NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of focal resurfacing implants to treat articular cartilage damage in the knee

Articular cartilage protects the ends of the bones in the knee joint from friction during movement. Damage from injury or disease to a small (focal) area of the articular cartilage can cause pain, stiffness in the knee and reduced mobility. In this procedure, done under general or regional anaesthesia, a surgeon makes a cut to access the knee joint. The damaged area of the cartilage and bone is removed and replaced with a small artificial implant that restores the smooth surface (resurfacing). The aim is to reduce symptoms, allow immediate weight bearing and preserve joint function. It also may reduce or delay the need for a later knee replacement.

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Abbreviations

Word or phrase	Abbreviation
Activities of daily living	ADL
Body mass index	BMI
Confidence interval	CI
International Cartilage Regeneration and Joint Preservation Society	ICRS
Knee Injury and Osteoarthritis Outcome Score	KOOS
Minimal clinically important difference	MCID
Osteochondral autograft transfer system	OATS
Oxford Knee Score	OKS
Quality of life	QoL
36-item Short Form Survey	SF-36
Standard deviation	SD
Total knee arthroplasty	TKA
Unicompartmental knee arthroplasty	UKA
Visual Analogue Scale	VAS
Western Ontario and McMaster Universities Osteoarthritis Index	WOMAC

Introduction

The National Institute for Health and Care Excellence (NICE) prepared this interventional procedure 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 professional opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in November 2021 and updated in June 2022.

Procedure name

- Focal resurfacing implants to treat articular cartilage damage in the knee.

Professional societies

- British Association for Surgery of the Knee
- British Orthopaedic Association

Description of the procedure

Indications and current treatment

Cartilage covers the ends of the bones comprising the knee joint. There are 2 types of cartilage in the knee – articular (or chondral) and meniscal. Damage because of injury or disease to a focal area of articular cartilage, particularly in the main weightbearing areas, can cause pain, stiffness in the knee and reduced mobility. Cartilage tissue has very limited self-healing potential and, if left untreated, cartilage damage can progress to osteoarthritis.

Treatment for focal articular cartilage damage typically involves arthroplasty or biological treatment. Types of arthroplasty include TKA, bicompartmental, UKA and patellofemoral knee. Types of biological treatment include microfracture, OATS and autologous chondrocyte implantation.

What the procedure involves

Focal articular resurfacing is aimed at people for whom biological treatments and arthroplasty may not be suitable because of age and other factors.

Before surgery, the articular cartilage damage is assessed using a preplanned MRI, an arthroscopy or both. Then, either the implant is customised to fit the damaged area, or an implant is selected from a catalogue to closely match the damaged area. The procedure is done under regional (spinal) or general anaesthesia. An incision is made to access the damage site. The damaged area is prepared by removing the damaged bone and cartilage, and drilling a hole for the stem of the implant. The implant is then press-fitted into the damaged area with or without bone cement. The surface of the implant is slightly recessed below the surrounding articular cartilage.

Rehabilitation after surgery depends on the person and implant. It typically includes either an immediate (as tolerated) or gradual return to full weight bearing and range of motion.

The aim of this procedure is to alleviate pain, allow immediate weight bearing, preserve physiological joint function, slow progression to osteoarthritis, and reduce or delay the need for TKA or UKA.

Outcome measures

Cartilage defects are typically assessed by the ICRS grading:

- 0 – Normal cartilage
- 1 – Nearly normal cartilage, superficial defect
- 2 – Abnormal, defect extending down to less than 50% of cartilage depth
- 3 – Severely abnormal, defect extending down more than 50% of cartilage depth but not through subchrondal bone
- 4 – Severely abnormal, depth of cartilage defect extends through subchrondal bone

Several instruments are used to assess patient-reported outcomes:

- The **KOOS** is a self-administered, 42-item instrument. Higher scores indicate better health. The publisher of the KOOS (http://www.koos.nu/) notes that the MCID is likely dependent on the patient population studied, but an MCID of 8 to 10 is appropriate. The KOOS is subdivided into 5 components:
    - Pain, Other symptoms, Function in daily living, Function in sport and recreation, and knee related QoL.

- The **OKS** is an instrument that consists of 12 questions about level of function, ADL, and pain over the preceding 4 weeks. Higher scores indicate better health.

- The **Tegner Activity Scale** documents the level of activity of participants before and after injury on an 11-point scale. Higher scores indicate a higher level of activity. A summary of the scale with an example activity follows:
    - 10 – Competitive football (elite level)
    - 9 – Competitive football (lower divisions)
    - 8 – Competitive badminton
    - 7 – Competitive tennis; recreational football
    - 6 – Recreational tennis; jogging at least 5 times per week
    - 5 – Heavy labour; competitive cycling
    - 4 – Moderately heavy labour; recreational cycling; jogging at least 2 times per week
    - 3 – Light labour; competitive and recreational swimming
    - 2 – Walking on uneven ground
    - 1 – Sedentary work
    - 0 – Sick leave or disability pension because of knee problems

- The **VAS** is an instrument that is often used to assess pain. The simplest VAS is a straight line of fixed length. The scale ranges from least pain to most pain and the participant marks line corresponding to the level of pain they feel. A ruler is used to measure the distance from the end of the line to the participant's mark. Higher scores indicate worse pain. An MCID of 22 mm has been reported for the improvement in pain in people who had TKA. Note that the units (centimetres or millimetres) used to report VAS are not always well described.

- The **SF-36** is a 36-item, self-administered instrument. Higher scores indicate better health. An MCID of 11 to 16 points has been reported for people who had TKA. The SF-36 covers 8 domains of health:
    - Vitality, Physical functioning, Bodily pain, General health perceptions, Physical role functioning, Emotional role functioning, Social role functioning, and Mental health.

Efficacy summary

Patient-reported outcomes

KOOS

A systematic review and meta-analysis of 127 people (before surgery) and 90 people (after surgery) found statistically significant improvements in each subscale of the KOOS instrument at 2-year follow up compared with before surgery (Elbardesy, 2021):

- Pain: standardised mean difference was -5.61 (95% CI -8.11 to -3.11), showing lower pain after surgery.
- Symptoms: standardised mean difference was -4.96 (95% CI -7.28 to -2.63), showing lesser symptoms after surgery.
- ADL: standardised mean difference was -5.08 (95% CI -7.40 to -2.76), showing less difficulty with ADL after surgery.
- Sport and recreational activities: standardised mean difference was -4.35 (95% CI -7.08 to -1.61), showing less difficulty doing sports and recreational activities.
- QoL: standardised mean difference was -4.35 (95% CI -7.08 to -1.61), showing less difficulty doing sports and recreational activities.

In a retrospective before-and-after study of 266 people, there was a statistically significant increase in KOOS from 51.83 (plus or minus 3.74) before surgery to 80.29 (plus or minus 7.04) at final follow up (mean 7.3 years; $p<0.001$; Megaloikonomos, 2021).

In a retrospective before-and-after study of 157 people, there was a statistically significant increase in KOOS from 52.8 (plus or minus 3.3) before surgery to 80.1 (plus or minus 6.8) at 4-year follow up ($p<0.0001$; van der Stok, 2022).

In a retrospective cohort study of 118 people, there were statistically significant improvements in KOOS QoL in people who had BioPoly (difference 29.96; $p<0.001$) and in people who had HemiCAP (difference 32.41; $p<0.001$) from before surgery to 2 years after surgery. In a comparative analysis, there was no difference in the change in KOOS QoL between people who had HemiCAP and people who had BioPoly ($p=0.150$; Çepni, 2020).

In a before-and-after study of 33 people, there was a statistically significant increase in KOOS overall from 44.9 (plus or minus 18.0) before surgery to 77.6 (plus or minus 16.6) at 2 years after surgery ($p<0.025$). There were also

statistically significant increases in KOOS overall (and component subscale scores) at 6 months, 1 year, and 2 years (all p<0.025; Nathwani, 2017).

In a before-and-after study of 75 people, there were statistically significant changes from baseline in each subscale of KOOS to 2 years after surgery (Holz, 2021):

- KOOS-Pain: change = 26.28 (95% CI 19.86 to 32.70; p<0.0001)
- KOOS-Symptoms: change = 18.30 (95% CI 12.70 to 23.90; p<0.0001)
- KOOS-ADL: change = 22.75 (95% CI 16.42 to 29.09; p<0.0001)
- KOOS-Sport: change = 25.27 (95% CI 17.04 to 33.50; p<0.0001)
- KOOS-QoL: change = 25.26 (95% CI 18.14 to 32.37; p<0.0001).

OKS

In the retrospective before-and-after study of 266 people, there was a statistically significant increase in OKS from 22.94 (plus or minus 3.34) before surgery to 39.71 (plus or minus 4.83) at final follow up (mean 7.3 years; p<0.001; Megaloikonomos, 2021).

In the retrospective before-and-after study of 157 people, there was a statistically significant increase in OKS from 23.6 (plus or minus 2.9) before surgery to 39.9 (plus or minus 4.9) at 4-year follow up (p<0.0001; van der Stok, 2022).

Tegner Activity Scale

In the retrospective cohort study of 118 people, there were statistically significant increases in Tegner Activity Scale scores in people who had BioPoly (difference 1.22; p<0.001) and in people who had HemiCAP (difference 1.30; p<0.001) from before surgery to 2 years after surgery. In a comparative analysis, people who had HemiCAP had a statistically significantly greater improvement in Tegner Activity Scale score than people who had BioPoly (p<0.001; Çepni, 2020).

In the before-and-after study of 33 people, there was a statistically significant increase in Tegner Activity Scale score from 2.5 (plus or minus 1.7) before surgery to 4.0 (plus or minus 1.9) at 2 years after surgery (p<0.025; Nathwani, 2017).

VAS pain

In the retrospective before-and-after study of 266 people, there was a statistically significant decrease in VAS pain from 7.18 (plus or minus 0.82) before surgery to 2.17 (plus or minus 1.04) at final follow up (mean 7.3 years; p<0.001; (Megaloikonomos, 2021).

In the retrospective before-and-after study of 157 people, there was a statistically significant decrease in VAS pain from 7.27 (plus or minus 0.8) before surgery to 2.17 (plus or minus 1.1) at 4-year follow up ($p<0.0001$; van der Stok, 2022).

