Were there clear criteria for inclusion in the case series?	YES
Was the condition measured in a standard, reliable way for all participants included in the case series?	YES
Were valid methods used for identification of the condition for all participants included in the case series?	YES
Did the case series have consecutive inclusion of participants?	YES
Did the case series have complete inclusion of participants?	YES
Was there clear reporting of the demographics of the participants in the study?	NO
Was there clear reporting of clinical information of the participants?	YES

Bibliographic reference	**Buord J M, Flecher X, Parratte S, Boyer L, Aubaniac J M, and Argenson J N. (2010). Garden I femoral neck fractures in patients 65 years old and older: Is conservative functional treatment a viable option?. Orthopaedics and Traumatology: Surgery and Research, 96(3), pp.228-234.**

Were the outcomes or follow up results of cases clearly reported?	YES
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
Was statistical analysis appropriate?	YES

G.2.2.2 Raaymakers 2002

Bibliographic reference	**Raaymakers E L. F. B. (2002). The non-operative treatment of impacted femoral neck fractures. Injury, 33(SUPPL. 3), pp.SC8-SC14.**
Study type	Case series
Aim	To answer the following questions: - What is the percentage of secondary instability (SI) after functional treatment? - Can risk factors for SI be identified? - Is a deleterious effect on mortality and the frequency of avascular necrosis caused by delaying operative treatment after SI?
Patient characteristics	**Inclusion criteria** - Impacted femoral neck fractures (IFNF) **Exclusion criteria** - Patients who were wrongly classified as displaced fractures and primarily treated with internal fixation or arthroplasty. **Baseline characteristics**

	Conservative management (early mobilisation) n = 319
Age (years) – Mean (range)	72 yrs (13 – 98)
Gender	NR
ASA status	NR
Mobility assessment / use of waking aids – n (%)	NR

<table>
<tr><td>Bibliographic reference</td><td colspan="2">Raaymakers E L. F. B. (2002). The non-operative treatment of impacted femoral neck fractures. Injury, 33(SUPPL. 3), pp.SC8-SC14.</td></tr>
<tr><td></td><td colspan="2"><table>
<tr><td>Place of residence – n (%)
• Home**
• Residential care
• Other</td><td>NR</td></tr>
<tr><td>Cognitive status / dementia (%)</td><td>7%</td></tr>
<tr><td>Time since admission (days) – Mean (SD) / range / Median (IQR)</td><td>NR</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td colspan="2">319</td></tr>
<tr><td>Intervention</td><td colspan="2">Conservative management: early mobilisation
- Weight bearing ‘early’ if it took place within 4 weeks of the date of fracture
- Patients admitted to ward and rested in bed with injured leg in a gutter splint until the pain subsided.
- Patients mobilised with the help of crutches or other support
- Partial weight bearing was preferable in the first 8 weeks but if this was not possible, full weight bearing was accepted.
The amount of valgus of the capital fragment was expressed as the anteroposterior Garden index and the amount of retroversion or anteversion as the lateral Garden index. The presence of a gap in the anterior cortex was noted on the axial (lateral) view and the inclination of the fracture line was expressed as Pauwels type 1, 2 or 3.</td></tr>
<tr><td>Comparison</td><td colspan="2">N/A</td></tr>
<tr><td>Length of follow up</td><td colspan="2">Unclear, study dates: 1980 – 2000</td></tr>
<tr><td>Location</td><td colspan="2">Netherlands</td></tr>
<tr><td>Outcomes measures and effect size</td><td colspan="2"><table>
<tr><th></th><th>Conservative management (early mobilisation) n = 319</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>
NR
19%
N/R
2 years mortality rate: 25%</td></tr>
<tr><td>Surgical revision (n)</td><td>29/319 (9.1%) received further treatment (including internal fixation and hemiarthroplasty)</td></tr>
</table></td></tr>
</table>

Bibliographic reference	**Raaymakers E L. F. B. (2002). The non-operative treatment of impacted femoral neck fractures. Injury, 33(SUPPL. 3), pp.SC8-SC14.**

Functional status • 1 year • 5 years	N/R
Quality of life	N/R
Length of stay – Mean (SD)	N/R
Place of residence at 1 year • Home • Residential care • Other	N/R

Source of funding	NR

Comments

JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)

Were there clear criteria for inclusion in the case series?	YES
Was the condition measured in a standard, reliable way for all participants included in the case series?	YES
Were valid methods used for identification of the condition for all participants included in the case series?	YES
Did the case series have consecutive inclusion of participants?	YES
Did the case series have complete inclusion of participants?	YES
Was there clear reporting of the demographics of the participants in the study?	NO
Was there clear reporting of clinical information of the participants?	NO
Were the outcomes or follow up results of cases clearly reported?	NO- confidence intervals not reported
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
Was statistical analysis appropriate?	Unclear – not reported.

G.2.2.3 Tanaka 2002

<table>
<tr><td>Bibliographic reference</td><td>Tanaka J, Seki N, Tokimura F, and Hayashi Y. (2002). Conservative treatment of Garden stage I femoral neck fracture in elderly patients. Archives of orthopaedic and trauma surgery, 122(1), pp.24-8.</td></tr>
<tr><td>Study type</td><td>Case series</td></tr>
<tr><td>Aim</td><td>To determine the factors that influence fracture union and to identify the treatment method that best minimises the risk of secondary displacement.</td></tr>
<tr><td>Patient characteristics</td><td>Inclusion criteria
- Fresh Garden stage I femoral neck fractures.

Exclusion criteria
- NR.

Baseline characteristics
<table>
<tr><th></th><th>Conservative management n = 38</th></tr>
<tr><td>Age (years) – Mean (range)</td><td>81 (68 - 92)</td></tr>
<tr><td>Gender – F (%)</td><td>92%</td></tr>
<tr><td>ASA status</td><td>NR</td></tr>
<tr><td>Mobility assessment / use of waking aids – n</td><td>1/38</td></tr>
<tr><td>Place of residence – n (%)
• Home**
• Residential care
• Other</td><td>NR</td></tr>
<tr><td>Cognitive status / dementia – severe dementia</td><td>12/38</td></tr>
<tr><td>Time since admission (days) – Mean (SD) / range / Median (IQR)</td><td>NR</td></tr>
</table></td></tr>
<tr><td>Number of Patients</td><td>38</td></tr>
<tr><td>Intervention</td><td>Anteroposterior x-rays were studied to determine the amount of valgus of the femoral head and lateral x-rays were studied to determine the amount of retroversion of the femoral head.

Two different methods of treatments applied randomly according to the wishes of the attending surgeon:
- 19/38 patients rested in bed for up to 2 weeks after injury and began bed-to-wheelchair transfer training 3-4 weeks after injury. Ambulation was attempted 4-5 weeks after injury.</td></tr>
</table>

<table>
<tr><td>Bibliographic reference</td><td>Tanaka J, Seki N, Tokimura F, and Hayashi Y. (2002). Conservative treatment of Garden stage I femoral neck fracture in elderly patients. Archives of orthopaedic and trauma surgery, 122(1), pp.24-8.</td></tr>
<tr><td></td><td>- 19/38 patients began bed-to-wheelchair transfer training and ambulation as individually tolerated within 13 days after injury.
If secondary displacement and pain occurred, the patient was treated with hemiarthroplasty.</td></tr>
<tr><td>Comparison</td><td>N/A</td></tr>
<tr><td>Length of follow up</td><td>Mean: 20 months (6 – 86 months)</td></tr>
<tr><td>Location</td><td>Japan</td></tr>
<tr><td>Outcomes measures and effect size</td><td>
<table>
<tr><th></th><th>Conservative management n=38</th></tr>
<tr><td>Mortality – n (%)
• 30 days
• 1 year
• 5 years</td><td>NR</td></tr>
<tr><td>Surgical revision (n)</td><td>16/38 (42%)had Moore prosthesis (14 due to fracture not uniting and 2 due to avascular necrosis)</td></tr>
<tr><td>Functional status
• 1 year
• 5 years</td><td>NR</td></tr>
<tr><td>Quality of life</td><td>NR</td></tr>
<tr><td>Length of stay – Mean (range) days</td><td>58.5 (10 – 130)</td></tr>
<tr><td>Place of residence at 1 year
• Home
• Residential care
• Other</td><td>NR</td></tr>
</table>
</td></tr>
<tr><td>Source of funding</td><td>NR</td></tr>
<tr><td>Comments</td><td>JBI critical appraisal checklist for case series (http://joannabriggs.org/research/critical-appraisal-tools.html)
<table>
<tr><td>Were there clear criteria for inclusion in the case series?</td><td>YES</td></tr>
<tr><td>Was the condition measured in a standard, reliable way for all participants included in the case series?</td><td>YES</td></tr>
<tr><td>Were valid methods used for identification of the condition for all participants included in the case series?</td><td>YES</td></tr>
</table>
</td></tr>
</table>

Bibliographic reference	Tanaka J, Seki N, Tokimura F, and Hayashi Y. (2002). Conservative treatment of Garden stage I femoral neck fracture in elderly patients. Archives of orthopaedic and trauma surgery, 122(1), pp.24-8.	
	Did the case series have consecutive inclusion of participants?	UNCLEAR – does not state that all participants with femoral neck fractures between 1990 – 1999 were included
	Did the case series have complete inclusion of participants?	UNCLEAR – does not state that all participants with femoral neck fractures between 1990 – 1999 were included
	Was there clear reporting of the demographics of the participants in the study?	YES
	Was there clear reporting of clinical information of the participants?	YES
	Were the outcomes or follow up results of cases clearly reported?	YES
	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	YES
	Was statistical analysis appropriate?	YES

Appendix H: GRADE profiles

H.1 RQ1 – Displaced intracapsular hip fracture

H.1.1 HA versus THR – dichotomous outcomes

Quality assessment							No of patients		Effect estimate		Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Hemiarthro-plasty	Total hip replacement	Relative (95% CI)	Absolute	
Outcome: Mortality at 30 days											
2[1]	RCT	No serious	No serious	No serious	Serious[2]	No serious	9/178 (5.1%)	5/155 (3.2%)	RR 1.4 (0.49 to 4)	13 more per 1000 (from 16 fewer to 97 more)	MOD
Outcome: Mortality at 1 year											
6[3]	RCT	Serious[4]	No serious	No serious	Serious[2]	No serious	66/441 (15%)	53/418 (12.7%)	RR 1.17 (0.84 to 1.63)	22 more per 1000 (from 20 fewer to 80 more)	LOW
Outcome: Mortality at 5 years											
8[5]	RCT	No serious	Serious[14]	No serious[6]	Serious[2]	No serious	219/505 (43.4%)	208/475 (43.8%)	RR 1.03 (0.82 to 1.28)	13 more per 1000 (from 79 fewer to 123 more)	LOW
Outcome: Surgical revision rates (range: 6 months to 13 years)											
9[7]	RCT	Serious[4]	Serious[8]	No serious	Very serious[9]	No serious	48/555 (8.6%)	28/514 (5.4%)	RR 1.48 (0.65 to 3.36)	26 more per 1000 (from 19 fewer to 129 more)	VERY LOW
Outcome: Place of residence at 1 year											

Quality assessment							No of patients		Effect estimate		Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Hemiarthro-plasty	Total hip replacement	Relative (95% CI)	Absolute	
1[10]	RCT	Serious[1] [1]	No serious	n/a[6]	No serious	No serious	53/55 (96.4%)	54/56 (96.4%)	RR 1 (0.93 to 1.07)	0 fewer per 1000 (from 67 fewer to 68 more)	MOD
Outcome: Dislocation rate within follow-up period (range: 30 days to 5 years)											
8[12]	RCT	Serious[4]	No serious	No serious	Serious[13]	No serious	14/512 (2.7%)	38/471 (8.1%)	RR 0.35 (0.15 to 0.83)	52 fewer per 1000 (from 14 fewer to 69 fewer)	LOW

1. Baker 2206; van den Bekerom 2010
2. 95% CIs cross line of no effect (no statistical difference in mortality between treatment groups)
3. Blomfeldt 2007; Cadossi 2013; Keating 2005; Macaulay 2008; Mouzopoulos 2008; Skinner 1989; van den Bekerom 2010
4. Studies contributing majority of weight to analysis have serious limitations (inadequate or unclear allocation procedure)
5. Baker 2006, Blomfeldt 2007, Cadossi 2013; Keating 2005; Macaulay 2008; Mouzopoulos 2008; Skinner 1989; van den Bekerom 2010
6. $Tau^2 = 0.04$
7. Baker 2006; Blomfeldt 2007; Cadossi 2013;Dorr 1986; Keating 2005; Macaulay 2008; Mouzopoulos 2008; Skinner 1989; van den Bekerom 2010
8. Some surgical revision reporting may include minor re-operations (e.g. treatment of infections, reduction of dislocations)
9. 95% CIs cross two GRADE default MIDs (RR 0.8 and 1.25)
10. Blomfeldt 2007
11. Serious study limitations (outcome assessor not blinded to treatment allocation)
12. Baker 2006; Blomfeldt 2007; Cadossi 2013;Dorr 1986; Keating 2005; Macaulay 2008; Skinner 1989; van den Bekerom 2010
13. 95% CIs cross one GRADE default MID (RR 0.8)
14. Serious indirectness due to data from different timepoints used

H.1.2 HA versus THR – continuous outcomes

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Hemiarthro-plasty	Total hip replacement	Mean difference (95% CI)	
Outcome: Functional status at 1 year: higher scores = better functioning										
4[1]	RCT	Serious[2]	No serious	No serious	No serious	No serious	154	159	MD 5.03 lower (7.45 to 2.62 lower)	MOD

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Hemiarthro -plasty	Total hip replacement	Mean difference (95% CI)	
Outcome: Functional status at 5 years higher scores = better functioning										
5[4]	RCT	Serious[5]	No serious	Very serious[6]	No serious	No serious	141	151	MD 6.58 lower (11.48 to 1.67 lower)	LOW
Outcome: Quality of life at 1 year: higher scores = better QoL										
1[7]	RCT	Serious[5]	No serious	n/a[8]	No serious	No serious	64	66	MD 0.08 lower (0.18 lower to 0.02 higher)	MOD
Outcome: Length of stay (days)										
3[9]	RCT	No serious	No serious	No serious	tbc	No serious	135	129	MD 0.42 lower (1.9 lower to 1.06 higher)	HIGH

1. Blomfeldt 2007; Keating 2005; Macaulay 2008; Mouzopoulos 2008
2. Studies contributing majority of weight to analysis have serious limitations (inadequate or unclear allocation procedure, or unblinded outcome assessment for functioning)
4. Blomfeldt 2007; Cadossi 2013; Keating 2005; Macaulay 2008; Mouzopoulos 2008
5. Serious study limitations (outcome assessor not blinded to treatment allocation)
6. Tau2 = 16.84
7. Keating 2005; Macaulay 2008
8. Data from a single study
9. Keating 2005; Macaulay 2008; Mouzopoulos 2008

H.1.3 IF versus HA – dichotomous outcomes

Quality assessment							No of patients		Effect estimate		Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Internal fixation	Hemiarthro-plasty	Relative (95% CI)	Absolute	
Outcome: Mortality at 30 days											
6[1]	RCT	No serious	No serious	No serious	Serious[2]	No serious	18/338 (5.3%)	25/427 (5.9%)	RR 0.79 (0.43 to 1.43)	12 fewer per 1000 (from 33 fewer to 25 more)	MOD
Outcome: Mortality at 1 year											
13[3]	RCT	No serious	No serious	No serious	Serious[2]	No serious	193/876 (22%)	211/960 (22%)	RR 0.98 (0.83 to 1.16)	4 fewer per 1000 (from 37 fewer to 35 more)	MOD
Outcome: Mortality at 5 years											
11[4]	RCT	No serious	No serious	No serious	Serious[2]	No serious	280/608 (46.1%)	305/685 (44.5%)	RR 0.98 (0.88 to 1.09)	9 fewer per 1000 (from 53 fewer to 40 more)	MOD
Outcome: Surgical revision within follow-up period (range: 1 to 13 years)											
15[7]	RCT	Serious[8]	Serious[9]	No serious	No serious	No serious	315/946 (33.3%)	61/1022 (6%)	RR 5.85 (3.08 to 11.1)	289 more per 1000 (from 124 more to 603 more)	LOW

1. Davison 2001; Frihagen 2007; Parker 2015; Soreide 1979; van Dortmont 2000; van Vugt 1993
2. 95% CIs cross line of no effect (no statistical difference in mortality between treatment groups)

3. Blomfeldt 2005; Davison 2001; Frihagen 2007; Hedbeck 2013; Keating 2005a; Keating 2005b; Mouzopoulos 2008; Parker 2002; Parker 2015; Skinner 1989; Soreide 1979; van Dortmont 2000; van Vugt 1993
4. Blomfeldt 2005; Davison 2001; Frihagen 2007; Hedback 2013; Keating 2005a; Keating 2005b; Mouzopoulos 2008; Puolakka 2001; Roden 2003; Skinner 1989; van Vugt 1993
5. Serious study limitations (inadequate allocation procedure)
6. Data from a single study
7. Blomfeldt 2005; Davison 2001; Frihagen 2007; Hecback 2013; Keating 2005a; Ketaing 2005b; Mouzopoulos 2008; Parker 2002; Parker 2015; Puolakka 2001; Roden 2001; Skinner 1989; Soreide 1979; van Dortmont 2000; van Vugt 1993
8. Studies contributing majority of weight in the analysis have serious study limitations (inadequate or unclear allocation procedure)
9. Some surgical revision reporting may include minor re-operations (e.g. extraction of screws, treatment of infections, reduction of dislocations)

H.1.4 IF versus HA – continuous outcomes

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Internal fixation	Hemiarthro-plasty	Mean difference (95% CI)	
Outcome: Functional status at 1 year (Harris Hip Score / Hip Rating Questionnaire): higher scores = better functioning										
4[1]	RCT	Serious[2]	No serious	No serious	No serious	No serious	N = 208	N = 186	MD 6.83 lower (9.39 to 4.26 lower)	MOD
Outcome: Functional status at 5 years (Harris Hip Score / Hip Rating Questionnaire): higher scores = better functioning										
4[1]	RCT	Serious[2]	No serious	No serious	No serious	No serious	N = 165	N = 164	MD 4.32 lower (8.41 to 0.23 lower)	MOD
Outcome: Quality of life at 2 years (EQ-5D): higher mean scores = better QoL										
5[4]	RCT	Serious[2]	No serious	No serious	Serious[5]	No serious	N = 233	N = 217	MD 0.05 lower (0.1 lower to 0 higher)-	LOW
Outcome: Length of stay (days)										
6[6]	RCT	Serious[7]	No serious	Very serious[8]	tbc	No serious	N = 355	N = 336	MD: 0.01 higher (2.73 lower to 2.75 higher)	VERY LOW

1. Frihagen 2007; Keating 2005a; Keating 2005b; Mouzopoulos 2008
2. Studies contributing majority of weight to analysis have serious limitations (inadequate or unclear allocation procedure, or unblinded outcome assessment for functioning)
4. Blomfeldt 2005; Frihagen 2007; Hedbeck 2013; Keating 2005a; Keating 2005b

5. 95% CIs cross 1 published MID for EQ-5D mean difference scores (MD -0.07 Walters and Brazier 2005).
6. Frihagen 2007; Keating 2005a; Keating 2005b; Mouzopoulos 2008; Parker 2015; Roden 2003
7. Studies contributing majority of weight to analysis have serious limitations (inadequate or unclear allocation procedure)
8. $Tau^2 = 8.35$

H.1.5 IF versus THR – dichotomous outcomes

Quality assessment							No of patients		Effect estimate		Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Internal fixation	Total hip replacement	Relative (95% CI)	Absolute	
Outcome: Mortality at 30 days											
1[1]	RCT	Serious[2]	No serious	n/a[3]	Serious[4]	No serious	0/24 (0%)	1/23 (4.3%)	RR 0.32 (0.01 to 7.48)	30 fewer per 1000 (from 43 fewer to 282 more)	LOW
Outcome: Mortality at 1 year											
4[5]	RCT	Serious[6]	No serious	No serious	Serious[4]	No serious	51/281 (18.1%)	46/269 (17.1%)	RR 1.04 (0.73 to 1.49)	7 more per 1000 (from 46 fewer to 84 more)	LOW
Outcome: Surgical revision rates within follow-up period (range: 2 years to 17 years)											
7[6]	RCT	Serious[7]	Serious[8]	No serious	No serious	No serious	199/517 (38.5%)	60/518 (11.6%)	RR 3.06 (2.29 to 4.09)	239 more per 1000 (from 149 more to 358 more)	LOW

1. Jonsson 1996
2. Serious study limitations (inadequate or unclear allocation procedure)
3. Data from a single study
4. 95% CIs cross line of no effect (no statistical difference in mortality between treatment groups)
5. Johansson 2002; Keating 2005; Mouzopoulos 2008; Skinner 1989
6. Chammout 2012; Johansson 2002; Keating 2005; Liehu 2014; Mouzopoulos 2008; Skinner 1989; Tidermark 2003
7. Studies contributing majority of weight in the analysis have serious study limitations (inadequate or unclear allocation procedure)
8. Some surgical revision reporting may include minor re-operations (e.g. extraction of screws, treatment of infections, reduction of dislocations)

H.1.6 IF versus THR – continuous outcomes

Quality assessment							No of patients		Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Internal fixation	Total hip replacement	Mean difference (95% CI)	
Outcome: Functional status at 1 year										
2[1]	RCT	Serious[2]	No serious	No serious	Serious[4]	No serious	87	87	MD 9.95 lower (12.26 to 7.63 lower)	LOW
Outcome: Functional status at 5 years										
2[1]	RCT	Serious[2]	No serious	Serious[3]	Serious[4]	No serious	66	79	MD 8.98 lower (12.18 to 5.78 lower)	VERY LOW
Outcome: Length of stay (days)										
2[5]	RCT	No serious	No serious	Very serious[6]	tbc	No Serious	240	269	MD 1.31 lower (8.43 lower to 5.81 higher)	LOW

1. Keating 2005; Mouzopoulos 2008
2. Studies have serious limitations (inadequate or unclear allocation procedure)
3. $Tau^2 = 6.48$
4. 95% CIs cross one MID (Harris Hip score MID = 10)
5. Keating 2005; Liehu 2014
6. $Tau^2 = 38.06$

H.2 RQ2 - Undisplaced intracapsular hip fracture

H.2.1 IF

Quality assessment							No of patients	Effect estimate	Quality
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Number undisplaced	Effect estimate	
Mortality at 30 days									
1 (Bjorgul 2007)	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	225	7% (95% CI: NR)	Low
Mortality at 1 year									
1 (Bjorgul	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	607	21%	Low

Quality assessment							No of patients	Effect estimate	
No of studies	**Design**	**Risk of bias**	**Indirectness**	**Inconsistency**	**Imprecision**	**Other considerations**	**Number undisplaced**	**Effect estimate**	**Quality**
2007 and Lapidus 2013)									
Lapidus 2013	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	382[7]	21.5%	Low
Mortality at 5 years									
1 (Lee 2008)	Case series	No serious[1]	Serious[5]	N/A[3]	NC[4]	None	90	8.9% (95% CI: NR)	Very low
Surgical revision									
2(Bjorgul 2007and van Walsum 2016)	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	374	Range = 4% - 19%)	Low
Lapidus 2013	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	382[7]	11.8%	Low
Functional status at 1 year - HHS									
1 (Song Hyung 2013)	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	78	Mean = 85.7 (95% CI: 83.3 – 88.0)	Low
Functional status at 5 years HHS									
2 (Lee 2008 and Yih-Shiunn 2007)	Case series	No serious[1]	Serious[6]	N/A[3]	NC[4]	None	150	Range = 80.16 - 83.36	Very low
Length of stay – mean days									

Quality assessment							No of patients	Effect estimate	
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Number undisplaced	Effect estimate	Quality
2 (Lee 2008 and Yih-Shiunn 2006)	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	174	Range = 7.7 – 8.4	Low

1. No serious risk of bias (assessed using the JBI critical appraisal checklist for case series).
2. No indirectness as population, intervention, outcomes meet criteria defined in the protocol.
3. Inconsistency not applicable as meta-analysis was not used to pool evidence
4. Imprecision not calculable as the evidence was not analysed statistically.
5. 2 year (25.5 months) follow-up data used.
6. 2 year (25.5 months) and 34.6 months data used
7 data reported as 382 hips from 379 patients. .

