Current surgical options for the treatment of symptomatic articular cartilage lesions of the knee

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Abstract

Articular cartilage lesions of the knee are common, although the majority are asymptomatic. If conservative measures fail in painful lesions, or if mechanical symptoms are evident, then surgical intervention may relieve symptoms. Awareness of current national guidelines is important in the appropriate consenting of patients undergoing surgery. Arthroscopic debridement is recommended as the initial intervention, unless primary fixation of a loose osteochondral lesion is required. If structured rehabilitation is unsuccessful, then there are effective surgical options available. Bone marrow stimulation, osteochondral grafting, osteochondral scaffolds, chondrocyte cell therapy, stem cell therapies, osteochondral allografts and focal replacements may offer relief of symptoms. Their relative merits and shortfalls are discussed in detail in this review article.

Keywords arthroscopic debridement; articular cartilage lesion; bone marrow stimulation; chondrocyte cell therapy; knee; medicolegal; microfracture; osteochondral allografts and focal replacements; osteochondral grafting; osteochondral scaffolds; stem cell therapies; structured rehabilitation

Introduction

Articular cartilage injuries and lesions of the knee are common: there are estimated to be about half a million per year in the USA, identified on the 2.5 million arthroscopies performed per year.[1] Articular cartilage lesions over 0.9 cm diameter will not heal spontaneously; however, the majority are not symptomatic, and a study of National Basketball Association (NBA) players showed that 7% had incidental asymptomatic cartilage defects on MRI.[2] Surgical invention is therefore reserved for those patients who have persisting symptoms despite effective conservative interventions.[3]

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Assessment

History

Symptomatic articular cartilage lesions present with localized pain and may have mechanical symptoms of locking, catching, giving way, recurrent effusions or a sensation of a loose body. Symptoms can be as severe and disabling as end-stage osteoarthritis, and warrant treatment.[4]

Previous surgical interventions in the knee should be considered in the planning of articular cartilage surgery.

Patient interview should include the factors listed in Table 1, which may influence the risk and outcome of articular cartilage surgery. Contraindications for focal cartilage defect surgery would include end-stage osteoarthritis, inflammatory joint disease, active septic arthritis, untreated instability or malalignment.

Clinical examination

Clinical examination findings may include localised tenderness in the symptomatic compartment of the knee, an effusion, a locked knee or a palpable loose body. It not uncommon, however, for none of these clinical signs to be present.

The knee should be assessed for ligament incompetence, patellar mal-tracking and malalignment of the limb, as these need to be corrected before any articular cartilage treatment should be considered. Failure to address malalignment has been shown to be the commonest cause of failure of articular cartilage surgery.[5]

Imaging

MRI is very useful for demonstrating the presence of a lesion and any co-existing pathology within the knee, but it often underestimates the size of the defect, which is something that can only really be determined after surgical debridement.[3]

Plain radiographs are needed to exclude significant osteoarthritic change. Long-leg weight-bearing alignment views are required to assess alignment in the coronal plane. If there is clinical suspicion of rotational malalignment, CT scannogram and axial alignment assessment is required.

Specific protocol CT or MRI may be required for operative planning of focal replacement or alignment correction procedures.

Assessment of the lesion

Size: this is measured post-debridement of unstable and loose flaps of articular cartilage that are not attached to subchondral bone. It is measured at the widest width and length in irregular shaped defects.[3]

Location: the location of the lesion within the knee is important for treatment selection. Some studies have shown defects of the patella have less favourable results, particularly for microfracture. Other studies have shown equivalent results for surgical treatment of patellar articular cartilage lesions with autologous chondrocyte implantation (ACI).[6]

Risk factors predicting poorer outcomes of surgical treatment for articular cartilage defects

- Age
- Body mass index
- Smoker
- Activity level
- Compliance
- Expectations
- Motivation
- Funding status

Table 1

Depth: the depth of a defect is a consideration in selection of treatment, and if there is underlying bone loss beneath the cartilage defect then this may need to be restored.[7] The depth of the lesion can be categorized according to the International Cartilage Regeneration & Joint Preservation Society (ICRS) grading system (Figure 1).