In the retrospective cohort study of 118 people, there were statistically significant decreases in VAS pain scores in people who had BioPoly (difference -4.60; $p<0.001$) and in people who had HemiCAP (difference -5.99; $p<0.001$) from before surgery to 2 years after surgery. In a comparative analysis, people who had HemiCAP experienced a statistically significantly greater improvement in VAS pain score than people who had BioPoly ($p<0.001$). People who had HemiCAP had statistically significantly higher VAS pain score before surgery than people who had BioPoly (Çepni, 2020).

In the before-and-after study of 33 people, there was a statistically significant decrease in VAS pain score from 4.1 (plus or minus 2.5) before surgery to 1.4 (plus or minus 2.2) at 2 years after surgery ($p<0.025$; (Nathwani, 2017).

In the before-and-after study of 75 people, there was a statistically significant change in VAS pain score of 30.22 (95% CI 22.34 to 38.11) from before surgery to 2-year follow up (Holz, 2021).

SF-36

In the retrospective before-and-after study of 266 people, there was a statistically significant increase in SF-36 score from 51.95 (plus or minus 3.72) before surgery to 78.84 (plus or minus 8.47) at final follow up (mean 7.3 years; $p<0.001$; Megaloikonomos, 2021).

In the retrospective before-and-after study of 157 people, there was a statistically significant increase in SF-36 score from 52.7 (plus or minus 3.5) before surgery to 79.1 (plus or minus 8.9) at 4-year follow up ($p<0.0001$; van der Stok, 2022).

In the before-and-after study of 33 people, there was a statistically significant increase in SF-36 physical component scores from 42.3 (plus or minus 32.0) before surgery to 81.9 (plus or minus 30.8) at 2 years after surgery ($p<0.025$; Nathwani, 2017).

Safety summary

Revisions and reoperations

Note: revisions were typically to the same (or different) focal resurfacing implant, UKA, or TKA. The reasons for revision were not always described in the publications. Some of the reasons may have been because of a lack of efficacy,

and others may have been because of complications. All revisions are presented in this section, regardless of the reasons for revision.

In a registry analysis of 220 procedures, there was a cumulative revision of 28% (95% CI 22.1% to 34.1%) at 5-year follow up, and 50% (95% CI 41.8% to 57.8%) at 12-year follow up. All procedures captured in this registry were done using the HemiCAP range of prostheses (Australian Orthopaedic Association National Joint Replacement Registry, 2020).

In a registry analysis of 379 implants, 5-year revision-free survival was 0.84 (95% CI 0.80 to 0.88) and 10-year revision-free survival was 0.80 (95% CI 0.75 to 0.84). Most implants captured by this registry were HemiCAP or UniCAP (95%), with a small proportion Episealer (5%; Christensen, 2021).

In the retrospective before-and-after study of 266 people, implant survival was 96% at 10 years, with a mean survival time of 9.25 years (95% CI 9.08 to 9.40 years). The cumulative hazard for reoperation for any reason was 12%. All procedures in this study were done with the HemiCAP implant. The reasons for revision included (Megaloikonomos, 2021):

- failure because of further knee injury, n=1
- symptomatic osteoarthritic changes, n=5.

In the retrospective before-and-after study of 157 people, implant survival was 99% after 9.4 years. The reoperation rate was 11% (n=17). All procedures in this study were done with the HemiCAP implant. The reasons for reoperation included (van der Stok, 2022):

- revision surgery, n=1
    - this person was revised to UKA
- partial meniscectomy, n=12
- debridement, n=6.

In the retrospective cohort study of 118 people, 13 (11%) needed revision surgery. In multivariate regression analysis, the BioPoly implant was a statistically significant risk factor for revision surgery (adjusted hazard ratio 6.9, 95% CI 1.04 to 45.73; p=0.045). However, this analysis may have been confounded because 3 of the revisions of the BioPoly implant were in people who experienced trauma leading to pain and implant loosening (Çepni, 2020). The reasons for revision were as follows:

- BioPoly:
    - progressive pain after trauma, implant loosening, chondral lesions in the patellofemoral compartment, n=2
    - progressive pain after trauma, implant loosening, n=1
    - progressive arthritis in the lateral compartment, n=2
    - progressive arthritis in the medial compartment, n=2

    - infection, n=1.
- HemiCAP:
    - generalised arthritis involving all compartments, n=2
    - progressive arthritis in the lateral compartment, n=1
    - progressive pain, implant loosening, generalised chondrolysis in all compartments, n=1
    - infection, n=1.

In the before-and-after study of 33 people, 1 person had a revision because of the failure of osseointegration. All procedures in this study were done with the BioPoly implants (Nathwani, 2017).

In a consecutive case series of 612 knees, a total of 14 (2%) had revisions over the 7-year follow-up period. Using Kaplan–Meier analysis, implant survivorship at 7 years was 96%. All procedures in this study were done with the Episealer implant (Ryd, 2021). The reasons for revision were as follows (some people had multiple reasons):

- pain, n=6
- disease progression, n=2
- multiple lesions, n=2
- implant was too small, n=2
- trauma after surgery, n=1
- metal allergy, n=1
- borderline indication, n=1
- tibial cartilage wear, n=1
- infection, n=1
- unknown, n=1
- high tibial osteotomy failed, n=1.

In the before-and-after study of 75 people, a total of 3 people had revisions, 2 during the 24-month follow up, and 1 at 27 months. This resulted in an overall revision rate of 4%. All procedures in this study were done with the Episealer implant (Holz, 2021). The reasons for revision were as follows:

- atypical lesion with significant bone marrow oedema condyle before surgery that did not improve after surgery and represented with increased pain, n=1
- cysts persisting from previous OATS plugs, symptoms did not improve after surgery, n=1
- severe pain, loose implant, infection, n=1.

Complications and adverse events

Note: This section contains complications and adverse events that were not reported to be reasons for revision. The previous section describes all reasons for revision, some of which were complications.

Deep vein thrombosis

In the before-and-after study of 75 people, deep vein thrombosis was reported in 1 person (Holz, 2021).

Pain

In the before-and-after study of 33 people, knee pain (arthralgia) was reported in 9 people, which was localised to the contralateral compartment in 4 of them. This adverse event was considered unrelated to the device (Nathwani, 2017).

In the before-and-after study of 75 people, painful mechanical clicking was reported in 1 person (Holz, 2021).

Infection

In the before-and-after study of 33 people, there was a wound infection in 1 person. This adverse event was considered unrelated to the device (Nathwani, 2017).

Stiffness

In the retrospective before-and-after study of 266 people, postoperative stiffness was reported in 63 people, which resolved after corticosteroid injections in 54 of them (Megaloikonomos, 2021).

In the before-and-after study of 33 people, stiffness was reported in 1 person. This adverse event was considered unrelated to the device (Nathwani, 2017).

Swelling

In the before-and-after study of 33 people, swelling was reported in 2 people. This adverse event was considered unrelated to the device (Nathwani, 2017).

Clicking and crepitation

In the before-and-after study of 33 people, crepitation was reported in 3 people. This adverse event was considered unrelated to the device (Nathwani, 2017).

In the before-and-after study of 75 people, painful mechanical clicking was reported in 1 person (Holz, 2021).

Loose cartilage body

In the before-and-after study of 33 people, a loose cartilage body was reported in 1 person. This adverse event was considered unrelated to the device (Nathwani, 2017).

Anecdotal and theoretical adverse events

In addition to safety outcomes reported in the literature, professional experts are asked about anecdotal adverse events (events which they have heard about) and about theoretical adverse events (events which they think might possibly occur, even if they have never happened).

For this procedure, the professional experts did not list any theoretical or anecdotal adverse events.

The evidence assessed

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to focal articular resurfacing implants for treating articular cartilage defects in the knee. The following databases were searched, covering the period from their start to 5th April 2022: 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 the literature search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The inclusion criteria 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.

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 with focal articular cartilage defects in the knee
Intervention/test	Focal articular cartilage resurfacing. • Patellofemoral arthroplasty using inlay or onlay trochlear protheses (including the HemiCAP PF Wave and WaveKahuna) were excluded. • Procedures that involved resurfacing a focal area of the trochlear (such as those using the HemiCAP PF Classic or the Episealer Trochlear solo) were included.
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 IP overview

This IP overview is based on approximately 2,300 people from 1 systematic review and meta-analysis, 2 registry analyses (1 of which was not published in a peer-reviewed journal), 1 cohort study, 4 before-and-after studies, and 1 case series.

Other studies that were considered to be relevant to the procedure but were not included in the main summary of the key evidence are listed in the appendix.

Summary of key evidence on focal resurfacing implants to treat articular cartilage damage in the knee

Study 1 Elbardesy H (2021)

Study details

Study type	Systematic review and meta-analysis
Country	Not described for individual studies
Recruitment period	Not described for individual studies
Study population and number	n=14 studies, 464 people People with a focal femoral condyle cartilage defect
Age & sex	47.9 years, 62.5% female (sex of 155 people was not reported)
Patient selection criteria	Inclusion criteria: any clinical trials involving HemiCAP, UniCAP (Arthrosurface) or other focal resurfacing implant with mean follow up at least 2 years. Exclusion criteria: all cadaveric, biomechanical studies, and studies about partial resurfacing of the patellofemoral joint.
Technique	Focal femoral condyle resurfacing with HemiCAP, UniCAP, Episealer (Episurf), or BioPoly (BioPoly) – see Other issues below.
Follow-up	1.56 to 11.7 years
Conflict of interest/source of funding	Conflict of interest: the authors report that they have no conflict of interest. Source of funding: the authors report no funding source was received.

Analysis

Follow up issues: The proportion of people lost to follow up ranged from 0 to 63.6%.

Study design issues: This systematic review and meta-analysis evaluated the outcomes of focal resurfacing of full-thickness cartilage defects. The study was reported to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The meta-analysis was conducted on KOOS. KOOS is a as well as subgroup analyses of KOOS component scores – pain, symptoms, ADL, QoL, and sport and recreational activities. Risk of bias of included studies was conducted according to the Cochrane risk of bias criteria.

Mean differences were computed with 95% CI discontinuous outcomes, using standard meta-analysis software (RevMan 5.3). Standardised mean differences were used to compute effect measures and a random-effects model for meta-analysis was used. I^2 statistic was used to quantify heterogeneity.

Other issues: The publication is written in poor English with multiple typographical errors. One of the studies (Nathwani [2017]) is included in the meta-analysis but is incorrectly described as using the HemiCAP implant.

Given Nathwani (2017) is a key publication for BioPoly, it is extracted as Study 7 in this overview. Another study, Stalmån (2018) is incorrectly described as using the HemiCAP implant. Stalmån (2018) used the Episealer implant and is included in the Appendix.

