NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of minimally invasive total hip replacement

Hip replacement surgery using a minimally invasive approach may be an option for people with worn or damaged hip joints. This condition is usually due to degeneration of the joint (osteoarthritis), which can make walking painful.

The procedure replaces the damaged hip joint (the top part of the upper leg bone and the socket in the hip bone that it fits into) with an artificial one. In order to undertake the surgery through small incisions without muscle damage, specially designed equipment is used to support the leg and pull back the surrounding tissues so the surgeon can see the joint. X-rays are sometimes used to check the position of the bones and the artificial joint.

Introduction

The National Institute for Health and Clinical Excellence (NICE) has prepared this overview to help members of the Interventional Procedures Advisory Committee (IPAC) make recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in March 2010.

Procedure name

- Minimally invasive total hip replacement

Specialty societies

- British Orthopaedic Association
- British Hip Society

Description

Indications and current treatment

Disability due to hip pain is common and is usually caused by osteoarthritis. Conservative treatments for arthritis of the hip joint include medications for pain and inflammation, and physiotherapy. If conservative treatments fail, hip resurfacing or a hip replacement may be necessary.

A traditional hip replacement involves making a large incision (20–30 cm in length) with division of muscles, ligaments and tendons. Several different approaches may be used.

What the procedure involves

The proposed benefits of this procedure over a standard incision total hip replacement include reduced postoperative pain, quicker rehabilitation and improved cosmetic outcome.

Minimally invasive total hip replacement approach may be performed with the patient under general or epidural anaesthesia. The approach aims to avoid damage to the muscles and tendons around the hip joint and usually the incision is shorter (either a single incision of 10 cm or less in length, or one incision at the front of the hip and one at the back). A specialised operating table may be employed and specially designed retractors and customised instruments are used to expose the hip joint, prepare the acetabular socket and the femur, and to insert the prosthesis. Some dissection of muscle may be necessary but to a lesser extent than in the traditional approach. Fluoroscopic guidance is often used to aid positioning of the implant, and computer-assisted navigation tools have also been developed. The prosthesis implanted may be the same as for a traditional hip replacement and it may be cemented or uncemented. A number of different prostheses are available for the procedure.

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to minimally invasive total hip replacement. Searches were conducted of the following databases, covering the period from their commencement to 11 March 2010 and updated to 28 May 2010: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches (see appendix C for details of search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The following selection criteria (table 1) were applied to the abstracts identified by the literature search. Where selection criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, or a laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising study methodology, unless they reported specific adverse events that were not available in the published literature.
Patient	Patients requiring hip replacement.
Intervention/test	Minimally invasive total hip replacement
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the overview

This overview is based on approximately 207,000 hips or procedures from 1 national register[1], 1 systematic review[2], 1 randomised controlled trial[3], 1 non-randomised comparative study[4], 5 case series[5,6,7,8,9], and a national registry (personal communication)[10].

Other studies that were considered to be relevant to the procedure but were not included in the main extraction table (table 2) have been listed in appendix A.

Table 2 Summary of key efficacy and safety findings on minimally invasive total hip replacement

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

Study details	Key safety findings	Comments
Kärrholm J (2008)[1] **Case series** (Swedish hip arthroplasty register) Sweden Recruitment period: 1992-2007 Study population: all patients who received hip arthroplasty in public and private hospitals **n = 182,432 (585 mini-incision between 2000 - 2007)** Age: 69 years (mean) Sex: not reported Patient selection criteria: see above Technique: mini-incision **(TWO and SINGLE INCISION)** vs **standard-incision (various approaches)** with cemented or uncemented prostheses. **Follow-up: 5.9 years (mean)** Conflict of interest/source of funding: not reported	Effect of age, gender, diagnosis, choice of incision and cemented / uncemented fixation on the risk of stem revision (excluding infection and surface replacement implants) **Risk** / **95% CI** **Increased Risk** Decreasing Age (years): 1.03 (1.03-1.03) Male: 1.89 (1.75-1.99) Secondary osteoarthritis to: • Fracture/Trauma: 1.89 (1.70-2.09) • Idiopathic femoral head necrosis: 1.38 (1.16-1.64) Mini-incision: 5.23 (2.94-9.32) **Decreased risk** Posterior incision: 0.62 (0.57-0.67) Anterior incision, patient on side: 0.73 (0.66-0.80) Uncemented stem: 0.58 (0.50-0.67) Authors state that “failures leading to revision may often be related to surgical technique where early revision for fracture is over-represented in uncemented fixation. We also find that the mini-incision is associated with a more than five- times greater risk of stem problems leading to revision”.	**This study prompted the review due to reported increased risk of revision when using mini-incision.** Only revision data are presented

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

Study details	Key efficacy findings	Key safety findings	Comments
Cheng T (2009)[2] **Systematic Review** China (International studies) Recruitment period: Studies published 1996 to 2008 Study population: Patients with osteoarthritis, osteonecrosis, rheumatoid arthritis, traumatic arthritis, hip dysplasia, or femoral neck fracture. **n = 1205 (597 mini-incision)** Studies included: Zhang (2004); Zhang(2006); Wright (2004); Kim (2006); Chung (2004); Dorr (2007); Hart (2005); Dutka (2007); Chimento (2005); Speranza (2007); Yan (2005); Ogonda (2005) Age: not reported Sex: not reported Patient selection criteria: not reported Technique: **SINGLE INCISION** (various approaches) or **TWO INCISION** THR with cemented or uncemented prostheses. **Follow-up: 6 weeks to 5 years (mean or median for included studies)** Conflict of interest/source of funding: none	Number of patients analysed: **1205 (597 mini-incision)** **Hip function** Harris score (0 to 100, higher scores better – based on functional ability and hip dynamics and ROM). Mini-incision vs standard incision (negative WMD indicates advantage of mini-incision). Outcome: Change in Harris hip score (points); n = 513; WMD (95% CI) 3.99 (-0.18 to 8.16); p value 0.06 Significant heterogeneity between the 5 studies **Operative characteristics** Mini-incision vs standard incision (negative WMD indicates advantage of mini-incision. Length of stay (days); n = 330; -3.59 (-5.69 to -1.50); 0.0008 Operative time (min); n = 875; -1.07 (-6.88 to 4.74); 0.72 Blood loss (ml); n = 875; -79.75 (-125.45 to -43.04); 0.0006 Significant heterogeneity between pooled studies When only studies with a posterior approach were analysed there was a superior WMD for the mini-incision technique over standard incision in terms of operative time (-4.73 [95% CI -7.37 to -2.09]) (p = 0.0004). **Radiographic assessment** Mini-incision vs standard incision (negative WMD indicates advantage of mini-incision). Cup anteversion (°); n = 350; 2.90 (1.05 to 4.74); p value 0.002 There was no significant difference in WMD between patients in the mini-incision or standard groups with regard to cup inclination, stem angle, acetabular outlier, femoral outline or grade of cement mantle.	**Complications** All postoperative complications. Mini-incision vs standard incision (negative odds ratio indicates advantage of mini-incision). All complications; n = 1205; Pooled odds ratio (95% CI) 1.08 (-0.59 to 1.97); p value 0.81 No heterogeneity between the 12 studies (p = 0.85) Complications included dislocation, DVT, nerve palsy and periprosthetic fracture in both groups; infection and wound healing problems in the mini-incision groups; and haematoma in the standard incision groups. The absolute rate of complications in the groups is not reported.	**Follow-up issues**: Not reported for individual studies **Study design issues**: Studies selected for inclusion with a randomised or quasi-randomised design. Study quality evaluated using the Jaded scale. Statistical heterogeneity tested for. A wide range of bibliographical databases and Internet search with search terms briefly listed. Cross-referencing undertaken. No language restriction on selection of studies. Only studies comparing mini-incision with standard-incision procedures were included. Random effect model used for meta analysis. **Study population issues**: No limit for inclusion criteria on the basis that diagnosis at baseline was used. **Other issues**: Authors state that the definition used for mini-incision technique varied between studies (usually 6 to 10 cm). Authors conclude that RCTs with long-term follow-up are needed to demonstrate implant survival and clinical outcomes.

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Lawlor M (2005)[3]

RCT

UK
Recruitment period: 2003-2004

Study population: patients requiring total hip replacement.

n = 219 (109 vs 110)

Age: mini-incision group: 67.4 years (mean), standard incision group: 65.9 years (mean)
Sex: mini-incision group: 45% (49/109) male; standard incision group: 52.7% (58/110) male

Patient selection criteria: exclusions: history of previous hip surgery, or inflammatory polyarthritis

Technique: SINGLE INCISION mini-incision (using posterior approach and incision of 10cm or less) vs SINGLE INCISION standard incision (using posterior approach and 16cm incision). The same hybrid total hip replacement prosthesis were used in both procedures. A standard anaesthetic and analgesia protocol was used, and a standardised physiotherapy assessment and treatment programme initiated in all patients.

Follow-up: 6 weeks

Conflict of interest/source of funding: none</td>
<td>Postoperative outcomes
There was no statistically significant difference in the ability to mobilise on day 1 after surgery between groups, with 85% (88/103) of the mini-incision group and 91% (96/105) of the standard incision group able (p = 0.54).

There were no statistically significant differences in the post operative pain scores or the volume of patient controlled morphine used.

At post operative day 2 there was no statistically significant difference in the type of walking aid used between the groups (p = 0.46).

No significant differences between the groups were found in functional assessment based on ability to move from supine to sitting, sitting to standing, or mobilisation without an aid.

Timed stair assessment
Patients were timed walking up and down stairs on the second postoperative day. There were no statistically significant differences between the groups in time to ascend (p=0.84) or descend (p = 0.22).

Timed walk test
Patients were timed over the middle 6 m of a 10 metre walk (to allow for acceleration and deceleration), at two days and 6 weeks follow up. Speeds in m/s, mean (Standard deviation)
<table>
<tr><th></th><th>Mini-incision</th><th>Standard incision</th><th>p value</th></tr>
<tr><td>2 day</td><td>0.26 (0.16)</td><td>0.26 (0.16)</td><td>p = 0.83</td></tr>
<tr><td>6 weeks</td><td>0.90 (0.30)</td><td>0.93 (0.27)</td><td>p = 0.54</td></tr>
</table>
</td>
<td>Complications
2 patients in the standard incision group died in the postoperative period, one from acute myocardial infarction (patient had a history of ischaemic heart disease), and one with bowel infarction from mesenteric vessel thrombosis.