H.2.2 CM

Quality assessment							No of patients	Effect estimate	
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Number undisplaced	Effect estimate	Quality
Mortality at 1 year									
1 (Raaymakers 2002)	Case series	No serious[1]	No serious[2]	N/A[3]	NC[4]	None	319	19% (95% CI: NR)	Low
Mortality at 5 years									
1 (Raaymakers 2002)	Case series	No serious[1]	Serious[5]	N/A[3]	NC[4]	None	319	25% (95% CI: NR)	Low
Revision - further treatment received (including internal fixation and hemiarthroplasty)									
3 (Buord 2010;	Case series	Serious[6]	No serious[2]	N/A[3]	NC[4]	None	397	Median % = 9.1% (range: 2.5% - 42%)	Very low

Quality assessment							No of patients	Effect estimate	
No of studies	Design	Risk of bias	Indirectness	Inconsistency	Imprecision	Other considerations	Number undisplaced	Effect estimate	Quality
Raaymakers 2002 and Tanaka 2002)									
Functional status at 5 years– HHS (mean)									
2 (Buord 2010 and Pihlajamaki 2006)	Case series	No serious[1]	Serious[7]	N/A[3]	NC[4]	None	106	Range = 82 – 97	Very low
Length of stay – mean days									
2 (Buord 2010 and Tanaka 2002)	Serious[6]	No serious[2]	N/A[3]	NC[4]	None	None	78	Range = 8 - 58.5	Very low

1. No serious risk of bias (assessed using the JBI critical appraisal checklist for case series).
2. No indirectness as population, intervention, outcomes meet criteria defined in the protocol.
3. Inconsistency not applicable as meta-analysis was not used to pool evidence.
4. Imprecision not calculable as the evidence was not analysed statistically.
5. 2 year mortality rate used.
6. Unclear if case series is consecutive in one study (Tanaka 2002).
7. End of follow-up data used (follow-up range 20 months – 18.3 yrs).

Appendix I: Forest plots

I.1 RQ1 – Displaced intracapsular hip fracture

I.1.1 HA versus THR

Figure 3: Mortality at 30 days

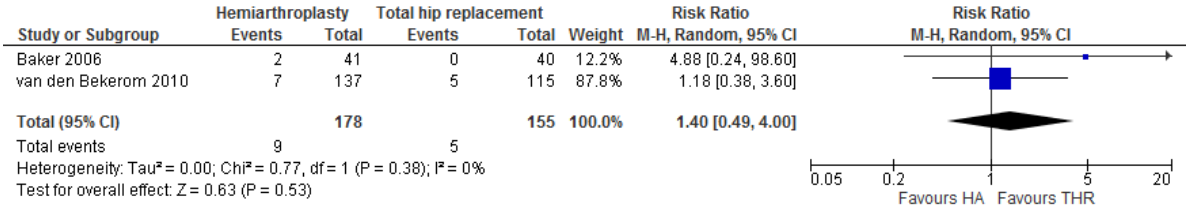


Figure 4: Mortality at 1 year

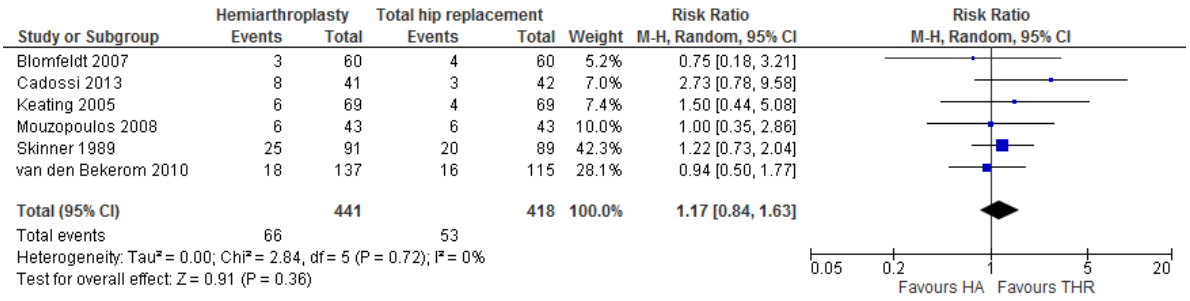


Figure 5: Mortality at 1 year – Subgroup by age

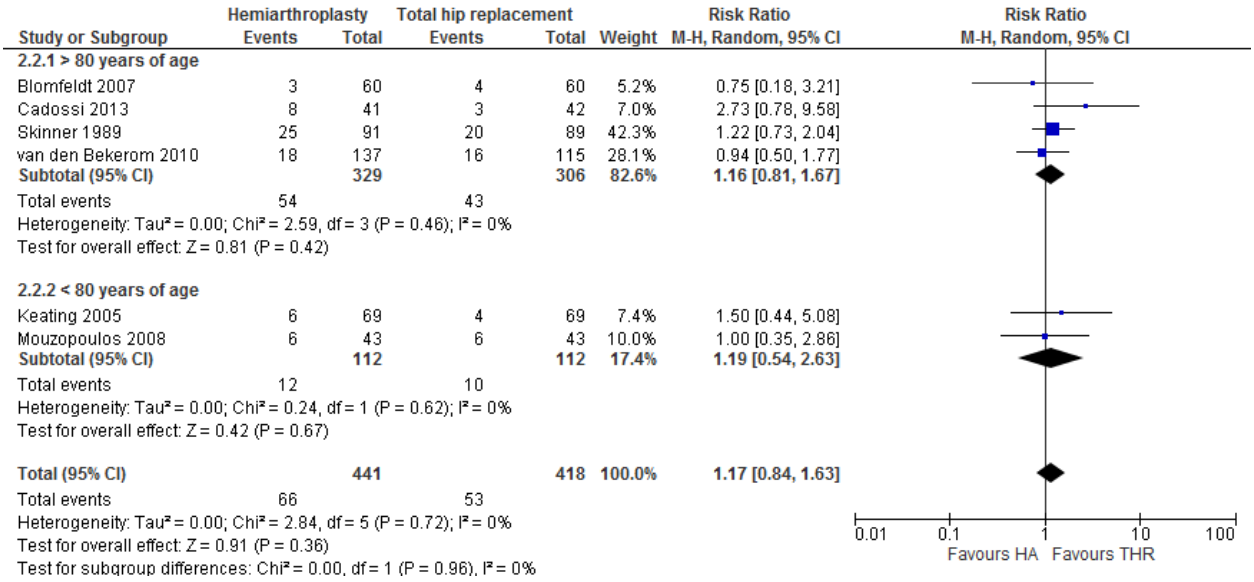


Figure 6: Mortality at 1 year – Subgroup by cognitive impairment

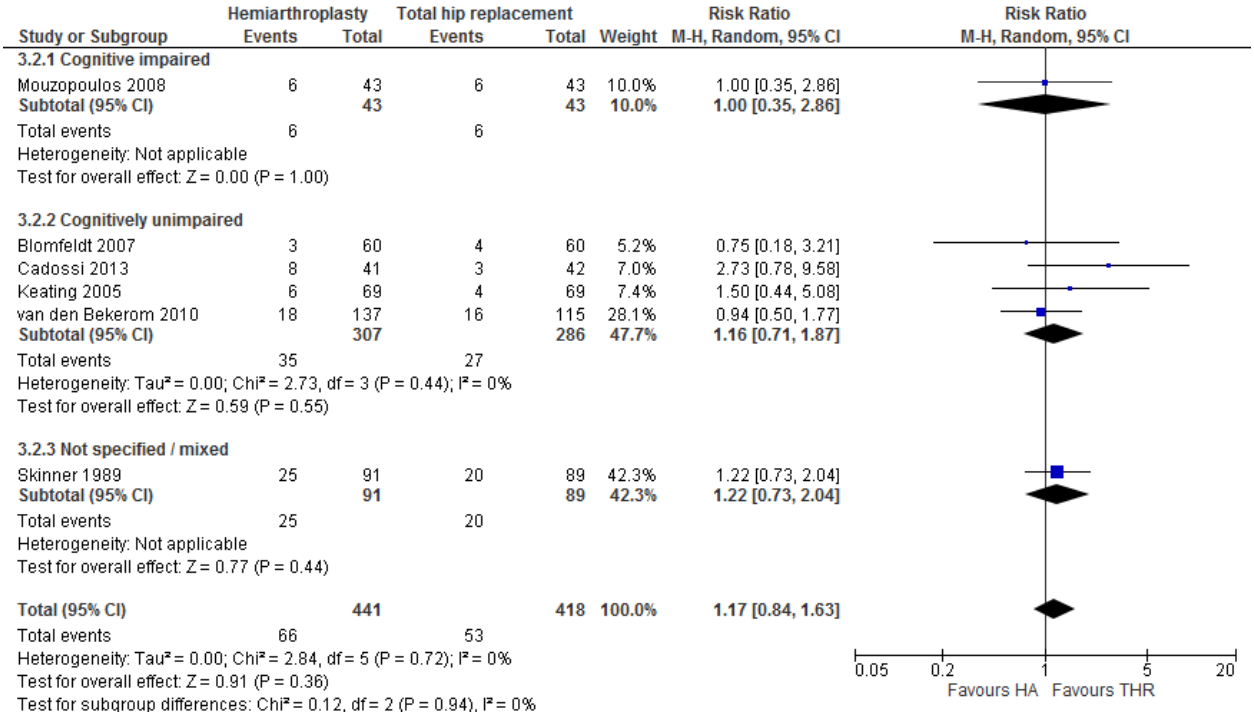


Figure 7: Mortality at 5 years

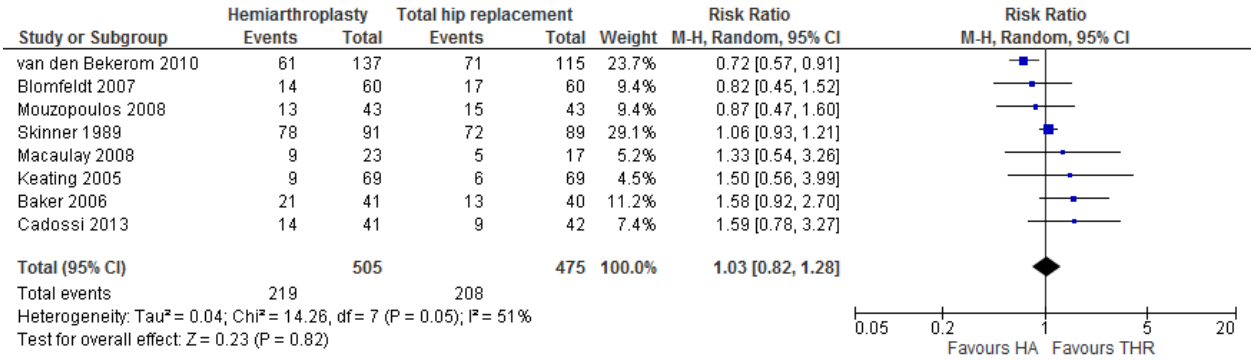


Figure 8: Mortality at 5 years – Subgroup by age

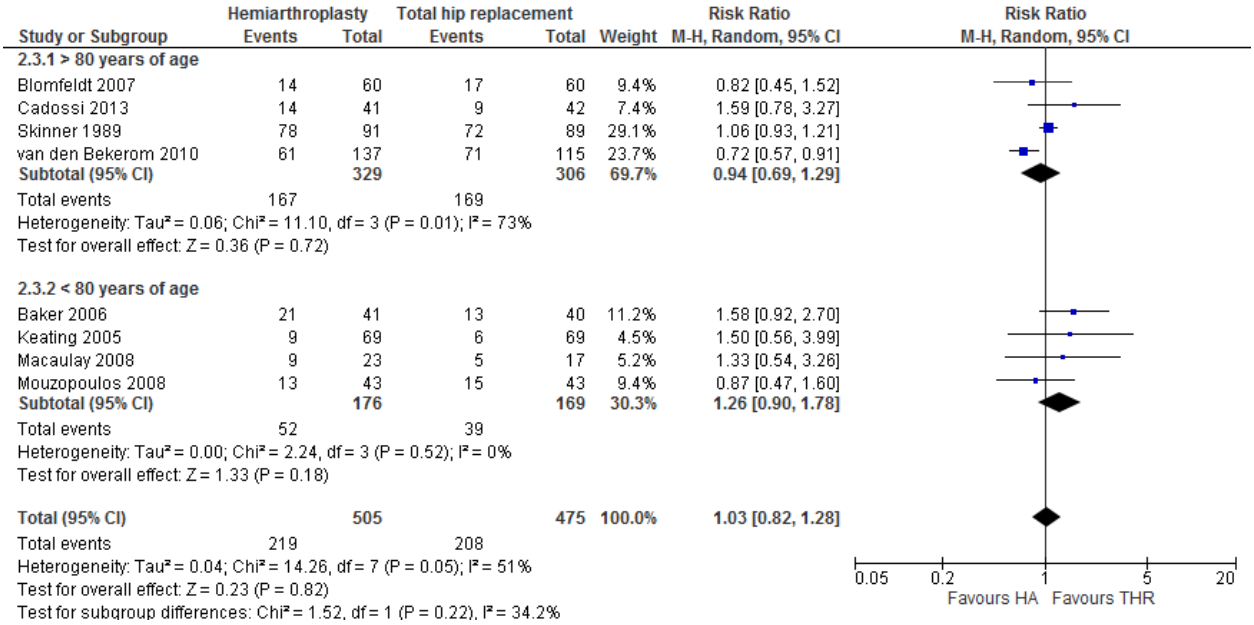


Figure 9: Mortality at 5 years – Subgroup by cognitive impairment

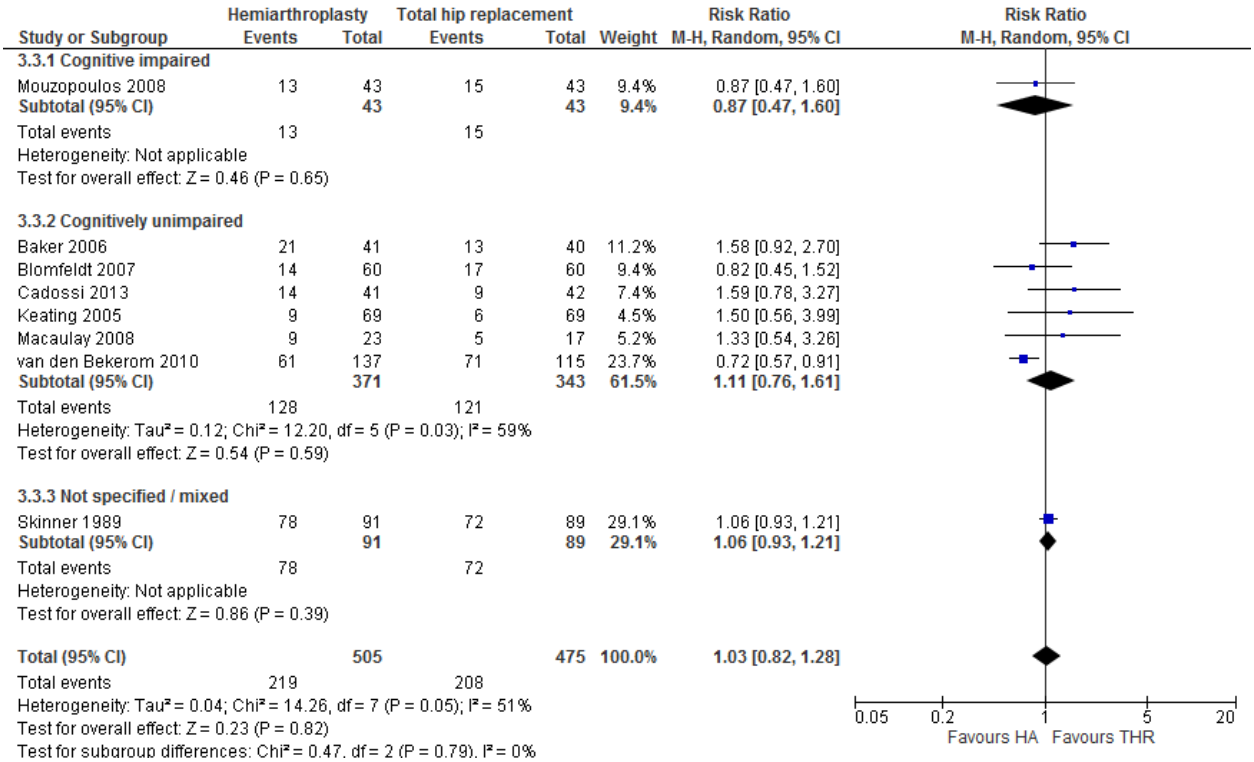
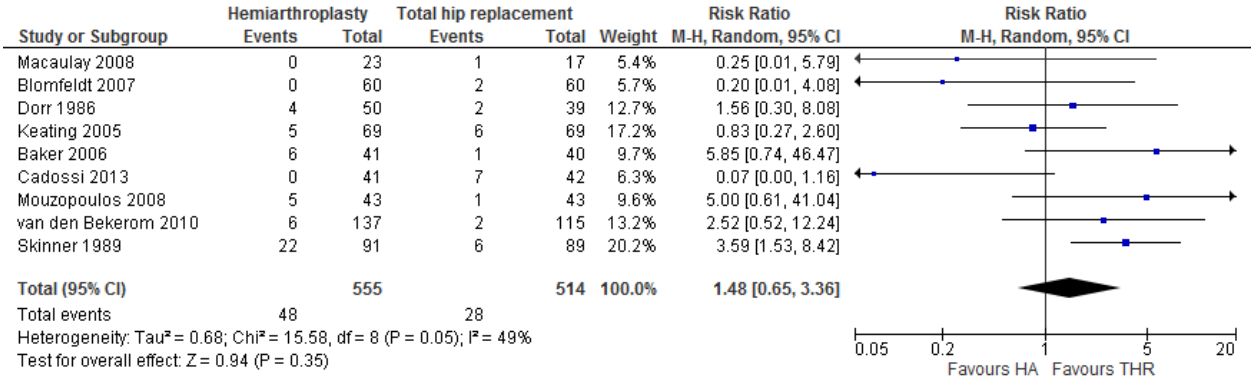


Figure 10: Surgical revisions within follow-up period (range: 6 months to 13 years)



Timepoints: within 6 months (Macaulay 2008); 1 year (Blomfeldt 2007); 2 years (Dorr 1986; Keating 2005); 3 years (Baker 2006; Cadossi 2013); 4 years (Mouzpoulos 2008); 5 years (van den Bekerom); 13 years (Skinner1989)

Figure 11: Surgical revisions within follow-up period - Subgroup by age

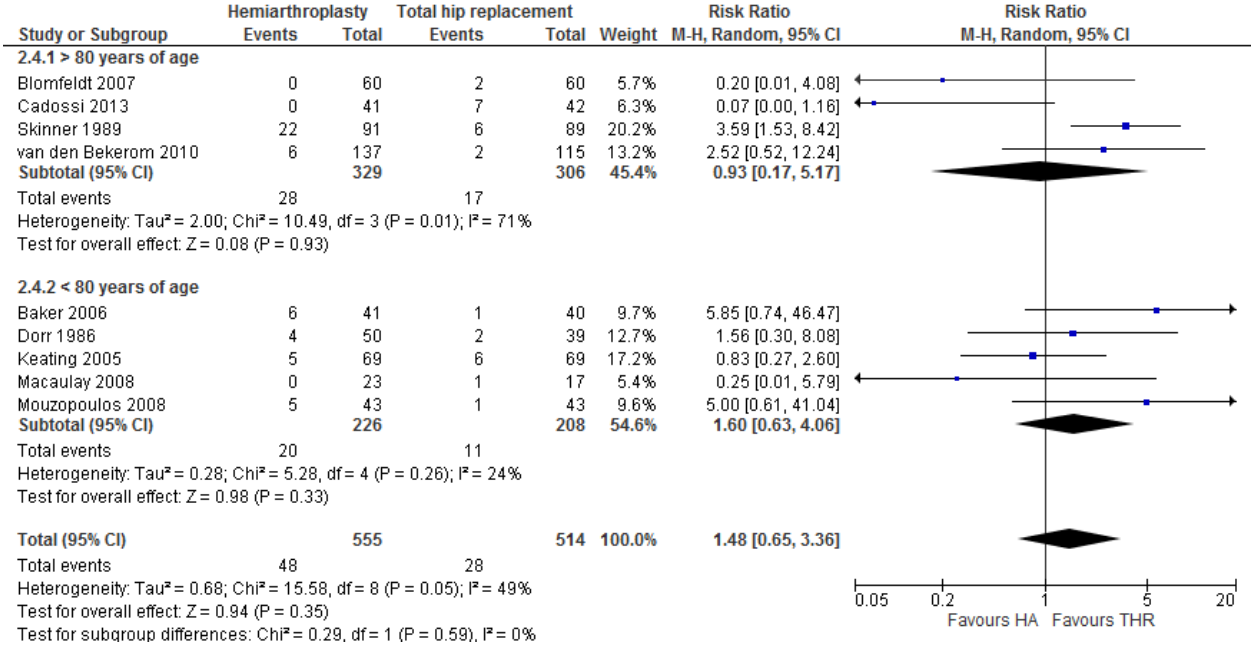


Figure 12: Surgical revisions within follow-up period - Subgroup by cognitive impairment