Borders: an uncontained defect extending into the notch or to the margin of the joint may require differing treatment strategies from those defects that are fully contained by a competent border of stable articular cartilage.

Previous treatments: previous treatments of the defect may affect the treatment selection, and assessment of intra-lesional osteophytes and sclerotic bone (which may, for example, be resultant of previous bone marrow stimulating techniques) could prejudice the success of cell therapy options.

Surgical treatment options

If the patient has failed conservative management, the surgical management options are broadly categorised in Table 2.

For many, and particularly for chronic isolated articular cartilage lesions, an adequate surgical debridement followed by effective physical therapy may render the patient symptom free. Certain conditions, such as unstable osteochondritis dissecans lesions, may require immediate attention.

Bone marrow stimulation techniques

Bone marrow stimulation was described as a drilling technique for salvage of end-stage osteoarthritis prior to widespread popularization of knee arthroplasty. The results of Pridie's drilling technique[8] form the basis for the development of bone marrow stimulation techniques for addressing articular cartilage lesions. These techniques aim to generate a blood clot in the base of the defect, which forms fibrocartilage.[9] It is perceived as a cheap technique and can be performed arthroscopically, but has poor results in terms of durability, longevity and return to sport.[10] Microfracture has been shown to adversely affect the outcome of subsequent salvage interventions.[11] In a series of over 800 patients, this has been comprehensively confirmed.[12]

There are no data on the efficacy of microfracture against other surgical interventions for small lesions, as this has not been studied. However, it should be a serious consideration that microfracture creates defects in the subchondral bone and prejudices the success of any subsequent surgery. It should not be undertaken opportunistically in small defects, and careful informed consent is required, particularly as the prolonged rehabilitation required for correct microfracture technique would be an unwelcome surprise after an arthroscopy. It should be borne in mind that debridement and physical therapy renders most patients with small lesions asymptomatic, and therefore, while the evidence for addressing small lesions with microfracture is lacking and it is well known that microfracture compromises subsequent treatment, the indications are few. Inaccessible tibial lesions below 2 cm^2 may be such an indication. The comparative evidence has been recognized following an exhaustive review of the literature and health economic assessment.[13,14] NICE guidelines[14] specifically identify that lesions over 2 cm^2 should be treated primarily with a cell-based treatment, NOT microfracture. Consent for any microfracture should be compliant with current legal guidance.[15] Prolonged non-weight-bearing and its effect on return to work would be considered as materially relevant to most of our patients. The role of microfracture as any 'gold standard'[16] should be reassessed in light of overwhelming evidence,[13] as it is clearly inferior to alternative techniques in the treatment of symptomatic articular cartilage lesions.

Narrower and deeper drilled techniques have been proposed, with benefits seen in a sheep model,[17] but no clinical benefit has been demonstrated to date in clinical practice.[18]

The evidence for microfracture variants, such as covering the clot with a membrane, has recently been evaluated in a systematic review.[19] There is insufficient evidence to recommend joint-specific indications for this. If these techniques are to be performed, they should be in the context of clinical trials, as there is a paucity of evidence for their efficacy, and no evidence for their superiority over established techniques.