Operative related complications
<table>
<tr><th></th><th>Mini</th><th>Standard</th></tr>
<tr><td>Deep infection</td><td>1% (1/109)</td><td>0%</td></tr>
<tr><td>Superficial infection</td><td>1% (1/109)</td><td>0%</td></tr>
<tr><td>Early dislocation</td><td>1% (1/109)</td><td>1% (1/110)</td></tr>
<tr><td>Proximal deep vein thrombosis</td><td>0%</td><td>1% (1/110)</td></tr>
</table>
Timing and treatment of complications is not reported.</td>
<td>Reported in table 2 of overview for ‘single mini-incision hip replacement’ published in 2005

Follow-up issues:
Loss to follow-up: 1.8% (4/219) at 6 weeks

Study design issues:
Randomisation by computer generated sequence.
Concealment of allocation by opaque envelopes until evening before surgery.
A single surgeon undertook all operations.
No standardisation of incision length for mini-incision group
Patients blinded to allocation by standardised wound dressings
All outcome assessments made by assessors blinded to allocation.
Outcome of ability to weight bear on operated leg may have been biased by amount of support for balance used by individuals.
Standardised outcome assessment data collection forms pilot before study.
Several patients unable to complete all outcome assessments. Not clear whether intention to treat analysis performed.
Some patients undertook postoperative outcome assessment after day 2 due to illness.

Study population issues:
No difference in age, gender, or BMI characteristics at baseline (p > 0.21)

Other issues:
None</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

Study details

Levine MJ (2007)[4]

Non randomised comparative study

USA
Recruitment period: 2003-2004
Study population: patients requiring total hip replacement .

n = 201 (126 vs 75)

Age: mini-incision group: 58.02 years (mean), standard incision group: 56.39 years (mean)
Sex: not reported

Patient selection criteria: mini-incision group: BMI<35, Dorr index (assessment of femoral bone quality) type A or B femurs, adequate home support and motivation and no other deformity. Standard group: BMI >35, significant deformity, significant osteopenia or inadequate social support and motivation for accelerated rehabilitation.

Technique: **TWO INCISIONS** mini-incision (5cm and 2-3 cm) under fluoroscopic guidance vs **SINGLE INCISION standard incision** (10-15cm) using a direct lateral approach. The same fiber-metal backed titanium acetabular component used in both procedures. All patients received enoxaparin for 2 weeks postoperatively.

Follow-up: minimum 2 years
Conflict of interest/source of funding: not reported

Key efficacy findings

	Mini (n=126)	Standard (n=75)	p value
Mean length of stay (days)	2.20	3.73	<0.01
Mean operative time (minutes)	98.01	110.12	<0.01

Key safety findings

	Mini (n=126)	Standard (n=75)	p value
Mean estimated blood loss (mL)	514.96	494.86	0.146
Dislocation treated with open reduction	2	0	Not reported
Fractures	2*	3‡	Not reported
Deep infection treated with two-stage exchange arthroplasty	3	2	Not reported
Wound problems	3†	3	Not reported
Early subsidence treated with femoral head exchange	2	0	Not reported
Ceramic head fracture at 90 days requiring revision of head and polyethylene liner	1	0	Not reported
Femoral nerve palsy (resolved in time)	1	0	Not reported
Loose stem	0	1	Not reported
Loose acetabular component	0	1	Not reported
Deep venous thrombosis requiring anticoagulation therapy	0	3	Not reported

*one treated with cerclage and one treated with fully porous coated implant
†one treated with debridement
‡ Intraoperative, treated by cerclage

Timing and treatment of complications is not reported unless otherwise stated.

Comments

Follow-up issues:
Loss to follow-up is not reported

Study design issues:
Retrospective study

Study population issues:
No difference in age or BMI at baseline

Other issues:
None

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Swanson (2005)[5]

Case series
USA

Recruitment period: 1997 onwards
Study population: mean BMI = 26.5 kg/m^2
n = 759 (1000 hips)

Age: 62 years
Sex: 42% male

Patient selection criteria: patients requiring removal of existing hardware, with significant deformity requiring structural bone grafts, and those undergoing femoral osteotomy were excluded.

Technique: In lateral decubitus position SINGLE INCISION without severing muscle, osteotomy of the femoral neck, insertion of prosthesis with additional acetabular screws where necessary. Prophylactic antibiotics and patient-controlled analgesic pump for 2 days. Physical therapy initiated on first day of follow-up with weight-bearing tolerated.

Follow-up: 37 months (mean)

Conflict of interest/source of funding: supported by manufacturer</td>
<td>Number of patients analysed: 759 (1000 hips)
Hip function
Harris hip score group mean and standard deviation
<table>
<tr><th>Baseline</th><th>37 months follow-up</th><th>p value</th></tr>
<tr><td>34 ± 12</td><td>92 ± 9</td><td>Not reported</td></tr>
</table>
Patients were able to begin unrestricted normal daily activities at a mean of 4.2 weeks follow-up (range 1 to 11 weeks).

Operative characteristics
Mean incision length was 8.8 cm (range 6 to 16 cm).
Mean operative time 61.2 (± 24.2) minutes
Mean length of stay 3.7 (± 1.8) days
Mean blood loss 317.3 (± 230.6) ml

56.4% (564/1000) of procedures did not require a blood transfusion.

Radiographic assessment
Mean cup abduction angle was 41.2° and mean anteversion 14.6°.</td>
<td>Complications
<table>
<tr><th>Outcome</th><th>Rate</th></tr>
<tr><td>Dislocation (revision required in 3 hips)</td><td>3.0% (30/1000)</td></tr>
<tr><td>Deep wound infection (removal of prosthesis)</td><td>0.3% (3/1000)</td></tr>
<tr><td>Superficial wound infection (surgical debridement)</td><td>0.5% (5/1000)</td></tr>
<tr><td>Delayed wound healing</td><td>1.0% (1/1000)</td></tr>
<tr><td>Intraoperative femoral shaft fracture (exposure and internal fixation in 1 hip)</td><td>0.7% (7/1000)</td></tr>
<tr><td>Trochanteric fracture (no treatment)</td><td>0.3% (3/1000)</td></tr>
<tr><td>Transient nerve palsy</td><td>0.6% (6/1000)</td></tr>
<tr><td>DVT / pulmonary embolism</td><td>1.2% (12/1000)</td></tr>
<tr><td>Revision surgery</td><td>2.1% (21/1000)</td></tr>
</table>
Heterotopic ossification
<table>
<tr><th>Grade</th><th>Rate</th></tr>
<tr><td>I or II</td><td>17.0% (170/1000)</td></tr>
<tr><td>III</td><td>2.8% (28/1000)</td></tr>
<tr><td>IV</td><td>0.0% (0/1000)</td></tr>
</table>
</td>
<td>Follow-up issues:
1000 of the first 1115 consecutive hips treated with 2-year follow-up were analysed. The other 115 hips were lost to follow-up or the patient had died.
Study design issues:
All procedures undertaken by one surgeon.
No independent outcome assessment.

Study population issues:
Study population in terms of diagnosis / reason for THR at baseline is not reported.

Other issues:
A number of different prosthesis types (both femoral and acetabular components) were used during the series.</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Kennon R E (2004)[6]

Case series
USA
Recruitment period: not reported
Study population: not reported
n = 2132

Age: not reported
Sex: not reported

Patient selection criteria: not reported

Technique: In supine position SINGLE INCISION with capsulectomy, insertion of cemented or uncemented prosthesis.

Follow-up: not reported

Conflict of interest/source of funding: not reported</td>
<td>Number of patients analysed: 2132

Operative characteristics
Typical incision length was 6 to 10 cm.</td>
<td>Complications
<table>
<tr><th>Outcome</th><th>Rate</th></tr>
<tr><td>Dislocation</td><td>1.3% (absolute figures not reported)</td></tr>
<tr><td>Permanent nerve palsy</td><td>0% (0/2132)</td></tr>
<tr><td>Lateral femoral cutaneous nerve injury</td><td>0.2% (5/2132)</td></tr>
<tr><td>Clinically significant haematoma</td><td>1.5% (31/2132)</td></tr>
<tr><td>Clinically significant thromboembolic disease</td><td>0.8% (17/2132)</td></tr>
</table>
</td>
<td>Follow-up issues:
Loss to follow-up not reported.
Patients recorded and tracked in a database.

Study design issues:
None

Study population issues:
Patient selection criteria not reported.

Other issues:
Authors report that the ‘modified anterior approach’ has been used in over 7000 with excellent results.</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Siguier T (2004)[7]

Case series
France

Recruitment period: 1993 to 2000
Study population: Patients with osteoarthritis(n = 950), dysplastic hip (n = 46), avascular necrosis (n = 20), inflammatory arthritis (n = 11), other (n = 10) undergoing primary arthroplasty.

n = 926 (1037 hips)

Age: 68 years (mean)
Sex: 36% male

Patient selection criteria: not reported

Technique: In dorsal decubitus position without navigation or image intensifier SINGLE INCISION of 6 to 8 cm and capsulectomy but sparing of periarticular muscles and tendons, insertion of cemented prosthesis closure with aspiration drain for 4 days. Weight-bearing allowed on second day of follow-up.

Follow-up: not reported

Conflict of interest/source of funding: none</td>
<td>Number of patients analysed: 926

Functional recovery
Most patients were able to walk without crutches ‘early postoperatively’. Walking aids were discontinued from 8 to 21 days.

Operative characteristics
Incision length <10 cm in all patients.</td>
<td>Complications
<table>
<tr><th>Outcome</th><th>Rate</th></tr>
<tr><td>Dislocation (reduction under general anaesthesia in 6 patients – treatment unknown in 4)</td><td>1.0% (10/1037)</td></tr>
<tr><td>Recurrent dislocation</td><td>0.3% (3/1037)</td></tr>
<tr><td>Reoperation – insertion of a different acetabular component</td><td>0.1% (1/1037)</td></tr>
<tr><td>Femoral paresis (resolved by 1 year)</td><td>0.2% (2/1037)</td></tr>
<tr><td>Perioperative non-displaced external malleolar fracture</td><td>0.1% (1/1037)</td></tr>
<tr><td>Septic complication (2 patients required revision surgery for loosening of septic origin)</td><td>0.5% (5/1037)</td></tr>
<tr><td>Aseptic loosening</td><td>0.3% (3/1037)</td></tr>
</table>
There was no haematoma requiring revision surgery or ‘considerable’ heterotopic ossification.</td>
<td>Reported in table 2 of overview for ‘single mini-incision hip replacement’ published in 2005

Follow-up issues:
Retrospective study.
45 patients lost to follow-up after first assessment at 3 months (none suffered dislocation in this period).
Patients were followed up at 3 months, 1 year and then annually but overall mean or median follow-up period not reported.