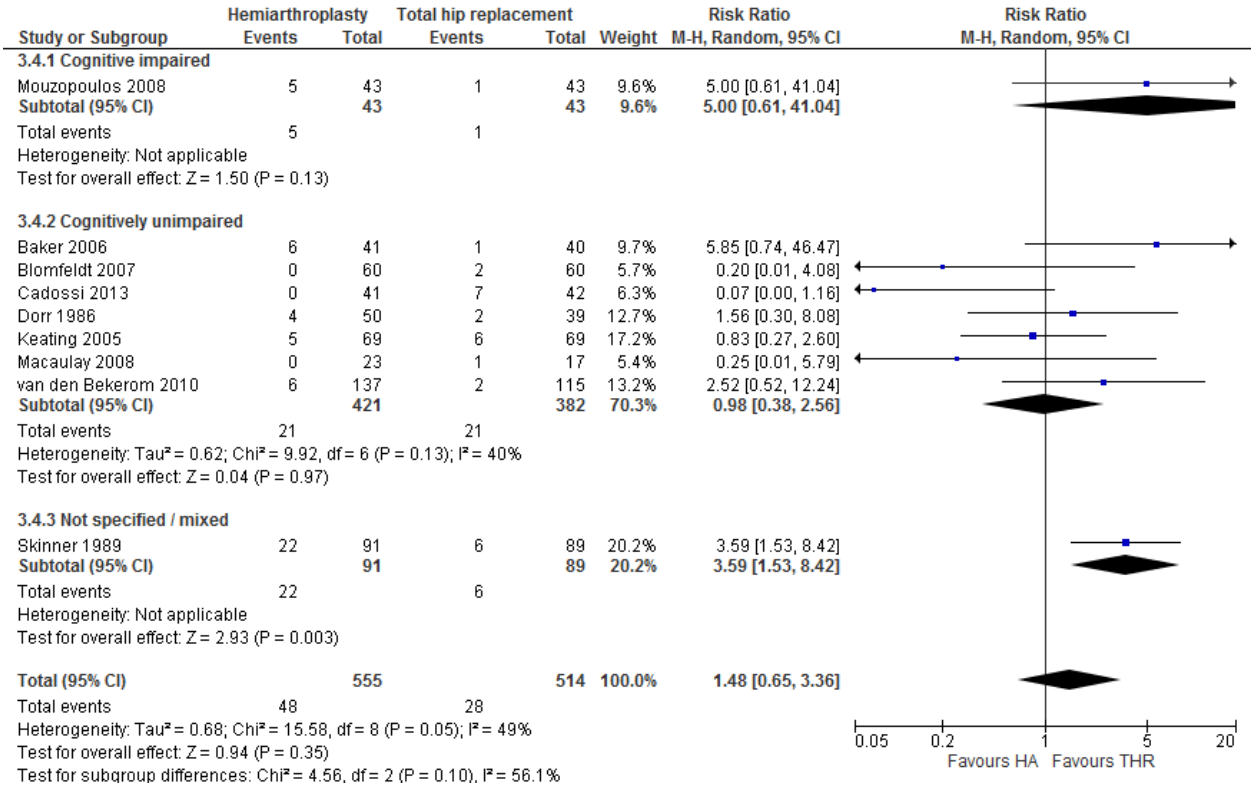


Figure 13: Functional status at 1 year (higher scores = better functioning)

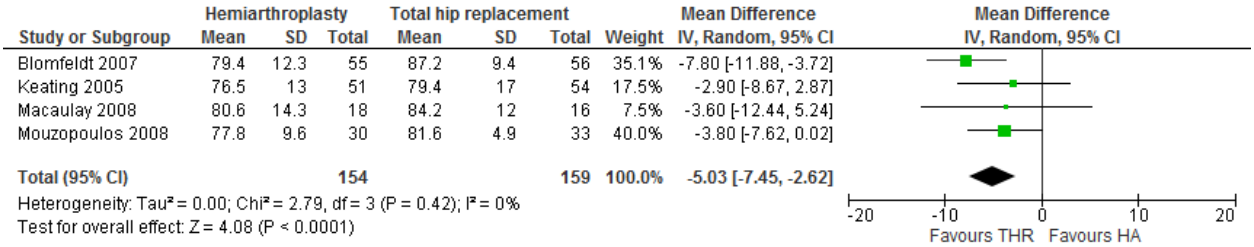


Figure 14: Functional status at 1 year – Subgroup by Age

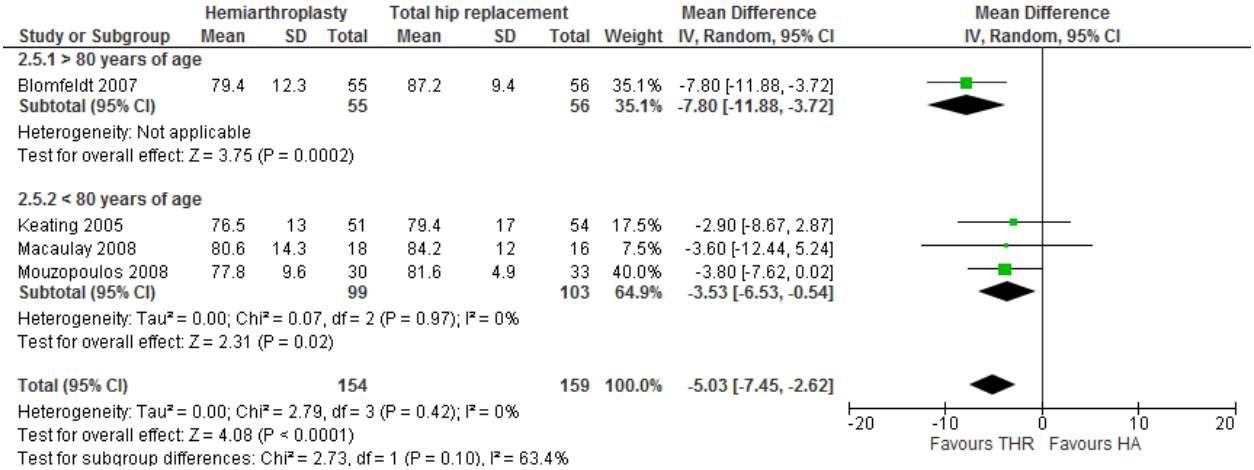


Figure 15: Functional status at 1 year – Subgroup by Cognitive impairment

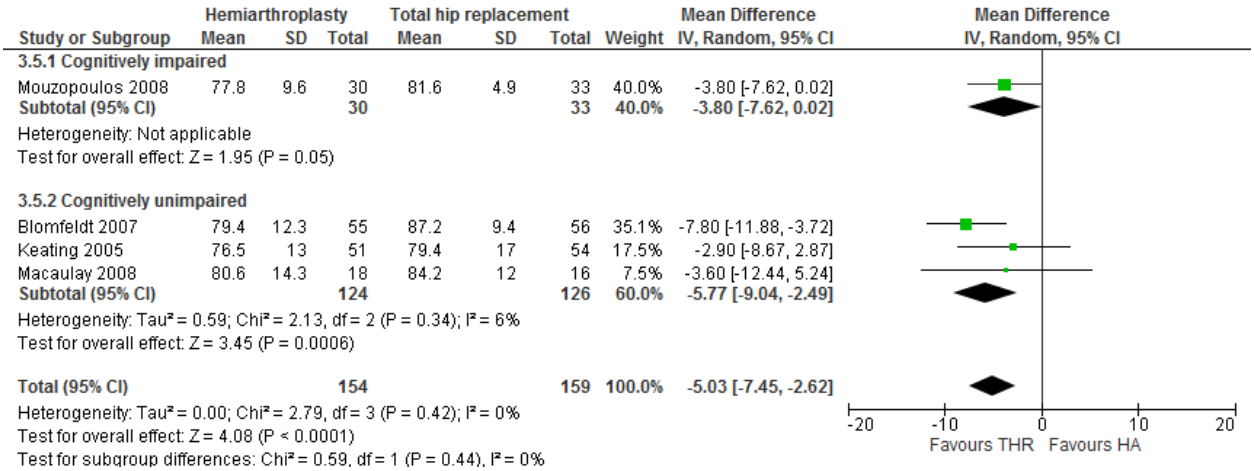
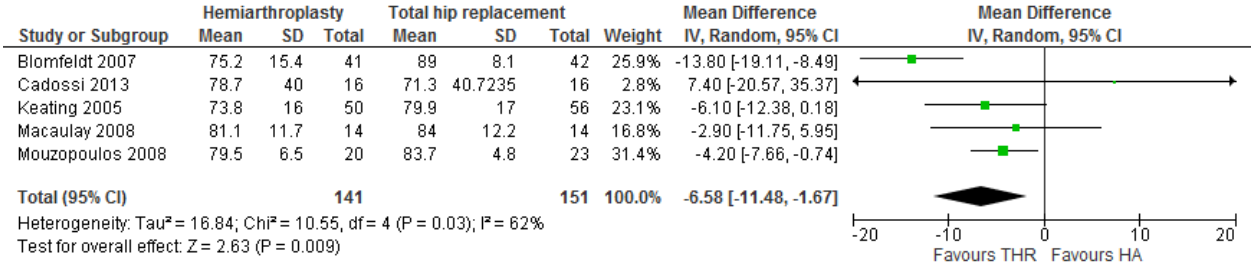


Figure 16: Functional status at 5 years (higher scores = better functioning)



Measures: Harris Hip Score (Blomdelft 2007, Macaulay 2008; Mouzopoulos 2008); Hip Rating Questionnaire (Keating 2005)

Figure 17: Functional status at 5 years – Subgroup by age (higher scores = better functioning)

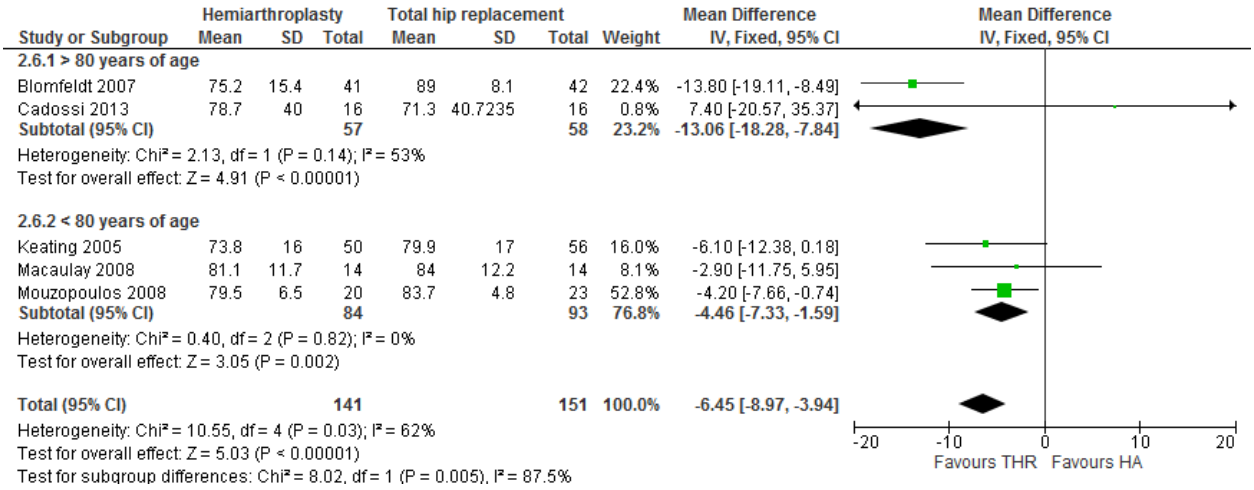


Figure 18: Functional status at 5 years – Subgroup by Cognitive impairment (higher scores = better functioning)

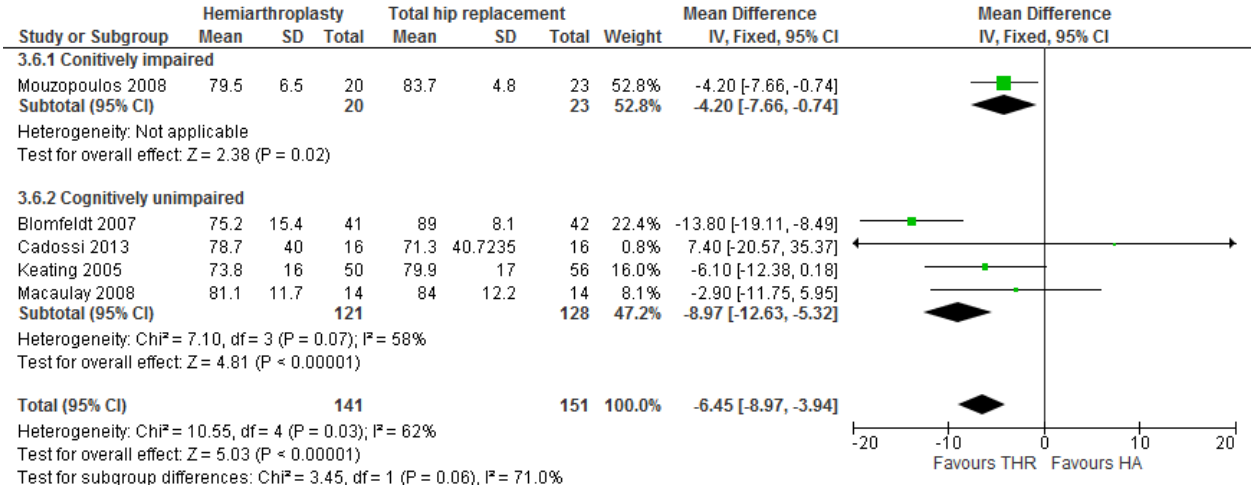


Figure 19: Quality of life (EQ5D) - at 4 months (higher scores = better QoL)

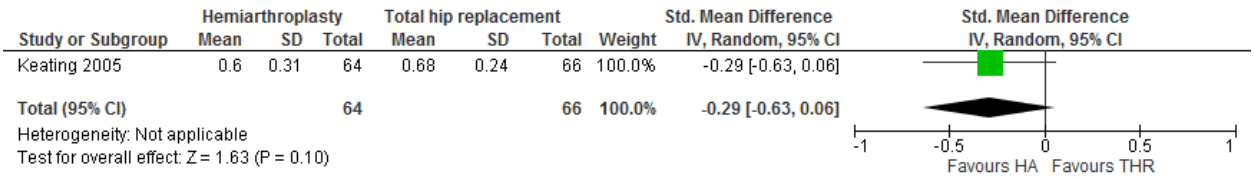


Figure 20: Length of stay (days)

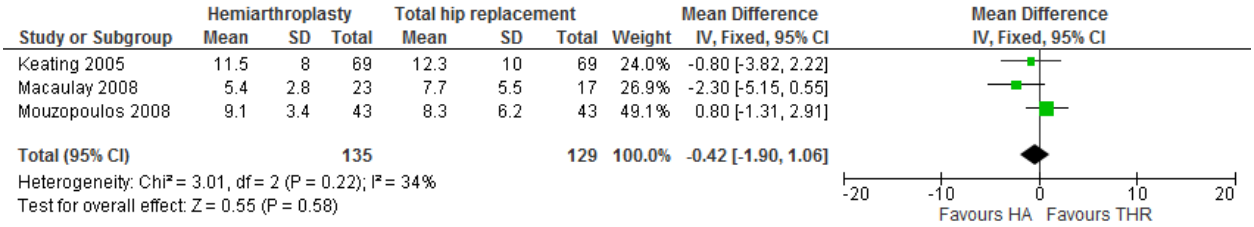


Figure 21: Place of residence – at 1 year

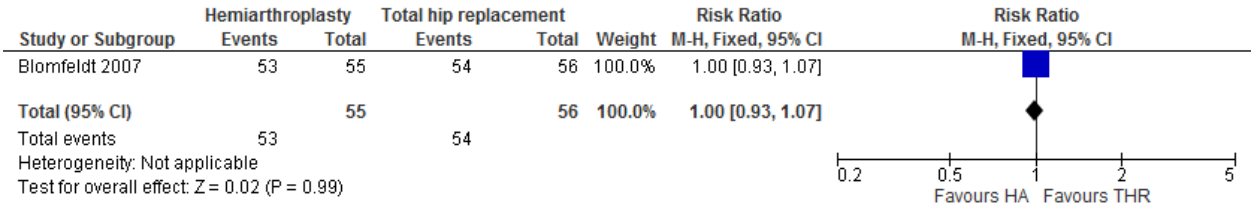
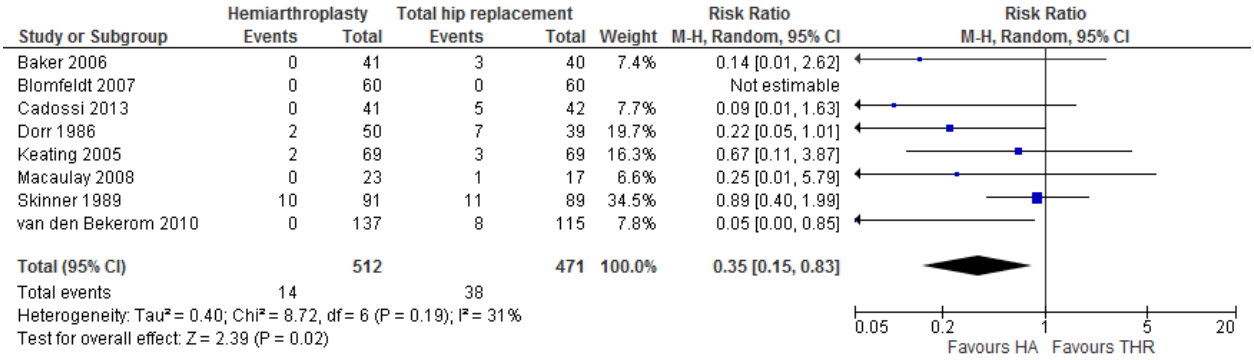
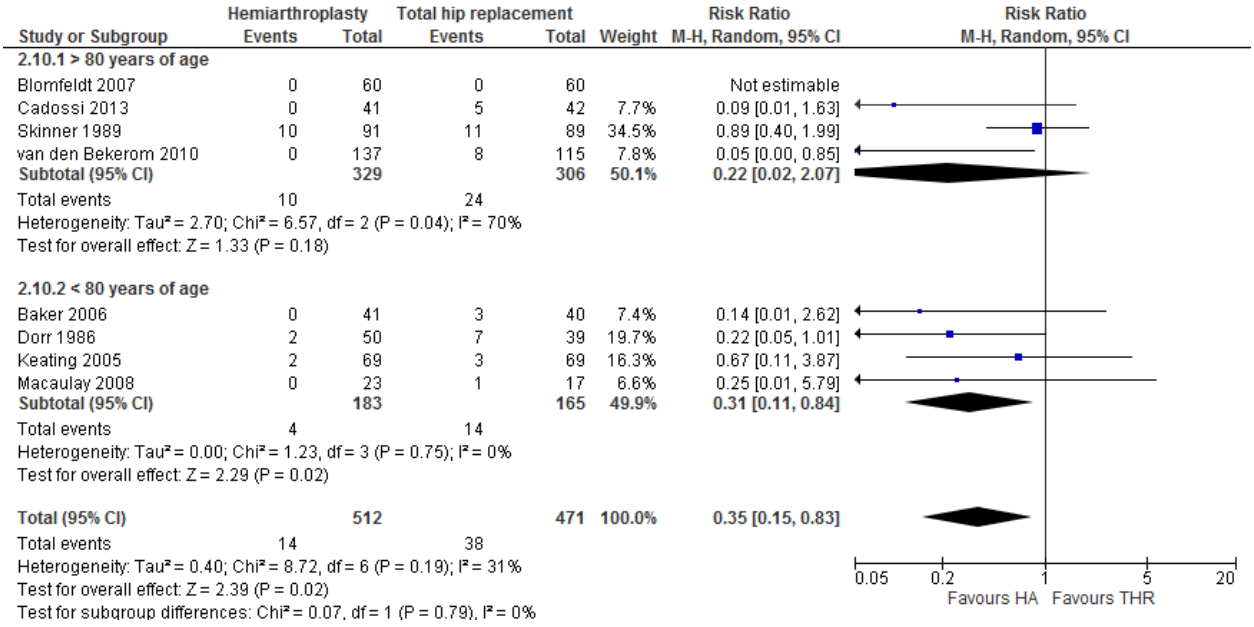


Figure 22: Dislocation rate at follow-up (range: 30 days – 5 years)



Timepoints: within 30 days (Baker 2006); within 6 months (Macaulay 2008); 1 year (Skinner 1989); years (Blomfeldt 2007; Dorr 1986; Keating 2005; 3 years (Cadossi 2013); 5 years (van den Bekerom)