Key efficacy findings

KOOS

Number of people analysed: 127 (before surgery); 90 (after surgery)
Follow up at time of assessment: 2 years

- There was a statistically significant improvement in each subset of the KOOS instrument from before surgery to after surgery. However, the studies were heterogenous, indicated by an I^2 values of 96 and 97% for all outcomes.
    - Pain: standardised mean difference was -5.61 (95% CI -8.11, -3.11), showing lower pain after surgery.
    - Symptoms: standardised mean difference was -4.96 (95% CI -7.28, -2.63), inferring lesser symptoms after surgery.
    - ADL: standardised mean difference was -5.08 (95% CI -7.40, -2.76), showing lesser difficulty with ADL after surgery.
    - Sport and recreational activities: standardised mean difference was -4.35 (95% CI -7.08, -1.61), showing lesser difficulty with sports and recreational activities.
    - QoL: standardised mean difference was -4.35 (95% CI -7.08, -1.61), showing lesser difficulty with sports and recreational activities.

Key safety findings

Revisions

Number of people analysed: 464
Follow up at time of assessment: variable, from 1.6 years to 11.7 years

- The revision rate ranged from 0% (6 studies) to 61% (1 study)
- The highest revision rates were seen in 2 studies using the UniCAP implant – 61% (Laursen [2019]) and 47% (Laursen [2016]).
    - These studies included people with relatively larger lesions.

Summary of revisions reported by studies identified

Study	Condyle defect size and implant used	Follow up length, years	Revisions, n/N (%)
Becher C, Kalbe C, Thermann H et al. (2011) Archives of orthopaedic and trauma surgery 131(8):1135-43	≤20 mm^2 HemiCAP	5.3	2/21 (10%)
Becher C and Cantiller EB. (2017) Archives of orthopaedic and trauma surgery 137(9):1307-17	NR HemiCAP	11.7	0/2 (0%)
Bollars P, Bosquet M, Vandekerckhove B et al. (2012) Knee surgery, sports traumatology, arthroscopy 20(9):1753-9	37% 20 mm^2/63% 15 mm^2 HemiCAP	2.8	0/19 (0%)
Dhollander AAM, Almqvist KF, Moens K et al. (2015) Knee surgery, sports traumatology, arthroscopy 23(8):2208-2212	50% 15 mm^2/50% 20 mm^2 HemiCAP	2.2	0/14 (0%)
Laursen JO. (2016) Knee surgery, sports traumatology, arthroscopy 24(5):1695-701	>4 cm^2 UniCAP*	2 Clinical 7 Complications and reoperations	30/64 (47%)
Laursen JO and Lind M. (2017) Knee surgery, sports traumatology, arthroscopy 25(3):746-51	<4 cm^2 HemiCAP**	2 Clinical 7 Complications and reoperations	9/36 (25%)
Laursen JO, Mogensen CB, Skjøt-Arkil H. (2019) Knee Surgery, Sport traumatology, arthroscopy 27(5):1693-7	>4 cm^2 UniCAP	7.2	36/59 (61%)
Miniaci A. (2014) Clinical Sports Medicine 33(1):57-65.	NR UniCAP*	1.6	0/35 (0%)
Nahas S, Monem M, Li L et al. (2020) The journal of knee surgery 33(10):966-70	NR HemiCAP	9.8	2/14 (14%)
Nathwani D, McNicholas M, Hart A et al. (2017) JB&JS Open Access 2(2)	2.7 cm^2 ± 0.6 cm^2 BioPoly*	2.0	0/33 (0%)
Pascual-Garrido C, Daley E, Verma NN, and Cole BJ. (2017) Arthroscopy: the journal of arthroscopic & related surgery 33(2):364-73	NR HemiCAP	2.0	8/32 (25%)
Stålman A, Skoldenberg O, Martinez-Carranza N et al. (2018) Knee surgery, sports traumatology, arthroscopy 26(7):2196-204	≤3.2 cm^2 Episealer*	2.0	0/10 (0%)

Study	Condyle defect size and implant used	Follow up length, years	Revisions, n/N (%)
Çepni Ş, Veizi E, Tahta M et al. (2019) Archives of orthopaedic and trauma surgery 140(2):209-18	3.6 cm^2 ± 0.5 cm^2 HemiCAP (62%) or BioPoly (38%)***	2.0	13/118 (11%) total 5/73 (7%) HemiCAP 8/45 (18%) BioPoly
Hobbs H, Ketse-Matiwane N, van der Merwe W et al. (2013) SA Orthopaedic Journal	<4 cm^2 HemiCAP	4.7	2/7 (29%)

*Incorrectly listed in Elbardesy (2021) as HemiCAP.
**Incorrectly listed in Elbardesy (2021) as UniCAP.
***Incorrectly listed in Elbardesy (2021) as HemiCAP only.

Study 2 Australian Orthopaedic Association National Joint Replacement Registry (2020)

Study details

Study type	Registry analysis – not published in a peer-reviewed journal
Country	Australia
Recruitment period	1999 to 2020 No partial knee resurfacing procedures were conducted in 2020, data here was extracted from the 2020 report (with data up to 2019).
Study population and number	n=245 procedures All partial knee resurfacing procedures reported to the Australian Orthopaedic Association National Joint Replacement Registry.
Age & sex	Not reported
Patient selection criteria	All partial knee resurfacing procedures reported to the registry. Partial resurfacing was defined as 'involves the use of one or more button implants to replace part of the natural articulating surface on one or more sides of the joint, in one or more articular compartments of the knee.'
Technique	All procedures used the HemiCAP range of implants. Most (n=145) were implanted on the femoral articular surface. There were 85 procedures that involved resurfacing the patella/trochlear joint either on 1 side (n=27) or both sides (n=58). As the specific implant type was not specified, some of these implants may have been the HemiCAP Wave or Wave Kahuna (see Rapid review of literature).
Follow-up	Up to 12 years
Conflict of interest/source of funding	Conflict of interest: Not reported Source of funding: Not reported

Analysis

Study design issues: This multicentre, prospective registry analysis reported the revision rate of partial knee resurfacing procedures conducted in hospitals in Australia.

Other issues: The data was published as a report and not in a peer-reviewed journal.

Key safety findings

Revisions

Number of people analysed: 220 procedures
Follow up at time of assessment: up to 12 years

- The cumulative percent revision of partial knee resurfacing for osteoarthritis was 49.5% at 12 years.
    - Most primary partial resurfacing implants were revised to either a total knee replacement (65.0%) or a unicompartmental knee replacement (19.0%).

Cumulative revision of partial knee resurfacing implants

			Cumulative percent revision of primary partial resurfacing knee replacement (primary diagnosis osteoarthritis)					
	N total	**N revised**	**1 year**	**2 years**	**3 years**	**5 years**	**8 years**	**12 years**
Partial knee resurfacing	220	93	6.4 (3.8, 10.5)	16.4 (12.1, 22.0)	17.8 (13.3, 23.6)	27.6 (22.1, 34.1)	37.9 (31.4, 45.2)	49.5 (41.8, 57.8)
Number at risk	-	-	206	181	174	140	87	42

Study 3 Christensen BB (2021)

Study details

Study type	Registry analysis
Country	Denmark
Recruitment period	1997 to 2020
Study population and number	n=379 implants All knee resurfacing procedures reported to the Danish Knee Arthroplasty Registry.
Age & sex	Mean 50 years; 57% female
Patient selection criteria	Reporting to the registry is mandatory for both public and private hospitals and data was collected directly by the surgeon through standardised forms.
Technique	A resurfacing implant was defined as UniCAP, HemiCAP, or Episealer. Most implants were isolated HemiCAPs (n=231; 61%). Other implants were isolated UniCAPs (n=112; 30%), isolated Episealers (n=20; 5%), or more than 1 implant in combination (n=16; 4%). As the specific implant type was not specified, some of these implants may have been the HemiCAP Wave or Wave Kahuna (see Rapid review of literature).
Follow-up	Median 8 years (IQR 3 to 10 years)
Conflict of interest/source of funding	Conflict of interest: The authors declared no conflict of interest. Source of funding: The authors declared that funding was not received.

Analysis

Study design issues: This retrospective analysis of prospectively collected data from the multicentre Danish Knee Arthroplasty Registry assessed the survival of knee resurfacing implants. Survival of the resurfacing implants was primarily analysed by the Kaplan-Meier method with observations included at the date of index surgery and with date of revision surgery as endpoint.

Study population issues: The majority of people (87%) were Charnley A class, indicating an issue with a single joint only. The predominant indication for resurfacing implants was secondary osteoarthritis (42%), followed by primary osteoarthritis (32%), and osteochondral lesions (20%). Most of the observations had prior knee surgery in the affected knee with arthroscopy (60%) and microfracture procedures (22%) being the most frequent.

Key safety findings

Revisions

Number of people analysed: 379 implants
Follow up at time of assessment: median 8 years, up to 12.5 years

- A total of 70 implants (19%) were revised to arthroplasties. This corresponded to estimates of:
    - 1-year revision-free survival: 0.95 (95% CI 0.93 to 0.97)
    - 5-year revision-free survival: 0.84 (95% CI 0.80 to 0.88)
    - 10-year revision-free survival: 0.80 (95% CI 0.75 to 0.84)
    - Median time to revision: 2 years (IQR 1 to 4 years).
- The revised implants were mainly UniCAP (n=35, 50%) and HemiCAP (n=33, 47%), with Episealer (n=1,1.5%) and combined implants (n=1, 1.5%) less common.
- Most revisions (n=61; 87%) were converted to cruciate-retaining total knee arthroplasties.

Study 4 Megaloikonomos PD (2021)

Study details

Study type	Single centre, retrospective, before-and-after study
Country	Germany
Recruitment period	2009 to 2013
Study population and number	n=266 People with symptomatic focal femoral condyle cartilage defects.
Age & sex	Mean 38.25; 58.6% male
Patient selection criteria	Inclusion criteria: Symptomatic patients with ICRS grade 3 or 4 chondral and osteochondral defects of the medial or lateral condyle. Exclusion criteria: BMI >35 kg/m^2, valgus/varus knee deformity >5 degrees, unaddressed ligamentous instability, kissing lesions, defect diameter >20 mm, meniscal deficiency (defined as >50% meniscal tissue resection), diabetes, metabolic disorders, inflammatory joint diseases, and administration of corticosteroids or immunosuppressive agents.
Technique	Implant: HemiCAP (100%) Technique: diagnostic arthroscopy was done to assess the defect. The diameter was measured, a guide wire inserted, and the defect was reamed. The implant was placed and recessed 1 mm deeper than surrounding cartilage. After surgery care: a hinged brace was recommended for 2 weeks, followed by functional rehabilitation and unrestricted range of motion. Complete return to everyday activities was allowed at 4 weeks and sports restrictions were gradually lifted at 3 months.
Follow-up	Mean 7.3 years (range 5 to 10 years)
Conflict of interest/source of funding	Conflict of interest: The authors report no conflicts of interest. Source of funding: The authors report that no funding was received for this study.

