NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee

The cartilage over the ends of bones in the knee joint (articular cartilage) can be damaged by trauma, resulting in isolated (discrete) defects. Radiofrequency chondroplasty aims to reduce further damage by using heat to smooth and contour the rough edges of a defect.

Introduction

The National Institute for Health and Care Excellence (NICE) has prepared this interventional procedure (IP) 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 IP overview was prepared in July 2013.

Procedure name

Arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee.

Specialist societies

British Association for Surgery of the Knee

British Orthopaedic Association

British Society of Rheumatology

Description

Indications and current treatment

Discrete chondral defects usually occur in articular cartilage as a result of trauma. The rough, irregular edges a defect may cause inflammation, swelling, pain and difficulty walking. Progressive degeneration of a chondral defect can lead to exposure of the underlying bone and result in arthritis. If pieces of cartilage break off from the edges of a defect they may lead to cartilage damage elsewhere in the knee, with subsequent arthritic changes.

Treatment options depend on the size and site of the chondral defect. The condition is usually chronic, and different treatment strategies may be needed at different stages. Conservative treatments include analgesics, corticosteroid injections and hyaluronic acid injections to relieve pain and inflammation. Physiotherapy and/or prescribed exercise may also be used to improve knee function and mobility.

What the procedure involves

Radiofrequency chondroplasty aims to slow the progression of discrete chondral defects by removing the unstable edges of the defect, producing a smooth, stable articular cartilage surface. The procedure is usually done with the patient under general anaesthesia. An arthroscope is inserted into the knee and large chondral defects are trimmed from the weight-bearing surfaces of the femoral condyles, using instruments such as a blunt hook or electric shaver. Under arthroscopic guidance, a radiofrequency probe is then used to smooth the edge of the cartilage defect with irrigation to stabilise temperature and flush any debris. The aim is to improve mechanical stability and prevent further progression of cartilage damage.

Chondral lesion classification

The Outerbridge classification system is the most widely used grading system to describe the size and depth of cartilage defects. The system has 5 categories:

- Grade 0: normal cartilage.
- Grade I: cartilage with softening and swelling.
- Grade II: a partial-thickness defect with fissures on the surface that do not reach subchondral bone or exceed 1.5 cm in diameter.
- Grade III: fissuring to the level of subchondral bone in an area with a diameter more than 1.5 cm.
- Grade IV: exposed subchondral bone.

Outcome measures

International Knee Documentation Committee score

The International Knee Documentation Committee (IKDC) score is a joint-specific tool that can be used to evaluate a variety of knee conditions according to symptoms, activity of daily living and function in sports activities. The IKDC questionnaire consists of 18 questions, 90% (16/18) of which need to be completed before an evaluative score can be obtained. Scores range from 0 to 100, with higher scores indicating better outcomes. An increase in score of 11.5 units is needed for a patient to perceive a significant improvement in their condition.

Knee injury and Osteoarthritis Outcome Score

The Knee injury and Osteoarthritis Outcome Score (KOOS) questionnaire evaluates the functional status and quality of life of patients with any type of knee injury who are at increased risk of developing osteoarthritis. It consists of 5 subscales: pain, other symptoms, activities of daily living, sport and recreational function, and knee-related quality of life. Standardised answer options are given and each question is assigned a score from 0 to 4. A normalised score (100 indicating no symptoms and 0 indicating extreme symptoms) is calculated for each subscale.

Lysholm knee scale:

The Lysholm knee scale was originally designed to assess ligament injuries of the knee. The outcome measure consists of 8 domains: limp, locking, pain, stair-climbing, support, instability, swelling, and squatting. Scores range from 0 to 100, with higher scores indicating better functionality.

- Scores from 95 to 100 indicate excellent function.
- Scores from 84 to 94 indicate good function.
- Scores from 65 to 83 indicate fair function.
- Scores less than 65 indicate poor function.

Tegner activity scale

The Tegner activity scale was designed as a score of activity level to complement other functional scores for patients with ligamentous knee injuries. Scores range from 0 (indicating the highest degree of disability relating to the knee joint) to 10 (indicating ability to participate in competitive sports).

Literature review

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee. Searches were conducted of the following databases, covering the period from their commencement to 26 July 2013: 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 with discrete chondral defects of the knee.
Intervention/test	Arthroscopic radiofrequency chondroplasty.
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 347 patients from 5 randomised controlled trials [1–5], 1 non-randomised comparative study[6] and 2 prospective case series[7,8].

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 arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments
Spahn (2010)[1] **Randomised controlled trial** Germany Recruitment period: Not reported Study population: Patients with grade III articular cartilage defects. **n = 60 (30 bRFE vs 30 MSD)** Mean age: , bRFE group: 42.9, MSD group: 43.8 years Sex: 53% female Patient selection criteria: knee pain ≥3months, positive clinical and MRI meniscus signs, and grade III cartilage defects on a weight bearing surface in the medial femoral condyle. Exclusion criteria: Major knee injury (dislocation of the patella, anterior or posterior cruciate ligament injuries or fractures), radiographic knee osteoarthritis (Kellgren-Lawrence grade II or higher) or prior surgery.	Number of patients analysed: **40 (25 bRFE vs 15 MSD)** **KOOS scores at 4 year follow-up (scores range from 0 to 100 with higher scores indicating less severe symptoms):** **Preoperative** / **Preop p value** / **Follow-up** / **p value at follow-up** bRFE | MSD | bRFE | MSD Pain: 14.7 | 12.1 | 0.588 | 75.1 | 55.7 | <0.001 Symptoms: 17.5 | 11.4 | 0.212 | 72.7 | 53.1 | <0.001 Activities of daily living: 15.1 | 11.4 | 0.375 | 69.9 | 50.9 | <0.001 Sports/recreation: 8.7 | 11.3 | 0.250 | 75.0 | 56.7 | <0.001 Knee-related Quality of Life: 14.5 | 9.5 | 0.132 | 67.0 | 52.9 | 0.017 Normalised KOOS score: 15.5 | 11.3 | 0.279 | 71.8 | 53.2 | <0.001 • Preoperative assessments revealed no significant differences in KOOS subgroup scores between bRFE and MSD groups (All p values >0.05). • Significant differences were observed in KOOS subgroup scores between bRFE and MSD groups at 4 year follow-up (All p values <0.05). **Tegner scores at 4 year follow-up (scores range from 0 to 10 with higher scores indicating higher activity levels):** Preoperative mean Tegner scores in the bRFE and MSD groups were 2.4 and 1.9 respectively (p=0.063). Tegner scores at follow-up in the bRFE and MSD groups were 4.5 and 3.3, respectively (p=0.005).	• No adverse events were reported: Unclear whether the occurrence of adverse events was actively assessed.	**Study may include the same patients reported in a previous paper by the same author (ref. 2) as part of a longer follow.** **Follow-up issues**: • 30% (20/60) of patients were lost to follow-up (5 bRFE and 15 MSD) **Study design issues**: • Patients were randomised on the morning of the operative day using sealed envelopes labelled MSD or RFC. • Single-blinded study where patients were blinded to their allocated groups. They were treated and assessed by 1 surgeon, leading to the potential for observer bias. • No adverse events were reported: Unclear whether the occurrence of adverse events was actively assessed. • There was no significant difference in frequency of partial or subtotal meniscectomy between the MSD and RFC groups

