SURGICAL TREATMENT OF EARLY OSTEOARTHRITIS OF THE KNEE PRIOR TO ARTHROPLASTY

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Sports Orthopedic Surgeon, Patras University Hospital, GR
Definition

OA is a heterogeneous group of conditions that leads to joint symptoms and signs which are associated with defective integrity of articular cartilage, in addition to related changes in the underlying bone at the joint margins.
**Definition**

Although OA is a disease of the whole joint, the primary change is loss of articular cartilage.

Bony remodelling, osteophyte formation and synovial, capsular, ligamentous and muscular changes are secondary
Incidence

Between 1991 and 2000, the number of primary total hip replacements being undertaken in England increased by 18%, and the number of primary knee replacements more than doubled. Revision hip and knee arthroplasty increased by 154% and 300%, respectively.
Twenty-three guidelines have been developed for the treatment of hip and/or knee OA, based on opinion alone, research evidence or both.

Although this suggests that a core set of recommendations for treatment exists, critical appraisal shows that the overall quality of existing guidelines is sub-optimal, and consensus recommendations are not always supported by the best available evidence.
OARSI recommendations for the management of hip and knee osteoarthritis, Part I: Critical appraisal of existing treatment guidelines and systematic review of current research evidence


University of Edinburgh, Osteoarticular Research Group, The Queen’s Medical Research Institute, 47 Little France Crescent, Edinburgh EH16 4TJ, United Kingdom

Non – pharmacological
- acupuncture
- manual therapy
- physical therapy
- devices (orthotics)
- education
- self-management
- weight loss
- TENS
- thermal modalities
- nutraceuticals (chondroitin)

Pharmacological
- Acetaminophen
- Topical NSAIDs
- Cox-2 inhibitors
- Opioids
- Glucosamine
- Chondroitin sulphate
- Diacerhein
- molecular HA (Hylan)

Surgical
- Arthroscopic lavage Knee
- Arthroscopic debridement Knee
- Patellar resurfacing Knee
- Osteotomy Knee
- Joint distraction
- TJR Both
- Knee aspiration
- Knee fusion
The first abnormality seen in osteoarthritic cartilage is oedema, which is secondary to disruption of the macromolecular framework and degradation of aggrecan.
ASPECTS OF CURRENT MANAGEMENT

The assessment of early osteoarthritis

Synovium

MRI

Synovial biomarkers
hyaluronan, COMP, CRP

Synovial interstitium

Lymphatic

Capillary

Monocyte macrophage system

Blood

Clinical measurement

Relative sensitivity of imaging modalities to histological change

dGEMRIC

Biomarkers of synthesis/degradation of aggrecan, collagen type II, COMP and other matrix proteins and proteoglycans, CRP

MRI

CT arthrography

HF ultrasound

Plain radiography

Synovial fluid

Superficial zone

Mid-zone

Deep zone

Tidemark

Calciﬁed cartilage

Subchondral bone

OARSI histological grade

Progression of osteoarthritis

T. C. B. Pollard,
S. E. Gwilym,
A. J. Carr

From the Nuffield
Orthopaedic Centre,
Oxford, England
Gadopentetate dimeglumine disperses inversely with the amount of GAG in cartilage; thus, normal articular cartilage should have a low concentration, and damaged cartilage should have a high concentration.
The NICE treatment algorithm for knee OA

Reprinted with permission from NICE.
Management of Osteoarthritis of the Knee in the Active Patient


Brian T. Feeley, MD
Robert A. Gallo, MD
Seth Sherman, MD
Riley J. Williams, MD
Surgical treatment for early osteoarthritis. Part I: cartilage repair procedures

A. H. Gomoll · G. Filardo · L. de Girolamo · J. Espregueira-Mendes · M. Marraeci · W. G. Rodkey · R. J. Steadman · S. Zaffagnini · E. Kon

Treatment options

1. Arthroscopic lavage & debridement
2. Bone marrow stimulation
3. Cell-based therapy
4. Osteochondral autograft transfer
5. Scaffolds