Analysis

Study design issues: This single centre, retrospective, before-and-after study assessed the outcomes of focal cartilage resurfacing for femoral condyle cartilage defects. It is not reported whether the patients included were consecutive. Outcomes included KOOS, OKS, SF-36, and VAS pain assessed before surgery and at final follow up. Reoperations, failures and complications were also recorded.

A statistical significance level was not explicitly specified in the methods. $p<0.05$ is used elsewhere to refer to statistically significant findings. An adjustment for multiple comparisons was not done.

Study population issues: Most people had some form of prior cartilage surgery, with 47.3% having debridement and 41.0% having regeneration.

Key efficacy findings

Patient-reported outcomes

Number of people analysed: 266
Follow up at time of assessment: final follow up mean 7.3 years

- There were statistically significant improvements from before surgery to final follow up in KOOS, OKS, SF-36, and VAS pain (all p<0.001).

Patient reported outcomes results

Outcome	Before surgery	Final follow up	Improvement	p-value
KOOS (max 100)	51.83 ± 3.74	80.29 ± 7.04	28.61 ± 7.59	<0.001
OKS (max 48)	22.94 ± 3.34	39.71 ± 4.83	16.83 ± 5.69	<0.001
SF-36 (max 100)	51.95 ± 3.72	78.84 ± 8.47	27.03 ± 8.98	<0.001
VAS pain (max 10)	7.18 ± 0.82	2.17 ± 1.04	−5.01 ± 1.32	<0.001

Key safety findings

Revisions and reoperations

Number of people analysed: 266
Follow up at time of assessment: final follow up mean 7.3 years

- Survival analysis showed that implant survival was 96.2% at 10 years.
- The mean survival time was 9.25 years (95% CI 9.08 to 9.40 years).
    - One implant failure was seen after a further knee injury – this person was revised to UniCAP.
    - Nine people had symptomatic osteoarthritic changes:
        - Conversion to UKA, n=4
        - Conversion to TKA, n=1
        - Arthroscopic debridement, n=3
        - Treated conservatively, n=1
- The cumulative hazard for reoperation for any reason was 12.0% (n=32).
    - Revision surgery, n=6
    - Arthroscopy, n=26

Complications

Number of people analysed: 266
Follow up at time of assessment: final follow up mean 7.3 years

- Postoperative stiffness, n=63
    - In 54 people, this resolved after corticosteroid injections.

Study 5 van der Stok J (2022)

Study details

Study type	Single centre, retrospective, before-and-after study
Country	Ireland
Recruitment period	2009 to 2013
Study population and number	n=157 People with focal femoral condyle cartilage defects.
Age & sex	Mean 40.2; 58% male
Patient selection criteria	Inclusion criteria: primary focal resurfacing procedure of the femoral condyle using a HemiCAP implant. Patients aged 20 to 60 years with an isolated and symptomatic cartilage defect, diagnosed on MRI or during arthroscopy as grade 3 or 4 according to ICRS. Exclusion criteria: resurfacing of a different location (for example trochlea), a different implant type, or who had resurfacing as a secondary procedure. A secondary procedure was defined as any prior biological procedure. Arthroscopic procedures in which the lesion was only debrided were excluded.
Technique	Implant: HemiCAP (100%) Technique: diagnostic arthroscopy was done to assess the defect. The diameter was measured, a guide wire inserted, and the defect was reamed. The implant was placed and recessed 1 mm deeper than surrounding cartilage. After surgery care: a hinged brace was recommended for 2 weeks. After 2 weeks, the brace was removed, and full weight-bearing was allowed. Patients were encouraged to start cycling and hydrotherapy at that point. Running was encouraged after 3 months, and return to contact sports after 6 months
Follow-up	Mean 9.4 years
Conflict of interest/source of funding	Conflict of interest: The authors report no conflicts of interest. Source of funding: The authors report that no funding was received for this study.

Analysis

Study design issues: This single centre, retrospective, before-and-after study assessed the outcomes of focal cartilage resurfacing for femoral condyle cartilage defects. Patients were identified retrospectively from medical records. Outcomes included KOOS, OKS, SF-36, and VAS pain assessed before surgery, and at 6 weeks, 6 months, and 4 years after surgery. Reoperations, failures and complications were also recorded.

$p<0.05$ was considered statistically significant. Dunn's multiple comparisons test was used to adjust for multiple comparisons.

Study population issues: Patients who had focal resurfacing secondary to biological procedures were excluded from the analysis.

Key efficacy findings

Patient-reported outcomes

Number of people analysed: 157
Follow up at time of assessment: 4 years

- There were statistically significant improvements from before surgery to final follow up in KOOS, OKS, SF-36, and VAS pain (all p<0.001).

Patient reported outcomes results

Outcome	Before surgery	6 weeks	6 months	4 years	p-value
KOOS (max 100)	52.8 ± 3.3	56.5 ± 6.0	68.6 ± 7.9	80.1 ± 6.8	<0.0001
OKS (max 48)	23.6 ± 2.9	25.3 ± 3.6	30.4 ± 5.9	39.9 ± 4.9	<0.0001
SF-36 (max 100)	52.7 ± 3.5	58.1 ± 5.7	65.3 ± 6.0	79.1 ± 8.9	<0.0001
VAS pain (max 10)	7.27 ± 0.8	6.97 ± 1.0	4.33 ± 1.6	2.17 ± 1.1	<0.0001

Key safety findings

Revisions and reoperations

Number of people analysed: 157
Follow up at time of assessment: mean 9.4 years

- The overall implant survival rate of was 99% after 9.4 years.
    - The implant was removed in 1 person because of osteoarthritis progression – this person was revised to UKA.
- The reoperation rate was 11% (n=17):
    - Revision surgery, n=1
    - Partial meniscectomy, n=12
    - Debridement, n=6

Complications

No complications were reported.

Study 6 Çepni Ş (2020)

Study details

Study type	Single centre, retrospective cohort study
Country	Turkey
Recruitment period	2014 to 2017
Study population and number	n=118 People with focal full-thickness knee cartilage lesions.
Age & sex	Mean 56.3 years; 81.4% female
Patient selection criteria	Inclusion criteria: people aged 40–65 years with a focal chondral lesion or defect of the medial or lateral femoral cartilage. Only lesions of ICRS grades 3 or 4 were included, with a maximum lesion area of 4 cm^2 or less. Exclusion criteria: people with BMI 35 kg/m^2 or more, generalised degenerative arthritis, chronic malalignment of the knee, ligamentous instability, symptomatic meniscal tear or total meniscectomy, kissing lesion on the tibia, metal allergies, inflammatory joint diseases, history of local and/or systemic corticosteroids, or the use of immunomodulating agents.
Technique	Implant: HemiCAP (61%) or BioPoly (38%). Technique: under either general or spinal anaesthesia, diagnostic arthroscopy was done to assess the defect. The diameter was measured, a guide wire inserted, and the defect was reamed. The implant was placed and recessed 1 mm deeper than surrounding cartilage. After surgery care: knee exercises on the 1st postoperative day, followed by gradually increasing weight-bearing. Full range of motion and weight bearing was permitted in the 6th week after surgery.
Follow-up	Mean 4.7 years
Conflict of interest/source of funding	Conflict of interest: The authors declared no conflict of interest. Source of funding: The authors declared that funding was not received.

Analysis

Follow up issues: A total of 143 people initially had treatment, of which 11 dropped out and 14 were lost to follow up.

Study design issues: This single centre retrospective cohort study assessed resurfacing for people with focal cartilage defects of the knee. Patient-reported outcomes included KOOS QoL, a VAS score for pain, and the Tegner activity score. The scoring of KOOS QoL, VAS for pain, and Tegner have been described in Outcome measures. Two-year follow up data was used for the analysis of KOOS QoL, VAS, and Tegner scores. Clinical and radiological outcomes were also assessed. These included the pain, loss of range of motion, allergies, infection, and wound problems.

Several significance tests were used depending on the type of data analysed. Univariate and multivariate regression were used to identify predictors for revision surgery, with all variables p<0.10 in univariate analysis entered into multivariate analysis. p<0.05 was considered statistically significant. There was no adjustment for multiple comparisons.

Study population issues: People who had BioPoly had a statistically significantly higher BMI than people who had HemiCAP implanted. People who had HemiCAP had statistically significantly higher preoperative scores on the VAS pain scale, indicating worse baseline pain. There were no other statistically significant differences in baseline characteristics between the groups.

Key efficacy findings

Patient-reported outcomes

Number of people analysed: 118
Follow up at time of assessment: 2 years

- In both treatment groups, there were statistically significant improvements in VAS pain (p<0.001 for both groups), KOOS QoL (p<0.001 for both groups), and Tegner activity score (p<0.001 for both groups) from assessment before surgery to 2 years after surgery.
- The following analyses compare outcomes between the treatment groups:
    - VAS Pain: At 2 years after surgery, people who had HemiCAP experienced a statistically significantly greater improvement in VAS pain than people who had BioPoly (p<0.001).
    - KOOS QoL: At 2 years after surgery, there was no difference in the change in KOOS QoL between people who had HemiCAP and people who had BioPoly (p=0.150).
    - Tegner Activity score: At 2 years after surgery, people who had HemiCAP experienced a statistically significantly greater improvement in Tegner Activity score than people who had BioPoly (p<0.001).