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments
Technique: All patients underwent partial or subtotal medial meniscectomy. Articular cartilage defects within the medial femoral condyle were treated either by bRFE or MSD. bRFE probe was set to 50^{o}c, 40W. MSD was carried out using a full-radius resector. Follow-up: **4 years** Conflict of interest/source of funding: None reported	Authors did not report whether the improvements in scores within groups were significant or not. **Width of medial joint space (On standard standing radiograph)** • In the bRFE group, mean medial joint space decreased from 4.9mm preoperatively to 3.9mm at follow-up (Author does not state whether observations were significant or not). • In the MSD group, mean medial joint space decreased from 4.4mm preoperatively to 2.6mm at follow-up (p<0.001). **Varus angle (On standard weight bearing radiograph)** • In the bRFE group the varus angle increased significantly from 1.6^{o} preoperatively to 2.3^{o} at follow-up (p<0.001). • In the MSD group, the varus angle increased significantly from 1.5^{o} preoperatively to 4.0^{o} at follow-up (p<0.001). • The varus angle at follow-up was significantly higher in MSD patients (p<0.001).		

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Spahn (2008)[2]

Randomised controlled trial
Germany

Recruitment period: July to September 2005

Study population: patients with a medial meniscus tear and had ICRS grade III cartilage defects on the medial femoral condyle.

n = 60 (30 bRFE vs 30 MSD)

Mean Age: bRFE group: 42.9, MSD group: 43.8 years.

Sex: 53.3% female

Patient selection criteria: ICRS grade III defect on the weight-bearing surface of the medial femoral condyle, no defects on the non-weight-bearing surfaces.
Exclusion criteria: deep cartilage defects (>grade II) on the medial tibial joint surface on the lateral compartment or patella-femoral compartment, significant bone oedema, had undergone prior surgery or had chronic history of injuries.</td>
<td>Number of patients analysed: 60 (30 bRFE vs 30 MSD)

Postoperative findings:
<table>
<tr><th></th><th>bRFE</th><th>MSD</th><th>p-value</th></tr>
<tr><td>Varus angle (degrees)</td><td>167.8 ± 2.6</td><td>168.6 ±1.9</td><td>0.133</td></tr>
<tr><td>Return to professional activities
(days)</td><td>16.4 ± 6.5</td><td>21.7 ± 6.1</td><td>0.002</td></tr>
<tr><td>Time using crutches (days)</td><td>10.7 ± 4.4</td><td>10.3 ± 1.9</td><td>0.792</td></tr>
<tr><td>NSAID use at 6 weeks (%)</td><td>60.0</td><td>50.0</td><td>0.302</td></tr>
<tr><td>NSAID use at 1 year (%)</td><td>2.0</td><td>23.0</td><td>0.026</td></tr>
</table>
• No statistically significant differences were observed between preoperative and postoperative medial joint spaces within each group (p values>0.05).

Mean KOOS scores at 6 week follow-up (scores range from 0 to 100 with higher scores indicating less severe symptoms):
<table>
<tr><th></th><th>bRFE</th><th>MSD</th><th>p value</th></tr>
<tr><td>Pain</td><td>28.1 ± 7.5</td><td>22.5 ± 6.4</td><td>0.003</td></tr>
<tr><td>Knee symptoms</td><td>35.6 ± 10.9</td><td>27.0 ± 12.5</td><td>0.006</td></tr>
<tr><td>Activities of daily living</td><td>37.4 ± 6.1</td><td>34.7 ± 4.3</td><td>0.064</td></tr>
<tr><td>Sports/recreation</td><td>36.5 ± 19.6</td><td>19.8 ± 9.0</td><td><0.001</td></tr>
<tr><td>Knee-related Quality of Life</td><td>47.7 ± 13.6</td><td>37.3 ± 17.4</td><td>0.013</td></tr>
<tr><td>Normalised KOOS score</td><td>35.9 ± 4.6</td><td>29.3 ± 4.3</td><td><0.001</td></tr>
</table>
NB: No statistically significant differences in preoperative KOOS scores were observed between groups (p values>0.366).

Mean KOOS scores at 1 year follow-up:</td>
<td>Occurrences of adverse events were actively monitored; however, no events were observed in either treatment group.</td>
<td>Study may include the same patients reported in a subsequent paper by the same author (ref. 1).

Follow-up issues:
• No indication of losses to follow-up.

Study design issues:
• Single-blinded randomised controlled trial: Patients were blinded to their group allocation. They were treated and examined by one surgeon, leading to the potential for observer bias.
Study population issues:
• Meniscectomy may have confounded results: Authors acknowledge that an ideal study sample should have included patients with grade III defects on the medial femoral condyle that did not have any other knee pathology.