Tibiofemoral compartment # Patellofemoral compartment
Treatment options

1. Osteochondral allografts

2. Allogenic cartilage grafts

3. Meniscal scaffolds and allograft transplantation

4. Osteotomy
Arthroscopic lavage

2 groups (3000ml) instead (250ml) of fluid irrigation
Beneficial only in patients with early OA and crystals
Arthroscopic lavage

Efficacy of joint lavage in knee osteoarthritis: meta-analysis of randomized controlled studies

Jérôme Avouac¹, Eric Vicaut², Thomas Bardin¹ and Pascal Richette¹

Rheumatology key messages

- Joint lavage is no more efficacious than placebo at 3 months on pain and function.
- Combination of joint lavage and corticosteroid injection does provide additional benefit.
The combination of both procedures show efficacy in reducing WOMAC pain scores and improving SF-36 PCS scores over a six month period.
In patients with osteoarthritis of the knee, neither arthroscopic lavage nor arthroscopic débridement was better than a placebo procedure for reducing pain or improving function.
No evidence that removal of loose debris, cartilage flaps, torn meniscal fragments, etc have any pain relief or functional benefit in patients that have joint space narrowing on standing radiographs.

3 indications only:

- removal of loose body
- meniscectomy

- anterior osteophyte (to improve extension)
Bone marrow stimulation

Symptomatic, focal high-grade chondral lesions of the weightbearing femoral condyles, trochlea, and patella in active patients

Incidental cartilage lesions

A defect size of $<4 \text{ cm}^2$

A short preoperative duration of symptoms (optimally, less than 12 months)

Optimal patient age should be $< 45$ years-old

Surgical technique

- Debridement, with use of an arthroscopic shaver, of any loose cartilage flaps to create a stable peripheral cartilage margin
Surgical technique

- débridement of the calcified cartilage layer with use of a curet to provide manual feedback control
Surgical technique

- the adequate depth of subchondral bone penetration and width of osseous bridges between the individual microfracture holes
Surgical technique

- the adequate depth of subchondral bone penetration and width of osseous bridges between the individual microfracture holes

3-4 mm
Surgical technique

- adequacy of the microfractures by noting the release of fat droplets and blood from the individual holes
The initially formed blood clot as produced by microfracturing is protected by the collagen membrane.
Surgical technique

- technique for microfracture of patellar lesions
## Rehabilitation

### Femoral condyle

<table>
<thead>
<tr>
<th>Phase</th>
<th>Weight Bearing</th>
<th>Brace</th>
<th>ROM</th>
<th>Therapeutic Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase I</strong> 0 - 8 weeks</td>
<td>Touchdown weight bearing (20-30%) for the first 6-8 weeks</td>
<td>None</td>
<td>Use of a CPM for 6-8 hours/day - set at a rate of 1 cycle/minute, advancing 10° daily - begin at a level of flexion that is comfortable for the patient - advance to full flexion as tolerated</td>
<td>Passive stretching/exercise for the first 6 - 8 weeks, quad/hamstring isometrics</td>
</tr>
<tr>
<td><strong>Phase II</strong> 8 - 12 weeks</td>
<td>Gradual return to full weight</td>
<td>None</td>
<td>Gain full and pain-free</td>
<td>Progressive active strengthening</td>
</tr>
<tr>
<td><strong>Phase III</strong> 12 weeks and beyond</td>
<td>Full</td>
<td>None</td>
<td>Full and pain-free</td>
<td>Return to full activities, including cutting, turning, and jumping</td>
</tr>
</tbody>
</table>
## Troclear-patellar defect

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<tr>
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<th>Weight Bearing</th>
<th>Brace</th>
<th>ROM</th>
<th>Therapeutic Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase I</strong></td>
<td>Weight bearing as tolerated</td>
<td>Locked 0 - 40° of flexion for weight bearing</td>
<td>Use of a CPM for 6-8 hours/day - begin at a rate of 1 cycle/minute, ranging from 0 - 40°</td>
<td>Passive stretching/exercise for the first 6 - 8 weeks, quad/hamstring isometrics</td>
</tr>
<tr>
<td>0 - 8 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Phase II</strong></td>
<td>Full</td>
<td>None</td>
<td>Gain full and pain-free</td>
<td>Begin closed chain activities, emphasizing a patellofemoral program</td>
</tr>
<tr>
<td>8 - 12 weeks</td>
<td></td>
<td></td>
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</tbody>
</table>
Clinical studies

- The overall clinical results of the microfracture arthroplasty have shown improved knee function in 70% to 95% of patients.