Figure 23: Dislocation rate at follow-up – Subgroup by Age



I.1.2 IF versus HA

Figure 24: Mortality at 30 days

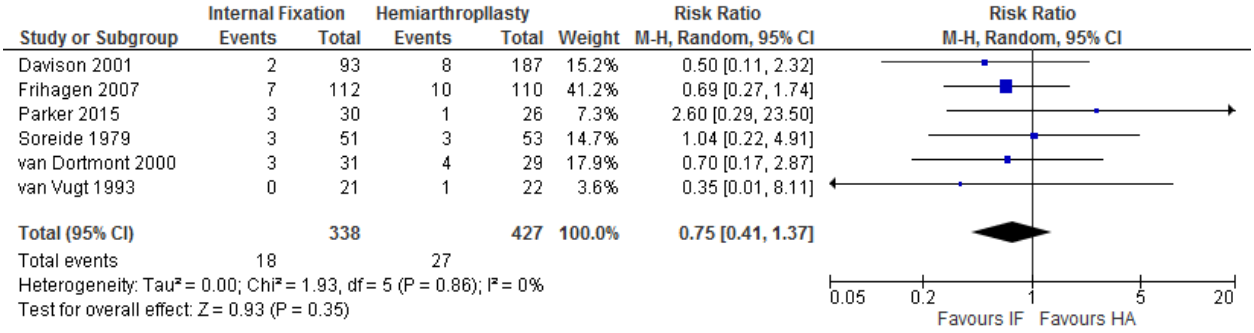


Figure 25: Mortality at 1 year

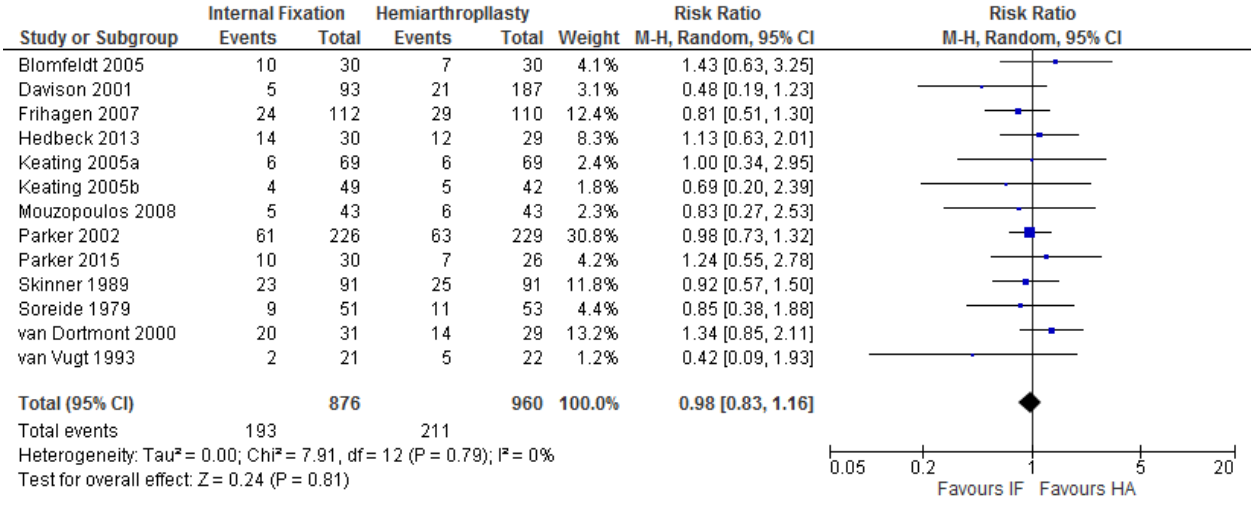


Figure 26: Mortality at 5 years

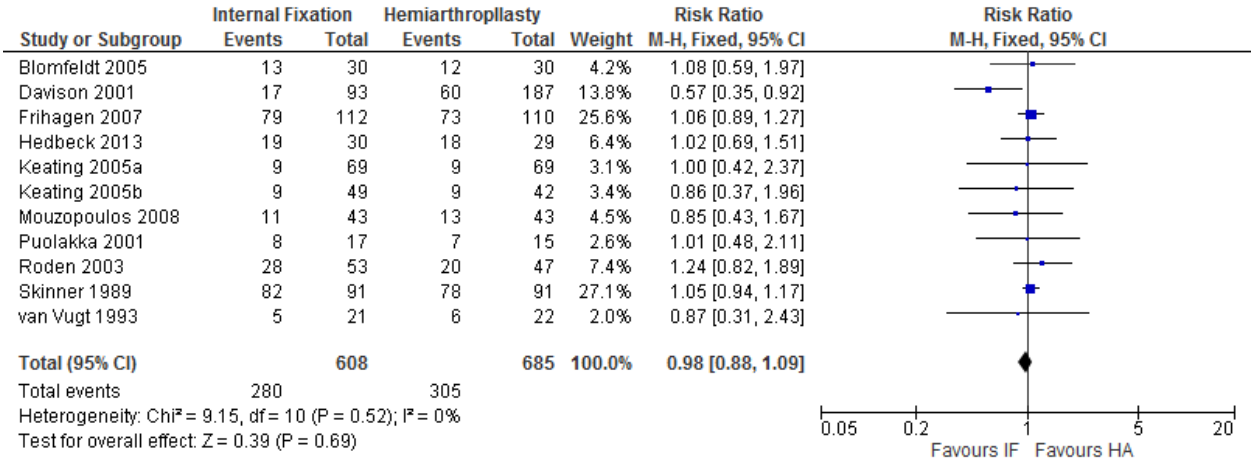
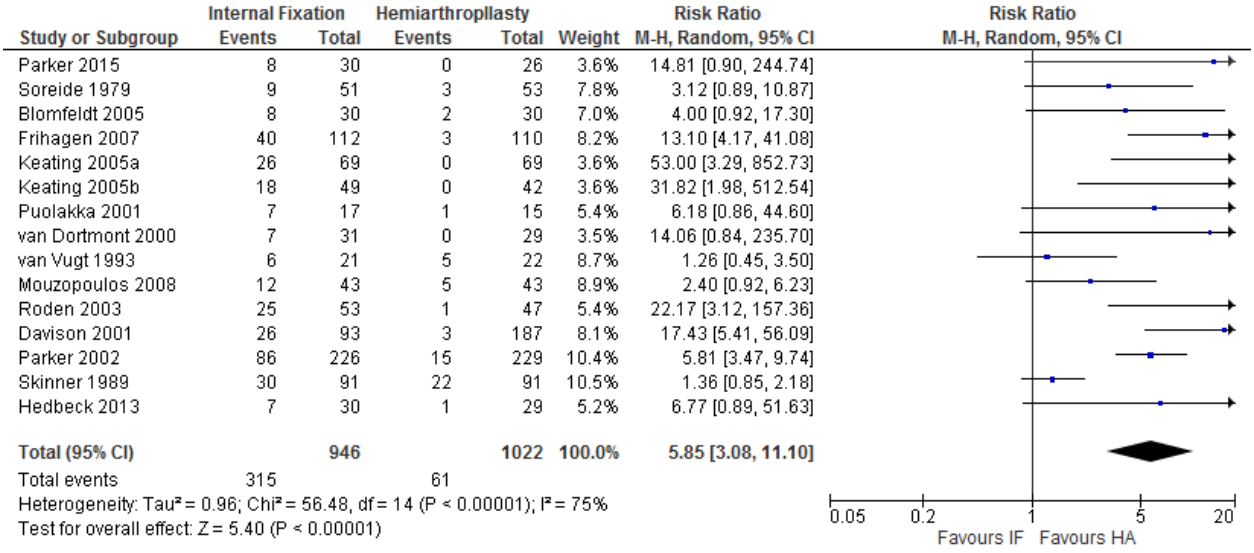


Figure 27: Surgical revisions within follow-up period (range: 1 to 13 years)



Timepoints; 1 year (Parker 2015; Soreide 1979); 2 years (Blomfeldt 2005; Hedbeck 2013; Keating 2005a; Keating 2005b); 3 years (Davison 2001; van Vugt 1993); 4 years (Mouzopoulos 2008); 6 years (Frihagen 2007); 11 years (Parker 2002); 13 years (Skinner 1989); unclear (Puolakka 2001)

Figure 28: Functional status at 1 year (higher mean scores = better functioning)

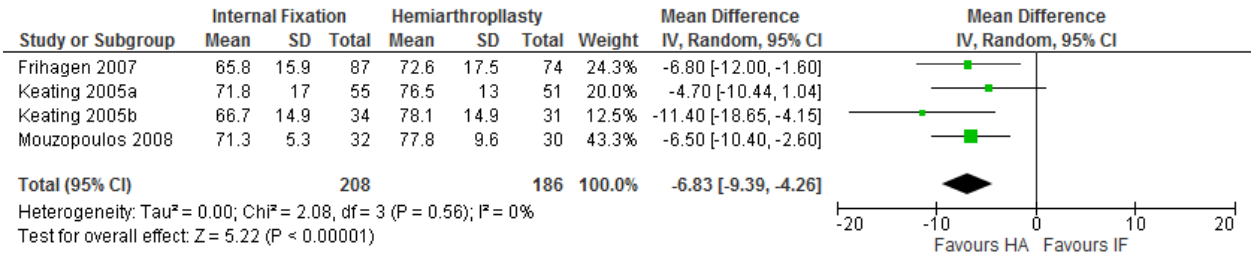


Figure 29: Functional status at 5 years (higher mean scores = better functioning)

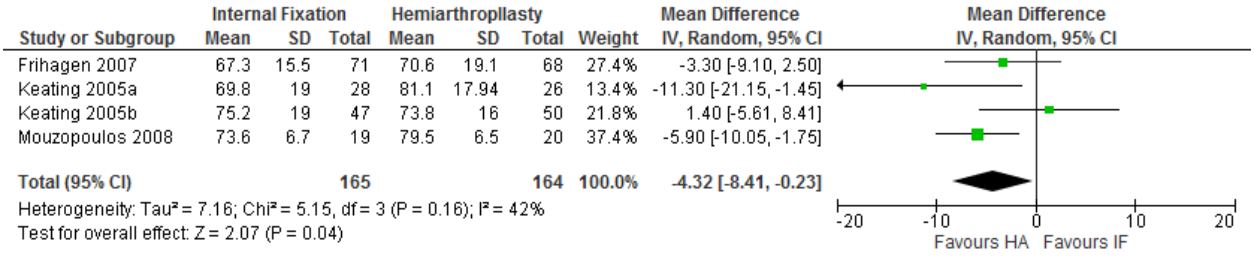


Figure 30: Quality of life - at 4 months (higher mean scores = better QoL)

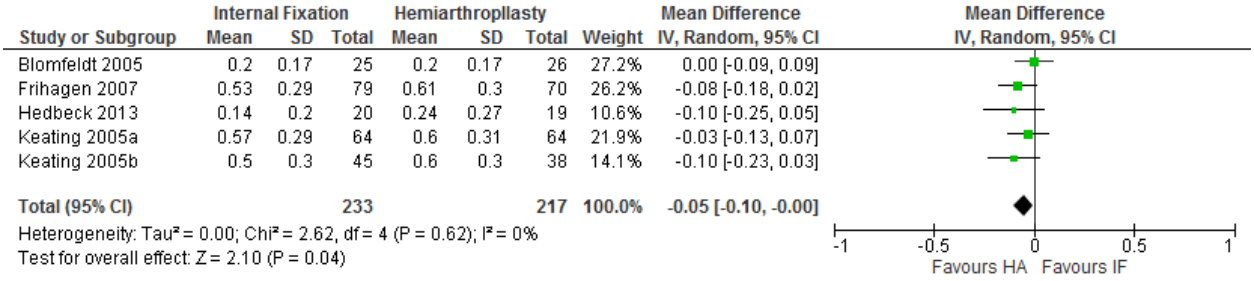
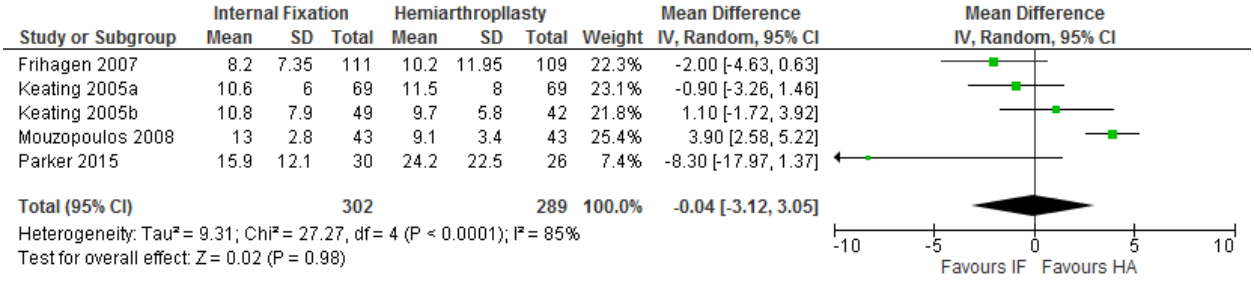


Figure 31: Length of stay (days)



I.1.3 IF versus THR

Figure 32: Mortality at 30 days

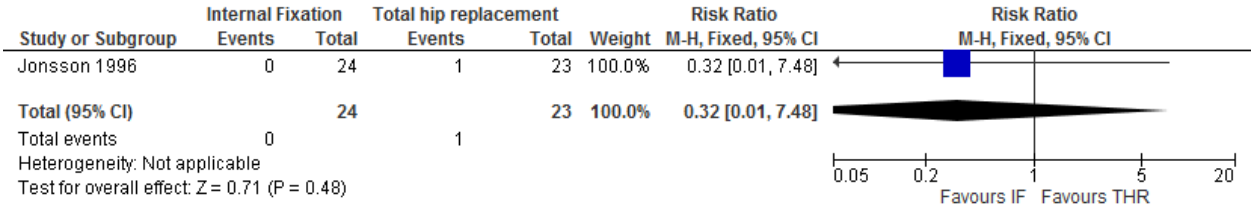


Figure 33: Mortality at 1 year

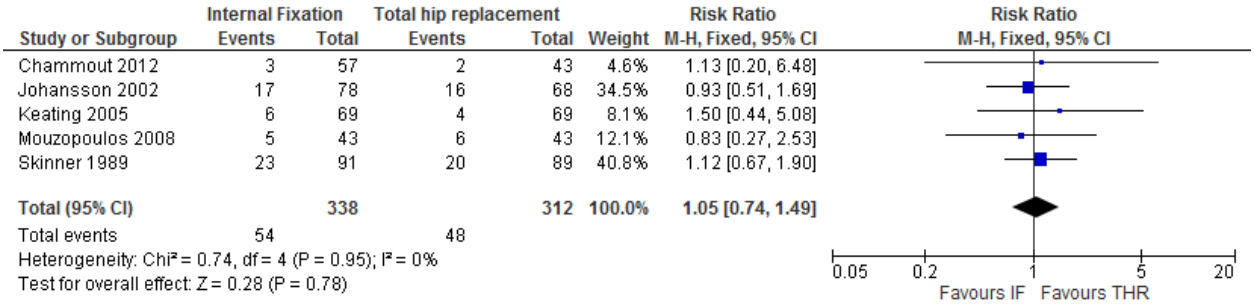


Figure 34: Mortality at 5 years

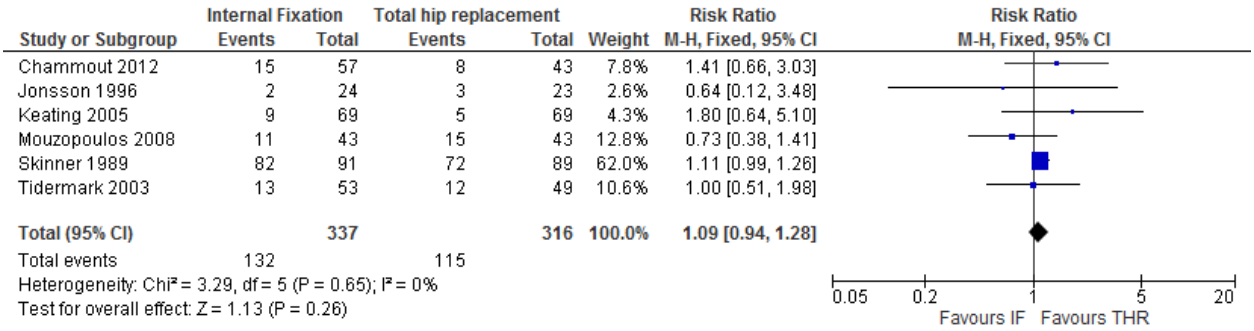
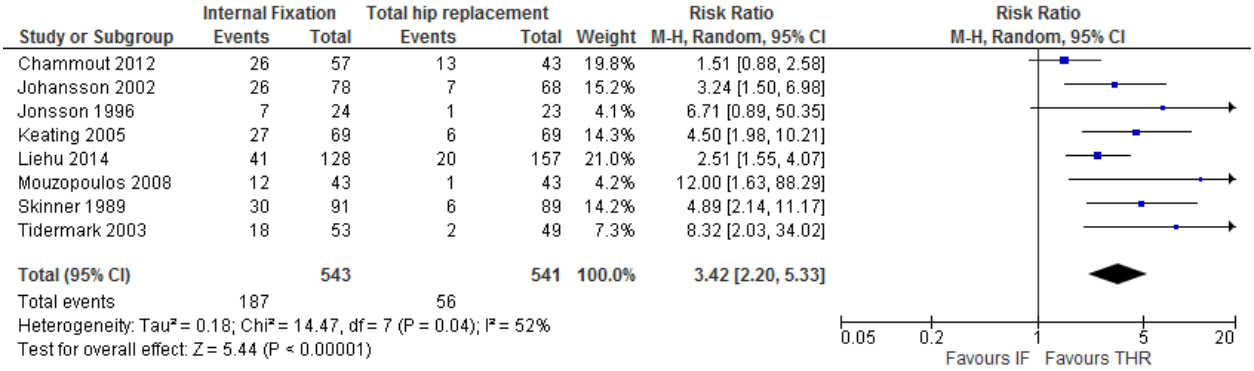


Figure 35: Surgical revisions within follow-up period (range: 2 years to 17 years)



Timepoints: 2 years (Johansson 2002; Jonsson 1996; Keating 2005; Tidermark 2003); 4 years (Mouzopoulos 2008); 5 years (Liehu 2014); 13 years (Skinner 1989); 17 years (Chammout 2012)

Figure 36: Functional status at 1 year (higher scores = better functioning)

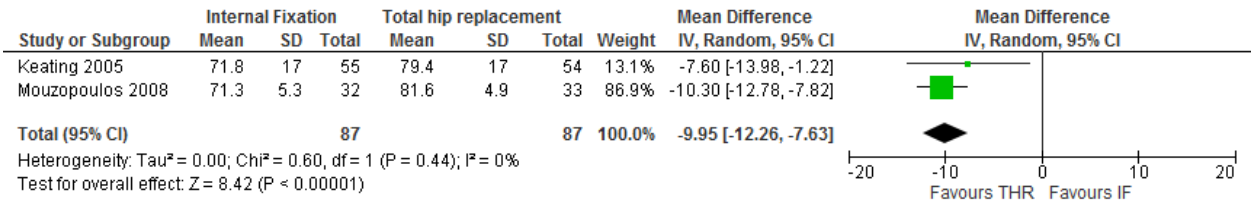


Figure 37: Functional status at 5 years (higher scores = better functioning)

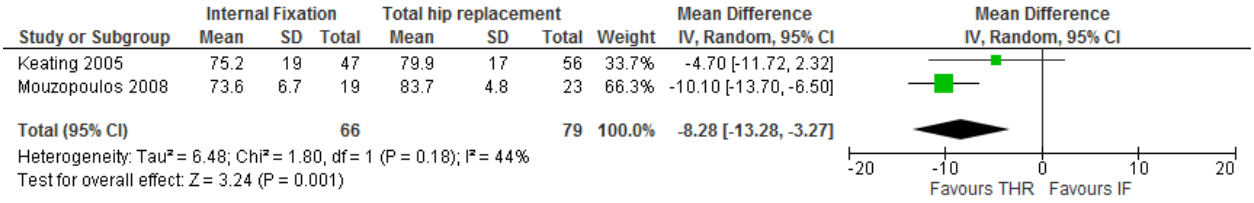


Figure 38: Quality of life – at 4 months (higher scores = better QoL)

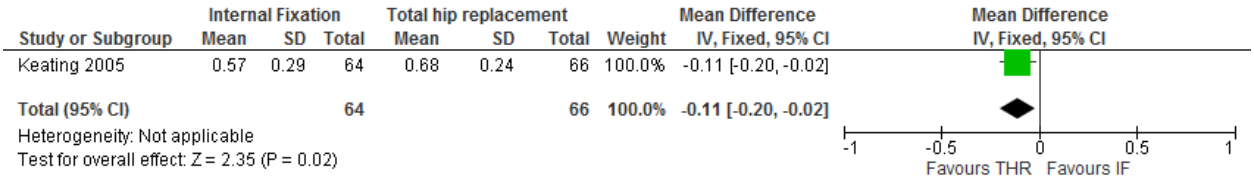
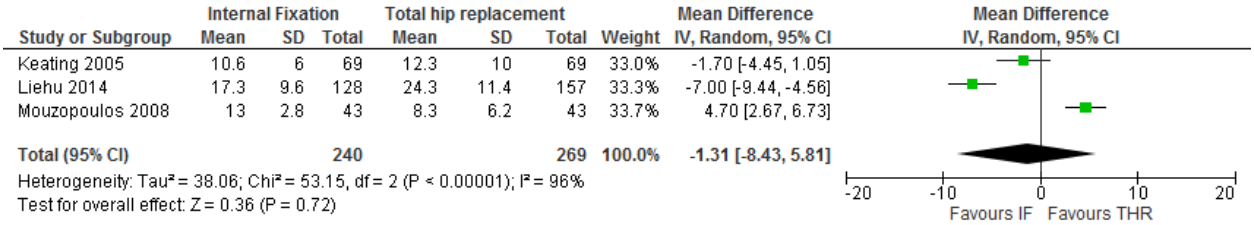


Figure 39: Length of stay (days)



Appendix J: Economic evidence review methods

Evidence of cost effectiveness

The Committee is required to make decisions based on the best available evidence of both clinical and cost effectiveness. Guideline recommendations should be based on the expected costs of the different options in relation to their expected health benefits rather than the total implementation cost.

Evidence on cost effectiveness related to the key clinical issues being addressed in the guideline update was sought. The health economist undertook a systematic review of the published economic literature.

Economic literature search

A systematic literature search was undertaken to identify health economic evidence within published literature relevant to the review questions. The evidence was identified by conducting a broad search relating to management of displaced intracapsular hip fracture in the NHS Economic Evaluation Database (NHS EED) and the Health Technology Assessment database (HTA). The search also included Medline and Embase databases using an economic filter. Studies published in languages other than English were not reviewed. The search was conducted on 20/06/16. The health economic search strategies are detailed in appendix K.

The health economist also sought out relevant studies identified by the surveillance review or Committee members.

Economic literature review

The health economist:

- Identified potentially relevant studies for each review question from the economic search results by reviewing titles and abstracts. Full papers were then obtained.
- Reviewed full papers against prespecified inclusion and exclusion criteria to identify relevant studies.
- Critically appraised relevant studies using the economic evaluations checklist as specified in *Developing NICE Guidelines: the manual 2014*.
- Extracted key information about the studies' methods and results into full economic evidence tables (appendix N).
- Generated summaries of the evidence in economic evidence profiles.

Inclusion and Exclusion criteria

Full economic evaluations (studies comparing costs and health consequences of alternative courses of action: cost-utility, cost-effectiveness, cost-benefit and cost-consequence analyses) and comparative costing studies that address the review question in the relevant population were considered potentially includable as economic evidence.

Studies that only reported burden of disease or cost of illness were excluded. Literature reviews, abstracts, posters, letters, editorials, comment articles, unpublished studies and studies not in English were excluded.

Remaining studies were prioritised for inclusion based on their relative applicability to the development of this guideline and the study limitations. For example, if a high quality, directly applicable UK analysis was available, then other less relevant studies may not have been included. Where selective exclusions occurred on this basis, this is noted in the excluded economic studies table (appendix M).

For more details about the assessment of applicability and methodological quality see the economic evaluation checklist contained in *Appendix H* of *Developing NICE Guidelines: the manual 2014*.

Economic evidence profile

The economic evidence profile summarises cost-effectiveness estimates. It shows an assessment of the applicability and methodological quality for each economic evaluation, with footnotes indicating the reasons for the assessment. These assessments were made by the health economist using the economic evaluation checklist from *Appendix H* of *Developing NICE Guidelines: the manual 2014*. It also shows the incremental cost, incremental effect and incremental cost-effectiveness ratio for the base case analysis in the evaluation, as well as information about the assessment of uncertainty.

Table 4 explains the information contained in the economic evidence profile.