Other issues:
• Authors state significant differences in KOOS scores between bRFE and MSD groups at 6 week and 1 year follow-up; however, they do not report whether the improvements in scores</td>
</tr>
</table>

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments
Technique: All patients received a partial or subtotal meniscectomy using a mechanical shaver. The grade III defect on the medial femoral condyle received either bRFE or MSD. Follow-up: **1 year** Conflict of interest/source of funding: None reported	See table below		were significant or not.

	bRFE	MSD	**p value**
Pain	81.2 ± 6.9	57.9 ± 13.7	<0.001
Knee symptoms	80.8 ± 7.3	58.3 ± 9.9	<0.001
Activities of daily living	81.5 ± 6.3	58.8 ± 8.4	<0.001
Function in sports/recreation	81.7 ± 8.2	57.3 ± 11.8	<0.001
Knee-related quality of life	80.2 ± 9.7	56.2 ± 17.7	<0.001
Normalised KOOS score	81.2 ± 6.9	57.3 ± 8.9	<0.001

NB: No statistically significant differences in preoperative KOOS scores were observed between groups (p values>0.366).

Mean Tegner scores (scores range from 0 to 10 with higher scores indicating higher activity levels):

- No significant differences in Tegner scores were observed between bRFE and MSD groups at 6 week follow-up (p>0.076).
- bRFE patients exhibited significantly higher Tegner scores than MSD patients at 1 year follow-up (p<0.001).

NB: Exact scores not stated: data was presented graphically.

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Owens (2002)[3]

Randomised controlled trial

Country: USA

Recruitment period: Not reported

Study population: Females with isolated patellar cartilage defects.

n = 48 (24 bRFE vs 24 MSD)

Mean age: MSD group: 37.5 years, bRFE group: 36.9 years.

Sex: 100% female

Patient selection criteria: Outerbridge grade I or II defects, moderate recreational athlete, failed 6 month course of conservative treatment.
Exclusion criteria: grade IV cartilage defects, instability, malalignment or patellar tracking dysfunction.

Technique: chondroplasty was carried out in the bRFE group using a probe set at non-ablative parameters (20W)

Follow-up: 24 months

Conflict of interest/source of funding: None reported</td>
<td>Number of patients analysed: 39 (19 MSD vs 20 bRFE)

Fulkerson-Shea Joint evaluation score (Higher scores indicate better outcomes)
<table>
<tr><th></th><th>bRFE</th><th>MSD</th><th>P value</th></tr>
<tr><td>Preoperative</td><td>59.6</td><td>59.2</td><td></td></tr>
<tr><td>12 months</td><td>87.9</td><td>80.0</td><td>0.003</td></tr>
<tr><td>24 months</td><td>86.6</td><td>77.5</td><td>0.0006</td></tr>
</table>
NB: Fulkerson Shea score is a self-administered knee-specific scale with 7 items: limp, mobility aid dependency, stair climbing, squatting, instability, pain and swelling. The scale is scored from 0 to 100 with low scores representing greater disability.

Physical examination at 2 year follow-up
• 55% (11/20) of bRFE had no crepitus whereas 32% (6/19) of patients in the MSD group had no crepitus: no p value was reported.
• The percentage of patients with effusions decreased by 40 percentage points (from 60% to 20%) in the bRFE group and 31 percentage points (from 47% to 16%) in the MSD group.</td>
<td>• No adverse events were reported: Unclear whether the occurrence of adverse events was actively assessed.</td>
<td>Follow-up issues:
2 patients in each group were removed due to the discovery of grade IV chondral defects during arthroscopy.
2 patients in the bRFE group and 3 patients in the MSD group were lost to follow-up

Study population issues:
• 100% female study sample and patellar cartilage is thicker than chondral cartilage elsewhere body. Therefore, findings may not be generalisable to other populations.

Study design issues:
• Patients were randomised according to their medical record numbers: even numbers underwent MSD, odd numbers underwent RFC.
• Single-blinded randomised controlled: ‘patients were blinded to the treatment they received, but the investigators were not blinded’. This leads to the potential for observer bias.
• Fulkerson-Shea score had not been adequately validated.</td>
</tr>
</table>

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

<table>
<tr><th>Study details</th><th>Key efficacy findings</th><th>Key safety findings</th><th>Comments</th></tr>
<tr>
<td>Barber (2006)[4]

Randomised controlled trial
U.S.A

Recruitment period: Not specified

Study population: Patients with grade III femoral condyle defects

n = 60 (30 mRFE plus MSD vs 30 MSD-only)

Age: mean 49 years (range: 22-76 years)
Sex: 53.3% female

Patient selection criteria: ≥18 years, a single Outerbridge grade III femoral condyle defect 1.5 to 3.0 cm in diameter, MRI confirmation of a lack of AVN, bone oedema or any significant abnormality.
Exclusion criteria: Anterior cruciate ligament tear, osteoarthritis, leg malalignment, inflammatory arthritis, total or near total meniscectomy (removal of >50%), prior femoral or tibial fracture, grade IV chondral defects or any concomitant orthopaedic condition.</td>
<td>Number of patients analysed: 56 (28 mRFE plus MSD vs 28 MSD-only)

Mean preoperative and postoperative knee scores (For all scales, apart from VAS, higher scores indicate better outcomes):
<table>
<tr><th></th><th>mRFE plus MSD</th><th>MSD-only</th><th>p value</th></tr>
<tr><td>IKDC</td><td></td><td></td><td></td></tr>
<tr><td>Preoperative</td><td>36</td><td>35</td><td>0.28</td></tr>
<tr><td>Postoperative</td><td>69</td><td>68</td><td>0.85</td></tr>
<tr><td>Cincinnati</td><td></td><td></td><td></td></tr>
<tr><td>Preoperative</td><td>43</td><td>47</td><td>0.33</td></tr>
<tr><td>Postoperative</td><td>77</td><td>81</td><td>0.78</td></tr>
<tr><td>Tegner</td><td></td><td></td><td></td></tr>
<tr><td>Preoperative</td><td>2.3</td><td>3.0</td><td>0.13</td></tr>
<tr><td>Postoperative</td><td>3.8</td><td>3.3</td><td>0.55</td></tr>
<tr><td>Lysholm [a]</td><td></td><td></td><td></td></tr>
<tr><td>Preoperative</td><td>50</td><td>53</td><td>0.37</td></tr>
<tr><td>Postoperative</td><td>83</td><td>86</td><td>0.90</td></tr>
<tr><td>VAS [b]</td><td></td><td></td><td></td></tr>
<tr><td>Preoperative</td><td>6.3</td><td>5.9</td><td>0.46</td></tr>
<tr><td>Postoperative</td><td>2.8</td><td>2.9</td><td>0.44</td></tr>
</table>
[a] Cincinnati knee rating scale: examines 11 functional components with particular reference to participation in sports. Scores range from 6 to 100 with higher scores indicating better outcomes.
[b] VAS: patients were asked to score their knee pain from 1 to 10 (1 being painless and 10 being the most painful)
• Statistically significant improvements in mean scores for all scales were observed within each group (All p values<0.05; individual comparison p values were not reported)
• No significant differences were observed in mean preoperative</td>
<td>• No adverse events were observed during the procedure.
• No AVN or heat-related damage was observed in either group at 12 month follow-up.
• Bone oedema was observed in 7.1% (2/28) of patients in both comparison groups at 12 month follow-up</td>
<td>The aim of this study was to assess the incidence of AVN in patients who underwent chondroplasties by MSD or mRFE. The presence/absence of AVN was established by examining knee radiograph series and MRIs.