Patient-reported outcomes comparison of people who had BioPoly or HemiCAP

Outcome	Total (N=118)	BioPoly (n=45)	HemiCAP (n=73)	p-value
VAS pain				
Before surgery				<0.001
Mean ± SD	6.63 ± 0.90	5.89 ± 0.53	7.08 ± 0.77	
2 years after surgery				0.134
Mean ± SD	1.16 ± 0.70	1.29 ± 0.78	1.09 ± 0.64	
Difference (before versus after)				<0.001
Mean ± SD	-5.46 ± 1.22	-4.60 ± 0.91	-5.99 ± 1.07	
KOOS QoL Score				
Before surgery				0.828
Mean ± SD	54.97 ± 3.48	54.83 ± 3.68	55.05 ± 3.37	
2 years after surgery				0.052
Mean ± SD	86.45 ± 7.26	84.79 ± 8.58	87.47 ± 6.16	
Difference (before versus after)				0.150

Outcome	Total (N=118)	BioPoly (n=45)	HemiCAP (n=73)	p-value
Mean ± SD	31.48 ± 8.14	29.96 ± 9.16	32.41 ± 7.35	
Tegner Activity Score				
Before surgery				0.062
Mean ± SD	1.07 ± 0.73	1.22 ± 0.77	0.97 ± 0.69	
2 years after surgery				<0.001
Mean ± SD	2.96 ± 0.74	2.44 ± 0.66	3.27 ± 0.61	
Difference (before versus after)				<0.001
Mean ± SD	1.89 ± 0.99	1.22 ± 0.73	1.30 ± 0.89	

Key safety findings

Revisions

Number of people analysed: 118
Follow up at time of assessment: 4.7 years

- A total of 13 people (11.0%) needed revision surgery.
- A numerically higher proportion of people who had BioPoly implanted needed revisions (17.8%) than people who had HemiCAP implanted (6.8%; p=0.077).
    - In multivariate regression analysis, the BioPoly implant was a statistically significant risk factor for revision surgery:
        - Adjusted hazard ratio (95% CI): 6.90 (1.04 to 45.73; p=0.045)
        - Note: this analysis may be confounded because 3 of the revisions of the BioPoly implant were in people who experienced trauma leading to pain and loosening (see below).

- Reasons for revision surgery were listed as follows:
    - BioPoly (2 revised to UKA, 6 to TKA):
        - Progressive pain after trauma, implant loosening, chondral lesions in the patellofemoral compartment, n=2
        - Progressive pain after trauma, implant loosening, n=1
        - Progressive arthritis in the lateral compartment, n=2
        - Progressive arthritis in the medial compartment, n=2
        - Infection, n=1
    - HemiCAP (2 revised to UKA, 3 to TKA):
        - Generalized arthritis involving all compartments, n=2
        - Progressive arthritis in the lateral compartment, n=1
        - Progressive pain, implant loosening, generalised chondrolysis in all compartments, n=1
        - Infection, n=1

Study 7 Nathwani D (2017)

Study details

Study type	Single arm, multicentre, before-and-after study*
Country	UK
Recruitment period	Not reported
Study population and number	n=33 People with symptomatic femoral condyle lesions who had BioPoly implanted.
Age & sex	Mean 42.7 years; sex not reported
Patient selection criteria	Inclusion criteria: Age 21 years or older; symptomatic femoral condyle lesions classified as ICRS grade 2, 3, or 4; femoral condyle lesion size 3.1 cm^2 or less circumscribed by normal or nearly normal (ICRS grade 0 or 1) cartilage with an overall depth 4 mm or less from the articulating surface; sufficient subchondral bone quality to support implant. Exclusion criteria: BMI 30 kg/m^2 or more; generalised degenerative or autoimmune arthritis; gout; uncorrected chronic malalignment of the knee (could be included if corrected during surgery); uncorrected ligamentous instability (could be included if corrected during surgery); uncorrected mechanically symptomatic meniscal tear or total meniscectomy (could be included if corrected during surgery); kissing lesion on tibia; 1 implant or more needed to accommodate lesion; patient-reported allergy to titanium alloy, ultrahigh molecular weight polyethylene, or hyaluronan/hyaluronic acid; use with opposing articulating tibial components; any concomitant painful or disabling disease of the spine, hips, or lower limbs that would interfere with evaluation of the affected knee; pregnant, prisoner, vulnerable population, unable to provide informed consent.
Technique	Implant: BioPoly (100%) Technique: done using the approved BioPoly surgical technique. The implantation site was prepared with use of a bone-sparing technique to establish the correct implant orientation and depth relative to surrounding anatomy. Once the implantation site was deemed appropriate, the BioPoly implant was press-fit into the site. After surgery care: immediately after surgery, active motion and weight-bearing as tolerated were permitted. At 1 to 3 weeks, and continuing through 4 to 7 weeks, weight-bearing as tolerated and unrestricted range of motion as tolerated were permitted. At 8 to 11 weeks – return to full activity as tolerated.
Follow-up	Up to 2 years
Conflict of interest/source of funding	Conflict of interest: three authors reported receiving personal fees from BioPoly LLC, the manufacturers of the BioPoly implant. Source of funding: the study was funded by BioPoly LLC.

*This study was included in Elbardesy (2021).

Analysis

Follow up issues: This is an interim publication of a planned 5-year study. At the time of analysis, 24 people had completed the 6-month follow up, 22 had completed the 1-year follow up and 12 had completed the 2-year follow up.

Study design issues: This multicentre, before-and-after study assessed the 2-year outcomes of BioPoly for people with focal cartilage defects of the femoral condyles. The primary outcome measures were KOOS overall and subscores, a VAS score for pain, the SF-36 physical component score, and the Tegner activity score.

Before versus after surgery comparisons were done using 2-sample, 1-tailed t-tests. $p<0.025$ was considered significant.

Study population issues: Most people had a history of knee surgery (75.8%).

Key efficacy findings

Patient-reported outcomes

Number of people analysed: 33
Follow up at time of assessment: up to 2 years

- There were statistically significant improvements in KOOS overall (and component subscale scores), VAS pain, and the SF-36 physical component from before surgery to 6 months, 1 year, and 2 years after surgery (all $p<0.025$).
- There was a statistically significant improvement in Tegner activity score at 2 years after surgery compared with before surgery ($p<0.025$). There were no statistically significant differences in Tegner activity score at 6-month or 1-year follow up.

Patient-reported outcomes at 6 months, 1 year, and 2 years

	Before surgery (N=33)	6-month follow up (N=24)	1-year follow up (N=22)	2-year follow up (N=12)
KOOS overall	44.9 ± 18.0*	67.9 ± 15.9	67.3 ± 18.9	77.6 ± 16.6
Pain	51.9 ± 20.4*	76.9 ± 14.9	75.6 ± 18.5	81.2 ± 16.2
QoL	22.2 ± 18.4*	50.8 ± 26.7	48.9 ± 26.7	68.2 ± 22.5
Sports	30.0 ± 27.4*	56.9 ± 22.1	56.4 ± 29.3	69.2 ± 25.8
ADL	64.2 ± 24.3*	84.9 ± 14.3	84.4 ± 16.1	89.0 ± 15.7
Symptoms	56.2 ± 20.6*	70.2 ± 18.0	71.3 ± 19.2	80.4 ± 12.9
VAS pain	4.1 ± 2.5*	2.4 ± 2.4	2.0 ± 2.0	1.4 ± 2.2
SF-36 physical	42.3 ± 32.0*	69.7 ± 28.2	71.0 ± 27.7	81.9 ± 30.8
Tegner activity	2.5 ± 1.7**	3.3 ± 1.4	3.1 ± 1.9	4.0 ± 1.9

*$p<0.025$ compared with scores at 6 months, 1 year, and 2 years.
**$p<0.025$ compared with score at 2 years.

Key safety findings

Revisions

Number of people analysed: 33
Follow up at time of assessment: Up to 2 years

- One person was revised after the 2-year follow up because of the failure of osseointegration.
    - This person was managed with an alternative biological treatment.

Complications

Number of people analysed: 33
Follow up at time of assessment: Up to 2 years

No device-related adverse events were reported.

The following adverse events were reported as non-device-related:

- Knee pain (arthralgia), n=9
    - Pain was localised to the contralateral compartment in 4 of these people.
- Wound infection, n=1
- Stiffness, n=1
- Swelling, n=2
- Crepitation, n=3
- Loose cartilage body, n=1
    - Identified in the operatively treated knee 4 months postoperatively. Necessitated arthroscopic surgery but was not related to the implant. The implant was assessed and was deemed to be functioning and well fixed.

Study 8 Ryd L (2021)

Study details

Study type	Consecutive case series
Country	Not reported
Recruitment period	2012 to 2020
Study population and number	n=612 knees, 682 implants People who had Episealer implanted for focal cartilage defects of the knee
Age & sex	Mean 48.6 years; sex not reported
Patient selection criteria	All postmarket surveillance records from all people in the manufacturer-held database without any exclusions from December 2012 (first implant) to June 2020.
Technique	Implant: Episealer (100%) Technique: Approved Episealer surgical approach. A 3-dimensional magnetic resonance imaging (MRI) scan was taken of the affected knee. The implant was then customised to fit the defect. Implantation was done using a person-specific instrumentation and drill guide which allowed precise placement and fine-tuning of the implant recession depth.
Follow-up	Up to 7 years
Conflict of interest/source of funding	Conflict of interest: 2 authors are paid consultants to Episurf Medical AB, the manufacturer of Episealer. The other author is an employee of Episurf Medical AB. Source of funding: Not reported, likely company funded.

Analysis

Follow up issues: One patient operated upon in 2018 died from unrelated causes in 2019 but was included in the analysis.

Study design issues: This multicentre, consecutive case series analysed the rate of revisions of the Episealer implant for people with focal condyle or trochlear cartilage defects. The outcome of this analysis was revision rates.

Implant revision rate was calculated using a Kaplan-Meier analysis. To calculate the cumulative revision rate, the number of knees ‘at risk’ of revision at the beginning of each year of follow up was determined. The number of revisions during each year of follow up was registered and divided by the numbers ‘at risk’ during that period and expressed as a percentage. These yearly percentages were added together to give a cumulative revision rate.

Key safety findings

Revisions

Number of people analysed: 612 knees
Follow up at time of assessment: up to 7 years

- A total of 14 of the 612 operated knees were revised, giving a crude revision rate of 2.3%.
- Using Kaplan-Meier analysis, implant survivorship at 7 years of follow up was 95.95%.
    - [Note: in the publication, it is stated that *'Kaplan-Meier survivorship at 6 years of follow-up was 96.3%*'. It is unclear why this figure is different to the data provided in the table.]