Osteochondral autografts

The use of such techniques in the UK has been influenced by the randomized controlled trial of Bentley et al.,[20] where there was shown to be inferior outcomes in the treatment of salvage lesions in the knee. Cell viability studies have shown that following harvesting of osteochondral plugs, approximately one-third of the chondrocytes in the plug (a ring at the periphery) are dead. This limits lateral integration to surrounding existing cartilage, and the space between plugs deteriorates in a similar manner to the fibrocartilage of microfractured defects.[21] Gudas et al. have shown some evidence that osteochondral plugs are superior for the repair of osteochondral defects compared to microfracture,[22] but there is no evidence for the superiority of plugs over cell-based techniques. Their use for small isolated defects may be appropriate in the context of clinical trials, where evidence is currently lacking. Donor site morbidity and existing clinical evidence excludes the use of osteochondral plugs in large defects.[20]

Osteochondral allografts

Osteochondral allografts are available for use in the UK via American suppliers, but to date have been unavailable from NHS Blood and Transplant. Their use in the USA and Canada is well established.[23,24] The survivorship reported by Bugbee is 90% at 10 years, with a 75% return to sport. Care should be taken to balance cell viability and microbiological safety in the harvest and processing and storage of cadaveric grafts.

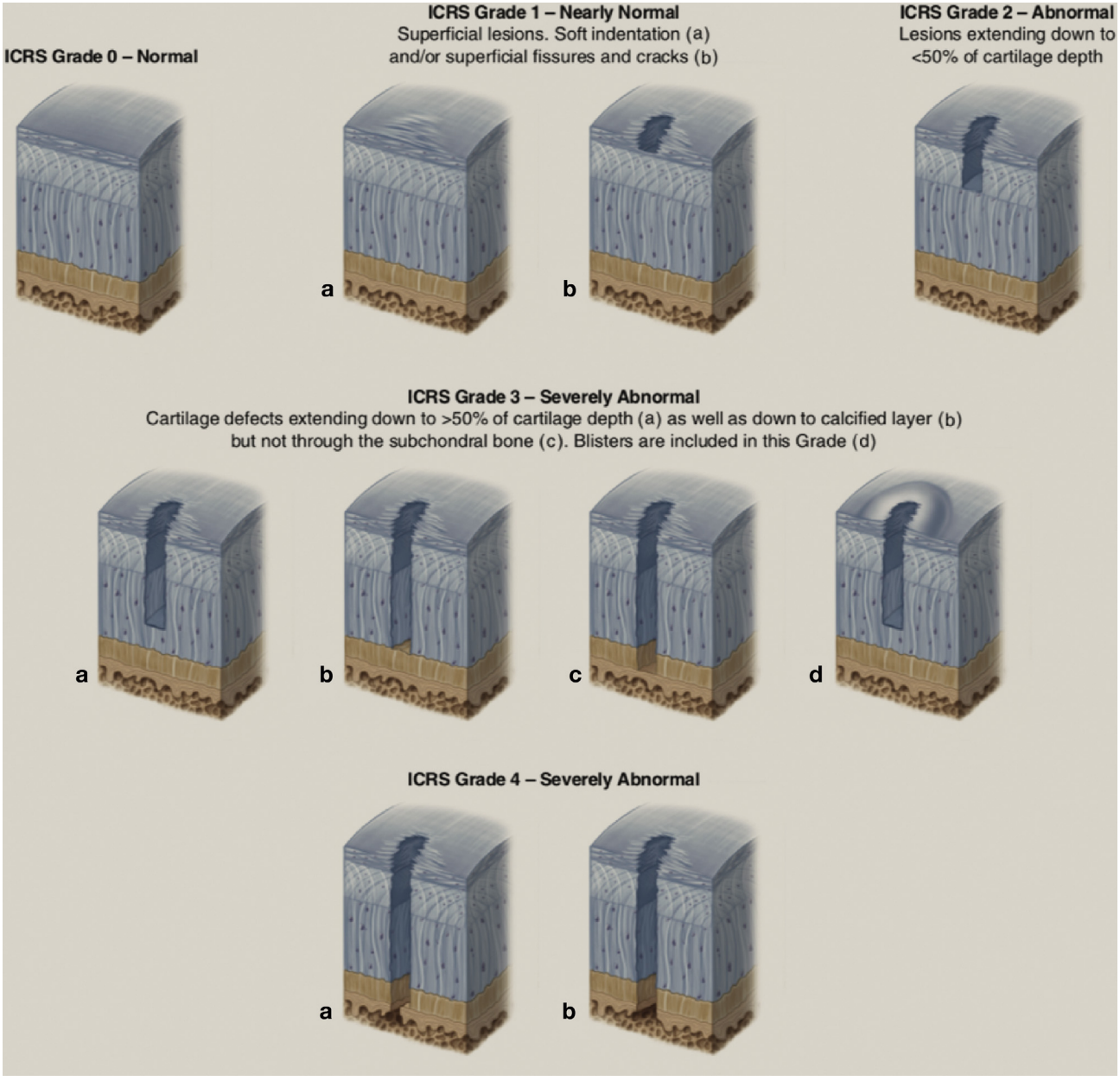

Figure 1 The International Cartilage Regeneration & Joint Preservation Society (ICRS) Cartilage Lesion Classification System (https://cartilage.org/society/publications/icrs-score/). Source: reproduced with permission from the International Cartilage Regeneration & Joint Preservation Society.

Current options for surgical treatment of articular cartilage defects

- Debridement
- Bone marrow stimulation (BMS)
- Osteochondral grafting (OCG)
- Osteochondral scaffolds
- Chondrocyte cell therapy (autologous chondrocyte implantation)
- Stem cell therapies
- Osteochondral allografts
- Partial replacements

Table 2

Cell-based treatments

Cell therapy can include autologous or allogenic chondrocytes, stem cells of different origins or a combination of these. Care should be given when evaluating the evidence, as not all stem cells exhibit the same chondrogenic potential, and the method of delivery to the defect is crucial.