Study design issues:
Initial experience of this procedure at the participating centre.
All procedures undertaken by 2 surgeons.

Study population issues:
15 obese patients requiring incision >10 cm and 8 men with large body frame requiring sectioning of the piriformis muscle were excluded from the series. There were no dislocations in any of these patients.
Other issues:
None.</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Hartzband M A (2007)[8]

Case series
USA
Recruitment period: 2002 onwards
Study population: Patients with osteoarthritis (81%), avascular necrosis (7%), hip dysplasia (7%), other (6%). Mean BMI = 27 kg/cm^2
n = 400

Age: 56 years
Sex: 68% Male

Patient selection criteria: not reported

Technique: Epidural anaesthesia, and prophylactic antibiotics. Under fluoroscopic guidance TWO INCISIONS with no cutting of muscles or tendons, hip not dislocated – in situ cut made in femoral neck, insertion of cementless prosthesis. Patients bear weight as tolerated.

Follow-up: not reported

Conflict of interest/source of funding: not reported</td>
<td>Number of patients analysed: 400 (split into consecutive groups of 100 patients treated)

Hip function
Harris score (0 to 100, higher scores better – based on functional ability, hip dynamics and ROM)
Mean scores improved significantly from 52 points at baseline to 94 points at final follow-up (measurement of significance and length of follow-up not reported).
99.6% (399/400) of patients were able to walk without support.

Quality of life
SF-12 physical function scores improved from 34 points at baseline to 51 points postoperatively (measurement of significance not reported).

Operative characteristics
Mean length of stay was 25 hours (range 6 to 72 hours), and the length of stay decreased with every 100 procedures performed ($p < 0.001$).
Mean incision size was 4.4 cm (range 3.2 to 6.5 cm) for the anterior incision and 2.9 cm (range 2.0 to 6.0 cm for the posterior incision).
Mean operative time was 55 minutes (range 38 to 140), and was significantly longer for the first 100 procedures performed ($p < 0.0001$).</td>
<td>Complications

<table>
<tr><th></th><th>First 100</th><th>Second 100</th><th>Third 100</th><th>Fourth 100</th></tr>
<tr><td>Total</td><td>6% (6/100)</td><td>2% (2/100)</td><td>0% (0/100)</td><td>4% (4/100)</td></tr>
<tr><td>Dislocation</td><td>1% (1/100)</td><td>0% (0/100)</td><td>0% (0/100)</td><td>0% (0/100)</td></tr>
<tr><td>DVT (patient had history of spontaneous DVT)</td><td>1% (1/100)</td><td>0% (0/100)</td><td>0% (0/100)</td><td>0% (0/100)</td></tr>
<tr><td>Fracture</td><td>3% (3/100)</td><td>2% (2/100)</td><td>0% (0/100)</td><td>0% (0/100)</td></tr>
<tr><td>Loosening</td><td>0% (0/100)</td><td>1% (1/100)</td><td>0% (0/100)</td><td>0% (0/100)</td></tr>
<tr><td>Intestinal obstruction</td><td>1% (1/100)</td><td>0% (0/100)</td><td>0% (0/100)</td><td>0% (0/100)</td></tr>
<tr><td>Nerve palsy (persistent)</td><td>1% (1/100)</td><td>0% (0/100)</td><td>0% (0/100)</td><td>0% (0/100)</td></tr>
<tr><td>Haematoma</td><td>0% (0/100)</td><td>0% (0/100)</td><td>0% (0/100)</td><td>1% (1/100)</td></tr>
<tr><td>Subsidence</td><td>0% (0/100)</td><td>0% (0/100)</td><td>0% (0/100)</td><td>1% (1/100)</td></tr>
</table>
Revision surgery was required in 1 of 400 patients for a loose femoral component at 18-month follow-up.

There were no reports of femoral shaft fracture.</td>
<td>Follow-up issues:
Prospective follow-up. Loss to follow-up not reported.

Study design issues:
Outcomes were analysed every 100 cases to evaluate learning curve.
A number of different prosthesis types used within the series, so learning curve may have restarted with new implants.

Study population issues:
Patient selection criteria not reported.

Other issues:
Period of follow-up not reported.</td>
</tr>
</table>

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

Study details	Key efficacy findings	Key safety findings	Comments
Floren M (2006)[9] **Case series** USA Recruitment period: 1988 to 1991 Study population: Patients with osteoarthritis (94.3%), rheumatoid arthritis (5.7%) **n = 70 (90 hips)** Age: 62 years (mean) Sex: 39% Male Patient selection criteria: not reported Technique: Posterior approach, **SINGLE INCISION** insertion of uncemented prostheses. Patients ambulated on first day, follow-up with physical therapy encouraging weight bearing as tolerated. **Follow-up: 11 years (mean)** Conflict of interest/source of funding: none	Number of patients analysed: **70 (90 hips)** **Hip function** Mean Harris hip score was 92.3 points (range 66 to 99). 11 years Excellent 90 to 100: 72.2% (65/90) Good 80 to 90: 20.0% (18/90) Fair 70 to 80: 6.7% (6/90) Poor <70: 1.1% (1/90) Maximum walking distance tolerated was unlimited in 73.3% (66/90) of procedures. **Operative characteristics** Mean length of stay 4.7 (± 2.0) days **Radiographic assessment** Data available for 77.8% (70/90) of hips. 82.9% (58/70) of hips were inserted in a neutral position, 17.1% (12/70) had varus alignment.	**Complications** Outcome / Rate Transfusion: 8% Dislocation: 0% Infection: 0% Absolute figures not reported Revision (due to wear) at mean follow-up of 6.8 years: 8.9% (8/90) Radiographic evidence of subsidence: 0% (0/70) Osteolysis: 11.4% (8/70)	**Follow-up issues**: Consecutive patient accrual. 26.2% of patients had died before minimum 10 year follow-up was reached, none had undergone revision. 2.5% of patients unable to attend follow-up all had prosthesis in place, 5.7% lost to follow-up, and 0.7% excluded from analysis as had complete revision for reason other than loosening. **Study design issues**: All procedures undertaken by the same surgeon. Previous experience not reported. No control group, wear of prosthesis might have been related to prosthesis rather than implantation procedure. Baseline scores for clinical outcomes are not reported or compared to those during follow-up. **Study population issues**: Period since onset of symptoms not reported. Unselected patients. **Other issues**: Discrepancy between study report text and table in terms of distance able to walk outcome.

Abbreviations used: ASA, American Society of Anesthesiologists ; BMI, body mass index; CI, confidence interval; DVT, deep vein thrombosis; RCT, randomised controlled trial; ROM, range of motion; THR, total hip replacement; WMD, weighted mean difference

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>National Joint Registry (2010)[10]

Registry / database (personal communication)

UK

Recruitment period: 2003 to 2010
Study population: Patients with osteoarthritis (90.9%), dysplastic hip (1.5%), avascular necrosis (2.3%). Baseline ASA grade P1 = 28.0%, P2 = 61.0%, P3 = 10.4%, P4 = 0.5%, P5 = > 0.1%. mean BMI 27.07kg/m^2

n = 19,041

Age: 69 years (mean)
Sex: 38% Male

Patient selection criteria: not reported

Technique: not reported

Follow-up: 0.11 to 6.53 years (analysed per year of procedure)

Conflict of interest/source of funding: none</td>
<td>Number of patients analysed: 19,041 minimally invasive procedures from a total of 344,953 procedures.
In 2003, 4.2% (1004/23,705) of primary hip replacements were undertaken with a minimally invasive approach; in 2009 the rate was 4.7% (2924 /61,563).</td>
<td>Complications
Incidence of events for minimally invasive and not minimally invasive procedures (excluding procedures where approach not reported)
<table>
<tr><th>Outcome</th><th>Rate Minimally invasive
n = 19,041</th><th>Rate Not minimally invasive
n = 306,625</th></tr>
<tr><td>Calcar crack</td><td>0.5% (95/19,041)</td><td>0.4% (1185/306,625)</td></tr>
<tr><td>Pelvic penetration</td><td>< 0.1% (10/19,041)</td><td>0.2% (479/306,625)</td></tr>
<tr><td>Shaft fracture</td><td>< 0.1% (10/19,041)</td><td>< 0.1% (192/306,625)</td></tr>
<tr><td>Shaft penetration</td><td>< 0.1% (5/19,041)</td><td>< 0.1% (89/306,625)</td></tr>
<tr><td>Trochanteric fracture</td><td>0.2% (29/19,041)</td><td>0.2% (622/306,625)</td></tr>
<tr><td>Other</td><td>0.2% (40/19,041)</td><td>0.2% (659/306,625)</td></tr>
</table>
</td>
<td>Follow-up issues:
No validation against other episode data to determine coverage of all procedures undertaken in the UK during this period.
Potentially not a consecutive case accrual

Study design issues:
Prospective case submission to registry. Annual analysis.
Study population issues:
Some data are available on patients undergoing minimally invasive surgery. For some patients it is not known whether minimally invasive surgery was performed or not.
All data excluded hip resurfacing procedures, but may not necessarily relate to total hip replacement. There may be subtotal / hemiarthroplasty procedures included too.
All data relates to primary arthroplasty and excludes revisions.
Other issues:
Single mini-incision and 2 mini-incision procedures are not distinguished.
Safety outcomes not defined further</td>
</tr>
</table>

Efficacy

A systematic review of 1205 patients reported that there was no statistically significant difference in the mean change of Harris hip score (scored from 0 to 100, higher scores better – based on functional ability and hip dynamics and ROM) from baseline in patients treated with mini-incision total hip replacement compared with those treated with the standard-incision approach (weighted mean difference [WMD] 3.99; 95% confidence interval [CI] -0.18 to 8.16) (p = 0.06) (length of follow-up not reported)[2]. A case series of 70 patients (90 hips) reported that mean Harris hip score was 92.3 points at a mean follow-up of 11-years (baseline scores not reported)[9]. A case series of 759 patients (1000 hips) reported that the mean Harris hip score improved from 34 points at baseline to 92 points at a mean of 37 months follow-up (measurement of significance not reported)[5]. In the same study, patients were able to resume unrestricted normal daily activities at a mean follow-up of 4.2 weeks following mini-incision total hip replacement.