Follow-up issues:
No explanation of losses to follow-up in each study group.

Study design issues:
• Randomisation occurred on the day of surgery by opening sealed envelopes containing group assignment.
• Unclear whether participants were blinded to their group allocation.
• Possibility of observer bias: all patients treated and assessed by 1 surgeon.

Study population issues:
• Patients with total or near-total meniscectomy (removal of >50%) were excluded.
• Post hoc power analysis revealed insufficient power to detect differences between groups: i.e. small sample sizes.</td>
</tr>
</table>

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.			
Study details	**Key efficacy findings**	**Key safety findings**	**Comments**
Technique: A motorised shaver was used to remove loose fragments in both groups. mRFE was then used to smooth over surfaces in the mRFE group (Specifications not reported). Follow-up: **mean 19 months (range: 12-27 months)** Conflict of interest/source of funding: none reported.	scores between study groups (All p values>0.05). • No significant differences were observed in mean postoperative scores between study groups (All p values>0.05).		**Other issues**: • p-values for preoperative vs postoperative score comparisons were not reported. • Associated defects (medial and lateral meniscus damage) were found and treated during surgery: impossible to completely isolate the effect of chondroplasties

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments

Kang (2008)[5]
 	
Randomised controlled trial
 	
USA
 	
Recruitment period: Apr 2001 to Dec 2003
 	
Study population: patients with Outerbridge grade II or III chondral defects
 	
n = **29 (15 mRFE plus MSD vs 14 MSD-only)**
 	
Mean age: mRFE plus MSD: 50 years (range: 35-69 years), MSD: 47 years (range: 25-63 years);
 	
Sex: 51.7% female
 	
Patient selection criteria: patients with Outerbridge grade II or III chondral defects that failed a 6 month conservative treatment regimen of anti-inflammatory medications and physical therapy.
Exclusion criteria: <18 years, grade I or IV chondral defects, concomitant ligamentous or patellofemoral defects, indications for autologous chondrocyte transplantation, diffuse
	Number of patients analysed: **29 (15 mRFE plus MSD vs 14 MSD-only)**
	
	Mean IKDC Scores (Scores range from 0 to 100 with higher scores indicating better outcomes):
	• In the mRFE plus MSD group, mean IKDC score increased significantly from 30 preoperatively to 49 at follow-up (p=0.003).
	• In the MSD-only group, mean IKDC score increased significantly from 36 preoperatively to 59 at follow-up (p=0.001).
	• Comparison of mean differences in IKDC scores between study arms revealed no statistically significant differences (p=0.444).
	
	Intraoperative cartilage stiffness measurements (measured in Newtons):
	
	• Mean stiffness of normal cartilage, chondral defects before treatment, cartilage after MSD-only and cartilage after mRFE plus MSD were 2.7N, 1.07N and 0.94N and 1.38N, respectively (p<0.002).
	• No statistically significant differences in mean cartilage stiffness measurements were observed in the following comparisons:
	  ○ Defects before treatment vs cartilage after MSD-only (p=0.57)
	  ○ Defects before treatment vs cartilage after mRFE plus MSD (p=0.134)
	  ○ Cartilage after MSD-only vs Cartilage after mRFE plus MSD (p=0.059)
	
	NB: Increase in cartilage stiffness is thought to restore biomechanical strength.
		• No adverse events were reported: Unclear whether the occurrence of adverse events was actively assessed.	**Follow-up issues**:
			• No losses to follow-up.
			
			Study design issues:
			• Randomisation was carried out using sealed envelopes with group allocations.
			• Single-blinded randomised controlled trial: Patients were blinded to their group allocation. They were treated and examined by one surgeon, leading to the potential for observer bias.
			• Post-hoc power calculations revealed the study had insufficient power to detect significant differences in 1) mean improvements in IKDC scores between groups and 2) intraoperative cartilage stiffness measurements.
			
			Study population issues:
			• The only concomitant procedure included in this study was partial meniscectomy.
			
			Other issues:
			• Unclear whether the occurrence of adverse events was actively assessed.

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.			
Study details	**Key efficacy findings**	**Key safety findings**	**Comments**
osteoarthritic changes, metabolic bone disease, peri-articular or patella fracture, neoplastic disease, or permanent severe disability of the lower limbs. Technique: mRFE plus MSD group: MSD was followed by mRFE (70°C, 30 Watts). The stiffness of defective cartilage regions was measured using an electronic probe. Follow-up range**: 10-28 months** Conflict of interest/source of funding: None reported			