Autologous chondrocyte implantation is a technique with over 30 years clinical experience, and is one of the most comprehensively evaluated techniques in orthopaedic surgery.[13] Unlike bone marrow stimulating techniques, it does not compromise the subchondral plate, so it is less painful, and it does not compromise any future treatments that may be required. ACI has been shown with robust long-term evidence to

be clinically superior to microfracture for larger lesions (Figure 2).

There have not been any studies in small lesions. Historically, the cost of ACI treatment has been a concern to orthopaedic surgeons. However, its cost-effectiveness has been shown to come well within the NICE framework[13,14] for cost per improved quality-adjusted life-year (QALY) compared to microfracture. The cost is minor compared to accepted treatments that offer similar quality of life improvements in other specialities.

First-generation ACI used a sutured autologous periosteal patch as a membrane over the implanted autologous chondrocytes. This technique was shown to be very effective, but hypertrophy of the membrane sometimes required arthroscopic debridement.[25] This was superseded by second-generation techniques that used a sutured porcine collagen membrane instead.[26] The third-generation techniques have collagen membranes carrying cells that are secured into the defect with a fibrin sealant.[27,28]

Arthroscopic ACI has been shown to be clinically effective.[29,30] However, a comparative cell viability study evaluating mini-arthrotomy vs arthroscopic third-generation ACI[31] showed 16 x more viable cells delivered to the defect when the operation was performed by mini-arthrotomy. This study has questioned the continued use of arthroscopic methods of delivery of cells for cartilage repair.

Return to sport is possible after ACI, with rates reported between 78 and 82%.[32–35] Rates of return to sport following ACI was better than those seen after microfracture. Return after microfracture was 7 months post-surgery, and 12 months after ACI; however, the microfracture patients deteriorated after 24 months.[35]

In 2017 NICE approved the use of cell-based therapies as a primary treatment for symptomatic articular cartilage lesions that have failed conservative treatment. The prolonged process of this appraisal (over 4 years) resulted in the two products originally appraised no longer being available in the UK. There are a number of other ACI products currently available, including one that has NICE approved,[36] but none of these have undergone the same rigorous long-term scientific validation of the previous two products. The currently available technologies may be equivalent, but longer-term data are awaited.