Cumulative revision of Episealer implant to 7-year follow up

Time (months)	Number at risk	Cumulative number revised	Implant survival		
			Estimate, %	95% confidence lower bound	95% confidence upper bound
0	612	-	-	-	-
12	478	4	99.25	98.02	99.72
24	327	7	98.57	97.01	99.32
36	191	14	95.95	93.08	97.64
48	97	14	95.95	93.08	97.64
60	42	14	95.95	93.08	97.64
72	15	14	95.95	93.08	97.64
84	4	14	95.95	93.08	97.64

- Reasons for revision (some people had multiple reasons):
    - Pain, n=6
    - Disease progression, n=2
    - Multiple lesions, n=2
    - Implant was too small, n=2
    - Trauma after surgery, n=1
    - Metal allergy, n=1
    - Borderline indication, n=1
    - Tibial cartilage wear, n=1
    - Infection, n=1
    - Unknown, n=1
    - High tibial osteotomy failed, n=1

Study 9 Holz J (2021)

Study details

Study type	Single arm, multicentre, before-and-after study*
Country	Belgium, Denmark, Germany, The Netherlands, Sweden, UK
Recruitment period	2013 to 2017
Study population and number	n=75 People who had Episealer for symptomatic cartilage defects in the knee
Age & sex	Mean 48 years; 59% female
Patient selection criteria	Inclusion criteria (selected): 18 years of age or older; focal femoral chondral or osteochondral lesions: ICRS 3 to 4–b; symptoms of pain and disability; failed conservative treatment. Exclusion criteria (selected): younger than 35 years of age or older than 70 years; bone on bone disease; multifocal chondral defects; severe chondral lesion (ICRS 3 to 4) on opposing surface; systemic and/or inflammatory joint disease; inflammatory arthritis or radiographic osteoarthritis; joint instability or malalignment that is not correctable at the time of treatment.
Technique	Implant: Episealer (100%). A total of 60 people had medial condyle lesions, 5 had lateral condyle lesions, and 10 had trochlear lesions. Technique: Approved Episealer surgical approach. A 3-dimensional MRI scan was taken of the affected knee. The implant was then customised to fit the defect. Implantation was done using a person-specific instrumentation and drill guide which allowed precise placement and fine-tuning of the implant recession depth. After surgery care: Full unrestricted motion was allowed from the outset. Protected touch weight bearing for 2 weeks followed by gradual progression to full weight bearing over the subsequent 2 weeks. Cycling and strength work could commence at 6 weeks building up proprioception and core control over a 6-month period before allowing return to activities.
Follow-up	2 years
Conflict of interest/source of funding	Conflict of interest: 4 authors are consultants for Episurf Medical AB, the manufacturer of Episealer. Source of funding: The authors report that no additional funding was received for this study.

*The people in this study were likely also included in Ryd (2021).

Analysis

Follow up issues: Of 80 people who had Episealer, 1 declined to participate in the final analysis. A further 4 people were excluded from the final analysis: 2 because of failure to complete outcome measures at set points, and 2 because they were revised during the study period.

Study design issues: This multicentre, before-and-after study evaluated the 2-year outcomes of a customised implant for people with focal chondral defects of the knee. Outcome measures included overall KOOS and

component subscale scores, and VAS for pain. KOOS was evaluated against a MCID of 10. This is recommended by the publisher of the KOOS. However, they note that 'Recent publications highlight that there is probably no such thing as one MIC for KOOS'. Outcomes were assessed at 3 months, 1 year, and 2 years.

Each clinical outcome score at different time points was compared against before surgery values, using 1-sample, 2-tailed paired t-tests. $p<0.05$ was considered statistically significant. Linear mixed-effects models were used to analyse the progression of outcome scores over the study. Categorical data were analysed against other variables using Chi^2 test, and significance of variation in clinically important difference using 2-tailed Fisher's exact test. There was no adjustment for multiple comparisons.

Study population issues: 48 people had previous treatment for their cartilage lesions. Thirty-one of these people had microfracture.

Key efficacy findings

Patient-reported outcomes

Number of people analysed: 75
Follow up at time of assessment: up to 2 years

- There were statistically significant improvements in all outcome measures from before surgery to 3-month, 1-year, and 2-year follow up ($p<0.0001$ to $p=0.024$).
    - There were no statistically significant differences in outcome score between groups according to implant type, lesion size, or previous repair surgery ($p>0.05$).

Change in patient-reported outcome measures over time

Clinical outcome	Time (months)	Mean change from before surgery	SD	95% CI	p-value at each time point	p-value over time
KOOS-Pain	3	16.73	2.77	11.20 to 22.25	<0.0001	
	12	22.92	3.46	16.02 to 29.82	<0.0001	
	24	26.28	3.22	19.86 to 32.70	<0.0001	0.002
KOOS-Symptoms	3	8.05	2.79	2.48 to 13.62	0.005	
	12	17.58	2.95	11.70 to 23.46	<0.0001	
	24	18.30	2.81	12.70 to 23.90	<0.0001	<0.0001
KOOS-ADL	3	16.42	2.85	10.73 to 22.10	<0.0001	
	12	24.75	3.28	18.20 to 31.29	<0.0001	
	24	22.75	3.18	16.42 to 29.09	<0.0001	<0.0001
KOOS-Sport	3	9.47	4.1	1.28 to 17.66	0.024	
	12	23.06	4.53	14.02 to 32.09	<0.0001	
	24	25.27	4.13	17.04 to 33.50	<0.0001	0.002
KOOS-QoL	3	14.60	3.17	8.27 to 20.92	<0.0001	
	12	24.05	3.76	16.54 to 31.55	<0.0001	
	24	25.26	3.57	18.14 to 32.37	<0.0001	<0.0001
VAS pain	3	26.31	3.22	19.89 to 32.73	<0.0001	
	12	27.12	4.29	18.57 to 35.67	<0.0001	

Clinical outcome	Time (months)	Mean change from before surgery	SD	95% CI	p-value at each time point	p-value over time
	24	30.22	3.95	22.34 to 38.11	<0.0001	<0.0001

Key safety findings

Revisions

Number of people analysed: 75
Follow up at time of assessment: 27 months

- A total of 3 people were revised, 2 during the 24-month follow up, and 1 at 27 months. This resulted in an overall revision rate of 4%.
- Reasons for revision were as follows:
    - Within the 24-month study period:
        - 1 person had an atypical lesion with significant bone marrow oedema condyle before surgery. Did not improve following implantation and represented with increased pain at 15 months. The implant was revised to a unicompartmental arthroplasty.
        - 1 person had cysts persisting from previous OATS plugs. Symptoms did not improve, and the implant was revised at 19 months to bone grafting and coverage with a chondrogide membrane.
    - At 27 months follow up:
        - 1 person reported severe pain. Implant was found to be loose, and cultures suggested infection. Revised to unicompartmental arthroplasty.

Complications

Number of people analysed: 75
Follow up at time of assessment: 27 months

Complications are poorly described. The publication states:

- 'Two patients underwent arthroscopy for painful mechanical clicking and for debridement of scar tissue, with both improving, and one patient developed a [deep vein thrombosis].'
    - It is not clear whether the people having arthroscopy both had painful mechanical clicking *and* needed debridement of scar tissue, or whether 1 person had painful mechanical clicking and the other needed debridement of scar tissue.
    - It is also unclear whether the deep vein thrombosis occurred in a person who had arthroscopy or another person.
    - The cause, severity, or treatment of the deep vein thrombosis is not described.

Validity and generalisability of the studies

- CE-marked devices (HemiCAP, UniCAP, Episealer, and BioPoly) were used in all studies.
- It is not clear which implant produces the most favourable outcomes. There was some evidence of high revision rates from the Australian Orthopaedic Association National Joint Replacement Registry for the HemiCAP implant. However, Christensen (2021) showed substantially lower revision rates. In the 1 comparative study (Çepni, 2020), BioPoly was found to be a statistically significant predictor of revision (versus HemiCAP), though this analysis may have been confounded by trauma in several people with BioPoly. Evidence from Ryd (2021) showed that the revision rate of Episealer may be relatively low.
- Several publications noted that improper patient and device selection may have resulted in higher revision rates.
- The Episealer implant is customised based on an MRI scan of the defect site. The BioPoly and HemiCAP/UniCAP implants are selected from catalogues of multiple sizes to closely fit the defect site.
- Studies were conducted in Australia, Belgium. Denmark, Germany, Ireland, Sweden, The Netherlands, Turkey, UK. Therefore, it is likely that the evidence is generalisable to UK clinical practice.
- Studies did not report adjustment for multiple comparisons. Testing many hypotheses without adjustment for multiple comparisons increases the likelihood of finding a statistically significant difference between sets of data that are only different due to chance.
- Studies mainly had an observational or quasi-experimental design. There were no randomised experimental studies identified. As this procedure is aimed at people for whom biological treatment or arthroplasty may be unsuitable, these study designs are appropriate.
- Primary outcomes were typically assessed at 2 years after surgery. The longest follow up was 12 years.

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.

Interventional procedures

- Mosaicplasty for symptomatic articular cartilage defects of the knee. NICE Interventional procedures guidance IPG607 (2018). Available from https://www.nice.org.uk/guidance/ipg607
- Microstructural scaffold (patch) insertion without autologous cell implantation for repairing symptomatic chondral knee defects. NICE Interventional procedures guidance 560 (2016). Available from https://www.nice.org.uk/guidance/ipg560
- Arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee. NICE Interventional procedures guidance IPG493 (2014). Available from https://www.nice.org.uk/guidance/ipg493
- Partial replacement of the meniscus of the knee using a biodegradable scaffold. NICE Interventional procedures guidance IPG430 (2012). Available from https://www.nice.org.uk/guidance/ipg430

Technology appraisals

- Autologous chondrocyte implantation for treating symptomatic articular cartilage defects of the knee. NICE Technology appraisal TA477 (replaced TA 89) (2017). Available from https://www.nice.org.uk/guidance/ta477
- Autologous chondrocyte implantation using chondrosphere for treating symptomatic articular cartilage defects of the knee. NICE Technology appraisal TA508 (2018). Available from https://www.nice.org.uk/guidance/ta508
- Autologous chondrocyte implantation using 3D collagen matrix (novocart 3D) for treating articular cartilage defects of the knee [ID2707] [GID-TA10667]. Expected publication date: TBC – suspended.

NICE guidelines

- Osteoarthritis: care and management. NICE guideline CG177 (updated December 2020). https://www.nice.org.uk/guidance/cg177

Additional information considered by IPAC

Professional experts' opinions

Expert advice was sought from consultants who have been nominated or ratified by their professional Society or Royal College. The advice received is their individual opinion and is not intended to represent the view of the society. The advice provided by professional experts, in the form of the completed questionnaires, is normally published in full on the NICE website during public consultation, except in circumstances but not limited to, where comments are considered voluminous, or publication would be unlawful or inappropriate.