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments
Osti (2010)[6] **Non-randomised comparative study** **NB: only data on patients treated by RFE were extracted (See Comments)** Location: Multicentre - Italy and UK Recruitment period: 2001 to 2004 Study population: patients with one-sided symptomatic anterior cruciate ligament deficiencies, cartilage defects and meniscal tears. n = **25 (in RFE arm)** Age: median 28 years (range: 17-29 years) Sex: 44% female Patient selection criteria: ≤40 years with symptomatic one-side anterior cruciate ligament deficiency, single and painful cartilage defect (1 to 3cm^2) and meniscal tears. Exclusion criteria: ≥40years, multi-ligament injured knee, prior surgery of affected or	Number of patients analysed: **25 (in RFC arm)** **Lysholm scores (scores range from 0 to 100 with higher scores indicating better outcomes):** • Median Lysolm scores increased from 39 (range 20-67) preoperatively to 91 (range 85-100) at 2 year follow-up (p<0.001). • At 5 year follow-up the median Lysholm score was 87 (range 82-100). This was also a significant improvement from preoperative scores (p<0.001). **IKDC ranking (scores range from 0 to 100 with higher scores indicating better outcomes):** • At 2 year follow-up 96% (24/25) of knees were rated normal or nearly normal (grades A or B) according to the IKDC ranking scale. • At 5 year follow-up 92% (23/25) of knees were rated normal or nearly normal. **Tegner activity scores (scores range from 0 to 10 with higher scores indicating higher activity levels)::** • At 2 year follow-up Tegner scores improved with 92% (23/25) of patients returning to their pre-injury sport activity. • At 5 year follow-up 2 patients (8%) decreased their activity levels. **Progression of osteoarthritis** • Patellofemoral joint narrowing was detected in 8% (2/25) patients at 5 year follow-up. • 20% (5/25) of patients exhibited grade I or II degenerative changes according to the Fairbank grading system.	• No adverse events were reported: Unclear whether the occurrence of adverse events was actively assessed.	**Study design issues**: • Possibility of observer bias: all patients treated and assessed by 1 surgeon. **Study population issues**: • Study included patients with potential confounders: patients with anterior cruciate ligament deficiencies. **Other issues**: • Authors describe study as a non-randomised comparative study. Patients with grade I-II cartilage defects treated by RFC were compared with patients who had grade III-IV chondral defects treated by microfractures. **Therefore, only data from the RFC group were extracted.** • Unspecified RFC device used: unclear whether mRFE or bRFE device.

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.			
Study details	**Key efficacy findings**	**Key safety findings**	**Comments**
contralateral knee, severe osteoarthritis, inflammatory joint disease, systemic disease or BMI >30. Technique: Following anterior cruciate ligament reconstruction patients with grade I or II defects underwent RFC Follow-up: **mean 6 years (range: 5-7 years and 2 months)** Conflict of interest/source of funding: None reported			

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments
Voloshin (2007)[7] **Prospective case series** United States Recruitment period: June 1999 to July 2002 Study population: patients with partial-thickness cartilage defects. n = **15 patients (25 knees)** Age: median 38.5 years (range: 27-52 years), Sex: 40% female Patient selection criteria: received previous RFC and subsequently underwent repeat arthroscopy secondary to a new cartilage injury or continued discomfort. Exclusion criteria: None reported Technique: Cartilage defects were initially treated by MSD to remove loose fragments of cartilage. bRFE used to smooth the base of the defect and create a stable rim. Follow-up: **mean 10.4 months (range: 0.7-32.7 months)** Conflict of interest/source of funding: None reported	Number of patients analysed: **25 (in bRFE arm)** **Characteristics of chondral defects at second-look arthroscopy** • The mean size of chondral defects decreased from 170.2mm^2 (range 9-625mm^2), at initial arthroscopy, to 107.7mm^2 (range 0-300mm^2) at follow-up arthroscopy. • The mean percentage change in defect size was -30.4% (-100 to 212.5%). • 32% (8/25) of defects exhibited no progressive damage to the articular surface. • 32% (8/25) of defects exhibited partial healing whilst 24% (6/25) of defects exhibited complete healing. • 12% (3/25) of defects exhibited unstable borders and progressive damage to surrounding cartilage. • Linear mixed model regression (unadjusted for initial defect size, time interval and presence of multiple defects) revealed that defect site was a significant predictor to change in defect size ($p<0.05$). Defects within the tibiofemoral joint were more predictive of healing than those within the patellofemoral joint	• No adverse events were reported: Unclear whether the occurrence of adverse events was actively assessed.	**Study population issues**: • Study included patients with potential confounders: patients with anterior cruciate ligament deficiencies. **Other issues**: • Potential for selection bias: included patients had symptoms sufficient to warrant repeat arthroscopy. Thus, there is a possibility of the overrepresentation of progressive cartilage defects in the sample.

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments
Cetik (2007)[8] **Prospective case series** Turkey Recruitment period: Not specified Study population: patients with Outerbridge grade II or III chondral defects. n = **50** Age: mean 45.5 years, Sex: 54% female Patient selection criteria: arthroscopically confirmed grade II or III defects, symptom duration >6 weeks, no osteonecrosis. Exclusion criteria: abnormal lower extremity mechanical axis, ligamentous instability, osteochondritis dessecans, rheumatoid arthritis, metabolic disease, history of steroid consumption or alcohol abuse. Technique: bRFE (65^{o}c) was used for debridement of chondral defects Follow-up: **at least 6 months following surgery.** Conflict of interest/source of funding: none reported.	Number of patients analysed: **50** • **No efficacy outcomes were reported.**	• Osteonecrosis of the medial femoral condyle was observed in 4% (2/50) of patients at follow-up of at least 6 months after surgery. • The mean size of the osteonecrosis with regard to the whole femoral condyle was measured as 27.5% (25-30%).	**Study design issues**: • All patients treated and assessed by 1 surgeon. **Study population issues**: • Heterogeneity in study population: patients were included regardless of the extent of synovial hypertrophy or degenerative or traumatic changes in the menisci. **Other issues**: • No clinical efficacy outcomes were assessed in this study.

Abbreviations used: AVN, avascular necrosis; bRFE, bipolar radiofrequency energy; IKDC, international knee documentation committee; KOOS, knee injury and osteoarthritis outcome score; mRFE, monopolar radiofrequency energy; RFC, radiofrequency chondroplasty; MSD, mechanical shaver debridement; NSAID, non-steroidal anti-inflammatory drugs; VAS, visual analogue scale.