Table 15: Explanation of fields used in the economic evidence profile

Item	Description
Study	This field is used to reference the study and provide basic details on the included interventions and country of origin.
Applicability	Applicability refers to the relevance of the study to specific review questions and the NICE reference case. Attributes considered include population, interventions, healthcare system, perspective, health effects and discounting. The applicability of the study is rated as: • Directly applicable – the study meets all applicability criteria or fails to meet one or more applicability criteria but this is unlikely to change the conclusions about cost effectiveness. • Partially applicable – the study fails to meet one or more applicability criteria and this could change the conclusions about cost effectiveness. • Not applicable – the study fails to meet one or more of the applicability criteria and this is likely to change the conclusions about cost effectiveness. Such studies would usually be excluded from the review.
Limitations	This field provides an assessment of the methodological quality of the study. Attributes assessed include the relevance of the model's structure to the review question, timeframe, outcomes, costs, parameter sources, incremental analysis, uncertainty analysis and conflicts of interest. The methodological quality of the evaluation is rated as having: • Minor limitations – the study meets all quality criteria or fails to meet one or more quality criteria, but this is unlikely to change the conclusions about cost effectiveness. • Potentially serious limitations – the study fails to meet one or more quality criteria and this could change the conclusions about cost effectiveness

Item	Description
	• Very serious limitations – the study fails to meet one or more quality criteria and this is highly likely to change the conclusions about cost effectiveness. Such studies would usually be excluded from the review.
Other comments	This field contains particular issues that should be considered when interpreting the study, such as model structure and timeframe.
Incremental cost	The difference between the mean cost associated with one strategy and the mean cost of a comparator strategy.
Incremental effect	The difference between the mean health effect associated with the intervention and the mean health effect associated with the comparator. This is usually represented by quality-adjusted life years (QALYs) in accordance with the NICE reference case.
Incremental cost effectiveness ratio (ICER)	The incremental cost divided by the incremental effect which results in the cost per quality-adjusted life year gained (or lost). Negative ICERs are not reported as they could represent very different conclusions: either a decrease in cost with an increase in health effects; or an increase in cost with a decrease in health effects. For this reason, the word 'dominates' is used to represent an intervention that is associated with decreased costs and increased health effects compared to the comparator, and the word 'dominated' is used to represent an intervention that is associated with an increase in costs and decreased health effects.
Uncertainty	A summary of the extent of uncertainty about the ICER. This can include the results of deterministic or probabilistic sensitivity analysis or stochastic analyses or trial data.

Cost-effectiveness criteria

NICE's report *Social value judgements: principles for the development of NICE guidance* sets out the principles that GDGs should consider when judging whether an intervention offers good value for money. In general, an intervention was considered to be cost effective if either of the following criteria applied (given that the estimate was considered plausible):

- the intervention dominated other relevant strategies (that is, it was both less costly in terms of resource use and more clinically effective compared with all the other relevant alternative strategies), or
- the intervention cost less than £20,000 per QALY gained compared with the next best strategy.

If the Committee recommended an intervention that was estimated to cost more than £20,000 per QALY gained, or did not recommend one that was estimated to cost less than £20,000 per QALY gained, the reasons for this decision are discussed explicitly in the 'evidence to recommendations' section of the relevant chapter, with reference to issues regarding the plausibility of the estimate or to the factors set out in *Social value judgements: principles for the development of NICE guidance*.

In the absence of economic evidence

When no relevant economic studies were found from the economic literature review, and de novo modelling was not feasible or prioritised, the Committee made a qualitative judgement about cost-effectiveness by considering expected differences in resource use between options and relevant UK NHS unit costs, alongside the results of the clinical review of effectiveness evidence. The UK NHS costs reported in the guideline were those presented to the Committee

and they were correct at the time recommendations were drafted; they may have been revised subsequently by the time of publication. However, we have no reason to believe they have been changed substantially.

Appendix K: Economic search strategy

Databases that were searched, together with the number of articles retrieved from each database are shown in Table 16. The economic search strategy for each database is shown in Table 17. The same strategy was translated for the other databases listed.

Table 16: Economic search summary

Database	Date searched	Number retrieved
MEDLINE (Ovid)	20/06/16	885
MEDLINE in Process (Ovid)	20/06/16	137
Embase (Ovid)	20/06/16	1075
EconLit (Ovid)	22/06/16	38
NHS Economic Evaluation Database (NHS EED) (legacy database)	20/06/16	41

Table 17: Economic search strategies

Database: Medline		
Strategy used:		
1	exp Hip Fractures/	20226
2	((femur* or femoral*) adj4 (head or neck or proximal) adj4 fracture*).ti,ab.	8706
3	((hip* or femur* or femoral* or intracapsular* or garden or valgus*) adj4 fracture*).ti,ab.	29131
4	((displace* or undisplace* or non-displace* or non displace*) adj4 fracture*).ti,ab.	6959
5	or/1-4	40507
6	Fracture Fixation, Internal/ or Hemiarthroplasty/ or Arthroplasty/ or Arthroplasty, Replacement, Hip/ or Bed Rest/ or Traction/	66181
7	((internal or reduc*) adj2 fixat*).ti,ab.	14798
8	((surgical or surgery) adj2 reduc*).ti,ab.	9183
9	((total or partial) adj4 (hip replac* or arthroplast*)).ti,ab.	34049
10	((pin*1 or nail* or screw*1 or plate*1 or fix*) adj3 (surgery or surgical or hip* or fixat*)).ti,ab.	116090
11	(arthroplast* or hemiarthroplast* or hemi-arthroplast* or hemi arthroplast* or prosthes* or osteosynthesis or osteo synthesis).ti,ab.	106783
12	(conservat* adj4 (treat* or therap* or manag* or method*)).ti,ab.	61326
13	(bed rest or traction).ti,ab.	17519
14	or/6-13	320811
15	Randomized Controlled Trial.pt.	420779
16	Controlled Clinical Trial.pt.	91003

Database: Medline		
17	Clinical Trial.pt.	502048
18	exp Clinical Trials as Topic/	294647
19	Placebos/	33419
20	Random Allocation/	87452
21	Double-Blind Method/	136790
22	Single-Blind Method/	22158
23	Cross-Over Studies/	38616
24	((random$ or control$ or clinical$) adj3 (trial$ or stud$)).tw.	833371
25	(random$ adj3 allocat$).tw.	23244
26	placebo$.tw.	165113
27	((singl$ or doubl$ or trebl$ or tripl$) adj (blind$ or mask$)).tw.	133744
28	(crossover$ or (cross adj over$)).tw.	61595
29	or/15-28	1517541
30	Observational Studies as Topic/	1471
31	Observational Study/	22526
32	Epidemiologic Studies/	7162
33	exp Case-Control Studies/	792572
34	exp Cohort Studies/	1556786
35	Cross-Sectional Studies/	219062
36	Controlled Before-After Studies/	145
37	Historically Controlled Study/	54
38	Interrupted Time Series Analysis/	163
39	Comparative Study.pt.	1752095
40	case control$.tw.	87982
41	case series.tw.	40024
42	(cohort adj (study or studies)).tw.	103214
43	cohort analy$.tw.	4312
44	(follow up adj (study or studies)).tw.	39227
45	(observational adj (study or studies)).tw.	52333
46	longitudinal.tw.	151520
47	prospective.tw.	381252
48	retrospective.tw.	305362
49	cross sectional.tw.	188511
50	or/30-49	3621831
51	Meta-Analysis.pt.	67225
52	Meta-Analysis as Topic/	15058
53	Review.pt.	2068405

Database: Medline		
54	exp Review Literature as Topic/	8727
55	(metaanaly$ or metanaly$ or (meta adj3 analy$)).tw.	79394
56	(review$ or overview$).ti.	307973
57	(systematic$ adj5 (review$ or overview$)).tw.	74900
58	((quantitative$ or qualitative$) adj5 (review$ or overview$)).tw.	5342
59	((studies or trial$) adj2 (review$ or overview$)).tw.	28754
60	(integrat$ adj3 (research or review$ or literature)).tw.	6494
61	(pool$ adj2 (analy$ or data)).tw.	17248
62	(handsearch$ or (hand adj3 search$)).tw.	6153
63	(manual$ adj3 search$).tw.	3666
64	or/51-63	2248959
65	or/29,50,64	6366873
66	and/5,14,65	9664
67	animals/ not humans/	4230831
68	66 not 67	9516
69	limit 68 to english language	7750

Database: MiP		
Strategy used:		
1	((femur* or femoral*) adj4 (head or neck or proximal) adj4 fracture*).ti,ab.	920
2	((hip* or femur* or femoral* or intracapsular* or garden or valgus*) adj4 fracture*).ti,ab.	3037
3	((displace* or undisplace* or non-displace* or non displace*) adj4 fracture*).ti,ab.	857
4	or/1-3	3795
5	((internal or reduc*) adj2 fixat*).ti,ab.	1788
6	((surgical or surgery) adj2 reduc*).ti,ab.	1082
7	((total or partial) adj4 (hip replac* or arthroplast*)).ti,ab.	3789
8	((pin*1 or nail* or screw*1 or plate*1 or fix*) adj3 (surgery or surgical or hip* or fixat*)).ti,ab.	11759
9	(arthroplast* or hemiarthroplast* or hemi-arthroplast* or hemi arthroplast* or prosthes* or osteosynthesis or osteo synthesis).ti,ab.	9462
10	(conservat* adj4 (treat* or therap* or manag* or method*)).ti,ab.	7336
11	(bed rest or traction).ti,ab.	1676
12	or/5-11	29883
13	4 and 12	1612
14	limit 13 to english language	1532

Database: Embase		
Strategy used:		
1	exp hip fracture/	34994
2	((femur* or femoral*) adj4 (head or neck or proximal) adj4 fracture*).ti,ab.	11517
3	((hip* or femur* or femoral* or intracapsular* or garden or valgus*) adj4 fracture*).ti,ab.	40668
4	((displace* or undisplace* or non-displace* or non displace*) adj4 fracture*).ti,ab.	8369
5	or/1-4	59433
6	osteosynthesis/ or total hip prosthesis/ or arthroplasty/ or hip arthroplasty/ or conservative treatment/ or bed rest/ or traction therapy/	153320
7	((internal or reduc*) adj2 fixat*).ti,ab.	18698
8	((surgical or surgery) adj2 reduc*).ti,ab.	14083
9	((total or partial) adj4 (hip replac* or arthroplast*)).ti,ab.	42009
10	((pin*1 or nail* or screw*1 or plate*1 or fix*) adj3 (surgery or surgical or hip* or fixat*)).ti,ab.	144726
11	(arthroplast* or hemiarthroplast* or hemi-arthroplast* or hemi arthroplast* or prosthes* or osteosynthesis or osteo synthesis).ti,ab.	133906
12	(conservat* adj4 (treat* or therap* or manag* or method*)).ti,ab.	91849
13	(bed rest or traction).ti,ab.	24319
14	or/6-13	448363
15	exp Clinical Trials/	197626
16	Randomization/	70714
17	Placebo/	289510
18	Double Blind Procedure/	131486
19	Single Blind Procedure/	22256
20	Crossover Procedure/	47432
21	((random$ or control$ or clinical$) adj3 (trial$ or stud$)).tw.	1237086
22	(random$ adj3 allocat$).tw.	32141
23	placebo$.tw.	239884
24	((singl$ or doubl$ or trebl$ or tripl$) adj (blind$ or mask$)).tw.	189694
25	(crossover$ or (cross adj over$)).tw.	82498
26	or/15-25	1660164
27	Systematic Review/	108644
28	Meta Analysis/	110402
29	Review/	2135107
30	Review.pt.	2169386
31	(metaanaly$ or metanaly$ or (meta adj3 analy$)).tw.	123272
32	(review$ or overview$).ti.	423548
33	(systematic$ adj5 (review$ or overview$)).tw.	114538
34	((quantitative$ or qualitative$) adj5 (review$ or overview$)).tw.	7525
35	((studies or trial$) adj2 (review$ or overview$)).tw.	39092
36	(integrat$ adj3 (research or review$ or literature)).tw.	8789
37	(pool$ adj2 (analy$ or data)).tw.	27926
38	(handsearch$ or (hand adj3 search$)).tw.	7936

Database: Embase		
39	(manual$ adj3 search$).tw.	5151
40	or/27-39	2636304
41	Clinical study/	122871
42	Case control study/	106264
43	Family study/	11456
44	Longitudinal study/	88510
45	Retrospective study/	469615
46	comparative study/	713232
47	Prospective study/	337593
48	Randomized controlled trials/	100545
49	47 not 48	334709
50	Cohort analysis/	246436
51	cohort analy$.tw.	7106
52	(Cohort adj (study or studies)).tw.	163263
53	(Case control$ adj (study or studies)).tw.	97104
54	(follow up adj (study or studies)).tw.	52494
55	(observational adj (study or studies)).tw.	92205
56	(epidemiologic$ adj (study or studies)).tw.	86347
57	(cross sectional adj (study or studies)).tw.	120138
58	case series.tw.	61728
59	prospective.tw.	592887
60	retrospective.tw.	532753
61	or/41-46,49-60	2702147
62	26 or 40 or 61	6063407
63	and/5,14,62	8687
64	nonhuman/ not human/	3736828
65	63 not 64	8640
66	limit 65 to (conference abstract or conference paper or conference proceeding or "conference review")	719
67	65 not 66	7921
68	limit 67 to english language	6720

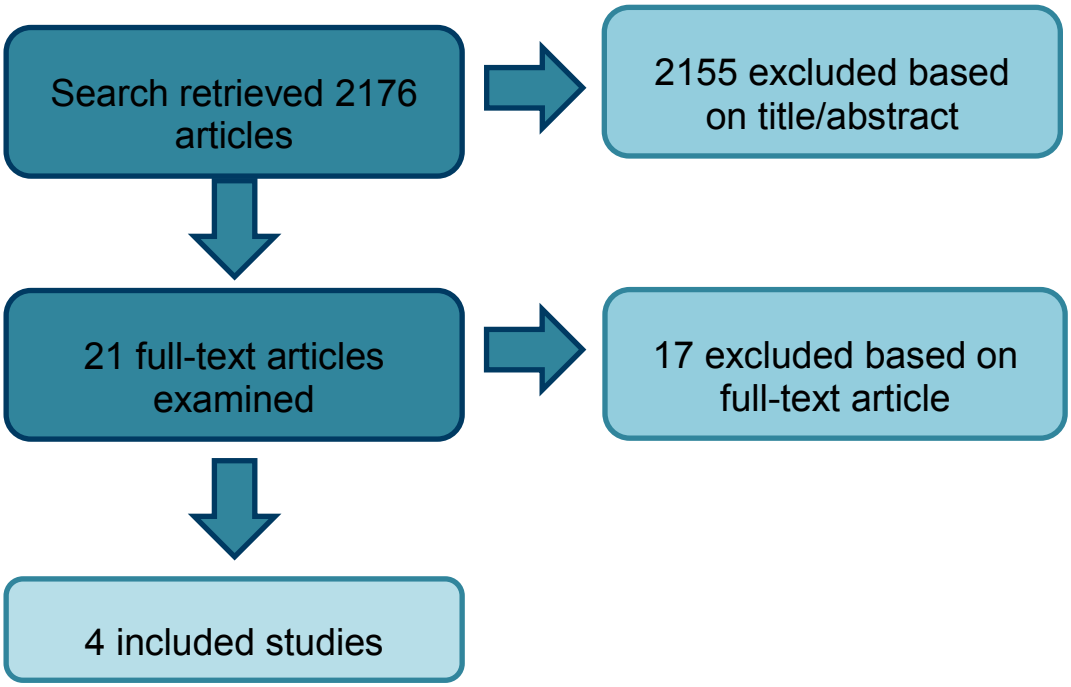
Database: Econlit

Strategy used:

1	((femur* or femoral*) adj4 (head or neck or proximal) adj4 fracture*).ti,ab,sh.
2	((hip* or femur* or femoral* or intracapsular* or garden or valgus*) adj4 fracture*).ti,ab,sh.
3	((displace* or undisplace* or non-displace* or non displace*) adj4 fracture*).ti,ab,sh.
4	or/1-3
5	((internal or reduc*) adj2 fixat*).ti,ab,sh.
6	((surgical or surgery) adj2 reduc*).ti,ab,sh.
7	((total or partial) adj4 (hip replac* or arthroplast*)).ti,ab,sh.

Database: Econlit	
8	((pin*1 or nail* or screw*1 or plate*1 or fix*) adj3 (surgery or surgical or hip* or fixat*)).ti,ab,sh.
9	(arthroplast* or hemiarthroplast* or hemi-arthroplast* or hemi arthroplast* or prosthes* or osteosynthesis or osteo synthesis).ti,ab,sh.
10	(conservat* adj4 (treat* or therap* or manag* or method*)).ti,ab,sh.
11	(bed rest or traction).ti,ab,sh.
12	or/5-11
13	4 and 12
14	limit 13 to english language

Appendix L:Economic flow chart



Appendix M: Excluded economic studies

Reference	Reason for exclusion
Alolabi B, Bajammal S, Shirali J, Karanicolas P J, Gafni A, and Bhandari M. (2009). Treatment of displaced femoral neck fractures in the elderly: a cost-benefit analysis (Provisional abstract). Journal of Orthopaedic Trauma, 23(6), 442-446.	Uses willingness-to-pay rather than effectiveness of the intervention as a measure of health benefit
Briggs A, Sculpher M, Britton A, Murray D, and Fitzpatrick R. (1998). The costs and benefits of primary total hip replacement: How likely are new prostheses to be cost-effective?. International Journal of Technology Assessment in Health Care, 14(4), 743-761.	Only assesses total hip replacement – no comparison to either hemiarthroplasty or internal fixation
Burgers P T. P. W, Hoogendoorn M, Van Woensel , E A C, Poolman R W, Bhandari M, Patka P, Van Lieshout , and E M M. (2016). Total medical costs of treating femoral neck fracture patients with hemi- or total hip arthroplasty: a cost analysis of a multicenter prospective study. Osteoporosis International, 27(6), 1999-2008.	Costing analysis – does not consider health benefits
Burns A W. R, and Bourne R B. (2006). (vi) Economics of revision total hip arthroplasty. Current Orthopaedics, 20(3), 203-207.	Only considers revision (rather than primary) arthroplasty
Campion E R. (1993). Costs associated with total hip arthroplasty and the diagnosis of occult hip fractures. The Journal of bone and joint surgery. American volume, 75(12), 1879-80.	Letter to the editor – not a full article
Faulkner A, Kennedy L G, Baxter K, Donovan J, Wilkinson M, and Bevan G. (1998). Effectiveness of hip prostheses in primary total hip replacement: a critical review of evidence and an economic model (Structured abstract). Health Technology Assessment Database, (2), 1.	Only considers different prosthesis types for total hip replacement – no comparison to either hemiarthroplasty or internal fixation
Frihagen Frede, Waaler Gudrun M, Madsen Jan Erik, Nordsletten Lars, Aspaas Silje, and Aas Eline. (2010). The cost of hemiarthroplasty compared to that of internal fixation for femoral neck fractures. 2-year results involving 222 patients based on a randomized controlled trial. Acta orthopaedica, 81(4), 446-52.	Costing analysis – does not consider health benefits
Garellick G, Malchau H, Herberts P, Hansson E, Axelsson H, and Hansson T. (1998). Life expectancy and cost utility after total hip replacement. Clinical Orthopaedics and Related Research, (346), 141-151.	Only assesses total hip replacement – no comparison to either hemiarthroplasty or internal fixation
Iorio R, Healy W L, Lemos D W, Appleby D, Lucchesi C A, and Saleh K J. (2001). Displaced femoral neck fractures in the elderly: outcomes and cost effectiveness. Clinical orthopaedics and related research, (383), 229-42.	Costing analysis – does not consider health benefits
Jacobs M J, and Markel D C. (1999). Geriatric intertrochanteric hip fractures: an economic analysis. American journal of orthopedics (Belle Mead, and N.J.), 28(10), 573-6.	Costing analysis – does not consider health benefits
Johansson T, Bachrach-Lindstrom M, Aspenberg P, Jonsson D, and Wahlstrom O. (2006). The total costs of a displaced femoral neck fracture: Comparison of internal fixation and total hip replacement - A randomised study of 146 hips. International Orthopaedics, 30(1), 1-6.	Costing analysis – does not consider health benefits
Marinelli M, Soccetti A, Panfoli N, de Palma , and L . (2008). Cost-effectiveness of cemented versus cementless total hip arthroplasty. A Markov decision analysis based on implant cost. Journal of orthopaedics	Only assesses cemented versus uncemented total hip replacement – no comparison to either

Reference	Reason for exclusion
and traumatology : official journal of the Italian Society of Orthopaedics and Traumatology, 9(1), 23-8.	hemiarthroplasty or internal fixation
Lavernia C, and Lyon R. (1998). The short-term economic implications of prosthetic selection in hemiarthroplasty of the hip. American journal of orthopedics (Belle Mead, and N.J.), 27(6), 415-8.	Costing analysis – does not consider health benefits
Parker M J, Myles J W, Anand J K, and Drewett R. (1992). Cost-benefit analysis of hip fracture treatment. Journal of Bone and Joint Surgery - Series B, 74(2), 261-264.	Does not adequately distinguish between interventions – only considers “surgery” versus “conservative treatment”
Swart E, Makhni E C, Macaulay W, Rosenwasser M P, and Bozic K J. (2014). Cost-effectiveness analysis of fixation options for intertrochanteric hip fractures. Journal of Bone and Joint Surgery - American Volume, 96(19), 1612-1620.	Analysis of intertrochanteric rather than intracapsular fractures
Tripuraneni K R, Carothers J T, Junick D W, and Archibeck M J. (2012). Cost comparison of cementless versus cemented hemiarthroplasty for displaced femoral neck fractures (Provisional abstract). Orthopedics, 35(10), e1461-e1464.	Costing analysis – does not consider health benefits
Zielinski S M, Bouwmans C A. M, Heetveld M J, Bhandari M, Patka P, Van Lieshout , and E M M. (2014). The societal costs of femoral neck fracture patients treated with internal fixation. Osteoporosis International, 25(3), 875-885.	Costing analysis – does not consider health benefits

Appendix N: Full economic evidence tables

These are the full evidence tables for all included economic studies.

Table 18: Full economic evidence tables

Bibliographic reference	**Bjornelv G M. W, Frihagen F, Madsen J E, Nordsletten L, and Aas E. (2012). Hemiarthroplasty compared to internal fixation with percutaneous cannulated screws as treatment of displaced femoral neck fractures in the elderly: Cost-utility analysis performed alongside a randomized, controlled trial. Osteoporosis International, 23(6), 1711-1719.**
Evaluation design	

Interventions	Hemiarthroplasty versus internal fixation
Comparators	As above
Base-line cohort characteristics	Elderly patients (mean age 82 years) with displaced femoral neck fracture
Type of Analysis	Cost-utility
Structure	In-trial
Cycle length	N/A
Time horizon	2 years
Perspective	Norwegian healthcare system
Country	Norway
Currency unit	Euros
Cost year	2006
Discounting	4%
Other comments	-

Bibliographic reference	**Bjornelv G M. W, Frihagen F, Madsen J E, Nordsletten L, and Aas E. (2012). Hemiarthroplasty compared to internal fixation with percutaneous cannulated screws as treatment of displaced femoral neck fractures in the elderly: Cost-utility analysis performed alongside a randomized, controlled trial. Osteoporosis International, 23(6), 1711-1719.**

Results

Comparison	Hemiarthroplasty versus internal fixation
Incremental cost	Total cost (direct and indirect hospital costs and societal costs): -€14,160 Total hospital cost (direct and indirect hospital costs): €-2,474
Incremental effects	0.2 QALYs (for patients completing EQ-5D)
Incremental cost effectiveness ratio	Hemiarthroplasty dominates internal fixation
Conclusion	Primary operation with hemiarthroplasty as surgical treatment for a displaced femoral neck fracture in the elderly generates higher QALYs in patients when compared to internal fixation. In addition, hemiarthroplasty is less costly.