Clinical studies

High-Impact Athletics After Knee Articular Cartilage Repair: A Prospective Evaluation of the Microfracture Technique
Kai Mithoefer, Riley J. Williams, III, Russell F. Warren, Thomas L. Wickiewicz and Robert G. Marx
Am. J. Sports Med. 2006; 34; 1413 originally published online May 30, 2006;

- 32 athletes were treated with microfracture for single articular cartilage lesions of the knee
- At last follow-up, 66% reported good or excellent results and 44% were able to regularly participate in high-impact, pivoting sports, 57% of these at the preoperative level.
- Return to high-impact sports was significantly higher in athletes with age <40 years, lesion size <200 mm², preoperative symptoms <12 months, and no prior surgical intervention.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Before Cartilage Injury</th>
<th>After Microfracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>32</td>
<td>100</td>
</tr>
<tr>
<td>Football</td>
<td>9</td>
<td>28</td>
</tr>
<tr>
<td>Soccer</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Basketball</td>
<td>14</td>
<td>44</td>
</tr>
<tr>
<td>Tennis</td>
<td>13</td>
<td>41</td>
</tr>
<tr>
<td>Squash</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Downhill skiing</td>
<td>7</td>
<td>22</td>
</tr>
</tbody>
</table>
Who is the ideal candidate for microfracture?

1. As a first line treatment
2. Isolated, well-contained lesion
3. Less than 12 months after the injury
4. Femoral condyle > troclear
5. Less than 4cm²
6. Less than 40 years
7. Low body mass index
8. Complied with the rehab program
ACI is ideal for symptomatic, unipolar, full thickness, or nearly full thickness chondral or shallow osteochondral defects.

Commonly, patients have failed previous treatments.

Occasionally, larger symptomatic lesions are indicated as a first line treatment.

Malalignment, ligament instability, and meniscus deficiency are not considered contraindications as long as they are addressed concomitantly or in a staged fashion.
10/58 patients failed, making a total failure rate of 18.5% at the 6-year follow-up.

A lower improvement was observed in less-active patients, thus confirming our previous findings on the importance of sport activity and an active lifestyle for the medium-term clinical outcome after second-generation ACI.
Typical P-ACI: surgical technique
Our data demonstrate that ACI results in clinically relevant reductions in pain and improvement in function, while apparently delaying the need for knee arthroplasty for over 5 years in 92% of patients.

An average of 2.1 defects per knee was treated with an average defect size of 4.9 cm$^2$ and a total treated surface area of 10.4 cm$^2$ per knee joint.
OA chondrocytes have the ability to proliferate, redifferentiate and secrete cartilage-specific matrix proteins. We also show that OA chondrocytes have an inability to shift definitely from a proliferative to a differentiating state.

OA chondrocytes are able to bind to a scaffold, but further studies will be needed to establish how far the cartilage in this scaffold should be differentiated.
Osteochondral autograft transfer

- patients less than 50 years
- full-thickness focal chondral defects
- $< 4 \text{ cm}^2$
- femoral condyles
Osteoarthritic degenerative changes of Fairbank grade I or II were observed in 43% of the affected joints.

The average size of the chondral defects in treated knees was 2.0 cm.

Only 8% of the athletes rated the postoperative knee function and symptom scores as being worse than before the procedure.
The ideal patient is less than 50-60 years old and has good joint environment:

Well contained focal defects

No more than 2-3 lesions

No ligamentous laxity

No generalized degeneration
Chondral scaffolds are usually monophasic, even though some have a bilayer structure to better follow the biphasic composition of the osteochondral unit.