Study details	Key efficacy findings	Key safety findings	Comments
MAUDE Adverse event reports[9] US FDA Date report accessed: 26 July 2013 **Case reports** Events occurred between 2002-2012 Techniques: Paragon T2, Turbovac 90, Tristar 50 (Arthrocare)	**Adverse events** • The ring at the distal end of the arthrowand detached within the patient's joint space during a knee arthroscopy. The ring was removed arthroscopically. No patient complications were reported as a result of this event (2012). • During a knee arthroscopy procedure, a portion from the tip of the wand detached. It is not known if the fragment remains in the pt. No other information was provided for this report (2010). • The metal ring inside the tip of the wand became displaced and material began flaking off the tip of the wand. It was not known whether anything fell into the surgical site. No procedure was planned to remove anything from the patient (2010). • The electrode at the distal end of the wand was missing. It was not known if the missing electrode remained in the patient's knee. There was no reported patient injury (2007) • The temperature ink indicator was reported to have detached from the tip of the wand and remained in the patient's knee joint. The large fragments were successfully removed and smaller fragments remained. No patient injury was reported (2006). • 3 days following chondroplasty, the patient was reported to have sustained a small, circular second degree burn approximately 2 cm in diameter. The burn was treated with a dressing. The hospital confirmed the device was not used properly: the device was not used with suction (2006). • During chondroplasty, the tip was reported to have detached and remained in the patient. The detached tip could not be retrieved. There was no report of patient injury (2005). • A foreign body was removed from a patient's knee during an orthopaedic procedure. The foreign body was identified as a disc from a radiofrequency wand (2002)		• Adverse events related to the mechanical failure of the device. • The second degree burn was related to the improper use of the device.

Efficacy

Bipolar radiofrequency energy

A randomised controlled trial of 60 patients treated by bRFE (n=30) or MSD (n=30) reported that patients in the bRFE group returned to work sooner than patients in the MSD group (16.4±6.5 days compared with 21.7±6.1 days, p=0.002)[2].

In the randomised controlled trial of 60 patients treated by bRFE or MSD, 2% of patients in the bRFE group and 23% of patients in the MSD group were using non-steroidal anti-inflammatory drugs at 1-year follow-up (p=0.026)[2].

In the randomised controlled trial of 60 patients treated by bRFE or MSD mean KOOS scores for pain, symptoms, activities of daily living, sports and quality of life (higher scores indicate better outcomes) were 81.2, 80.8, 81.5, 81.7 and 80.2 respectively in the bRFE group and 57.9, 58.3, 58.8, 57.3 and 56.2 respectively in the MSD group at 1-year follow-up (p<0.001 for all inter-group comparisons). At 4-year follow-up, scores continued to be significantly higher for patients in the bRFE group: mean KOOS scores for pain, symptoms, activities of daily living, sports and quality of life were 75.1, 72.7, 69.9, 75.0 and 67.0 respectively in the bRFE group (n=25) and 55.7, 53.1, 50.9, 56.7 and 52.9 respectively in the MSD group (n=15) (p<0.001 for all inter-group comparisons)[1].

A randomised controlled trial of 48 patients treated by bRFE (n=24) or MSD (n=24) reported mean Fulkerson-Shea joint evaluation scores (higher scores indicate better outcomes) of 87.9 and 80.0 respectively at 12-month follow-up (p=0.003). Mean Fulkerson-Shea scores in the bRFE group and MSD group were 86.6 and 77.5 respectively at 24-month follow-up (p=0.0006)[3].

A prospective case series of 15 patients (25 knees) treated by bRFE reported that the mean size of chondral defects decreased from 170.2mm^2 (range 9–625mm^2) at initial arthroscopy to 107.7mm^2 (range 0–300mm^2) at follow-up arthroscopy after a mean of 10.4 months: 32% (8/25) of defects showed no progressive damage to the articular surface; 32% (8/25) showed partial healing; and 24% (6/25) had healed completely. Twelve per cent (3/25) of defects showed unstable borders with progressive damage to the surrounding cartilage[7].

Monopolar radiofrequency energy

A randomised controlled trial of 60 patients treated by mRFE plus MSD (n=30) or MSD only (n=30) reported significant improvements in mean IKDC, Cincinnati, Tegner, Lysholm and visual analogue scale (VAS) pain scores in both groups at a mean follow-up of 19 months. In the mRFE plus MSD group, mean IKDC, Cincinnati, Tegner, Lysholm and VAS scores improved from 36, 43, 2.3, 50 and 6.3 preoperatively to 69, 77, 3.8, 83 and 2.8 at follow up (p values<0.05). In the MSD-only group mean IKDC, Cincinnati, Tegner, Lysholm and VAS scores

improved from 35, 47, 3.0, 53 and 5.9 preoperatively to 68, 81, 3.3, 86 and 2.9 at follow up (p values<0.05). No statistically significant differences in all postoperative scores were observed between groups (p values>0.05)[4].

A randomised controlled trial of 29 patients treated by mRFE plus MSD (n=15) or MSD only (n=14) reported that mean IKDC scores improved significantly from 30 to 49 (p=0.003) and from 36 to 59 (p=0.001) respectively at a mean follow-up of 19 months. A comparison of the mean improvements in IKDC scores between the 2 groups revealed no significant differences (p=0.444). Mean stiffness of normal cartilage, chondral defects before treatment, cartilage after MSD only and cartilage after mRFE plus MSD were 2.7N, 1.07N, 0.94N and 1.38N respectively (p<0.002). No statistically significant differences in mean cartilage stiffness measurements were observed in the stiffness of chondromalacic cartilage before treatment versus after MSD-only; cartilage before treatment versus after mRFE plus MSD; and cartilage after MSD-only versus cartilage after mRFE plus MSD (p values>0.05)[5].

Safety

Osteonecrosis of the medial femoral condyle was observed in 4% (2/50) of patients at a follow-up assessment that occurred at least 6 months after treatment, in a prospective case series of 50 patients. No clinical consequences were reported as a result of this[8].

A second-degree burn after radiofrequency chondroplasty (RFC) was reported in the US Food and Drug Administration's (FDA) manufacturer and user facility device experience (MAUDE) database. This was attributed to improper use of the radiofrequency equipment: a suction line, which should have been attached to the probe during the procedure, was not attached[9].

The confirmed or presumed detachment of a mechanical component of the radiofrequency probe within a patient's knee was reported on 7 occasions between 2002 and 2012 in the MAUDE database[9].

Validity and generalisability of the studies

- It is unclear whether the occurrence of adverse events was actively monitored in 3 of the randomised controlled trials[1,3,5] and 2 of the other studies[6,7] included in table 2.
- Osteonecrosis was observed as an adverse event following RFC. However, patients included in the study suffered from moderate to severe osteoarthritis, which may have caused the MRI appearances noted[8].
- Only 1 study reported considerable safety events associated with RFC. Hence, there is limited evidence on the safety of RFC in human in vivo studies.
    - Literature searches identified over 20 in vitro studies and 11 animal studies that reported potential risks associated with RFC.