Data sources

Base-line data	N/A – costs and utilities taken directly from RCT
Effectiveness data	N/A – costs and utilities taken directly from RCT
Cost data	Resource use and costs were calculated prospectively at the individual level during the RCT accompanying the economic analysis
Utility data	Utilities were elicited using EQ-5D at 4, 12 and 24 months. At inclusion, HRQoL was assumed to be 0.78 in both intervention groups – taken from a Swedish population with femoral neck fractures.

Uncertainty

One-way sensitivity analysis	N/A
Probabilistic sensitivity analysis	Bootstrapping of all cost and effect measures with 1,000 iterations. The mean incremental effect of hemiarthroplasty was 0.149 QALYs, while the mean incremental cost after bootstrapping was -€2,421 (total hospital cost). 2% of iterations were not cost effective based on a threshold of €37,500.

Applicability

Partially Applicable

This study compares two of the relevant outcomes in a relevant patient population, but is only partially applicable due to the non-UK healthcare system perspective.

Bibliographic reference	**Bjornelv G M. W, Frihagen F, Madsen J E, Nordsletten L, and Aas E. (2012). Hemiarthroplasty compared to internal fixation with percutaneous cannulated screws as treatment of displaced femoral neck fractures in the elderly: Cost-utility analysis performed alongside a randomized, controlled trial. Osteoporosis International, 23(6), 1711-1719.**
Limitations	**Potentially serious limitations** This study suffers from a relatively short time horizon (2 years). However, this is unlikely to change the outcome, as the higher revision rate for internal fixation means that results are likely to be conservative against hemiarthroplasty.
Conflicts	**Funding from the Norwegian Foundation for Health and Rehabilitation through the Norwegian Osteoporosis Society, South-Eastern Norway Regional Health Authority, the Norwegian Research Council, Nycomed, Smith and Nephew, and OrtoMedic.**

Acronyms
ICER: incremental cost-effectiveness ratio; QALY: quality-adjusted life year

Bibliographic reference	**Carroll C, Stevenson M, Scope A, Evans P, and Buckley S. (2011). Hemiarthroplasty and total hip arthroplasty for treating primary intracapsular fracture of the hip: A systematic review and cost-effectiveness analysis. Health Technology Assessment, 15(36), iii-50.**
Evaluation design	

Interventions	Total hip replacement versus hemiarthroplasty
Comparators	As above
Base-line cohort characteristics	Patients with displaced intracapsular fracture who are cognitively intact with high pre-fracture mobility or function.
Type of Analysis	Cost-utility
Structure	Trial-based data
Cycle length	N/A
Time horizon	2 years (with extrapolations of health effects to 3 and 5 years)
Perspective	NHS/PSS
Country	UK
Currency unit	GBP
Cost year	2007
Discounting	3.5% (costs and health benefits)
Other comments	-

Bibliographic reference	**Carroll C, Stevenson M, Scope A, Evans P, and Buckley S. (2011). Hemiarthroplasty and total hip arthroplasty for treating primary intracapsular fracture of the hip: A systematic review and cost-effectiveness analysis. Health Technology Assessment, 15(36), iii-50.**

Results

Comparison	Total hip replacement versus hemiarthroplasty
Incremental cost	£3989 (for 2-, 3- and 5-year time horizons)
Incremental effects (QALYs)	2-year horizon: 0.147 3-year horizon: 0.285 5-year horizon: 0.580
Incremental cost effectiveness ratio (cost per QALY)	2-year horizon: £27,023 3-year horizon: £16,146 5-year horizon: £7,952
Conclusion	Total hip replacement appears to be more cost-effective than HA, although it is likely that this will be associated with increased costs in the initial 2-year period.

Data sources

Base-line data	N/A – costs and utilities taken directly from an RCT
Effectiveness data	N/A – costs and utilities taken directly from an RCT
Cost data	RCT of total hip replacement compared with hemiarthroplasty over a two year period – mean costs associated with each intervention presented in five categories: initial inpatient episode, hip-related admissions, non-hip-related admissions, total hip-related costs, and total costs
Utility data	RCT of total hip replacement compared with hemiarthroplasty over a two year period – QALYs elicited via the EQ-5D

Uncertainty

One-way sensitivity analysis	An exploratory sensitivity analysis was conducted using utility data from an alternative RCT comparing bipolar hemiarthroplasty with total hip replacement. Cost per QALY for each time period was as follows: 2-year horizon: £44,997 3-year horizon: £30,511 5-year horizon: £18,932
Probabilistic sensitivity analysis	Probabilistic sensitivity analysis results are only displayed as a graphical cost-effectiveness acceptability curve, so exact figures are unavailable. However, results indicate that the probability that total hip replacement is more cost-effective than hemiarthroplasty at a £20,000 threshold is >30% for a 2-year horizon, >60% for a 3-year horizon, and >80% for a 5-year horizon.

Bibliographic reference	**Carroll C, Stevenson M, Scope A, Evans P, and Buckley S. (2011). Hemiarthroplasty and total hip arthroplasty for treating primary intracapsular fracture of the hip: A systematic review and cost-effectiveness analysis. Health Technology Assessment, 15(36), iii-50.**
Applicability	**Directly applicable** This analysis is directly applicable, as it compares two of the interventions of interest in the context of the UK healthcare system
Limitations	**Potentially serious limitations** In the base case, this analysis uses only a 2-year horizon, which is likely insufficient to capture all relevant costs and health benefits. Although, results are given for 3- and 5-year horizons, health benefits are extrapolated in a simplistic manner (last observation carried forward) and no additional costs are considered. The fact that the analysis does not consider revisions or displacements beyond 2 years means that the cost-effectiveness of total hip replacement is likely underestimated.
Conflicts	**N/A**

Acronyms
ICER: incremental cost-effectiveness ratio; QALY: quality-adjusted life year
[9]

Bibliographic reference	**Keating, J.F., Grant, A., Masson, M., Scott, N.W. and Forbes, J.F., 2005. Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technol Assess, 9(41), 1-65.**
Evaluation design	

Interventions	Total hip replacement versus hemiarthroplasty versus internal fixation
Comparators	As above
Base-line cohort characteristics	Previously fit patients aged 60 years or older with a displaced subcapital hip fracture.
Type of Analysis	Cost effectiveness
Structure	Trial-based data
Cycle length	N/A
Time horizon	2 years
Perspective	NHS/PSS
Country	UK
Currency unit	GBP

Bibliographic reference	**Keating, J.F., Grant, A., Masson, M., Scott, N.W. and Forbes, J.F., 2005. Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technol Assess, 9(41), 1-65.**

	Cost year	2000/2001
	Discounting	None
	Other comments	Note - This analysis provides both costs associated with procedures and EQ-5D values at specified time points, but cannot be considered a cost utility analysis as these two measures are not combined in the form of cost/ QALY and ICERs. However, it appears that total hip replacement dominates both hemiarthroplasty and internal fixation, as total costs are lower and EQ-5D scores are higher at every time point. It should also be noted that the trial consisted of both a two-arm (HA versus IF) and a three-arm (THR versus HA versus IF) analysis. For consistency, three-arm results are reported in this table.

Results

Comparison	Total hip replacement versus hemiarthroplasty
Incremental cost (95% CI)	-£3,027 (-£7,455 to £1,400)
Incremental EQ-5D scores (95% CI)	4 months: 0.08 (-0.02 to 0.18) 12 months: 0.04 (-0.06 to 0.15) 24 months: 0.16 (0.04 to 0.28)
Incremental cost effectiveness ratio (cost per QALY)	Total hip replacement dominates hemiarthroplasty
Conclusion	When compared with hemiarthroplasty, total hip replacement may be the preferred strategy. This study suggests that the costs of total hip replacement are lower, but the confidence intervals do not rule out the possibility that it may be more expensive.

Comparison	Hemiarthroplasty versus internal fixation (confidence intervals for this comparison calculated manually as not provided by the authors)
Incremental cost (95% CI)	£381 (-£5,308 to £6,070)
Incremental EQ-5D scores (95% CI)	4 months: 0.03 (-0.07 to 0.13) 12 months: 0.08 (-0.04 to 0.2) 24 months: -0.05 (-0.18 to 0.08)

Bibliographic reference	**Keating, J.F., Grant, A., Masson, M., Scott, N.W. and Forbes, J.F., 2005. Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technol Assess, 9(41), 1-65.**

Incremental cost effectiveness ratio (cost per QALY)	N/A
Conclusion	Given the disadvantages of fixation when measured against surgical and health-related quality of life end-points and the suggested attendant increase in resource consequences, it may be argued that either hemiarthroplasty or total hip replacement offers a more cost-effective approach.

Comparison	Total hip replacement versus internal fixation
Incremental cost (95% CI)	-£2,996 (-£7,487 to £1,888)
Incremental EQ-5D scores (95% CI)	4 months: 0.11 (0.01 to 0.2) 12 months: 0.12 (0.01 to 0.23) 24 months: 0.11 (-0.01 to 0.23)
Incremental cost effectiveness ratio (cost per QALY)	Total hip replacement dominates internal fixation
Conclusion	As per hemiarthroplasty versus internal fixation

Data sources

Base-line data	N/A – costs and utilities measured directly
Effectiveness data	N/A – costs and utilities measured directly
Cost data	Prospective measurement and valuation of direct health service costs from NHS perspective
Utility data	EQ-5D forms completed by participants at 4, 12 and 24 months

Uncertainty

One-way sensitivity analysis	Results were robust to changes in cost of prosthesis and hip-related admissions – varying values over a range from -50% to +100% did not change outcomes.
Probabilistic sensitivity analysis	N/A

Applicability

Partially applicable

While this analysis compares all relevant interventions in an appropriate population, the fact that that costs and health benefits are not combined in the form of ICERs makes it only partially applicable.

Bibliographic reference	**Keating, J.F., Grant, A., Masson, M., Scott, N.W. and Forbes, J.F., 2005. Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technol Assess, 9(41), 1-65.**
Limitations	**Potentially serious limitations** Although unlikely to affect outcomes, this analysis suffers from a limited 2-year time horizon.
Conflicts	**N/A**

Bibliographic reference	**Slover J, Hoffman M V, Malchau H, Tosteson A N, and Koval K J. (2009). A cost-effectiveness analysis of the arthroplasty options for displaced femoral neck fractures in the active, healthy, elderly population (Provisional abstract). Journal of Arthroplasty, 24(6), 854-860.**
Evaluation design	

Interventions	Total hip replacement and hemiarthroplasty
Comparators	As above
Base-line cohort characteristics	Active, healthy, elderly patients (70 years old) with displaced femoral neck fracture
Type of Analysis	Cost-utility
Structure	Markov model
Cycle length	1 year
Time horizon	20 years
Perspective	US healthcare system
Country	USA
Currency unit	USD
Cost year	2003
Discounting	3%
Other comments	-

Bibliographic reference	**Slover J, Hoffman M V, Malchau H, Tosteson A N, and Koval K J. (2009). A cost-effectiveness analysis of the arthroplasty options for displaced femoral neck fractures in the active, healthy, elderly population (Provisional abstract). Journal of Arthroplasty, 24(6), 854-860.**

Results

Comparison	Total hip replacement versus hemiarthroplasty
Incremental cost	$3,000
Incremental effects	1.53 QALYs
Incremental cost effectiveness ratio	$1,960
Conclusion	It appears that total hip replacement is the more cost-effective arthroplasty option for displaced femoral neck fractures in the active, healthy, elderly patient population, despite the potential for increased morbidity compared with hemiarthroplasty.

Data sources

Base-line data	Mortality rates: Assumed to be equal for both procedures – relative risks for first two years following fracture taken from an analysis of mortality after hip fracture in Medicare patients and applied to baseline age-specific death rate according to 2001 US life tables.
Effectiveness data	Implant survival rates: Revision rates for total hip replacement and hemiarthroplasty taken from the Swedish Arthroplasty Register
Cost data	Initial hospital charges and revision costs taken from the 2003 National Inpatient Survery
Utility data	Baseline utilities for patients with a total hip replacement and hemiarthroplasty were taken from an RCT comparing the two procedures. However, the baseline utility for patients following a revision, and disutility values for the period following surgery appear to be estimates.

Uncertainty

One-way sensitivity analysis	At a threshold of $50,000: Setting identical utility values for the two procedures still results in total hip replacement being the more cost-effective option. The lifetime cost associated with treating a patient with total hip replacement must be greater than $78,000, while the lifetime cost associated with using a hemiarthroplasty must be less than $22,000 for hemiarthroplasty to be the more cost-effective option. The utility value of hemiarthroplasty must be 0.68, even without any revisions of hemiarthroplasties, for this strategy to be the more cost-effective option.
Probabilistic sensitivity analysis	N/A

Bibliographic reference	**Slover J, Hoffman M V, Malchau H, Tosteson A N, and Koval K J. (2009). A cost-effectiveness analysis of the arthroplasty options for displaced femoral neck fractures in the active, healthy, elderly population (Provisional abstract). Journal of Arthroplasty, 24(6), 854-860.**
Applicability	**Partially Applicable** This study compares two of the relevant outcomes in a relevant patient population, but is only partially applicable due to the non-UK healthcare system perspective.
Limitations	**Minor Limitations** The analysis considers most relevant outcomes over a sufficiently long time horizon, though suffers from estimated utility values and lack of consideration of dislocations.
Conflicts	**N/A**

Acronyms
ICER: incremental cost-effectiveness ratio; QALY: quality-adjusted life year

Appendix O: Economic modelling report

O.1 Introduction

There is currently considerable variation in clinical practice in the management of displaced intracapsular hip fractures. This economic analysis was conducted to determine the relative cost effectiveness of three surgical procedures: total hip replacement (THR), hemiarthroplasty (HA), and internal fixation (IF).

O.2 Methods

O.2.1 Type of analysis

This evaluation was a cost utility analysis, in which costs were measured in GBP and health effects were measured in quality adjusted life years (QALYs).

O.2.2 Target population

The population for this analysis is patients who have sustained an intracapsular hip fracture who were previously able to walk independently, are not cognitively impaired, are medically fit for anaesthesia, and are eligible for any of the three interventions.

O.2.3 Interventions

The following surgical interventions were included in the analysis:

- Total hip replacement (THR)
- Hemiarthroplasty (HA)
- Reduction and internal fixation (IF) with screws

O.2.4 Time horizon

A lifetime time horizon was used in this analysis.

O.2.5 Perspective

The analysis was conducted from the perspective of the NHS and personal and social services (PSS).

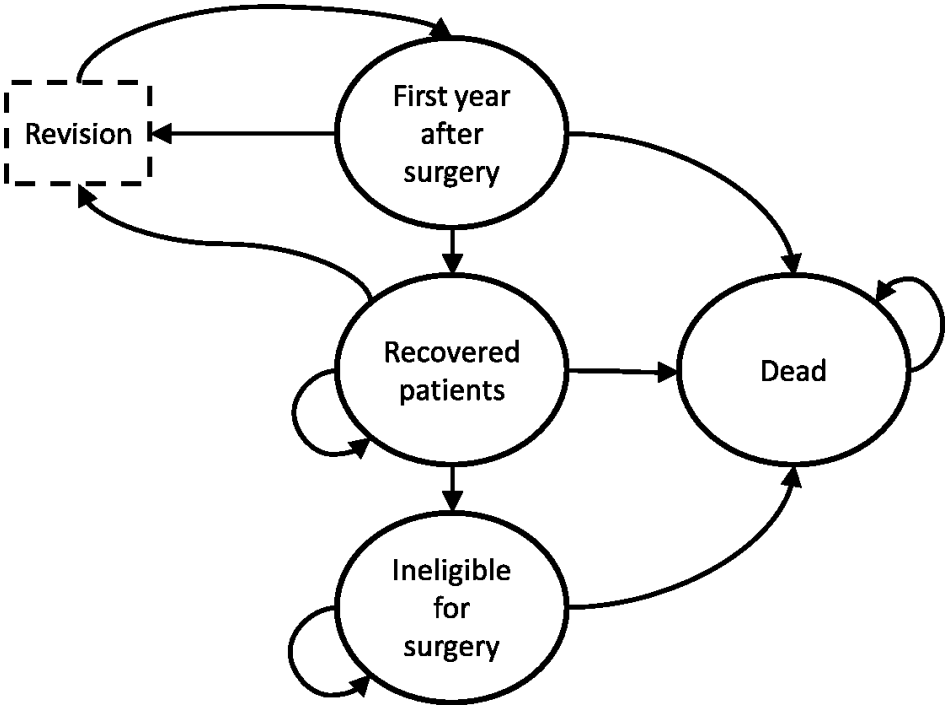
O.2.6 Discounting

A discount rate of 3.5% per annum was applied to all costs and QALYs after the first year.

O.2.7 Model structure

A Markov model with a cycle length of one year was used to simulate the progression of patients over a lifetime time horizon. The structure of the model is displayed in Figure 40.

Figure 40: Diagram of model structure



At the start of the model, all patients undergo a surgical procedure (THR, HA, or IF) and enter the 'first year after surgery' state. Subsequently, patients may die, or may require a revision procedure, which results in those patients returning to the 'first year after surgery' state for the next cycle of the model. The remainder of patients progress through to the 'recovered patients' state. Patients in this state are also associated with an annual probability of death and revision. However, it is assumed that not all patients requiring revision in this state are eligible. Those patients for whom surgical procedures are deemed too risky progress to the 'ineligible for surgery' state, where they remain until death occurs.

In the model base case, the assumption was made that, in the HA and IF arms of the model, 80% of patients requiring a revision procedure would receive THR, while the remaining 20% would receive HA. For patients in the THR arm, the assumption was made that all patients requiring a revision procedure would receive THR. These assumptions were based on expert opinions from the committee.

The assumption was made that 50% of patients who require revision after the first year are not eligible. It was therefore assumed that, from the second year after surgery onwards, the rate of patients requiring revision is twice that of the actual revision rate, with 50% of patients receiving a revision procedure and 50% progressing to the 'ineligible for surgery' state. It was assumed that all patients requiring a revision procedure in the first year after surgery will receive one, although this assumption is relaxed during sensitivity analysis.

To inform the HA arm of the model, annual revision probabilities and mortality rates were calculated for patients undergoing hemiarthroplasty. To inform the THR and IF arms, relative risks were applied to the baseline rates for HA, in order to calculate treatment-specific mortality and revision rates.

O.2.8 Mortality rates

For the first year after surgery, a baseline mortality rate for patients receiving HA was calculated from the studies included in the clinical review. Odds ratios of mortality rates between each of the three treatments were calculated via a Bayesian network meta-analysis (NMA) using data from studies included in the clinical review, the methodology of which is

detailed in Appendix P:. Baseline mortality rate for HA and odds ratios are displayed in Table 19.

Table 19: Baseline mortality rate and odds ratios for mortality rates for the first year after surgery

Parameter	Baseline mortality rate (HA) (95% CIs)	Odds ratio: THR versus HA (95% CIs)	Odds ratio: IF versus HA (95% CIs)	Odds ratio: IF versus THR (95% CIs)
Value	19.5% (17.2% to 21.8%)	0.86 (0.57 to 1.22)	0.91 (0.69 to 1.16)	1.09 (0.72 to 1.58)
Distribution for probabilistic sensitivity analysis	Beta	Randomised selection of iterations from NMA output	Randomised selection of iterations from NMA output	Randomised selection of iterations from NMA output

To inform the model, each odds ratio was transformed into a relative risk value via the following formula:

$$RR = OR/(1 - p(p \times OR))$$

Where p is the baseline mortality rate for each pair of interventions. Relative risks are shown in Table 20. These values were then applied to the mortality rate for HA in order to calculate mortality for THR and IF.

Table 20: Relative risks for mortality rates for the first year after surgery

Parameter	Relative risk: THR versus HA (95% CIs)	Relative risk: IF versus HA (95% CIs)	Relative risk: IF versus THR (95% CIs)
Value	0.88 (0.63 to 1.19)	0.92 (0.74 to 1.13)	1.08 (0.75 to 1.47)

The assumption was made that patients who have undergone revision surgery are associated with the same mortality rate in the year following surgery as patients who have undergone a primary procedure.

For patients in the 'recovered' and 'ineligible for surgery' states it is assumed that mortality returns to the baseline rate for the general population. Age-related mortality rates are taken from Office for National Statistics National Life Tables: England and Wales for 2013-15.

O.2.9 Revision rates

For the first year after surgery, a baseline revision rate for patients receiving HA was calculated using data from studies included in the clinical review. Odds ratios of revision rates for the first year after surgery between each of the three treatments were calculated using data from studies included in the clinical review, via the same NMA methods outlined in the mortality rates section. Odds ratios and baseline revision rate for the first year after surgery are displayed in Table 21.

Table 21: Baseline revision rate and odds ratios for revision in the year after surgery

Parameter	Baseline revision rate (HA) (95% CIs)	Odds ratio: THR versus HA (95% CIs)	Odds ratio: IF versus HA (95% CIs)	Odds ratio: IF versus THR (95% CIs)
Value	3.7% (2.3% to 5.1%)	1.45 (0.35 to 4.20)	9.25 (2.81 to 25.88)	8.73 (1.78 to 26.97)
Distribution for probabilistic	Beta	Randomised selection of	Randomised selection of	Randomised selection of

Parameter	Baseline revision rate (HA) (95% CIs)	Odds ratio: THR versus HA (95% CIs)	Odds ratio: IF versus HA (95% CIs)	Odds ratio: IF versus THR (95% CIs)
sensitivity analysis		iterations from NMA output	iterations from NMA output	iterations from NMA output

To inform the model, odds ratios were transformed to relative risks using the formula outlined in the mortality rates section (shown in Table 22). These relative risks were applied to the revision rate for HA to produce revision rates for THR and IF.

Table 22: Relative risks for revision in the year after surgery

Parameter	Relative risk: THR versus HA (95% CIs)	Relative risk: IF versus HA (95% CIs)	Relative risk: IF versus THR (95% CIs)
Value	1.43 (0.37 to 4.17)	7.10 (2.63 to 13.54)	6.83 (1.73 to 13.96)

Annual revision rates for years subsequent to the first year after surgery required a more complex multi-step approach to calculate. This was because studies identified by the clinical review used a variety of different time horizons for reporting revision rates, and these rates also incorporated revision procedures which took place within the first year after surgery.

The first step in this approach was to calculate relative risks for each pair of interventions for the long-term revision rate. This was achieved by first calculating the baseline rate for HA and odds ratios for the long term revision rate (including revisions occurring in the first year after surgery). As with previous model inputs, these values were calculated using data from studies identified in the clinical literature review, with odds ratios calculated using an NMA. The resulting values are displayed in Table 23.