An RCT of 219 patients reported no difference between mini-incision and standard-incision groups in ability to mobilise on day 1 postoperatively (85% (88/103) vs 91% (96/105, p = 0.54) or to move from supine to sitting, sitting to standing or mobilisation without aid at 2 days postoperatively. The same study reported no difference in type of walking aid used at 2 days between the groups (p = 0.46) and no difference in walking speed at 2 days (p = 0.83) and 6 weeks (p = 0.54)[3].

A case series of 926 patients (1037 hips) reported that walking aids were discontinued at 8 to 21 days following mini-incision total hip replacement[7]. A case series of 400 patients reported that mean quality of life score (measured by SF-12) improved from 34 points at baseline to 51 points following the procedure (measurement of significance and length of follow-up not reported)[8].

The systematic review of 1205 patients reported that mean length of hospital stay was significantly shorter following mini-incision hip replacement than following a standard-incision procedure (WMD -3.59; 95% CI -5.69 to -1.50) (p = 0.0008)[2]. A non randomised comparative study of 201 patients reported that the mean length of hospital stay was significantly shorter following min-incision hip replacement than following a standard-incision procedure (2.2 days vs 3.7 days, p < 0.01)[4].

Safety

The systematic review of 1205 patients reported that the overall rate of complications was not significantly different between patients treated with mini-incision total hip replacement and those undergoing surgery with a standard-incision procedure (OR 1.08; 95% –CI -0.59 to 1.97) (p = 0.81)[2].

A national register of 182,432 procedures reported an increased risk of revision surgery if a mini-incision was used (risk: 5.23, 95% CI: 2.94-9.32)[1]. The rate of

revision surgery following mini-incision total hip replacement was less than 1% (1/400) in the case series of 400 hips at 18-month follow-up[8], 2% (21/1000) of hips in the case series of 759 patients at a mean follow up of 37 months[5] and 9% (8/90) of hips in the case series of 70 patients at a mean follow-up of 11 years[9].

Deep vein thrombosis was reported in 1 patient with a history of spontaneous DVT in the case series of 400 patients (follow-up not reported) this event occurred during the first 100 patients treated at the centre[8]. Deep vein thrombosis or pulmonary embolism was reported in 1% (12/1000) of hips in the case series of 759 patients at 37-month follow-up[5]. The RCT of 219 patients reported no patients with DVT in the mini-incision group and 1 patient with DVT in the standard-incision group at 6-weeks follow-up[3]. The non randomised comparative study of 201 patients reported no patients with DVT in the mini-incision group and 4% (3/75) patients with DVT in the standard-incision group at minimum 2-years follow-up (significance not stated)[4].

The National Joint Registry (personal communication) reported similar rates of complications in patients treated with mini-incision hip replacement and those treated with surgery using a standard incision. The rates of calcar crack were less than 1% (95/19,041 and 1185/306,625 respectively), and the rates of shaft fracture were less than 1% (10/19,041 and 192/306,625 respectively) at follow-up of 0.1 to 6.5 years[10]. The non randomised comparative study of 201 patients reported 2% (2/126) patients with fractures (1 treated with cerlage and 1 with fully porous coated implant) in the mini-incision group and 4% (3/75) patients with fractures (intraoperatove, treated with cerclage) in the standard-incision group at minimum 2-years follow-up[4].

A case series of 759 patients (1000 hips) reported heterotopic ossification in 20% (198/1000) of hips at a mean follow-up of 37-months, but none of these were high grade (grade IV) or required further treatment[5]. The case series of 70 patients (90 hips) reported osteolysis in 11% (8/70) of hips that underwent radiographic assessment at a mean follow up of 11 years[9].

Validity and generalisability of the studies

- Little long-term data have been published. Failure may occur in the long term.
- A number of different outcome measures have been used for assessment of functional mobility, making comparison between studies difficult.
- Patient selection criteria are not generally well reported.
- A variety of different prostheses have been used within and between studies. However similar implants are used for mini-incision and standard techniques.

- The definition of mini-incision varies between studies but it generally indicates 1 or 2 incisions of 10 cm or less.
- In some studies it was hard to distinguish between the number of patients treated and number of hips replaced.

Existing assessments of this procedure

There were no published assessments from other organisations identified at the time of the literature search.

Related NICE guidance

Below is a list of NICE guidance related to this procedure. Appendix B gives details of the recommendations made in each piece of guidance listed.

Interventional procedures

- Single mini-incision hip replacement. NICE interventional procedures guidance 152 (2006). Available from www.nice.org.uk/IPG152
- Minimally invasive two-incision surgery for total hip replacement. NICE interventional procedures guidance 112 (2005). Available from www.nice.org.uk/IPG112

Technology appraisals

- Certolizumab pegol for the treatment of rheumatoid arthritis. NICE technology appraisal 186 (2010). Available from www.nice.org.uk/TA186
- Adalimumab, etanercept and infliximab for the treatment of rheumatoid arthritis. NICE technology appraisal 130 (2007). Available from www.nice.org.uk/TA130
- Rituximab for the treatment of rheumatoid arthritis. NICE technology appraisal 126 (2007) Available from www.nice.org.uk/TA126
- Abatacept for the treatment of rheumatoid arthritis. NICE technology appraisal 141 (2008). Available from www.nice.org.uk/TA141
- Hip disease - metal on metal hip resurfacing. NICE technology appraisal 44 (2002). Available from www.nice.org.uk/TA44

Clinical guidelines

- The care and management of osteoarthritis in adults. NICE clinical guideline 59 (2008). Available from www.nice.org.uk/CG059

Specialist Advisers' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College. The advice received is their individual opinion and does not represent the view of the society.

Mr T McAuliffe (British Orthopeadic Association), Miss S K Muirhead-Allwood (British Orthopeadic Association)

- Single mini incision for THR are commonly less than 10cm but can be extended to up to 14 cm where anatomy dictates.
- Two incision surgery is no longer carried out anywhere in the UK.
- The one Specialist Adviser who commented on the status of the procedure categorised it as established and no longer new.
- Reported adverse events associated with this procedure include malposition of components leading to dislocation, and femoral fracture.
- Other theoretical adverse events may include neurovascular damage due to poor operative view.
- The key efficacy outcomes for this procedure include length of stay, blood loss, requirement for analgesics, and long-term functional result.
- If found to be safe and efficacious, the procedure is likely to be made available at most or all district general hospitals.

Patient Commentators' opinions

- The NICE Patient and Public involvement Programme was unable to provide patient commentary for this procedure.

Issues for consideration by IPAC

- This overview includes data on both single mini-incision and 2-incision hip arthroplasty. The incision type has been highlighted in table 2. This overview will form the basis of a review of 2 existing pieces of NICE IP guidance: 'Minimally invasive two-incision surgery for total hip replacement' (special arrangements) and 'Single mini-incision surgery for total hip replacement' (normal arrangements). See Appendix B for details.
- Data have not been selected on the basis of underlying aetiology (all have been included). However studies in revision arthroplasty have not been included.
- Data on hip replacement have been made available from the UK National Joint Registry, some of which is specific to patients undergoing a 'minimally invasive' procedure. This is summarised in table 2 above. However this registry is unable to distinguish between single- or 2-incision procedures.
- No specific equalities issues were highlighted with regard to this procedure at scoping stage.
- A considerable number of studies are included in Appendix A.

References

1. Kärrholm J, Garellick G, Rogmark C et al. (2008) Swedish Hip Arthroplasty Register: Annual Report 2007. Department of Ortopaedics, Sahlgrenska University Hospital 1-138.

2. Cheng T, Feng JG, Liu T et al. (2009) Minimally invasive total hip arthroplasty: a systematic review. [Review] [52 refs]. International Orthopaedics 33:1473-1481.

3. Lawlor M, Humphreys P, Morrow E et al. (2005) Comparison of early postoperative functional levels following total hip replacement using minimally invasive versus standard incisions. A prospective randomized blinded trial. Clinical Rehabilitation 19:465-474.

4. Levine MJ, West K, Michelson J et al. (2007) Retrospective Comparison of Two-Incision Total Hip Arthroplasty with a Standard Direct Lateral Approach: A Single Surgeon's Experience. Seminars in Arthroplasty 18:268-271.

5. Swanson TV. (2005) Early results of 1000 consecutive, posterior, single-incision minimally invasive surgery total hip arthroplasties. Journal of Arthroplasty 20: Suppl-32.

6. Kennon RE, Keggi JM, and Keggi KJ. (2004) The anterior approach to hip arthroplasty: The short, single minimally invasive incision. Operative Techniques in Orthopaedics 14:85-93.

7. Siguier T, Siguier M, and Brumpt B. (2004) Mini-incision anterior approach does not increase dislocation rate: a study of 1037 total hip replacements. Clinical Orthopaedics & Related Research 164-173.

8. Hartzband MA and Klein GR. (2007) Two-Incision Total Hip Arthroplasty: The Hackensack Experience. Seminars in Arthroplasty 18:251-256.

9. Floren M and Lester DK. (2006) Durability of implant fixation after less-invasive total hip arthroplasty. Journal of Arthroplasty 21:783-790.

10. National Joint Register. (2010) Personal communication Calire Newell.

Appendix A: Additional papers on minimally invasive total hip replacement

The following table outlines the studies that are considered potentially relevant to the overview but were not included in the main data extraction table (table 2). It is by no means an exhaustive list of potentially relevant studies.