- The adverse events reported in the FDA's MAUDE database were mainly associated with the mechanical failure of the device.
- The majority of randomised controlled trials included in table 2 were single-blinded, resulting in a possibility of observer bias[1,2,3,5].
- No studies were identified that compared the efficacy and safety of mRFE with bRFE.
- No studies were identified that compared any type of RFC to the natural progression of chondral defects.
- The available evidence indicated that RFC had been used to treat discrete chondral defects rather than to treat chondral defects related to osteoarthritis.

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

- Mosaicplasty for knee cartilage defects. NICE interventional procedures guidance 162 (2006). Available from www.nice.org.uk/guidance/IPG162
- Partial replacement of the meniscus of the knee using a biodegradable scaffold. NICE interventional procedures guidance 430 (2012). Available from www.nice.org.uk/guidance/IPG430

Technology appraisals

- The use of autologous chondrocyte implantation for the treatment of cartilage defects in knee joints. NICE technology appraisal 89 (2005). Available from www.nice.org.uk/guidance/TA89

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.

Professor Simon Donell and Mr Ian McDermott (British Association for Surgery of the Knee); Mr Mark Bowditch, Mr Barry Ferris and Mr Tony Hui (British Orthopaedic Association).

- Two specialist advisers reported that they regularly perform the procedure, 2 specialist advisers reported that they had performed the procedure at least once and 1 adviser reported that he had never performed the procedure.

- Four specialist advisers described the procedure as established and no longer new while 1 specialist adviser stated that the procedure was a minor variation of an existing procedure, which is unlikely to alter that procedure's safety and efficacy.

- All specialist advisers considered the use of an arthroscopic mechanical shaver as the closest comparator treatment to the procedure.

- One specialist adviser reported that fewer than 10% of specialists were engaged in this area of work; while 3 advisers reported that 10–50% of specialists were engaged in this area of work.

- Three specialist advisers could not identify any additional adverse events reported in the literature.

- Theoretical adverse events include excessive debridement of articular cartilage, avascular necrosis, chondrocyte death and damage to surrounding cartilage and other structures.

- Key efficacy outcomes include MRI findings and functional scores, such as the Tegner, IKDC and Lysholm scores.

- Two specialist advisers stated minimal training in the use of the radiofrequency probes as a key concern surrounding the procedure and its efficacy. One adviser reported that it is difficult to ascertain the depth of unseen 'normal' articular cartilage damage when using a radiofrequency probe. One adviser reported that, following radiofrequency, chondroplasty defects may look visually better but there may be no change in pain or crepitus. Patients may have malformed grooves (trochlear dysplasia) or discoordinated muscles (poor proprioception), which may be the underlying

cause of the damage and would need to be addressed. The adviser also noted that patients may have undiagnosed hypermobility syndrome which could be made worse by the procedure.

- Three specialist advisers considered the procedure to have a minor impact on the NHS. One adviser considered the procedure to have a moderate impact on the NHS.

Patient commentators' opinions

NICE's Public Involvement Programme sent 1 questionnaire to 1 NHS trust for distribution to patients who had the procedure (or their carers). NICE received no completed questionnaires.

Issues for consideration by IPAC

- The available evidence indicated that RFC had been used to treat discrete chondral defects rather than to treat chondral defects related to osteoarthritis.
- There is limited evidence on the safety of RFC in human in vivo studies; conversely, a number of in vitro studies and animal studies were identified that highlight the potential risks associated with RFC.
- Currently there are no trials that compare the efficacy of monopolar radiofrequency energy with bipolar radiofrequency energy.
- Thermal damage to surrounding cartilage is a potential problem noted by advisors. They advise that this will be related to the amount of energy deployed at surgery and the efficacy of the cooling (fluid flow) mechanisms used at the time of surgery.

Ongoing trials

- NCT01527201: Arthroscopic debridement for chondral lesions in the knee; type: randomised controlled trial; estimated enrolment: 190; location: New York, USA; estimated completion date: January 2015.
- NCT01803880: Mechanical debridement versus radiofrequency-based debridement to treat articular cartilage lesions with partial meniscectomy in the knee (ACT); type: randomised controlled trial; estimated enrolment: 106; location: multicentre, USA; estimated completion date: March 2015.

References

1. Spahn G, Klinger HM, Muckley T et al. (2010) Four-year results from a randomised controlled study of knee chondroplasty with concomitant medial meniscectomy: mechanical debridement versus radiofrequency chondroplasty. Arthroscopy 26 (9): S73-S86.

2. Spahn G, Kahl E, Muckley et al. (2008) Arthroscopic knee chondroplasty using a bipolar radiofrequency-based device compared to mechanical shaver: results of a prospective, randomised, controlled study. Knee Surgery Sports Traumatology Arthroscopy 16: 565-573.

3. Owens BD, Stickles BJ, Balikian P. (2002) Propective analysis of radiofrequency versus mechanical debridement of isolated patellar chondral lesions. Arthroscopy 18 (2): 151-155.

4. Barber AF and Iwasko NG. (2006) Treatment if grade III femoral chondral lesions: mechanical chondroplasty versus monopolar radiofrequency probe. Arthroscopy 22(12): 1312-1317

5. Kang RW, Gommoll AH, Nho SJ, Pylawka TK, Cole BJ. (2008) Outcomes of mechanical debridement and radiofrequency ablation in the treatment of chondral defects: a randomised controlled study. Journal of knee surgery 21(2): 116-121

6. Osti L, Papalia R, Del Buono A, Amato C, Danero V, Maffulli N. (2010) Good results five years after surgical management of anterior cruciate ligament tears, and meniscal and cartilage injuries. Knee Surgery Sports Traumatology Arthroscopy 18(10): 1385-1390

7. Voloshin I, Morse RK, Allred CD, Bissell SA, Maloney MD, DeHaven KE (2007) Arthroscopic evaluation of radiofrequency chondroplasty of the knee. American Journal of sports science 35(10): 1702-1707

8. Cetik O, Cift H, Comert B, Cirpar M. (2009) Risk of osteonecrosis of the femoral condyle after arthroscopic chondroplasty using radiofrequency: a prospective clinical series. Knee Surgery Sports Traumatology Arthroscopy 17: 24-29