Table 23: Baseline revision rate and odds ratios for long-term revision rates (including the first year after surgery)

Parameter	Baseline revision rate (HA) (95% CIs)	Odds ratio: THR versus HA (95% CIs)	Odds ratio: IF versus HA (95% CIs)	Odds ratio: IF versus THR (95% CIs)
Value	6.3% (5.0% to 7.6%)	1.13 (0.51 to 2.19)	7.99 (4.27 to 14.28)	7.66 (3.65 to 14.83)
Distribution for probabilistic sensitivity analysis	Beta	Randomised selection of iterations from NMA output	Randomised selection of iterations from NMA output	Randomised selection of iterations from NMA output

Odds ratios were transformed to relative risks using the formula outlined in the mortality rates section. These values were then applied to the revision rate for HA, to produce a long-term revision rate (including first year revisions) for each intervention. These were converted into long-term revision rates without first year revisions by subtracting the revision rate for the first year after surgery from each value. Relative risks for each pair of interventions were then recalculated from the long-term revision rates, and these values were used to inform the model (shown in Table 24).

Table 24: Relative risks for long-term revision rates (excluding the first year after surgery) – confidence intervals not applicable

Parameter	Relative risk: THR versus HA	Relative risk: IF versus HA	Relative risk: IF versus THR
Value	1.12	5.55	4.93

The next step was to calculate the baseline annual long-term revision rate for HA. This was achieved using data from the Swedish Hip Arthroplasty Register Annual Report 2014, which

was used due to a lack of long-term revision rate data with a specific endpoint for the English population, and was agreed by the guideline committee to be the most appropriate source. The register reported a reoperation rate of 4.5% between the years 2005 and 2014, and a reoperation rate in the first 6 months after surgery of 2.8% for patients receiving arthroplasty for hip fracture. Subtracting the latter value from the former provided a long-term revision rate of 1.7% over 9.5 years. This value was converted to an annual revision rate using the following formula:

$$1 - \exp(\ln(1 - revision\ rate\ over\ 9.5\ years)/9.5)$$

As the data used to calculate this rate included patients receiving both HA and THR, the proportion of patients receiving each procedure was used to calculate the revision rate specific to HA. The Swedish Hip Arthroplasty Register Annual Report 2014 reported that, in 2014, 5,835 arthroplasties were performed, of which 1,696 were THRs, meaning that 21.9% of procedures were THRs, and 70.9% were HAs. The annual revision rate for years subsequent to the first year after surgery for HA was calculated via the following formula:

$$Overall\ revision\ rate/(proportion\ HA\ procedures + proportion\ THR\ procedures \times RR\ long\ term\ revision\ rate{:}\ THR\ versus\ HA)$$

This provided an annual revision rate for HA of 0.20%, which was used to populate the model.

O.2.10 Costs

Costs for each type of primary surgical procedure were taken from the initial inpatient episode reported from Keating et al (2005), adjusted to 2016 values using annual consumer price index inflation rates from the Office for National Statistics. These values accounted for all resource use during patients' initial hospital stay (including high dependency and intensive care costs), and consisted of three components: inpatient stay costs, theatre costs, prosthesis and hardware costs. Inpatient stay costs were calculated from length of stay data in the RCT section of the Keating study, multiplied by average attendance costs. Theatre costs considered duration of theatre time in the trial and trauma staff composition. Hardware costs were based on unit costs for four university orthopaedic centres participating in the trial. Total costs for each procedure are displayed in Table 25.

Table 25: Costs of surgical procedures

Surgical procedure	THR	HA	IF
Cost (95% CI)	£10,453 (£9,654 to £11,253)	£10,895 (£9,649 to £12,141)	£9,103 (£7,845 to £10,363)
Distribution for probabilistic sensitivity analysis	Gamma	Gamma	Gamma

In the base case, the assumption was made that costs of revision procedures are the same as those of primary procedures, though this assumption was relaxed during sensitivity analysis.

This costing method makes the implicit assumption that there are no differences in costs of hospital readmissions which do not result in a revision procedure between the interventions. The committee felt this was a justifiable assumption, revision surgery is the predominant reason for hip-related readmission.

O.2.11 Utilities

A range of EQ-5D-derived utility values were used to estimate the average utility for patients in each Markov state. These values, along with their sources, are shown in Table 26.

Table 26: Utility values used to populate the model

Health state	EQ-5D score (95% CIs)	Distribution for probabilistic sensitivity analysis	Source
4 months after THR	0.68 (0.62 to 0.74)	Transformed Gamma	Keating et al (2005)
4 months after HA	0.60 (0.52 to 0.68)	Transformed Gamma	Keating et al (2005)
4 months after IF	0.57 (0.50 to 0.64)	Transformed Gamma	Keating et al (2005)
Baseline for individuals 75 years and above	0.73 (0.70 to 0.76)	Transformed Gamma	Kind et al (1999)
Utility decrement 6 weeks after internal fixation procedure	0.21 (0.13 to 0.29)	Transformed Gamma	Parsons et al (2014)

As evidence from the clinical literature suggests that patients' utility scores are typically stable 4 months after surgery, it was assumed that individuals in the 'recovered patients' state (i.e. at least one year after surgery) have an average utility corresponding to the 4 month score associated with their most recent procedure.

For patients in the 'first year after surgery' state, it was assumed that patients' utility changes linearly from their utility score immediately after surgery to the 4 month score for the relevant procedure, and remains at the 4 month level thereafter. However, utility scores immediately following surgery were scarce in the literature, so a value was imputed from available values using the following formula:

$$utility\ 4\ months\ after\ IF - ((utility\ 4\ months\ after\ IF - (baseline\ utility\ 75\ and\ above - utility\ decrement\ 6\ weeks\ after\ initial\ procedure)) \times 1.6$$

This provided a utility value of 0.49 following surgery. Making the assumption that patients' utility is identical between procedures immediately after surgery, this value was used to estimate average utility in the year after surgery for each procedure via the following formula:

$$1/3 \times ((utility\ immediately\ following\ surgery + utility\ 4\ months\ after\ THR)/2) + 2/3 \times utility\ 4\ months\ after\ THR$$

Since patients requiring revision surgery are expected to have a lower utility than recovered patients, the assumption was made that patients who are ineligible for surgery have an average utility midway between the utility score immediately after surgery and the score 4 months after their most recent procedure.

O.2.12 Sensitivity analysis

Both deterministic and probabilistic sensitivity analyses were used to characterise the uncertainty surrounding the base case results of the model.

For the deterministic sensitivity analysis, costs and QALYs were calculated for each of the following scenarios:

- Utility values for all procedures set to those of THR
- Costs of all procedures set to those of THR

- Cost of revision surgery twice the cost of primary procedures
- All patients are eligible for revision (no patients enter the 'ineligible for surgery' state)
- 50% of patients requiring revision in the first year after surgery are deemed ineligible (as well as in years subsequent to the first year)
- In the HA and IF arms, 80% of revision procedures are HA and the remainder are THR
- Relative risks for revision rates derived from NMA without data from Skinner 1989. This analysis was carried out as including Skinner 1989 causes inconsistency between NMA and pairwise MA results: relative risks for revision rates favour THR in the former case and HA in the latter case. Relative risks for the NMA without the Skinner study are shown in Table 27.
- Relative risks for revision rates and one year mortality derived from pairwise meta-analyses. This analysis was carried out to explore the effects of discrepencies between pairwise MA and NMA results. Relative risks for pairwise MAs are shown in Table 28.
- Model time horizon set to 2, 3, 4, and 5 years. These analyses were conducted in order to investigate the potential cost effectiveness of different interventions in patient populations with a shorter life expectancy.

Table 27: Relative risks for revision rates derived from NMA without Skinner 1989

Parameter	Relative risk: THR versus HA	Relative risk: IF versus HA	Relative risk: IF versus THR
Revision rate first year after surgery	0.42	10.42	8.19
Long term revision rate	0.63	7.20	4.73

Table 28: Relative risks for revision rates and mortality rate from pairwise MA

Parameter	Relative risk: THR versus HA	Relative risk: IF versus HA	Relative risk: IF versus THR
Revision rate first year after surgery	0.68	4.52	4.42
Long term revision rate	0.68	5.84	3.42
Mortality rate first year	0.85	0.97	1.05

Additionally, a threshold analysis was carried out, in which the cost of a THR was varied to determine the value at which the procedure was no longer cost effective at a threshold of £20,000 per QALY. This threshold analysis was also repeated for the one-way sensitivity analysis scenarios in which the model time horizon was set to 2, 3, 4, and 5 years.

For the probabilistic sensitivity analysis, all model input parameters were assigned probability distributions (rather than being expressed as point estimates) to reflect the uncertainty surrounding the available clinical and cost data. 1,000 iterations of the model were run, each drawing random values from parameter distributions.

Probability parameters were assigned beta distributions in order to account for the fact that probability values must lie between 0 and 1. Cost parameters were assigned gamma distributions, to ensure that costs could not be negative. As utilities are bound at 1 but have no lower bound, these values were transformed via the formula: D = 1 – utility. The resulting D was assigned a gamma distribution (as this value is bound at 0 with no upper limit), and subsequently transformed back into a utility value.

Since relative risks values were derived via an NMA from the mean of 150,000 Markov iterations, for each iteration of the probabilistic sensitivity analysis, the outputs of a randomly selected iteration of the NMA were used to populate the model.

Where available, standard errors or 95% confidence intervals were used to inform the shape of distributions. For parameters for which these values were not available, it was assumed that standard error was 20% of the parameter mean.

O.3 Results

O.3.1 Deterministic results

Base case costs, QALYs and incremental cost effectiveness ratios (ICERs) for each intervention are displayed in Table 29. These results show that THR is associated with both the lowest cost (£11,083) and the highest number of QALYs (4.05) and therefore dominates the other two procedures. Conversely, IF is associated with the highest cost (£12,134) and lowest number of QALYs (3.44).

Table 29: Deterministic model results

Intervention	Cost	QALYs	ICER
Total hip replacement	£11,083	4.05	-
Hemiarthroplasty	£11,387	3.51	dominated
Internal fixation	£12,134	3.44	dominated

Table 30 displays intermediate outcomes from the model base case. These results show that HA is associated with the fewest surgical revision procedures (50 per 1,000 patients, compared to 64 and 303 for THR and IF, respectively). However, THR is associated with the fewest deaths overall (182 per 1,000 patients) and the highest mean utility for living patients (0.675). As a result, despite the lower number of revisions associated with HA, THR is the procedure resulting in the highest number of QALYs.

While the intermediate results show that HA is associated with the lowest mean revision surgery cost per patient, THR is still the least costly option overall, due to a lower cost of the initial procedure compared to HA. Despite having the lowest cost per procedure, IF is the most costly strategy overall. The reason for this is demonstrated by the intermediate results: IF is associated with a mean revision surgery cost per patient of £3,031 per patient.

Table 30: Intermediate model outcomes

Outcome	THR	HA	IF
Total number of revision procedures per 1,000 patients	64	50	303
Number of deaths occuring in the year following primary surgery/revision surgery per 1,000 patients	182	204	233
Number of deaths in the year following revision surgery per 1,000 patients	11	9	53
Mean utility for living patients	0.675	0.599	0.592
Average revision surgery cost per patient	£629	£492	£3,031

O.3.2 Sensitivity analysis

Results of the one way sensitivity analyses are shown in Table 31. These results demonstrate that outcomes are generally robust to changes in key assumptions behind model parameters. Only two scenarios result in a change in the order of outcomes: the scenario in which costs of all procedures are set to those of THR, and the scenario in which relative risks of revision are set to the values derived from the NMA without data from Skinner 1989. In both of these scenarios HA is the least costly option, but THR is still the most cost effective option, due to an ICER well below the £20,000 threshold.

Also of note is the scenario in which utility values for all procedures are set to those of THR. While THR still dominates the other two interventions in this scenario, the differences in QALYs associated with each procedure are much smaller, demonstrating that utility scores are a key driver of health outcomes.

The scenarios in which the model time horizon is reduced demonstrate that THR remains the most cost effective strategy, even at a time horizon of 2 years. This indicates that THR is likely to be a cost effective strategy in patients with shorter life expectancies.

Table 31: One-way sensitivity analysis results

Utility values for all procedures set to those of THR			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,083	4.04	-
Hemiarthroplasty	£11,387	3.94	dominated
Internal fixation	£12,134	3.89	dominated
Costs of all procedures set to those of THR			
Intervention	**Cost**	**QALYs**	**ICER**
Hemiarthroplasty	£10,941	3.51	-
Total hip replacement	£11,083	4.05	£264
Internal fixation	£13,460	3.44	dominated
Cost of revision twice the cost of primary procedure			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,712	4.05	-
Hemiarthroplasty	£11,879	3.51	dominated
Internal fixation	£15,164	3.44	dominated
All patients eligible for revision			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,083	4.05	-
Hemiarthroplasty	£11,388	3.52	dominated
Internal fixation	£12,141	3.44	dominated
50% of patients requiring revision in the first year after surgery deemed ineligible			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,078	4.02	-
Hemiarthroplasty	£11,382	3.50	dominated
Internal fixation	£12,025	3.37	dominated
80% of patients in HA and IF arms receive hemiarthroplasty as revision procedure			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,083	4.05	-
Hemiarthroplasty	£11,396	3.50	dominated
Internal fixation	£12,185	3.36	dominated

Relative risks for revision calculated from NMA without Skinner 1989			
Intervention	**Cost**	**QALYs**	**ICER**
Hemiarthroplasty	£11,408	3.51	-
Total hip replacement	£11,470	4.03	£118
Internal fixation	£13,488	3.46	dominated
Relative risks from pairwise meta analyses used for revision rate and one year mortality			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£10,782	4.08	-
Hemiarthroplasty	£11,377	3.51	dominated
Internal fixation	£11,400	3.40	dominated
Model time horizon set to 2 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£10,983	1.19	-
Hemiarthroplasty	£11,269	1.05	dominated
Internal fixation	£11,753	1.02	dominated
Model time horizon set to 3 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,020	1.67	-
Hemiarthroplasty	£11,301	1.47	dominated
Internal fixation	£11,915	1.43	dominated
Model time horizon set to 4 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,032	2.10	-
Hemiarthroplasty	£11,316	1.83	dominated
Internal fixation	£11,959	1.79	dominated
Model time horizon set to 5 years			
Intervention	**Cost**	**QALYs**	**ICER**
Total hip replacement	£11,041	2.47	-
Hemiarthroplasty	£11,329	2.15	dominated
Internal fixation	£11,991	2.11	dominated

Results of the threshold analysis investigating the maximum acceptable cost of a THR at a threshold of £20,000 are shown in Table 32. These results demonstrate that, with a lifetime time horizon, the cost per THR procedure would have to be above £21,208 for the intervention to no longer be considered cost effective. Threshold values at shorter time horizons are lower, as QALY gains produced by THR are smaller in these scenarios. However, even at a 2 year time horizon, the cost of THR would have to be substantially higher for the procedure to no longer be considered cost effective.

Table 32: Threshold analysis results – cost per procedure above which THR would no longer be cost effective at a £20,000 threshold

Model time horizon	Lifetime	2 years	3 years	4 years	5 years
Cost above which THR would not be cost effective	£21,208	£13,511	£14,807	£15,958	£16,963

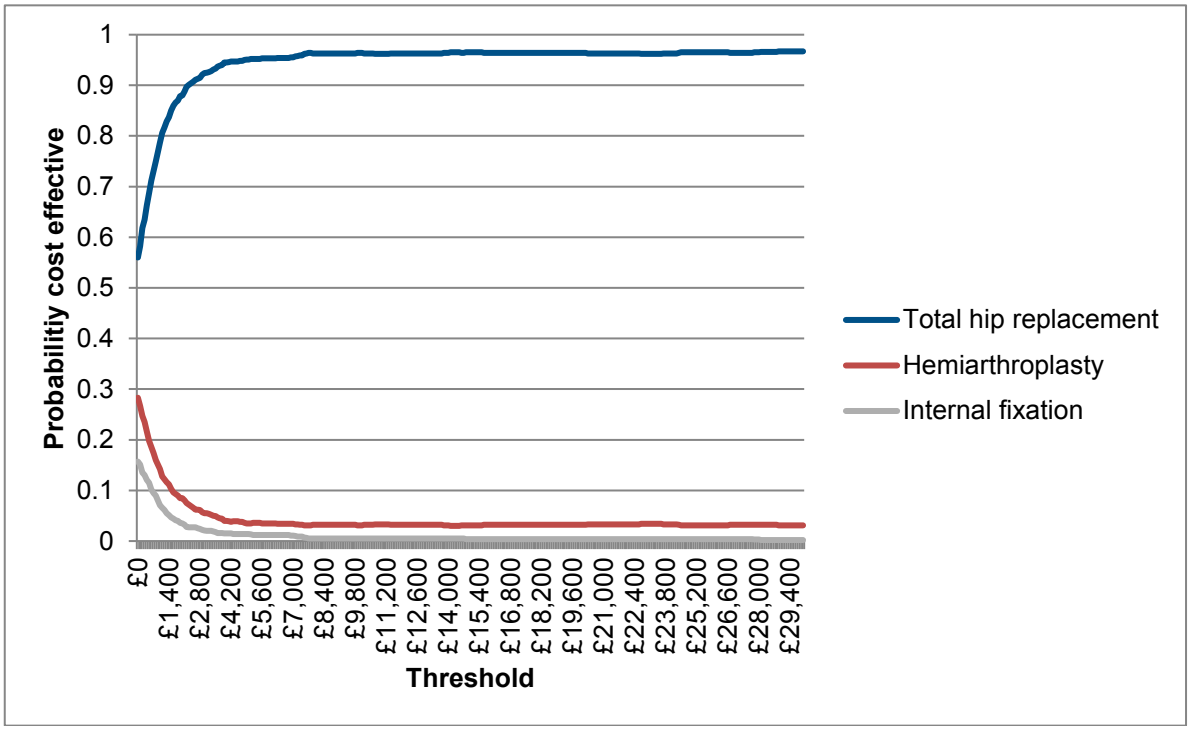
Mean cost effectiveness results of the probabilistic sensitivity analysis are shown in Table 33. These values are generally similar to the results of the deterministic analysis, and result in the same conclusion: THR dominates both HA and IF.

Table 33: Mean probabilistic sensitivity analysis results

Intervention	Cost	QALYs	ICER
Total hip replacement	£11,057	4.05	-
Hemiarthroplasty	£11,372	3.50	Dominated
Internal fixation	£11,856	3.44	Dominated

Figure 41 shows the results of the probabilistic sensitivity analysis as a cost effectiveness acceptability curve. The results show that THR has the highest probability of being the most cost effective intervention at any threshold. At a threshold of £20,000 per QALY, THR has a 96% probability of being the most cost effective intervention. The fact that there is a greater amount of uncertainty surrounding results at very low thresholds indicates that there is some uncertainty as to whether THR is the least costly intervention, but there is a high probability that it produces the largest number of QALYs.

Figure 41: Cost effectiveness acceptability curve of probabilistic sensitivity analysis results



O.4 Discussion

The results of this cost utility analysis show that THR is likely to be the most cost effective strategy for the management of displaced, intracapsular hip fracture in previously healthy patients. Despite a higher revision rate than HA, THR is associated with the highest expected number of QALYs, due to lower mortality rates and higher utility scores following surgery. Due to a lower initial procedure cost than HA, and a lower revision rate than IF, THR is also associated with the lowest expected cost.

Sensitivity analyses have shown that results are robust overall, with deterministic sensitivity analyses demonstrating that, even assuming that all procedures are associated with equal costs or equal utility scores, THR is the most cost effective option.

This analysis was characterised by a number of limitations. First, it is likely that a model with a cycle length of a year lacks sufficient granularity to fully represent the occurrence of mortality and revision following surgery. This is because hip fracture management strategies

are typically associated with sharply increased mortality and revision rates in the period shortly after surgery. While this increased rate is implicitly captured in outcomes for the first year following surgery, the model makes the assumption that all revisions and deaths occur after one year has elapsed, thereby potentially overestimating the QALYs associated with each intervention. Unfortunately, the lack of RCT data in the short term after surgery necessitated designing the model with a one year cycle length.

Second, the analysis is potentially over-reliant on data inputs from a single source – Keating et al (2005) – from which both utility and cost inputs were taken. However, other sources listing utility data at 4 months are largely consistent in the relative utility scores between interventions and, as demonstrated by deterministic sensitivity analysis, results are relatively insensitive to changes in the cost of interventions. Third, due to lack of data in the published literature, the analysis made a number of assumptions. Namely, these assumptions related to the proportion of patients ineligible for revision surgery, the proportion of patients receiving THR or HA as a revision procedure, and the utility of patients immediately following surgery and patients ineligible for surgery. Again, deterministic sensitivity analyses have shown that results are robust to changes in these assumptions.

Finally, it should be noted that the majority of data used to populate the model were sourced from RCTs (or meta-analyses of RCTs) which were generally conducted on previously healthy, non-cognitively impaired patients, and therefore results of this analysis are specific to this population. Unfortunately, the scarcity of data in other patient groups made sub-population analysis impractical. While it may be possible to extrapolate results to other patient populations, it should be noted that mortality rates, revision rates, utilities, and costs may differ in these groups.

In conclusion, this analysis shows that, in previously healthy patients, THR is likely to be the most cost effective management strategy for displaced intracapsular hip fracture, demonstrating both lower costs and higher number of QALYs compared to HA and IF.

Appendix P: Network meta analysis

P.1 Methods

Hierarchical Bayesian Network Meta-Analyses (NMAs) were conducted to obtain more precise estimates for mortality and revision inputs to the health economic model. NMAs use the data from all arms of all relevant trials and are able to combine direct and indirect evidence where conventional pairwise meta-analyses do not.

A random effects NMA was chosen for consistency with the clinical review. Conventional fixed effects meta-analysis assumes that the relative effect of one treatment compared to another is the same across an entire set of trials. In a random effects model, it is assumed that the relative effects are different in each trial but that they are from a single common distribution and that this distribution is common across all sets of trials. Network meta-analysis requires an additional assumption over conventional meta-analysis. The additional assumption is that intervention A has the same effect on people in trials of intervention A compared to intervention B as it does for people in trials of intervention A versus intervention C, and so on. Thus, in a random effects network meta-analysis, the assumption is that intervention A has the same effect distribution across trials of A versus B, A versus C and so on.

The analysis also provides estimates of effect (with 95% credible intervals) for each intervention compared to one another and compared to a single baseline risk (in this case the baseline treatment was hemiarthroplasty). These estimates were used to parameterise treatment effects in the de novo cost-effectiveness modelling.

The outcome data on mortality at 1 year, revision at 1 year and revision at any endpoint were extracted from the clinical review for this addendum and analysed using WinBUGS v14 software. The NMAs all used random effects models with binomial likelihood and a logit link function, consistent with advice in the NICE DSU Technical Support Document 2 (2011). The code used accounted for the correlation between study level effects induced by multi-arm trials as some of the trials included all three interventions. For each NMA, 50,000 burn-in iterations were run to allow convergence, then a further 50,000 iterations were run to produce the outputs. Convergence was assessed by examining the history and kernel density plots. The goodness of fit of the model was tested by calculating the residual deviance and comparing it with the number of arms across all trials in the networks.

The WinBUGS code is available in Appendix Q:.

P.2 Inputs

The total number of patients receiving each intervention and the number of pairwise comparisons are illustrated in Figure 36, 37 and 38. These data were the same as those considered by the committee during the clinical review, with the exception of revision at 1 year. As there was no pairwise meta-analysis for revision at 1 year presented in the clinical review so this was conducted separately using a random effects model (as with the other meta-analyses). Pairwise meta–analyses are available in Appendix H: and WinBUGs code in Appendix Q:.