Two professional expert questionnaires for focal articular resurfacing implants for treating articular cartilage defects in the knee were submitted and can be found on the NICE website.

Patient commentators' opinions

NICE's Public Involvement Programme sent questionnaires to NHS trusts for distribution to patients who had the procedure (or their carers). NICE received 7 completed questionnaires.

The patient commentators' views on the procedure were consistent with the published evidence and the opinions of the professional experts.

Company engagement

A structured information request was sent to 3 companies who manufacture a potentially relevant device for use in this procedure. NICE received 2 completed submissions. These were considered by the IP team and any relevant points have been taken into consideration when preparing this overview.

Issues for consideration by IPAC

- The following are ongoing studies for the BioPoly and Episealer implants:
    - NCT01473199: BioPoly RS Knee Registry Study for Cartilage Defect Replacement. Multicentre, open label, prospective, consecutive series registry database. Single group, n=38 people with focal cartilage defects of the femoral condyles treated with the BioPoly RS partial resurfacing knee implant; primary outcome: change in KOOS at 6 months and 2 years; location UK; study completion date December 2021. Status Active, not recruiting.

- NCT02991300: BioPoly RS partial resurfacing patellofemoral registry study; open label, prospective, consecutive series registry database of BioPoly RS partial resurfacing patellofemoral implant. Single group, n=35 people with focal cartilage defects of the patellofemoral compartment. Primary outcomes: KOOS sub-scores, Kujala anterior knee pain scale, QoL (SF-36), activity using Tegner score, pain using VAS score. Planned follow up: 5 years, location UK; completion date September 2026. Status Recruiting.

- NCT04000659: Episealer Knee System IDE Clinical Study. Randomized (2:1), prospective, multicentre, controlled trial of the Episealer Knee System for patients with a focal femoral knee chondral or osteochondral lesion. Episealer knee system compared with microfracture (with or without debridement). Two groups, n=180 people, primary outcome: KOOS sub-scores, VAS pain scores, incidence of secondary surgical intervention, subsidence or migration at 24 months, and weight bearing status at 8 weeks; location UK, US, Denmark, Germany; estimated completion date June 2022. Status Recruiting.

- NCT03755388: Clinical Trial of an MRI Based Patient Specific Focal Knee Resurfacing Implant. Long-term prospective interventional clinical trial of an MRI based patient specific focal knee resurfacing implant - Episealer 2 Study. Single group, n=30 people. Primary outcome is 10-year survival of the Episealer implant. Location Belgium; estimated completion date December 2032. Status recruiting.

References

1. Elbardesy H, Nagle M, Simmons L, and Harty J. (2021) The partial femoral condyle focal resurfacing (HemiCAP-UniCAP) for treatment of full-thickness cartilage defects, systematic review and meta-analysis. Acta orthopaedica Belgica 87(1):93-102.
2. Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Hip, Knee & Shoulder Arthroplasty: 2020 Annual Report.
3. Christensen BB, El-Galaly A, Laursen JO, Lind M (2021) Eighty Percent Survival of Resurfacing Implants in the Knee After 10 Years: A Nationwide Cohort Study on 379 Procedures from the Danish Knee Arthroplasty Registry. Cartilage.
4. Megaloikonomos PD, Becher C, van der Stok J, and O'Donnell T. (2021) Femoral condyle resurfacing using an inlay metal implant: low revision rate of 266 patients in a 5-10 years follow-up. Archives of Orthopaedic and Trauma Surgery.
5. van der Stok J, van Buul GM, Stanclik J et al. (2022) Focal articular surface replacement as primary treatment for focal chondral defects of the femoral condyles: A series of 157 cases. The Knee 34:108-17.
6. Çepni Ş, Veizi E, Tahta M et al. (2020) Focal metallic inlay resurfacing prosthesis in articular cartilage defects: short-term results of 118 patients and 2 different implants. Archives of orthopaedic and trauma surgery 140(2):209-18
7. Nathwani D, McNicholas M, Hart A et al. (2017) Partial Resurfacing of the Knee with the BioPoly Implant: Interim Report at 2 Years. JB & JS open access 2(2)
8. Ryd L, Flodström K, and Manley MT (2020). Patient-Specific Implants for Focal Cartilage Lesions in The Knee: Implant Survivorship Analysis up to Seven Years Post-Implantation. Surgical technology international 37
9. Holz J, Spalding T, Boutefnouchet T et al. (2021) Patient-specific metal implants for focal chondral and osteochondral lesions in the knee; excellent clinical results at 2 years. Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA 29(9):2899-910

Literature search strategy

Databases	Date searched	Version/files
Cochrane Database of Systematic Reviews – CDSR (Cochrane Library)	05/04/2022	Issue 4 of 12, April 2022
Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library)	05/04/2022	Issue 3 of 12, March 2022
International HTA database (INAHTA)	05/04/2022	
MEDLINE (Ovid)	05/04/2022	1946 to April 04, 2022
MEDLINE In-Process (Ovid)	05/04/2022	1946 to April 04, 2022
MEDLINE Epubs ahead of print (Ovid)	05/04/2022	April 04, 2022
EMBASE (Ovid)	05/04/2022	1974 to 2022 April 04

Trial sources searched April 2022

- Clinicaltrials.gov
- ISRCTN
- WHO International Clinical Trials Registry

Websites searched April 2022

- National Institute for Health and Care Excellence (NICE)
- NHS England
- Food and Drug Administration (FDA) - MAUDE database
- Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP – S)
- Australia and New Zealand Horizon Scanning Network (ANZHSN)
- General internet search

MEDLINE search strategy

The MEDLINE search strategy was translated for use in the other sources.

Strategy used:

1 ((chondral or osteochondral or chondrocyt* or chondroblast* or osteochondriti*) adj4 (defect* or damag* or injur* or lesion*)).tw.

2 ((knee* or patella* or trochlea* or cartilage or chondrocyte* or condyle* or chondropath*) adj4 (defect* or damag* or injur* or lesion* or osteoarthritis or disease*)).tw.

3 Knee Injuries/

4	Osteochondritis/
5	exp Cartilage Diseases/
6	Osteoarthritis, Knee/
7	or/1-6
8	(inlay adj4 resurfac* adj4 prosthesis).tw.
9	((focal* or femoral*) adj4 (implant* or resurfac* or replac*)).tw.
10	(knee* adj4 resurfac*).tw.
11	Knee Joint/
12	"Prostheses and Implants"/
13	11 and 12
14	8 or 9 or 10 or 13
15	7 and 14
16	HemiCAP.tw.
17	UniCAP.tw.
18	Episealer.tw.
19	Biopoly.tw.
20	or/16-19
21	15 or 20
22	limit 21 to english language
23	Animals/ not Humans/
24	22 not 23

Appendix

The following table outlines the studies that are considered potentially relevant to the IP overview but were not included in the summary of the key evidence. It is by no means an exhaustive list of potentially relevant studies.

Additional papers identified

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
Al-Bayati M, Martinez-Carranza N, Roberts D et al. (2021) Good subjective outcome and low risk of revision surgery with a novel customized metal implant for focal femoral chondral lesions at a follow-up after a minimum of 5 years. Archives of Orthopaedic and Trauma Surgery	n=10 FU=75 months	A good subjective outcome, a low risk of progression to degenerative changes and the need for subsequent surgery were seen at the mid-term follow-up with the Episealer customised focal knee-resurfacing implant.	Studies with more people or longer follow up are included.
Becher C, Kalbe C, Thermann H et al. (2011) Minimum 5-year results of focal articular prosthetic resurfacing for the treatment of full-thickness articular cartilage defects in the knee. Archives of orthopaedic and trauma surgery 131(8):1135-43	n=21 FU=5.3 years	HemiCAP appears to be an effective reconstructive treatment option for large full-thickness cartilage and osteochondral lesions of the knee in middle-aged people.	Studies with more people or longer follow up are included. Revision rates reported by Elbardesy (2021).
Becher C and Cantiller EB. (2017) Focal articular prosthetic resurfacing for the treatment of full-thickness articular cartilage defects in	n=2 FU=12 years	In a 12-year follow up of 2 people who had treatment with the HemiCAP implant, the results suggest that focal articular prosthetic resurfacing is an	Studies with more people included. Revision rates reported by Elbardesy (2021).

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
the knee: 12-year follow-up of two cases and review of the literature. Archives of orthopaedic and trauma surgery 137(9):1307-17		effective and safe treatment option in selected people.	
Beyzadeoglu T and Pehlivanoglu T. (2018) Biological Response Following Inlay Arthroplasty of the Knee: Cartilage Flow Over the Implant. Cartilage 9(2):156-60	n=35 people, 41 knees FU=14 months	Joint surface reconstruction using the HemiCAP implant showed stable fixation with peripheral cartilage coverage ranging from 9% to 20% and no further chondral damage on opposing surfaces.	Studies with more people or longer follow up are included.
Bollars P, Bosquet M, Vandekerckhove B et al. (2012) Prosthetic inlay resurfacing for the treatment of focal, full thickness cartilage defects of the femoral condyle: a bridge between biologics and conventional arthroplasty. Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA 20(9):1753-9	n=19 FU=34 months	Focal femoral condyle resurfacing showed excellent results for pain and function in middle-aged, well selected people with full thickness cartilage and osteochondral defects. Patient profiling and assessment of confounding factors, mechanical joint alignment; meniscal function; and healthy opposing cartilage surfaces, are important for an individual treatment approach and successful outcomes.	Studies with more people or longer follow up are included. Revision rates reported by Elbardesy (2021).
Cases E, Natera L, Anton C et al. (2020) Focal inlay resurfacing for full-thickness chondral defects of the femoral medial condyle may delay the progression to varus deformity.	n=10 FU=9 years	In the setting of small to moderate size, unique femoral medial condyle full-thickness chondral lesions, filling the defect with an inlay prosthetic resurfacing may protect against the progression to varus deformity.	Studies with more people included.