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Archibeck, M. J. and White, R. E., Jr. (2004) Learning curve for the two-incision total hip replacement. Clinical Orthopaedics & Related Research (429) 232–238.	Case series n = 851 Follow-up = not reported	Complication rates and the demonstrated learning curve may be altered by changes in training and surgical techniques	Studies with longer follow-up included in table 2
Asayama I, Kinsey TL, Mahoney OM. (2006) Two-year experience using a limited-incision direct lateral approach in total hip arthroplasty. The Journal of arthroplasty 21:1083–91.	Non randomised comparative study n = 138 (77 mini) Follow-up = 2 years minimum	We did not observe evidence that minimally invasive surgical technique provided clinically significant benefit to these patients	Larger studies included in table 2
Bal B S, Haltom D, Aleto T, and Barrett M (2005) Early complications of primary total hip replacement performed with a two-incision minimally invasive technique. Journal of Bone & Joint Surgery - American Volume 87 (11) 2432–2438.	Non randomised comparative study n = 185 (89 mini) Follow-up = not reported	While the rate diminished with increasing experience, total hip replacement with use of 2 incisions and fluoroscopic guidance is a technically demanding procedure that may be associated, especially initially, with higher rates of complications and repeat surgery	Larger studies included in table 2
Bal, B. S. and Vallurupalli, S (2008) A modified two-incision technique for primary total hip arthroplasty. Indian Journal of Orthopaedics 42 (3) 267–274.	Case series n = 102 FU= not reported	Provided that the surgeon has received appropriate training, primary total hip arthroplasty can be performed safely with the modified two-incision technique	Larger studies included in table 2
Bennett D, Ogonda L, Elliott D et al (2006) Comparison of gait kinematics in patients receiving minimally invasive and traditional hip replacement surgery: a prospective blinded study. Gait & Posture 23 (3) 374–382.	RCT n = 95 (43 mini) Follow-up = 2 days	Contrary to previous studies, there was no improvement in early post-operative gait for those patients who received THR using the minimally invasive technique	Larger studies included in table 2
Berger RA, Jacobs JJ, Meneghini RM, (2004) Rapid rehabilitation and recovery with minimally invasive total hip arthroplasty Clinical orthopaedics and related research 429:239–47.	Case series n = 100 Follow-up = 3 months	A rapid rehabilitation protocol is safe and fulfills the potential benefits of a rapid recovery with minimally invasive total hip arthroplasty.	Larger studies included in table 2 Reported in appendix A of overview for 'single mini-incision hip replacement' published in 2005

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Berger R A, Duwelius P J (2004) The two-incision minimally invasive total hip arthroplasty: technique and results. Orthopedic Clinics of North America 35 (2) 163–172.	Case series n = 100 Follow-up = 3 months	This technique is technically challenging, however; as such, proper training, including cadaveric training, is essential to minimise complications and ensure success	Larger studies included in table 2 Probably the same patients as Berger (2004)
Berger RA (2006) Minimally Invasive Total Hip Arthroplasty With Two Incisions. Operative Techniques in Orthopaedics 16 (2) 102–111.	Case series n = 200 Follow-up = not reported	While this minimally invasive 2-incision technique shows great promise, this technique requires meticulous surgical technique, specialised instrumentation, and special instruction	Larger studies included in table 2
Bombelli, M. and Memminger, M. (2005) Single-incision minimally invasive anterior approach in total hip arthroplasty: Surgical technique and literature review. Journal of Orthopaedics and Traumatology 6 (3) 117–125.	Case series n = 49 Follow-up = not reported	This article describes the surgical technique that we adopted in 2003 and compares it to other minimally invasive surgical techniques	Larger studies included in table 2
Bottner F and Sculco TP (2006) Mini-incision total hip arthroplasty: The posterior approach. Seminars in Arthroplasty 16 (3) 172–178.	Non randomised comparative study n = 84 (42 mini) Follow-up = 5 years	A shorter incision might offer few clinical benefits besides a more attractive scar	Larger studies included in table 2
Chen D W, Hu CC, Chang YH, et al (2009) Comparison of clinical outcome in primary total hip arthroplasty by conventional anterolateral transgluteal or 2-incision approach. Journal of Arthroplasty 24 (4) 528–532.	Non randomised comparative study n = 166 (83 mini) Follow-up = 6 months	The current study indicates that the benefit of minimally invasive surgery 2 technique was only short-term with quicker functional recovery and shorter duration use of non-steroid anti-inflammatory drugs postoperatively	Larger studies included in table 2
Chung WK, Liu D, Foo LS (2004) Mini-incision total hip replacement--surgical technique and early results. Journal of Orthopaedic Surgery 12 (1) 19–24.	Case series n = 60 Follow-up = 14 months	Uncemented total hip replacement can be effectively performed through a smaller incision utilising minimally invasive THR without increased risk of complications	Larger studies included in table 2 Reported in Table 2 of overview for 'single mini-incision hip replacement' published in 2005
Cohen RG (2007) Early Outcomes of Total Hip Replacements with the Minimally Invasive Two-Incision Technique. Seminars in Arthroplasty 18 (4) 257–	Case series n = 65 Follow-up = 1	The 2-incision THR is a safe and extremely beneficial arthroplasty technique for many patients	Larger studies included in table 2

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
261.	years minimum		
D'Arrigo, C., Speranza, A., Monaco, E. (2009) Learning curve in tissue sparing total hip replacement: Comparison between different approaches. Journal of Orthopaedics and Traumatology 10 (1) 47–54.	Randomised comparative study n = 60 (20 mini) Follow-up = not reported	The antero-lateral tissue sparing surgery approach seems to be safer and less demanding than standard THR surgery, and is suitable for use with different stems	Larger studies included in table 2
Desser, D. R., Mitrick, M. F., Ulrich, S. D et al (2010) Total hip arthroplasty: comparison of two-incision and standard techniques at an AOA-accredited community hospital. Journal of the American Osteopathic Association 110 (1) 12–15.	RCT n = 58 (28 mini) FU= not reported	Patients who receive the two-incision THA should be selected carefully and advised about the potential for increased complications	Larger studies included in table 2
DiGioia AM, III, Plakseychuk AY, Levison TJ et al (2003) Mini-incision technique for total hip arthroplasty with navigation. Journal of Arthroplasty 18 (2) 123–128.	Non randomised comparative study n = 66 (33 mini) Follow-1 year	There was no significant difference between groups for pain, function, or range of motion at the 1-year follow-up examination	Larger studies included in table 2
Diwanji SR, Park KS, Yoon TR et al (2009) Bilateral simultaneous two-incision minimally invasive total hip arthroplasty. Journal of Orthopaedic Science 14 (5) 517–524.	Case series n = 62 Follow-up = 41 months	Bilateral simultaneous minimally invasive total hip arthroplasty using a modified 2-incision technique gave satisfactory clinical, radiological, and functional results	Larger studies included in table 2
Duwelius PJ, Burkhart RL, Hayhurst JO et al (2007) Comparison of the 2-incision and mini-incision posterior total hip arthroplasty technique: a retrospective match-pair controlled study. Journal of Arthroplasty 22 (1) 48–56	Non randomised comparative study n = 86 (43 mini) Follow-up = not reported	Complications did not differ between surgical techniques. No patients were revised. The 2-incision operation was better for function and length of stay, and the posterior mini-incision was easier to perform, although these groups used different selection criteria	Larger studies included in table 2
Ebert FR, Gay DP, Dunnavan L J (2007) The two incision total hip arthoplasty : technique and results. Seminars in arthroplasty 18: 240 – 245.	Case series n = 265 Follow-up =not reported	Two-incision total hip arthroplasty can be a safe alternative to more invasive hip replacement surgery	Larger studies included in table 2
Feinblatt JS, Berend KR, Lombardi AV, Jr. (2005) Severe symptomatic heterotopic ossification and dislocation: a complication	Case report n = 1	This case report profiles a patient who required removal of Brooker stage III heterotopic ossification after a 2-incision minimally invasive total hip	Larger studies included in table 2 Safety outcome

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
after two-incision minimally invasive total hip arthroplasty. Journal of Arthroplasty 20 (6) 802–806.	Follow-up = 18 months	arthroplasty	reported elsewhere
Han KY, Garino JP, Rhyu KH (2009) Gains and losses of small incision lateral total hip arthroplasty: what the patients want and its index case result. Archives of Orthopaedic & Trauma Surgery 129 (5) 635–640.	Non randomised comparative study n = 37 (18 mini) Follow-up = 2 years	The use of a small incision in total hip arthroplasty resulted in subtle and temporary gains, at the cost of several major early complications	Larger studies included in table 2
Hananouchi T, Takao M, Nishii T et al (2009) Comparison of navigation accuracy in THA between the mini-anterior and -posterior approaches. The International Journal Of Medical Robotics + Computer Assisted Surgery: MRCAS 5 (1) 20–25.	Non randomised comparative study n = 40 (20 mini) Follow-up = 1 year	This procedure provides navigation accuracy without significant differences between the two approaches and with favourable alignment of the cup	Larger studies included in table 2 Comparison of two mini incision techniques
Hartzband MA (2004) Posterolateral minimal incision for total hip replacement: technique and early results. Orthopedic Clinics of North America 35 (2) 119–129.	Case series n = 98 Follow-up = 2 years	The author's perception is that the advantages of minimally invasive posterolateral approach total hip arthroplasty are multiple	Larger studies included in table 2 Reported in appendix A of overview for 'single mini-incision hip replacement' published in 2005
Higuchi F, Gotoh M, Yamaguchi N et al (2003) Minimally invasive uncemented total hip arthroplasty through an anterolateral approach with a shorter skin incision. Journal of Orthopaedic Science 8 (6) 812–817.	Non randomised comparative study n = 212 (115 mini) Follow-up = to discharge	We concluded that total hip arthroplasty through a mini- or short incision was indeed efficient for patients compared with total hip arthroplasty using a conventional incision	Larger studies included in table 2 Studies with longer follow up included in table 2 Reported in appendix A of overview for 'single mini-incision hip replacement' published in 2005
Howell JR, Masri BA, Duncan, C (2004) Minimally invasive	Non randomised comparative study	Further study is required to clarify the benefits conferred by	Larger studies included in table