Figure 42: NMA diagram for revisions at 1 year

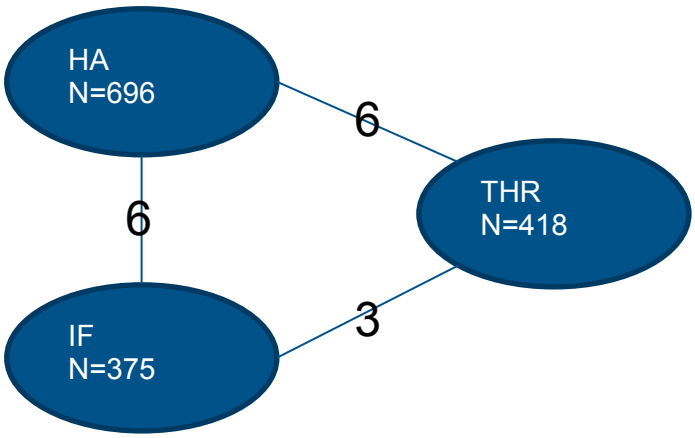


Figure 43: NMA diagram for revisions at any point

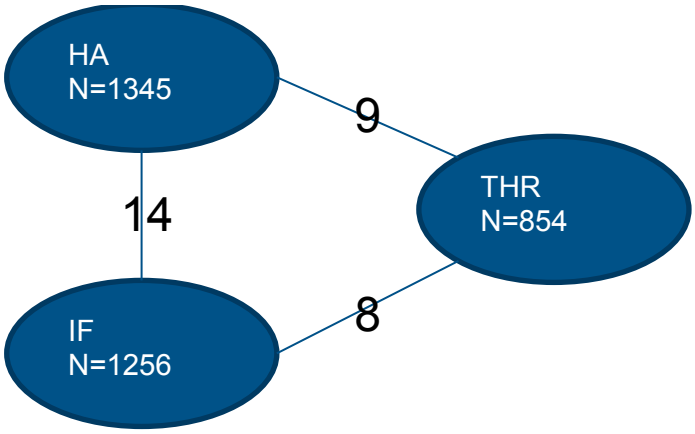
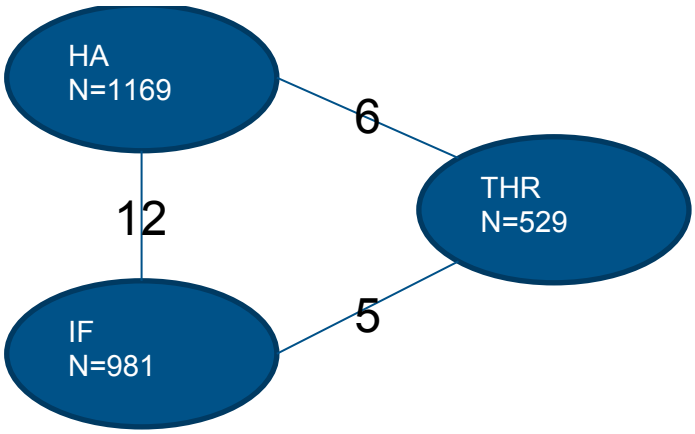


Figure 44: NMA diagram for mortality at 1 year



The initial NMA for revisions at 1 year produced estimates that were extremely inconsistent with the pairwise data and therefore lacked face validity. It was thought that this inconsistency could be due to the presence of a large number of zero-event arms within the network. To adjust for this zero events were replaced by 0.5s (as they were in the pairwise

analysis) and the resulting estimates became far more consistent. While there were zero-event arms in the network for revision at any time point, this did not generate results that were inconsistent with the pairwise analysis. Another network for this outcome, replacing zeros with 0.5s was run and analysis of residual deviance indicated the network a better fit to the data. This, along with the preservation of consistency with the methods in the pairwise analysis, meant that the latter network was preferred in the base case. Differences in results between the two methods were not large or statistically significant.

P.3 Results

Table 34 shows the comparisons between the results of the pairwise and network meta-analyses. The odds ratio outputs from the NMA have been converted into relative risks via the formula RR = OR / (1 – p + (p x OR) for ease of comparison with the pairwise results and for use within the health economic model. In this formula, p is the baseline risk of the event occurring in the comparator (THR or HA) across all arms in the NMA.

Table 34: Pairwise MA and NMA results

Revision 1 year							
Comparison	**Baseline risk (all arms)**	**Pairwise RR**	**LCI**	**UCI**	**NMA RR (mean)**	**LCI**	**UCI**
HA vs THR	3.6%	1.46	0.71	2.92	0.70	0.24	2.67
IF vs HA	3.7%	4.52	2.42	7.89	7.10	2.63	13.54
IF vs THR	3.6%	4.42	2.28	7.94	6.83	1.73	13.96
Revision any endpoint							
Comparison	**Baseline risk (all arms)**	**Pairwise RR**	**LCI**	**UCI**	**NMA RR (mean)**	**LCI**	**UCI**
HA vs THR	8.3%	1.48	0.65	3.36	0.89	0.48	1.80
IF vs HA	6.3%	5.84	2.99	11.39	5.55	3.54	7.78
IF vs THR	8.3%	3.42	2.20	5.33	4.93	2.99	6.90
Mortality 1 year							
Comparison	**Baseline risk (all arms**	**Pairwise RR**	**LCI**	**UCI**	**NMA RR (mean)**	**LCI**	**UCI**
HA vs THR	13.4%	1.17	0.84	1.63	1.14	0.84	1.58
IF vs HA	19.5%	0.97	0.81	1.15	0.92	0.74	1.13
IF vs THR	13.4%	1.05	0.74	1.48	1.08	0.75	1.47

The NMA data are largely consistent (ORs in same direction and within the relevant CI) with those from the pairwise analysis with the exception of the revision outcomes in the HA vs THR comparison. While non-significantly different from unity, the pairwise analysis favours THR, whereas the network favours HA. For the ‘revision at any endpoint’ outcome, the odds ratios are within the confidence intervals for the pairwise estimates. For the ‘revision at 1 year’ outcome, the NMA RR lies just outside the lower confidence interval of the pairwise estimate. This is explained by the fact that the evidence from the three arm trials (which are represented in all the pairwise comparisons) have a far higher rate of revision for HA than the two arm trials (9.4% vs 1.3%), this is particularly true of Skinner 1989. The removal of Skinner 1989 from the MA and NMA for revision at 1 year and any endpoint leads to greater consistency between the results; both the MA and NMA favour HA over THR but the NMA RR for IF vs THR is outside the upper confidence interval of the MA (highlighted in Table 35).

As there was not a clear clinical or methodological reason for excluding the Skinner study from the analysis, NMA outputs including the study were used in the model base case, and a sensitivity analysis was conducted using the outputs without the Skinner study.

Table 35: MA and NMA data excluding Skinner 1989

Revision 1 year							
Comparison	**Baseline Risk (All arms)**	**Pairwise RR**	**LCI**	**UCI**	**NMA RR (mean)**	**LCI**	**UCI**
HA vs THR	3.3%	0.86	0.32	2.23	0.42	0.14	2.14
IF vs HA	2.2%	6.40	3.51	11.02	10.42	3.28	21.01
IF vs THR	3.3%	3.45	1.35	7.93	8.19	1.33	15.32
Revision any endpoint							
Comparison	**Baseline Risk (All arms)**	**Pairwise RR**	**LCI**	**UCI**	**NMA RR (mean)**	**LCI**	**UCI**
HA vs THR	8.5%	0.78	0.35	1.64	0.63	0.31	1.42
IF vs HA	5.0%	6.72	4.28	9.69	7.20	4.39	10.45
IF vs THR	8.5%	3.18	2.40	4.11	4.73	2.67	6.84

Table 36 shows the residual deviance and total data points for each network along with the probability that each intervention is best. Hemiarthroplasty had the highest probability of being best in all the revision networks and total hip replacement had the highest probability of being best in the mortality network.

Table 36: NMA outcome data

Network	**Residual Deviance**	**Data Points**	**p(HA Best)**	**p(THR Best)**	**p(IF Best)**
Revision 1 Year	17.095	18	61%	39%	0%
Revision Any	51.672	53	56%	44%	0%
Mortality 1 Year	30.499	37	6%	61%	33%
Revision 1 Year Excl	19.942	21	83%	17%	0%
Revision Any Excl	54.305	50	85%	15%	0%

Appendix Q: WinBUGs code for network meta analysis

Q.1 Network 1 – Revision at 1 Year

```
# Binomial likelihood, logit link

# Random effects model for multi-arm trials


model{                  # *** PROGRAM STARTS


for(i in 1:ns){         # LOOP THROUGH STUDIES
  w[i,1] <- 0  # adjustment for multi-arm trials is zero for control arm
  delta[i,1] <- 0       # treatment effect is zero for control arm
  mu[i] ~ dnorm(0,.0001)        # vague priors for all trial baselines
  for (k in 1:na[i]) {     # LOOP THROUGH ARMS
    r[i,k] ~ dbin(p[i,k],n[i,k]) # binomial likelihood
    logit(p[i,k]) <- mu[i] + delta[i,k] # model for linear predictor
    rhat[i,k] <- p[i,k] * n[i,k] # expected value of the numerators


#Deviance contribution
   dev[i,k] <- 2 * (r[i,k] * (log(r[i,k])-log(rhat[i,k]))
     + (n[i,k]-r[i,k]) * (log(n[i,k]-r[i,k]) - log(n[i,k]-rhat[i,k]))) }


# summed residual deviance contribution for this trial
 resdev[i] <- sum(dev[i,1:na[i]])
 for (k in 2:na[i]) {     # LOOP THROUGH ARMS
# trial-specific LOR distributions
     delta[i,k] ~ dnorm(md[i,k],taud[i,k])
# mean of LOR distributions (with multi-arm trial correction)
     md[i,k] <- d[t[i,k]] - d[t[i,1]] + sw[i,k]
# precision of LOR distributions (with multi-arm trial correction)
     taud[i,k] <- tau *2*(k-1)/k
# adjustment for multi-arm RCTs
     w[i,k] <- (delta[i,k] - d[t[i,k]] + d[t[i,1]])
# cumulative adjustment for multi-arm trials
     sw[i,k] <- sum(w[i,1:k-1])/(k-1)
  }
 }
totresdev <- sum(resdev[])    # Total Residual Deviance
```

```
d[1]<-0    # treatment effect is zero for reference treatment
# vague priors for treatment effects
for (k in 2:nt){ d[k] ~ dnorm(0,.0001) }
sd ~ dunif(0,5) # vague prior for between-trial SD
tau <- pow(sd,-2) # between-trial precision = (1/between-trial variance)

# pairwise ORs and LORs for all possible pair-wise comparisons, if nt>2
for (c in 1:(nt-1)) {
for (k in (c+1):nt) {
or[c,k] <- exp(d[k] - d[c])
lor[c,k] <- (d[k]-d[c])
}
}
# ranking on relative scale
for (k in 1:nt) {
# rk[k] <- nt+1-rank(d[],k) # assumes events are “good”
rk[k] <- rank(d[],k) # assumes events are “bad”
best[k] <- equals(rk[k],1) #calculate probability that treat k is best
}
}
# *** PROGRAM ENDS
list(ns=25, nt=3)
```

t[,1]	t[,2]	t[,3]	r[,1]	r[,2]	r[,3]	n[,1]	n[,2]	n[,3]	na[]
1	2	NA	0.5	1	NA	23	17	NA	2
1	2	NA	0.5	2	NA	60	60	NA	2
1	2	NA	4	2	NA	50	39	NA	2
1	2	3	5	6	27	69	69	69	3
1	2	NA	6	1	NA	41	40	NA	2
1	2	NA	0.5	7	NA	41	42	NA	2
1	2	3	5	1	12	43	43	43	3
1	2	NA	6	2	NA	137	115	NA	2
1	3	NA	0.5	8	NA	26	30	NA	2
1	3	NA	3	9	NA	53	51	NA	2
1	3	NA	2	8	NA	30	30	NA	2
1	3	NA	3	40	NA	110	112	NA	2
1	3	NA	1	18	NA	42	49	NA	2
1	3	NA	1	7	NA	15	17	NA	2
1	3	NA	0.5	7	NA	29	31	NA	2

```
1	3	NA	5	6	NA	22	21	NA	2
1	3	NA	1	25	NA	47	53	NA	2
1	3	NA	3	26	NA	187	93	NA	2
1	3	NA	15	86	NA	229	226	NA	2
1	2	3	22	6	30	91	89	91	3
2	3	NA	7	26	NA	68	78	NA	2
2	3	NA	1	7	NA	23	24	NA	2
2	3	NA	2	18	NA	49	53	NA	2
2	3	NA	20	41	NA	157	128	NA	2
2	3	NA	13	26	NA	43	57	NA	2

END

#Set Initial Values
#chain 1
list(d=c( NA, 0, 0), sd=1,
mu=c(0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0))
#chain 2
list(d=c( NA, -1, -1), sd=4,
mu=c(-3, -3, -3, -3, -3, -3, -3, -3, -3, -3,
    -3, -3, -3, -3, -3, -3, -3, -3, -3, -3,
    -3, -3, -3, -3, -3))
#chain 3
list(d=c( NA, 2, 2), sd=2,
mu=c(-3, 5, -1, -3, 7, -3, -4, -3, -3, 0,
    -3, -3, 0, 3, 5, -3, -3, -1, -3, -7,
    -3, -3, 5, -1, 7))
```

Q.2 Network 2 – Revision at any Endpoint

```
# Binomial likelihood, logit link
# Random effects model for multi-arm trials

model{                  # *** PROGRAM STARTS

for(i in 1:ns){         # LOOP THROUGH STUDIES
  w[i,1] <- 0  # adjustment for multi-arm trials is zero for control arm
```

```
   delta[i,1] <- 0      # treatment effect is zero for control arm
   mu[i] ~ dnorm(0,.0001)       # vague priors for all trial baselines
   for (k in 1:na[i]) {     # LOOP THROUGH ARMS
     r[i,k] ~ dbin(p[i,k],n[i,k]) # binomial likelihood
     logit(p[i,k]) <- mu[i] + delta[i,k] # model for linear predictor
     rhat[i,k] <- p[i,k] * n[i,k] # expected value of the numerators

#Deviance contribution
    dev[i,k] <- 2 * (r[i,k] * (log(r[i,k])-log(rhat[i,k]))
     + (n[i,k]-r[i,k]) * (log(n[i,k]-r[i,k]) - log(n[i,k]-rhat[i,k]))) }

# summed residual deviance contribution for this trial
  resdev[i] <- sum(dev[i,1:na[i]])
  for (k in 2:na[i]) {     # LOOP THROUGH ARMS
# trial-specific LOR distributions
     delta[i,k] ~ dnorm(md[i,k],taud[i,k])
# mean of LOR distributions (with multi-arm trial correction)
     md[i,k] <- d[t[i,k]] - d[t[i,1]] + sw[i,k]
# precision of LOR distributions (with multi-arm trial correction)
     taud[i,k] <- tau *2*(k-1)/k
# adjustment for multi-arm RCTs
     w[i,k] <- (delta[i,k] - d[t[i,k]] + d[t[i,1]])
# cumulative adjustment for multi-arm trials
     sw[i,k] <- sum(w[i,1:k-1])/(k-1)
   }
 }
totresdev <- sum(resdev[])     # Total Residual Deviance
d[1]<-0    # treatment effect is zero for reference treatment
# vague priors for treatment effects
for (k in 2:nt){ d[k] ~ dnorm(0,.0001) }
sd ~ dunif(0,5) # vague prior for between-trial SD
tau <- pow(sd,-2) # between-trial precision = (1/between-trial variance)

# pairwise ORs and LORs for all possible pair-wise comparisons, if nt>2
for (c in 1:(nt-1)) {
for (k in (c+1):nt) {
or[c,k] <- exp(d[k] - d[c])
lor[c,k] <- (d[k]-d[c])
}
```

```
}
# ranking on relative scale
for (k in 1:nt) {
# rk[k] <- nt+1-rank(d[],k) # assumes events are “good”
rk[k] <- rank(d[],k) # assumes events are “bad”
best[k] <- equals(rk[k],1) #calculate probability that treat k is best
}
}
# *** PROGRAM ENDS
list(ns=25, nt=3)
```

t[,1]	t[,2]	t[,3]	r[,1]	r[,2]	r[,3]	n[,1]	n[,2]	n[,3]	na[]
1	2	NA	0.5	1	NA	23	17	NA	2
1	2	NA	0.5	2	NA	60	60	NA	2
1	2	NA	4	2	NA	50	39	NA	2
1	2	3	5	6	27	69	69	69	3
1	2	NA	6	1	NA	41	40	NA	2
1	2	NA	0.5	7	NA	41	42	NA	2
1	2	3	5	1	12	43	43	43	3
1	2	NA	6	2	NA	137	115	NA	2
1	3	NA	0.5	8	NA	26	30	NA	2
1	3	NA	3	9	NA	53	51	NA	2
1	3	NA	2	8	NA	30	30	NA	2
1	3	NA	3	40	NA	110	112	NA	2
1	3	NA	1	18	NA	42	49	NA	2
1	3	NA	1	7	NA	15	17	NA	2
1	3	NA	0.5	7	NA	29	31	NA	2
1	3	NA	5	6	NA	22	21	NA	2
1	3	NA	1	25	NA	47	53	NA	2
1	3	NA	3	26	NA	187	93	NA	2
1	3	NA	15	86	NA	229	226	NA	2
1	2	3	22	6	30	91	89	91	3
2	3	NA	7	26	NA	68	78	NA	2
2	3	NA	1	7	NA	23	24	NA	2
2	3	NA	2	18	NA	49	53	NA	2
2	3	NA	20	41	NA	157	128	NA	2
2	3	NA	13	26	NA	43	57	NA	2

```
END
```

```
#Set Initial Values
#chain 1
list(d=c( NA, 0, 0), sd=1,
mu=c(0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0))
#chain 2
list(d=c( NA, -1, -1), sd=4,
mu=c(-3, -3, -3, -3, -3, -3, -3, -3, -3, -3,
    -3, -3, -3, -3, -3, -3, -3, -3, -3, -3,
    -3, -3, -3, -3, -3))
#chain 3
list(d=c( NA, 2, 2), sd=2,
mu=c(-3, 5, -1, -3, 7, -3, -4, -3, -3, 0,
    -3, -3, 0, 3, 5, -3, -3, -1, -3, -7,
    -3, -3, 5, -1, 7))
```

Q.3 Network 3 – Mortality at 1 Year

```
# Binomial likelihood, logit link
# Random effects model for multi-arm trials

model{                  # *** PROGRAM STARTS

for(i in 1:ns){         # LOOP THROUGH STUDIES
  w[i,1] <- 0  # adjustment for multi-arm trials is zero for control arm
  delta[i,1] <- 0       # treatment effect is zero for control arm
  mu[i] ~ dnorm(0,.0001)        # vague priors for all trial baselines
  for (k in 1:na[i]) {     # LOOP THROUGH ARMS
    r[i,k] ~ dbin(p[i,k],n[i,k]) # binomial likelihood
    logit(p[i,k]) <- mu[i] + delta[i,k] # model for linear predictor
    rhat[i,k] <- p[i,k] * n[i,k] # expected value of the numerators

#Deviance contribution
   dev[i,k] <- 2 * (r[i,k] * (log(r[i,k])-log(rhat[i,k]))
     + (n[i,k]-r[i,k]) * (log(n[i,k]-r[i,k]) - log(n[i,k]-rhat[i,k]))) }

# summed residual deviance contribution for this trial
```

```
  resdev[i] <- sum(dev[i,1:na[i]])
  for (k in 2:na[i]) {     # LOOP THROUGH ARMS
# trial-specific LOR distributions
      delta[i,k] ~ dnorm(md[i,k],taud[i,k])
# mean of LOR distributions (with multi-arm trial correction)
      md[i,k] <- d[t[i,k]] - d[t[i,1]] + sw[i,k]
# precision of LOR distributions (with multi-arm trial correction)
      taud[i,k] <- tau *2*(k-1)/k
# adjustment for multi-arm RCTs
      w[i,k] <- (delta[i,k] - d[t[i,k]] + d[t[i,1]])
# cumulative adjustment for multi-arm trials
      sw[i,k] <- sum(w[i,1:k-1])/(k-1)
    }
 }
totresdev <- sum(resdev[])     # Total Residual Deviance
d[1]<-0    # treatment effect is zero for reference treatment
# vague priors for treatment effects
for (k in 2:nt){ d[k] ~ dnorm(0,.0001) }
sd ~ dunif(0,5) # vague prior for between-trial SD
tau <- pow(sd,-2) # between-trial precision = (1/between-trial variance)

# pairwise ORs and LORs for all possible pair-wise comparisons, if nt>2
for (c in 1:(nt-1)) {
for (k in (c+1):nt) {
or[c,k] <- exp(d[k] - d[c])
lor[c,k] <- (d[k]-d[c])
}
}
# ranking on relative scale
for (k in 1:nt) {
# rk[k] <- nt+1-rank(d[],k) # assumes events are “good”
rk[k] <- rank(d[],k) # assumes events are “bad”
best[k] <- equals(rk[k],1) #calculate probability that treat k is best
}
}
# *** PROGRAM ENDS
list(ns=17, nt=3)

t[,1]        t[,2]        t[,3]        r[,1]        r[,2]        r[,3]        n[,1]        n[,2]        n[,3]        na[]
```

```
1	2	NA	3	4	NA	60	60	NA	2
1	2	NA	8	3	NA	41	42	NA	2
1	2	3	6	4	6	69	69	69	3
1	2	3	6	6	5	43	43	43	3
1	2	3	25	20	23	91	89	91	3
1	2	NA	18	16	NA	137	115	NA	2
1	3	NA	7	10	NA	30	30	NA	2
1	3	NA	21	5	NA	187	93	NA	2
1	3	NA	29	24	NA	110	112	NA	2
1	3	NA	5	4	NA	42	49	NA	2
1	3	NA	63	61	NA	229	226	NA	2
1	3	NA	7	10	NA	26	30	NA	2
1	3	NA	11	9	NA	53	51	NA	2
1	3	NA	14	20	NA	29	31	NA	2
1	3	NA	5	2	NA	22	21	NA	2
2	3	NA	2	3	NA	43	57	NA	2
2	3	NA	16	17	NA	68	78	NA	2
END


#Set Initial Values
#chain 1
list(d=c( NA, 0, 0), sd=1,
mu=c(0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 0, 0))
#chain 2
list(d=c( NA, -1, -1), sd=4,
mu=c(-3, -3, -3, -3, -3, -3, -3, -3, -3, -3,
    -3, -3, -3, -3, -3, -3, -3))
#chain 3
list(d=c( NA, 2, 2), sd=2,
mu=c(-3, 5, -1, -3, 7, -3, -4, -3, -3, 0,
    -3, -3, 0, 3, 5, -3, -3))
```