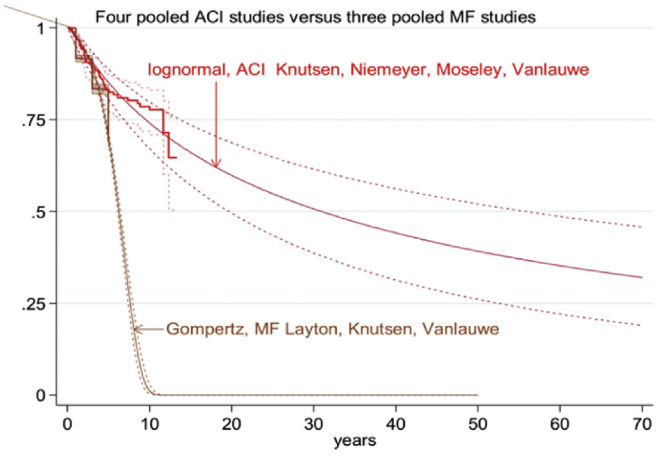

Figure 2 Comparison of long-term outcomes of cell-based treatment to microfracture studies. Source: reproduced from reference 13 with permission from the National Institute for Health Research.

Stem cell-based therapies are being used to treat articular cartilage lesions as described above, and in some centres abroad for the treatment of osteoarthritic knees.[37] The source of stem cells may be autologous or allogeneic. There are techniques to harvest from the iliac crest bone marrow,[38] adipose tissue[39] or peripheral blood.[37] Stem cells have been used in isolation[37] or in combination with chondrocytes.[40] The IMPACT study from the Netherlands showed good safety and early efficacy for implanting allogenic mesenchymal stem cells with recycled autologous chondrons in a single-stage procedure.[40] The work in Malaysia on peripheral blood stem cells is based on animal studies and 10-year clinical experience. Short-term published results are encouraging,[37] but long-term outcomes are awaited.

Focal arthroplasty

Focal arthroplasty involves the use of a metal-backed non-biological implant to fill a focal osteochondral defect. The articular surface of the implant designed to articulate against native cartilage can be metal or advanced polyethylene. The largest series of the original design had high failure rates (26.4% at 5 years in 176 implants), reported in the Australian Arthroplasty Registry.[41] The majority of failures were revised to total knee arthroplasty, suggesting that the focal implants were being used in degenerate osteoarthritic knees. This resulted in a clearer understanding of the indications. The newer technologies report improved success rates in short-term studies.[42,43] Rehabilitation is less arduous than with biological treatments. Longer-term outcomes are awaited.

The importance of outcome data

Any treatment of articular cartilage lesions should be followed up to assess outcomes, using validated scoring systems. The ICRS has developed a General Data Protection Regulation (GDPR)-compliant internet-based registry to facilitate follow-up of the patients undergoing such treatments. It was launched in 2016 and is available in five languages.[44] The Registry is free to use and can follow any non-arthroplasty treatment, including injections, bracing, debridement, and cartilage surgery, ligament reconstruction, osteotomy etc. NICE guidelines have suggested the use of this registry in its appraisal of osteochondral autograft surgery.[45]

Summary

Focal articular cartilage lesions can be as disabling as an osteoarthritic knee. The majority of articular cartilage lesions that remain symptomatic after appropriate conservative management can be helped by simple arthroscopic debridement. For those lesions that remain symptomatic after rehabilitation following that debridement, there are a large number of surgical interventions available. There are well-established cell-based treatments with long-term follow-up that have been shown to be cost effective, but frustratingly difficult to obtain for UK patients at present, despite NICE approval. Alternatives are available, with encouraging early results. We recommend that any such interventions should be followed up using an established registry to allow comparative analysis and medium to long-term outcome

assessments. As with all our interventions, we need independent data to justify what we do, and we should aspire to continually improve patient outcomes using evidence-based treatments. ◆

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