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
versus standard incision anterolateral hip replacement: a comparative study. Orthopedic Clinics of North America 35 (2) 153–162.	n = 102 (46 mini) Follow-up = to discharge	a minimal-incision anterolateral approach	2 Reported in Table 2 of overview for 'single mini-incision hip replacement' published in 2005
Hozack W and Klatt BA (2008) Minimally Invasive Two-Incision Total Hip Arthroplasty: Is the Second Incision Necessary? Seminars in Arthroplasty 19 (2) 205–208.	Non randomised comparative study n = 79 (36 two-incision) Follow-up = 6 months	Minimally invasive total hip arthroplasty can be performed safely with excellent results using the direct anterior incision alone	Larger studies included in table 2
Hu CC, Yang WE, Chang YH et al. (2008) Fluoroscopy cannot recognize intraoperative fracture in patients receiving 2-incision total hip arthroplasty. Journal of Arthroplasty 23:1031–1036.	Non randomised comparative study n = 36 Follow-up = min 2 years	2 femoral neck fractures in the fluoroscopy group and could not be detected by fluoscopy	Larger studies included in table 2
Inaba, Y., Dorr, L. D., Wan, Z., (2005) Operative and patient care techniques for posterior mini-incision total hip arthroplasty. Clinical Orthopaedics & Related Research 441 104–114.	Non-randomised comparative study n = 200 Follow-up = 3 months	The posterior mini-incision operation has shown improved results with experience and changes in technique and patient care treatment	Larger studies included in table 2
Iorio, R., Specht, L. M., Healy, W. L (2006) The effect of EPSTR and minimal incision surgery on dislocation after THA. Clinical Orthopaedics & Related Research 447 39–42	Non randomised comparative study n = 390 (120 mini) Follow-up = not reported	A 10 cm mini-incision posterior approach with enhanced posterior soft tissue repairs maintained the low dislocation rate. Revision rate for dislocation was equivalent between the 3 groups	Studies with longer follow up included in table 2
Irving JF (2004) Direct two-incision total hip replacement without fluoroscopy. Orthopedic Clinics of North America 35 (2) 173–181.	Case series n = 167 Follow-up = 6 weeks to 2 years	This procedure allows flexibility of implant choices and patient selection and the opportunity for rapid rehabilitation.	Larger studies included in table 2 Reported in Table 2 of overview for 'minimally invasive two-incision surgery for total hip replacement';

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
			published in 2005
Krych AJ, Pagnano MW, Wood KC et al (2010) No benefit of the two-incision THA over mini-posterior THA: a pilot study of strength and gait. Clinical Orthopaedics & Related Research 468 (2) 565–570.	RCT n = 21 Follow-up = 6 weeks	We found no evidence that patients who had two-incision THR had less muscle damage, less antalgic gait, or better gait kinematics than patients who had mini-posterior THR	Larger studies included in table 2 Comparison of two mini incision techniques
Laffosse JM, Chiron P, Accadbled F (2006) Learning curve for a modified Watson-Jones minimally invasive approach in primary total hip replacement: Analysis of complications and early results versus the standard-incision posterior approach. Acta Orthopaedica Belgica 72 (6) 693–701.	Non randomised comparative study n = 100 (42 mini) Follow-up = not reported	During the initial period of the learning curve, it would be preferable to select patients with an appropriate morphology	Larger studies included in table 2
Lee, M. S., Kuo, C.-H., Senan, V et al (2006) Two-incision total hip replacement: Intra-operative fluoroscopy versus imageless navigation for cup placement. HIP International 16 (SUPPL. 4) S35–S41.	Non randomised comparative study n = 29 Follow-up = 1 year minimum	This study demonstrated that the role of intraoperative fluoroscopy could safely be replaced by an imageless navigation system for this procedure	Larger studies included in table 2
Lin DH, Jan MH, Liu TK et al (2007) Effects of anterolateral minimally invasive surgery in total hip arthroplasty on hip muscle strength, walking speed, and functional score. Journal of Arthroplasty 22 (8) 1187–1192.	Non randomised comparative study n = 106 (53 mini) Follow-up = 1 year	Although the mini-incision technique is more difficult than the conventional technique, its use by experienced surgeons can produce quicker short-term recovery	Larger studies included in table 2
Matta, J. M., Shahrdar, C., and Ferguson, T. (2005) Single-incision anterior approach for total hip arthroplasty on an orthopaedic table. Clinical Orthopaedics & Related Research 441 115–124.	Case series n = 437 Follow-up = to discharge	This technique allows accurate and reproducible component positioning and leg-length restoration and does not increase the rate of hip dislocation	Studies with longer follow up are included in table 2

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Mayr, E., Nogler, M., Benedetti, M. G et al (2009) A prospective randomized assessment of earlier functional recovery in THA patients treated by minimally invasive direct anterior approach: a gait analysis study. Clinical biomechanics (Bristol, Avon) 24 (10) 812–818.	RCT n = 33 (16 mini) FU= not reported	The majority of improvements occurred between the 6- and 12-week follow-ups	Larger studies included in table 2
McGrory, B. J., Finch, M. E., Furlong, P. J. (2008) Incision length correlates with patient weight, height, and gender when using a minimal-incision technique in total hip arthroplasty. Journal of Surgical Orthopaedic Advances 17 (2) 77–81.	Case series n = 115 Follow-up = not reported	Selecting appropriate incision length for minimally invasive THA reduces potential associated complications	Larger studies included in table 2
Meneghini RM, Smits SA (2009) Early discharge and recovery with three minimally invasive total hip arthroplasty approaches: a preliminary study. Clinical Orthopaedics & Related Research 467 (6) 1431–1437.	RCT n = 24 Follow-up = 14 months	We found no difference between the three minimally invasive approaches in early hospital discharge or early functional recovery utilizing a rapid rehabilitation protocol	Larger studies included in table 2 Comparison of three mini incision techniques
Meneghini RM, Smits SA, Swinford RR et al (2008) A randomized, prospective study of 3 minimally invasive surgical approaches in total hip arthroplasty: comprehensive gait analysis. Journal of Arthroplasty 23 (6:Suppl 1) Suppl-73.	RCT n = 24 (18 two incision) Follow-up = 6 weeks	These results fail to demonstrate any significant advantage of the 2-incision approach over the posterior approach in kinetic gait parameters.	Larger studies included in table 2 Comparison of three mini incision techniques Probably the same patients as Meneghini (2009)
Mow, C. S., Woolson, S. T., Ngarmukos, S. G., (2005) Comparison of scars from total hip replacements done with a standard or a mini-incision. Clinical Orthopaedics & Related Research 441 80–85.	Non randomised comparative study n = 34 (20 mini) Follow-up = not reported	The cosmesis of mini-incision total hip replacement scars may be inferior to standard-incision scars because of skin and soft tissue damage produced by high retractor pressures needed for exposure using a limited skin incision	Larger studies included in table 2
Nakamura S, Matsuda K, Arai N et al (2004) Mini-incision posterior approach for total hip arthroplasty. International Orthopaedics 28 (4) 214–217.	Non randomised comparative study n = 92 (50 mini)	With the mini-incision posterior approach, surgical invasion was reduced, and short-term outcome was as good as with a conventional posterior approach	Larger studies included in table 2 Reported in appendix A of overview for

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
	Follow-up =6 months		'single mini-incision hip replacement' published in 2005
O'Brien, D. A. and Rorabeck, C. H. (2005) The mini-incision direct lateral approach in primary total hip arthroplasty. Clinical Orthopaedics & Related Research 441 99–103.	Non randomised comparative study n = 87 (34 mini) Follow-up = to discharge	We conclude that it is safe to continue further study with this approach because as there was no increase in complications or component malpositioning	Larger studies included in table 2
Otto TJ, Otto RJ, Israel H, (2007) Early Results of Two-Incision Total Hip Arthroplasty: Experience with 250 Consecutive Cases at Saint Louis University. Seminars in Arthroplasty 18 (4) 233–239.	Case series n = 234 Follow-up = not reported	Mini-incision 2-incision THR remains a challenging technical alteration from traditional total hip operative methods	Larger studies included in table 2
Pagnano MW, Leone J, Lewallen DG et al (2005) Two-incision THA had modest outcomes and some substantial complications. Clinical Orthopaedics & Related Research 441 86–90.	Non randomised comparative study n = 200 (80 two incision) Follow-up = not reported	Patient and surgeon enthusiasm for the potential benefits of the 2-incision total hip arthroplasty should be tempered by the modest early outcomes and the substantial prevalence of complications found in this group of typical patients having total hip arthroplasty	Larger studies included in table 2
Pagnano MW, Trousdale RT, Meneghini RM et al (2008) Slower recovery after two-incision than mini-posterior-incision total hip arthroplasty. A randomized clinical trial. Journal of Bone & Joint Surgery - American Volume 90 (5) 1000–1006.	RCT n = 72 (36 two incision) Follow-up = 1 year	Our hypothesis that the 2-incision technique for total hip arthroplasty would substantially improve the short-term recovery after total hip arthroplasty compared with the mini-posterior incision technique was not proved	Larger studies included in table 2 Comparison of two mini incision techniques
Palutsis, R. S., Sheridan, K. C., and Wasielewski, R. C. (2010) One surgeon's experience with the 2-incision technique for total hip arthroplasty. Journal of Arthroplasty 25 (1) 71–75.	Case series n = 200 FU= 12 weeks	This study shows that the 2-incision technique can be performed with a low risk of major complications, and patients can expect reduced tissue trauma and faster rehabilitation.	Studies with longer follow up are included in table 2
Peck CN, Foster A, McLauchlan GJ (2006) Reducing incision length or intensifying rehabilitation: what makes the difference to length of stay in total hip replacement in a UK setting? International Orthopaedics 30 (5) 395–398	Non randomised comparative study n = 96 (51 mini) Follow-up = 17 months	This study suggests that in a standard UK setting, intensive physiotherapy can significantly decrease inpatient stay, but reducing the incision length does not	Larger studies included in table 2