Appendix A: Additional papers on Arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee

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
Encalada I., and Richmond MD. (2004) Osteonecrosis after arthroscopic meniscectomy. Arthroscopy: 20 (6): 632-636	n=1 Follow-up: 7 months	Diagnosis of subchondral osteonecrosis of both femoral condyles.	Another study was available that highlighted the incidence of osteonecrosis in a larger group of patients.
Voloshin I., De Haven KE., and Steadman JR. (2005) Second-look arthroscopic observations after radiofrequency treatment of partial thickness cartilage defects in human knees. Journal of knee surgery. 18: 116-122	n=4 Follow-up: not reported	Initial chondral defects had filled with smooth and stable tissue resembling fibrocartilage in 4 patients. 3 patients exhibited additional chondral lesions at second-look arthroscopy.	Larger studies were available with more informative outcome measures.
Hogan CJ., and Diduch DR. progressive articular cartilage loss following radiofrequency treatment of a partial-thickness lesion.	n=1 Follow-up 14 months	Progression of a medial femoral condyle lesion.	Larger studies were available with more informative outcome measures.

Appendix B: Related NICE guidance for arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee

Guidance	Recommendations
Interventional procedures	**Mosaicplasty for knee cartilage defects. NICE interventional procedures guidance 162 (2006)** 1.1 Current evidence suggests that there are no major safety concerns associated with mosaicplasty for knee cartilage defects. There is some evidence of short-term efficacy, but data on long-term efficacy are inadequate. In view of the uncertainties about the efficacy of the procedure, it should not be used without special arrangements for consent and audit or research. 1.2 Clinicians wishing to undertake mosaicplasty for knee cartilage defects should take the following actions. • Inform the clinical governance leads in their Trusts. • Ensure that patients understand the uncertainty about the procedure's efficacy and the options for alternative treatments. They should provide them with clear written information. In addition, use of the Institute's information for the public is recommended. • Audit and review clinical outcomes of all patients having mosaicplasty for knee cartilage defects. The Institute may review the procedure upon publication of further evidence. **Partial replacement of the meniscus of the knee using a biodegradable scaffold. NICE interventional procedures guidance 430 (2012)** 1.1 Current evidence on partial replacement of the meniscus of the knee using a biodegradable scaffold raises no major safety concerns.

	Evidence for any advantage of the procedure over standard surgery, for symptom relief in the short term, or for any reduction in further operations in the long term, is limited in quantity. Therefore, this procedure should only be used with special arrangements for clinical governance, consent and audit or research. 1.2 Clinicians wishing to undertake partial replacement of the meniscus of the knee using a biodegradable scaffold should take the following actions. • Inform the clinical governance leads in their Trusts. • Ensure that patients understand that there are uncertainties about any possible long-term advantage over other surgical options and that considerable rehabilitation is required after this procedure. Clinicians should provide patients with clear written information. In addition, the use of NICE's information for patients ('Understanding NICE guidance') is recommended. • Audit and review clinical outcomes of all patients having partial replacement of the meniscus of the knee using a biodegradable scaffold (see section 3.1). 1.3 The procedure should only be carried out by surgeons who are highly experienced in arthroscopic meniscal surgery. 1.4 NICE encourages further research and data collection on partial replacement of the meniscus of the knee using a biodegradable scaffold. This should include clear descriptions of patient selection and adjunctive treatments. Outcome measures should include symptom relief and functional ability in the short term and the need for further treatment in the longer term.

Technology appraisals	**Cartilage injury – autologous chondrocyte implantation (review). NICE technology appraisal 89 (2005)** 1.1 Autologous chondrocyte implantation (ACI) is not recommended for the treatment of articular cartilage defects of the knee joint except in the context of ongoing or new clinical studies that are designed to generate robust and relevant outcome data, including the measurement of health-related quality of life and long-term follow-up. Patients should be fully informed of the uncertainties about the long-term effectiveness and the potential adverse effects of this procedure.

Appendix C: Literature search for arthroscopic radiofrequency chondroplasty for discrete chondral defects of the knee

Databases	Date searched	Version/files
Cochrane Database of Systematic Reviews – CDSR (Cochrane Library)	26/07/13	Issue 6 of 12, June 2013
Database of Abstracts of Reviews of Effects – DARE (CRD website)	26/07/13	Issue 2 of 4, Apr 2013
HTA database (CRD website)	26/07/13	Issue 2 of 4 Apr 2013
Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library)	26/07/13	Issue 6 of 12, June 2013
MEDLINE (Ovid)	26/07/13	1946 to July Week 3 2013
MEDLINE In-Process (Ovid)	26/07/13	Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations July 25, 2013
EMBASE (Ovid)	26/07/13	1974 to 2013 Week 29
CINAHL (NLH Search 2.0 or EBSCOhost)	26/07/13	-

Trial sources searched on

- Current Controlled Trials *meta*Register of Controlled Trials – *m*RCT
- Clinicaltrials.gov
- National Institute for Health Research Clinical Research Network Coordinating Centre (NIHR CRN CC) Portfolio Database

Websites searched

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

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

1	chondroplast*.tw.
2	((subchondr* or chondr*) adj3 (arthroplast* or arthroscop*)).tw.
3	Arthroscopy/
4	arthroscop*.tw.
5	Catheter Ablation/
6	(ablation* adj3 (elect* or catheter)).tw.
7	Debridement/
8	debridement*.tw.
9	or/1-8
10	(radiofrequenc* or radio-frequenc* or RF or RFE or RFC).tw.
11	((knee* or chondr* or articular* or cartilage*) adj3 (damage* or lesion* or degenerat* or fribrillat* or defect* or trauma* or injur*)).tw.
12	Cartilage, Articular/
13	(cartilage* adj3 (knee* or joint* or disease*)).tw.
14	exp Cartilage Diseases/
15	chondromalacia.tw.
16	Knee Injuries/
17	Knee Joint/su [Surgery]
18	Osteochondritis/
19	osteochond*.tw.
20	or/11-19
21	9 and 10 and 20
22	(paragon adj3 arthrocare).tw.
23	21 or 22
24	Animals/ not Humans/
25	23 not 24