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
European journal of orthopaedic surgery & traumatology: orthopedie traumatologie 31(1):57-63			
Davidson PA and Rivenburgh D. (2008) Focal Anatomic Patellofemoral Inlay Resurfacing: Theoretic Basis, Surgical Technique, and Case Reports. Orthopedic Clinics of North America 39(3):337-46	n=2 FU=3 months	Both people had the HemiCAP patellofemoral implant had successful outcomes.	Studies with more people or longer follow up are included.
Defrere J and Franckart A. (1992) Teflon/polyurethane arthroplasty of the knee: the first 2 years preliminary clinical experience in a new concept of artificial resurfacing of full thickness cartilage lesions of the knee. Acta chirurgica Belgica 92(5):217-27	n=23 people, 37 implants FU=2 years	Teflon/polyurethane composite implant was successful as a prosthetic knee resurface implant and shows good biocompatibility. However, the use of unicompartmental bipolar implants should be avoided.	Studies with more people or longer follow up are included.
Dhollander AAM, Almqvist KF, Moens K et al. (2015) The use of a prosthetic inlay resurfacing as a salvage procedure for a failed cartilage repair. Knee surgery, sports traumatology, arthroscopy:official journal of the ESSKA 23(8):2208-2212	n=14 FU=26.1 months	The HemiCAP resurfacing system is feasible as a salvage treatment for a failed index cartilage procedure and resulted in a gradual clinical improvement. However, the favourable clinical outcome was not confirmed by the radiographical findings.	Studies with more people or longer follow up are included. Revision rates reported by Elbardesy (2021).

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
Fuchs A, Eberbach H, Izadpanah K et al. (2018) Focal metallic inlay resurfacing prosthesis for the treatment of localized cartilage defects of the femoral condyles: a systematic review of clinical studies. Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA 26(9):2722-32	n=6 studies, 186 people FU=ranged from 2 to 7 years	Focal metallic inlay resurfacing prosthesis seems to be a viable option for a carefully selected group of people. Significant improvement in knee function and pain was seen in most people, though 20% needed to be converted to arthroplasty after 4 years. Uncertainty remains about progression of osteoarthritis because of conflicting results and inconsistent reporting. Lower rates of revision were seen with the UniCAP implant than the smaller HemiCAP implant.	More recent systematic review included.
Hobbs H, Ketse-Matiwane N, van der Merwe W et al. (2013) Focal full thickness articular cartilage lesions treated with an articular resurfacing prosthesis in the middle-aged. SA Orthopaedic Journal.	n=22 FU=4.7 years	HemiCAP articular resurfacing is an effective treatment option for pain in the middle-aged patient with a focal articular cartilage defect in the knee.	Studies with more people or longer follow up are included. Revision rates reported by Elbardesy (2021).
Jeuken RM, van Hugten PPW, Roth AK et al. (2021) A Systematic Review of Focal Cartilage Defect Treatments in Middle-Aged Versus Younger Patients. Orthopaedic Journal of Sports Medicine 9(10)	n=2 studies	Two studies were included that used the Episealer implant – Martinez-Carranza (2020) and Holz (2021). Both found statistically significant improvements in patient-reported outcome measures.	More recent systematic review included. Holz (2021) included.

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
Laursen JO. (2017) 3-Year Clinical Result of a Customized Metal Mini-Prosthesis for Focal Chondral Lesion in The Knee Of A Formerly Active 31-Year-Old Man. Journal of Exercise, Sports & Orthopedics 2(4):1-3	n=1 FU=3 years	In a 31-year-old formerly active man. focal condyle cartilage lesion did not respond to microfracture. Use of Episealer to repair lesion was successful over 3 years of follow up.	Studies with more people or longer follow up are included.
Laursen JO and Lind M. (2017) Treatment of full-thickness femoral cartilage lesions using condyle resurfacing prosthesis. Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA 25(3):746-51	n=61 FU=2 years	This study showed improved subjective outcome and reduced pain after femoral resurfacing using the HemiCAP implant in a relatively large cohort of people with symptomatic cartilage lesions. A 23% reoperation rate with conversion to arthroplasty was found.	Studies with more people or longer follow up are included. Revision rates reported by Elbardesy (2021).
Laursen JO. (2016) Treatment of full-thickness cartilage lesions and early OA using large condyle resurfacing prosthesis: UniCAP(R). Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA 24(5):1695-701	n=64 FU=2 years	This study showed an improved subjective outcome and reduced pain after femoral resurfacing using the UniCAP implant in a relatively large cohort of people with symptomatic large cartilage lesions or early OA. A 47% reoperation rate with conversion to arthroplasty was found.	Studies with more people or longer follow up are included. Revision rates reported by Elbardesy (2021).
Laursen JO, Mogensen CB, and Skjot-Arkil H. (2019) HemiCAP Knee Implants: Mid- to Long-Term Results. Cartilage.	n=62 FU=7.3 years	This study found good clinical and radiographic outcomes, and for those people who did not need revisions, there were long-term improvements in disability and function.	Studies with more people or longer follow up included. Revision rates reported by Elbardesy (2021).

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
Laursen JO, Backer Mogensen C, and Skjot-Arkil H. (2019) UniCAP offers a long-term treatment for middle-aged patients, who are not revised within the first 9 years. Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA 27(5):1693-7	n=64 FU=mean 7.2 years, max 9 years	There was a survival rate of approximately 40% after 9 years of follow-up, but in the group of people (35 to 65 years old) not eligible for a final total arthroplasty. These people were often left with pain and disability. This implant can be a temporary or even long-term treatment because it improved the disability and function over the long-term without a major progression in the osteoarthritis, function or pain	High dropout rate, studies with more people or longer follow up included.
Laursen JO, Mogensen CB, Skjot-Arkil H et al. (2020) A long-term prospective follow-up study of resurfacing mini-prosthesis suitable for patients above sixty-five years with localized cartilage lesions or early osteoarthritis in the knee. Journal of Experimental Orthopaedics 7(1):96	n=23 FU=9.6 years	HemiCAP/UniCAP implant treatment for early OA in people older than 65 years can need revision to knee arthroplasty in 30% of people. But in people that are not revised, long-term improvements in subjective clinical outcome was shown.	Studies with more people included. Incomplete follow-up (10 people).
Malahias MA, Thorey F, and Chytas D. (2018) The clinical outcome of the different hemiCAP and uniCAP knee implants: A systematic and comprehensive review. Orthopedic Reviews 10(2):58-64	n=10 studies FU=2 to 7 years	The progression of osteoarthritis, the persisting pain and the subsequent high revision or failure rates in the limited available studies with long-term follow-up, seem to be the major drawbacks of partial resurfacing techniques. Utilisation of partial	More recent systematic review included.

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
		resurfacing for femoral or patellofemoral compartments results in good short-term outcome for middle-aged people as a step between biological technique and TKA.	
Martinez-Carranza N, Rockborn P, Roberts D et al. (2020) Successful Treatment of Femoral Chondral Lesions with a Novel Customized Metal Implant at Midterm Follow-Up. Cartilage	n=30 FU=55 months	This customised resurfacing metal implant showed good safety and patient satisfaction. The risk of osteoarthritis progression and implant loosening is low. Subjective function and pain improved statistically significantly.	Studies with more people or longer follow up are included.
Moewis P, Kaiser R, Trepczynski A et al. (2021) Patient-specific resurfacing implant knee surgery in subjects with early osteoarthritis results in medial pivot and lateral femoral rollback during flexion: a retrospective pilot study. Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA.	n=10 FU=1 year	A clear physiological knee kinematics pattern of medial pivot, lateral femoral rollback and coupled axial external femoral rotation during flexion was seen in patients who had treatment with an Episealer resurfacing procedure. However, higher femoral rollback and axial external rotation in comparison to healthy knees was seen, suggesting possible postoperative muscle weakness and consequent insufficient stabilization at high flexion.	Studies with more people or longer follow up are included.
Nahas S, Monem M, Li L et al. (2020) Ten-Year Average Full Follow-up and Evaluation of a	n=14 FU=8.9 years	This series shows that focal resurfacing is a safe, suitable, and useful temporising step in knee arthroplasty surgery. The	Studies with more people are included. Revision rates reported by Elbardesy (2021).

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
Contoured Focal Resurface Prosthesis (HemiCAP) in Patients in the United Kingdom. The journal of knee surgery 33(10):966-70		use of the focal resurfacing implant in this way allows the delay in transition to knee arthroplasty. This series shows an excellent functional outcome for remaining implants at average 10 years, with low complication rates.	
Pascual-Garrido C, Daley E, Verma NN, and Cole BJ. (2017) A Comparison of the Outcomes for Cartilage Defects of the Knee Treated With Biologic Resurfacing Versus Focal Metallic Implants. Arthroscopy: the journal of arthroscopic & related surgery: official publication of the Arthroscopy Association of North America and the International Arthroscopy Association 33(2):364-73	n=32 FU=2 years	Careful person selection can achieve high satisfaction rates with both biological and focal metal resurfacing procedures for the treatment of isolated focal chondral lesions of the femoral condyle in the knee. Focal metallic resurfacing results in similar clinical outcomes and provides excellent success rates at short-term follow-up.	Studies with more people or longer follow up are included. Revision rates reported by Elbardesy (2021).
Stålman A, Skoldenberg O, Martinez-Carranza N et al. (2018) No implant migration and good subjective outcome of a novel customized femoral resurfacing metal implant for focal chondral lesions. Knee surgery, sports	n=10 FU=2 years	The short-term Episealer implant safety and patient-related outcome measures showed good-to-excellent results.	Studies with more people or longer follow up are included.

Article	Number of patients/ follow up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
traumatology, arthroscopy: official journal of the ESSKA 26(7):2196-204			
van Buul GM, Headon R, O'Toole G et al. (2020) Does resurfacing of asymptomatic full-thickness localized articular defects of the trochlear influence the outcome following unicompartmental knee arthroplasty of the medial compartment?: A retrospective cohort study with minimum seven-year follow-up. The Knee 27(5):1492-1500	n=30 FU=97.4 months	This study found a 100% survivorship of the HemiCAP PFC implant at an average 8-year follow-up. However, no clinical benefits were found in doing trochlear resurfacing in conjunction with medial UKA for asymptomatic end-stage trochlear cartilage lesions. Therefore, these lesions can be safely ignored when doing a medial UKA.	Studies with more people or longer follow up are included. All people also had UKA.
van Buul GM, Stanclik J, van der Stok J et al. (2021) Focal articular surface replacement of knee lesions after failed cartilage repair using focal metallic implants: A series of 132 cases with 4-year follow-up. The Knee 29: 134-41	n=32 FU=4 years	This report shows good to excellent clinical results of resurfacing as a salvage procedure after failed cartilage repair, with a low re-operation rate and a high survival of 97.7% at 4-year follow-up.	Studies with more people or longer follow up are included.

Abbreviations: FU, follow-up.