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Pospischill, M., Kranzl, A., Attwenger, B. et al (2010) Minimally invasive compared with traditional transgluteal approach for total hip arthroplasty: a comparative gait analysis. The Journal of bone and joint surgery.American volume 92 (2) 328–337.	RCT n = 40 (20 mini) FU= 12 weeks	the present study showed no significant benefit for patients who underwent a total hip arthroplasty through a minimally invasive Watson-Jones approach in comparison with those who were managed with a standard transgluteal approach	Larger studies included in table 2
Pour, A. E., Parvizi, J., Sharkey, P. F (2007) Minimally invasive hip arthroplasty: what role does patient preconditioning play? Journal of Bone & Joint Surgery - American Volume 89 (9) 1920–1927.	RCT n = 94 (44 mini incision) Follow-up = not reported	The aforementioned factors, and not the surgical technique per se, may play a major role in imparting the better outcome after minimally invasive total hip arthroplasty that has been reported by various investigators	Larger studies included in table 2 Study compares effects of rehabilitation protocol
Procyk S (2007) Initial results with a mini-posterior approach for total hip arthroplasty. International Orthopaedics 31 Suppl-20.	Case series n = 60 Follow-up = not reported	Preliminary results from 60 patients operated on using this approach indicate rapid functional recovery, minimal postoperative pain, a reduced duration of hospitalisation, few complications and optimal component positioning	Larger studies included in table 2
Roy, L., Laflamme, G. Y., Carrier, M., et al (2010) A randomised clinical trial comparing minimally invasive surgery to conventional approach for endoprosthesis in elderly patients with hip fractures. Injury 41 (4) 365–369.	RCT n = 56 (25 mini FU= 2 years	Based on the results of the present study, we cannot recommend the use of a minimally invasive approach over a standard approach in the implantation of a cemented endoprosthesis	Larger studies included in table 2
Sherry E, Egan M, Warnke PH et al (2003) Minimal invasive surgery for hip replacement: a new technique using the NILNAV hip system. ANZ Journal of Surgery 73 (3) 157–161.	Case series n = 14 Follow-up = 2 months	This new minimal-access total hip replacement technique was successfully performed on 7 patients. There are several advantages of using this system compared with the more traditional techniques	Larger studies included in table 2 Reported in appendix A of overview for 'single mini-incision hip replacement' published in 2005
Shitama, T., Kiyama, T., Naito, M., et al (2009) Which is more invasive-mini versus standard incisions in total hip arthroplasty? International Orthopaedics 33 (6) 1543–1547.	RCT n = 62 (? Mini) FU= 6 months	A 5.0 cm difference in the skin incision to the hip joint seemed to have no influence on the degree of surgical invasion during THA	Larger studies included in table 2
Shinar AA, Calendine C, Hamilton A (2008) Improved Accuracy and Low Fracture and Dislocation Rate with the	Non randomised comparative study	No hip dislocated, and no early infections or femoral or sciatic nerve palsies occurred	Larger studies included in table 2

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Two-Incision Total Hip Replacement Technique. Seminars in Arthroplasty 19 (2) 194–197.	n = 70 (35 two incision) Follow-up = not reported		
Sugano N, Takao M, Sakai T (2009) Comparison of mini-incision total hip arthroplasty through an anterior approach and a posterior approach using navigation. Orthopedic Clinics of North America 40 (3) 365–370.	Non randomised comparative study n = 72 Follow-up = 2 years	The intraoperative joint stability measurements showed no large difference between the 2 groups when malpositioning of the cup was eliminated	Larger studies included in table 2 Comparison of two mini incision techniques
Suzuki K, Kawachi S, Sakai H et al (2004) Mini-incision total hip arthroplasty: a quantitative assessment of laboratory data and clinical outcomes. Journal of Orthopaedic Science 9 (6) 571–575.	Non randomised comparative study n = 94 (36 mini) Follow-up = to discharge	The mini-incision total hip arthroplasty was considered to be less invasive	Larger studies included in table 2 Reported in appendix A of overview for 'single mini-incision hip replacement' published in 2005
Swank, M. L. and Alkire, M. R. (2009) Minimally invasive hip resurfacing compared to minimally invasive total hip arthroplasty. Bulletin of the NYU Hospital for Joint Diseases 67 (2) 113–115.	Non randomised comparative study n = 234 (106 mini) Follow-up = 2 years	Rare incidence of complications, marked decreased pain scores and marked elevation in function were results found in this sample of Birmingham resurfacing	Larger studies included in table 2
Szendroi M, Sztrinkai G, Vass R et al (2006) The impact of minimally invasive total hip arthroplasty on the standard procedure. International Orthopaedics 30 (3) 167–171.	Non randomised comparative study n = 102 (38 mini) Follow-up = not reported	Because of the understandable demand of the patients for a less invasive intervention, the surgeon should use a smaller incisions but not necessarily mini-incisions with minimal soft tissue trauma that still allows him to perform the procedure well, without compromising the type of implants and the otherwise excellent long-term results	Larger studies included in table 2
Tanavalee A, Jaruwannapong S, Yuktanandana P et al (2006) Early outcomes following minimally invasive total hip arthroplasty using a two-incision approach versus a mini-posterior approach. HIP International 16 (SUPPL. 4) S17–S22.	Non randomised comparative study n = 70 (35 two incision) Follow-up = 20 months	Surgeons have to weigh the advantages and disadvantages of this technique including, increased operative time, blood loss and their familiarity with similar standard incisions and landmarks	Larger studies included in table 2
Waldman BJ (2002) Minimally invasive total hip replacement and perioperative	Case series	This article presents the author's early experience and preliminary outcomes with this	Larger studies included in table 2

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
management: early experience. Journal of the Southern Orthopaedic Association ;11(4):213-7.	n = 32 Follow-up = to discharge	new and potentially useful approach to total hip replacement.	Reported in appendix A of overview for 'single mini-incision hip replacement' published in 2005
Functional recovery of muscles after minimally invasive total hip arthroplasty. Ward, S. R., Jones, R. E., Long, W. T., Thomas, D. J., and Dorr, L. D. Instructional Course Lectures 57 249–254.	Case series n = 69 Follow-up = 3 months	This finding suggests that the amount of muscle, or the particular muscle cut, does not have a significant effect on the recovery of postoperative gait function	Larger studies included in table 2
Weeden SH and Schmidt R (2007) Early Results of Minimally Invasive Two-Incision Total Hip Arthroplasty: A Review at 24-Month Follow-Up. Seminars in Arthroplasty 18 (4) 246–250.	Case series n = 125 Follow-up = 2 years	Results suggest that 2-incision minimally invasive-total hip arthroplasty may permit earlier function than standard total hip arthroplasty and can be performed with an acceptable complication rate when done on select clients by specially trained hip specialists	Larger studies included in table 2
Weil Y, Mattan Y, Kandel L et al (2006) Navigation-assisted minimally invasive two-incision total hip arthoplasty. Orthopedics 29 (3) 200–206.	Case series n = 10 Follow-up = to discharge	Fluoroscopy-based navigation can increase accuracy in 2-incision minimally invasive total hip arthroplasty, a novel technique developed for promoting fast recovery	Larger studies included in table 2
Wenz JF, Gurkan I, Jibodh SR (2002) Mini-incision total hip arthroplasty: a comparative assessment of perioperative outcomes. Orthopedics 25 (10) 1031–1043.	Non randomised comparative study n = 173 (111 mini) Follow-up = 2 weeks	This procedure achieved accurate and reproducible implantation, regardless of patient habitus	Larger studies included in table 2 Reported in appendix A of overview for 'single mini-incision hip replacement' published in 2005
Williams SL, Bachison C, Michelson JD et al (2008) Component position in 2-incision minimally invasive total hip arthroplasty compared to standard total hip arthroplasty. Journal of Arthroplasty 23 (2) 197–202.	Non randomised comparative study n = 95 (67 two incision) Follow-up = 2 years	Radiographic assessment of component position of total hip arthroplasty in 2-incision minimally invasive vs a standard direct lateral approach reveals no significant differences. Components are placed in acceptable positions with both techniques	Larger studies included in table 2
Wong TC, Chan B, Lam D (2007) Minimally invasive total hip arthroplasty in a Chinese	Non randomised comparative study	Anterolateral mini-incision technique for primary THR is a safe method without significant	Larger studies included in table 2

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
population. Orthopedics 30 (6) 483–486.	n = 48 (24 mini) Follow-up = to discharge	complications	
Woolson ST, Mow CS, Syquia JF et al (2004) Comparison of primary total hip replacements performed with a standard incision or a mini-incision. Journal of Bone & Joint Surgery - American Volume 86-A (7) 1353–1358.	Non randomised comparative study n = 153 (50 mini) Follow-up = to discharge	There was no evidence that the mini-incision technique resulted in less bleeding or less trauma to the soft tissues of the hip, factors that would have produced a quicker recovery and a shorter hospital stay, than did the standard technique	Larger studies included in table 2 Reported in Table 2 of overview for 'single mini-incision hip replacement' published in 2005
Wright JM, Crockett HC, Delgado S et al (2004) Mini-incision for total hip arthroplasty: a prospective, controlled investigation with 5-year follow-up evaluation. Journal of Arthroplasty 19 (5) 538–545.	Non randomised comparative study n = 84 (42 mini) Follow-up = 5 years	Total hip arthroplasty can be performed safely and effectively through an abridged surgical incision, but this investigation confirms no dramatic clinical benefit other than cosmetic appeal	Larger studies included in table 2 Reported in Table 2 of overview for 'single mini-incision hip replacement' published in 2005
Yoon, T. R., Abbas, A. A., Lee, K. B., (2009) Modified two-incision minimally invasive total hip replacement for ankylosed hips. Journal of Orthopaedic Science 14 (1) 107–113.	Case report n = 5 Follow-up = 2 years maximum	Conversion THR from hip ankylosis is technically difficult.	Larger studies included in table 2
Yoon, T. R., Park, K. S., Song, E. K (2009) New two-incision minimally invasive total hip arthroplasty: comparison with the one-incision method. Journal of Orthopaedic Science 14 (2) 155–160.	Non randomised comparative study n = 113 Follow-up = not reported	The findings of this study show that our new two-incision MIS-THR is an excellent surgical modality that allows early rehabilitation	Larger studies included in table 2
Yoon, T. R., Bae, B. H., and Choi, M. S et al (2006) A modified two-incision minimally invasive total hip arthroplasty: technique and short-term results. HIP International 16 Suppl-34.	Case series n = 425 FU= not reported	A modified two-incision THA was found to be an excellent surgical modality, which allows early rehabilitation and does not increase complications when compared to other MIS two-incision THA techniques	Larger studies included in table 2
Zhang XL, Wang Q, Shen H et al (2007) Minimally invasive two-incision total hip arthroplasty: a short-term retrospective report of 27 cases. Chinese Medical Journal 120 (13) 1131–1135.	Case series n = 27 Follow-up = 18 months	Two-incision total hip arthroplasty has the advantage of being muscle sparing and minimally invasive with less blood loss and rapid recovery. However, this technique is time consuming, technically demanding, and requires fluoroscopy	Larger studies included in table 2

Appendix B: Related NICE guidance for minimally invasive total hip replacement

Guidance	Recommendations
Interventional procedures	**Single mini-incision hip replacement. NICE interventional procedures guidance 152 (2006) CURRENT GUIDANCE** 1.1 Current evidence on the safety and efficacy of single mini-incision hip replacement appears adequate to support the use of this procedure, provided that the normal arrangements are in place for consent, audit and clinical governance. 1.2 The benefits of a single mini-incision may include less tissue trauma, less blood loss and less pain, but the procedure should only be used in appropriately selected patients by clinicians with adequate training in this technique. The British Hip Society has been asked to produce standards for training. 1.3 Clinicians should submit data on all patients treated using this procedure to the National Joint Registry (www.njrcentre.org.uk). **Minimally invasive two-incision surgery for total hip replacement. NICE interventional procedures guidance 112 (2005) CURRENT GUIDANCE** 1.1 Current evidence on the safety and efficacy of minimally invasive two-incision surgery for total hip replacement does not appear adequate for this procedure to be used without special arrangements for consent and for audit or research. More evidence is required on the long-term safety and efficacy of this procedure and clinicians should submit data to the National Joint Registry (www.njrcentre.org.uk). 1.2 Clinicians wishing to undertake minimally invasive two-incision surgery for total hip replacement should take the following actions. • Inform the clinical governance leads in their Trusts. • Ensure that patients understand the uncertainty about the procedure's safety and efficacy and provide them with clear written information. Use of the Institute's *Information for the public* is recommended. 1.3 Clinicians should have adequate training before performing this procedure. The British Hip Society has agreed to produce standards for training. 1.4 Further research will be useful. Clinicians are encouraged to enter patients into well-designed randomised controlled trials and to collect longer-term follow-up data. The Institute may review the procedure upon publication of further evidence.

Technology appraisals	**Abatacept for the treatment of rheumatoid arthritis NICE technology appraisal 141 (2008)** 1.1 Abatacept is not recommended (within its marketing authorisation) for the treatment of people with rheumatoid arthritis. 1.2 Patients currently receiving abatacept for the treatment of rheumatoid arthritis should have the option to continue therapy until they and their clinicians consider it appropriate to stop. **Rituximab for the treatment of rheumatoid arthritis NICE technology appraisal 126 (2007)** 1.1 Rituximab in combination with methotrexate is recommended as an option for the treatment of adults with severe active rheumatoid arthritis who have had an inadequate response to or intolerance of other disease-modifying anti-rheumatic drugs (DMARDs), including treatment with at least one tumour necrosis factor-α (TNF-α) inhibitor therapy. 1.2 Treatment with rituximab plus methotrexate should be continued only if there is an adequate response following initiation of therapy. An adequate response is defined as an improvement in disease activity score (DAS28) of 1.2 points or more. Repeat courses of treatment with rituximab plus methotrexate should be given no more frequently than every 6 months. 1.3 Treatment with rituximab plus methotrexate should be initiated, supervised and treatment response assessed by specialist physicians experienced in the diagnosis and treatment of rheumatoid arthritis. **Adalimumab, etanercept and infliximab for the treatment of rheumatoid arthritis NICE technology appraisal 130 (2007)** 1.1 The tumour necrosis factor alpha (TNF-α) inhibitors adalimumab, etanercept and infliximab are recommended as options for the treatment of adults who have both of the following characteristics. • Active rheumatoid arthritis as measured by disease activity score (DAS28) greater than 5.1 confirmed on at least two occasions, 1 month apart. • Have undergone trials of two disease-modifying anti-rheumatic drugs (DMARDs), including methotrexate (unless contraindicated). A trial of a DMARD is defined as being normally of 6 months, with 2 months at standard dose, unless significant toxicity has limited

	the dose or duration of treatment. 1.2 TNF-α inhibitors should normally be used in combination with methotrexate. Where a patient is intolerant of methotrexate or where methotrexate treatment is considered to be inappropriate, adalimumab and etanercept may be given as monotherapy. 1.3 Treatment with TNF-α inhibitors should be continued only if there is an adequate response at 6 months following initiation of therapy. An adequate response is defined as an improvement in DAS28 of 1.2 points or more. 1.4 After initial response, treatment should be monitored no less frequently than 6-monthly intervals with assessment of DAS28. Treatment should be withdrawn if an adequate response (as defined in 1.3) is not maintained. 1.5 An alternative TNF-α inhibitor may be considered for patients in whom treatment is withdrawn due to an adverse event before the initial 6-month assessment of efficacy, provided the risks and benefits have been fully discussed with the patient and documented. 1.6 Escalation of dose of the TNF-α inhibitors above their licensed starting dose is not recommended. 1.7 Treatment should normally be initiated with the least expensive drug (taking into account administration costs, required dose and product price per dose). This may need to be varied in individual cases due to differences in the mode of administration and treatment schedules. 1.8 Use of the TNF-α inhibitors for the treatment of severe, active and progressive rheumatoid arthritis in adults not previously treated with methotrexate or other DMARDs is not recommended. 1.9 Initiation of TNF-α inhibitors and follow-up of treatment response and adverse events should be undertaken only by a specialist rheumatological team with experience in the use of these agents.

	Certolizumab pegol for the treatment of rheumatoid arthritis NICE technology appraisal 186 (2010) 1.1 Certolizumab pegol is recommended as an option for the treatment of people with rheumatoid arthritis only if: • certolizumab pegol is used as described for other tumour necrosis factor (TNF) inhibitor treatments in 'Adalimumab, etanercept and infliximab for the treatment of rheumatoid arthritis' (NICE technology appraisal guidance 130) and • the manufacturer provides the first 12 weeks of certolizumab pegol (10 pre-loaded 200-mg syringes) free of charge to all patients starting treatment. 1.2 When using the DAS28 (as set out in NICE technology appraisal guidance 130), healthcare professionals should take into account any physical, sensory or learning disabilities, or communication difficulties that could affect a person's responses to the DAS28 and make any adjustments they consider appropriate. **Hip disease - metal on metal hip resurfacing. NICE technology appraisal 44 (2002).** 1.1 Metal on metal (MoM) hip resurfacing arthroplasty is recommended asone option for people with advanced hip disease who would otherwise receive and are likely to outlive a conventional primary total hip replacement. In considering hip resurfacing arthroplasty, it is recommended that surgeons take into account activity levels of potential recipients and bear in mind that the current evidence for the clinical and cost effectiveness of MoM hip resurfacing arthroplasty is principally in individuals less than 65 years of age 1.2 When MoM hip resurfacing arthroplasty is considered appropriate, the procedure should be performed only in the context of the ongoing collection of data on both the clinical effectiveness and cost effectiveness of this technology. Ideally, this data collection should form part of a UK national joint registry 1.3 This guidance should be read in conjunction with the Institute's guidance on devices for total hip replacement (Guidance on the selection of prostheses for primary total hip replacement: NICE Technology Appraisal Guidance No 2. April 2000). In that guidance, the Institute recommended that the best prostheses (using long-term viability as the determinant) should demonstrate a 'benchmark' revision rate (the rate at which they need to be replaced) of 10% or less at 10 years or, as a minimum, a 3 year revision rate consistent with this 10- year benchmark. Establishing

	and confirming similar benchmarking criteria will be necessary for MoM hip resurfacing arthroplasty and will be facilitated by a UK national joint registry. In the interim, the 3 year minimum benchmark should apply to MoM hip resurfacing devices 1.4 MoM hip resurfacing arthroplasty should be performed only by surgeons who have received training specifically in this technique 1.5 Surgeons should ensure that patients considering MoM hip resurfacing arthroplasty understand that less is known about the medium- to longterm safety and reliability of these devices or the likely outcome of revision surgery than for conventional total hip replacements. This additional uncertainty should be weighed against the potential benefits claimed for MoM devices
Clinical guidelines	**The care and management of osteoarthritis in adults** **NICE clinical guideline 59 (2008)** 1.5.1.1 Clinicians with responsibility for referring a person with osteoarthritis for consideration of joint surgery should ensure that the person has been offered at least the core (non-surgical) treatment options. 1.5.1.2 Referral for joint replacement surgery should be considered for people with osteoarthritis who experience joint symptoms (pain, stiffness and reduced function) that have a substantial impact on their quality of life and are refractory to non-surgical treatment. Referral should be made before there is prolonged and established functional limitation and severe pain. 1.5.1.3 Patient-specific factors (including age, gender, smoking, obesity and comorbidities) should not be barriers to referral for joint replacement surgery. 1.5.1.4 Decisions on referral thresholds should be based on discussions between patient representatives, referring clinicians and surgeons, rather than using current scoring tools for prioritisation.

Appendix C: Literature search for minimally invasive total hip replacement

Database	Date searched	Version/files
Cochrane Database of Systematic Reviews – CDSR (Cochrane Library)	11/03/2010	Issue 1, February 2010
Database of Abstracts of Reviews of Effects – DARE (CRD website)	11/03/2010	N/A
HTA database (CRD website)	11/03/2010	N/A
Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library)	11/03/2010	Issue 1, February 2010
MEDLINE (Ovid)	11/03/2010	1950 to March Week 1 2010
MEDLINE In-Process (Ovid)	11/03/2010	March 10, 2010
EMBASE (Ovid)	11/03/2010	1980 to 2010 Week 09
CINAHL (NLH Search 2.0/EBSCOhost)	11/03/2010	1981 to Present
BLIC (Dialog DataStar)	11/03/2010	1995 to date

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

1	Surgical Procedures, Minimally Invasive/
2	(Mini* adj3 Invasiv* adj3 (Surg* or Tech* or Procedure*)).tw.
3	MIS.tw.
4	Fluoroscopy/
5	Fluoroscop*.tw.
6	or/1-5
7	((Mini* or Stand* or Single* or Double*) adj3 (Incis* or Access* or Dissect*)).tw.
8	((One* or Two*) adj3 (Incis* or Access* or Dissect*)).tw.
9	1 Incis*.tw.
10	1 Access*.tw.
11	2 Incis*.tw.

12	2 Access*.tw.
13	or/7-12
14	Arthroplasty, Replacement, Hip/
15	(Total* adj3 Hip* adj3 (Arthroplast* or Replace*)).tw.
16	(THA or THR).tw.
17	Hip Prosthesis/
18	(Total* adj3 Hip* adj3 (Prosthe* or Implant*)).tw.
19	or/14-18
20	6 and 13 and 19
21	Animals/ not Humans/
22	20 not 21