The most commonly used chondral matrices consist of collagen and hyaluronic acid.
**Scaffolds: types**

**MACI** technique (bilayer collagen I/III matrix seeded with autologous chondrocytes)

**Chondro-Gide** (bilayer porcine collagen I/III matrix)

**Hyalograft C** or **HyalofastTM** (hyaluronic acid)

**BioCart II** (combines chondrocytes with a 3-dimensional open pore fibrin and hyaluronic acid matrix.

**Bioseed C** (fibrin, polyglycolic/polylactic acid, and polydioxanone)
Matrix-assisted ACI: surgical technique
We could not detect a correlation between histological findings and clinical outcome based on the scores.

To conclude this study of 25 patients, MACT confirmed objective and subjective clinical improvement over a period of up to 5 years after operation.

The MACT/ACI represents a very cost-intensive procedure and to date it is covered by private insurance in individual cases only. Therefore, we have not performed any MACT since 2001.
53 patients with symptomatic isolated or multiple localized osteochondral defects (2–10 cm²)

Mean age was 40 years (18–60 years).

Satisfying outcomes on 17 patients who were reevaluated 5 years after surgery. At 60 months, MRI scans showed complete integration with the surrounding native cartilage without any sign of detachment or bone marrow edema in 15 cases.
The ideal candidate for ACI is

a young and fit patient

with high preoperative IKDC scores

and no previous operations

who is <12 months symptomatic

and has an isolated and small-sized cartilage defect
Biphasic scaffolds for osteochondral regeneration:

**Trufit:** bilayer porous PLGA-calcium-sulfate biopolymer

**Maioregen:** nanostructured biomimetic scaffold with a porous 3-dimensional tri-layer hydroxyapatite-collagen composite structure, mimicking the osteochondral anatomy
2 years postoperatively

... the plugs do not show any evidence of bone ingrowth, osteoconductivity, or integration, but rather lead to subchondral cyst formation in all cases.


...even an unfavorable mid-term MRI can significantly improve with time and therefore recommended perseverance.

28 pt / slower improvement was observed in older, less active patients, in case of adverse events or with patellar lesions.

At 2 years, uniformly good results were seen in both clinical and MRI evaluations (complete filling and graft integration in 70% of the lesions
We do not have evidence based methods for the treatment of cartilage defects in the knee

Jan P. Benthien · Manuela Schwaninger · Peter Behrens
We do not have evidence based methods for the treatment of cartilage defects in the knee

Jan P. Benthien · Manuela Schwaninger · Peter Behrens
Treatment options

1. Osteochondral allografts

2. Allogenic cartilage grafts

3. Meniscal scaffolds and allograft transplantation

4. Osteotomy
### Indications

<table>
<thead>
<tr>
<th>Condition</th>
<th>Reconstruction option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spontaneous osteonecrosis of the medial femoral condyle</td>
<td>Focal allograft, with or without HTO</td>
</tr>
<tr>
<td>2. Steroid-associated osteonecrosis</td>
<td>Multiple plugs or shell graft</td>
</tr>
<tr>
<td>3. Tibial plateau fracture malunion</td>
<td>Combined tibial plateau allograft and meniscal transplantation, with or without osteotomy</td>
</tr>
<tr>
<td>4. Unicompartmental tibiofemoral arthrosis (secondary to meniscectomy or repetitive chondral trauma)</td>
<td>Realignmet osteotomy, if indicated</td>
</tr>
<tr>
<td>5. Patellofemoral arthrosis</td>
<td>Bipolar plug or shell allograft, with or without tibial tubercle osteotomy</td>
</tr>
</tbody>
</table>
Osteochondral allografts

- Availability
- size matched to the patient
- accredited tissue banks
- disease transmission
- high cost
- better fresh (viable cartilage)

“sell allografts”
“bipolar allografts”
Technical aspects

A **plug graft** is a round graft prepared by commercially available instruments that form grafts between 15 and 35 mm in diameter.

**Shell grafts** are more complex geometric shapes that must be prepared by hand. These are utilized for resurfacing the femoral condyle, patella, and tibial plateau.

75% 10-year survivorship of tibial grafts in the management of post-traumatic OA and up to 75% good to excellent outcomes using allografts for patellofemoral disease.


90% graft survival rate at 6 years
- 25 FOCA transplantation in femoral condyle
- average age 35 years (range, 17-49 years)
- follow-up: 35 months (range, 24-67 )
- 84% satisfaction
- X-ray: 22 of the grafts (88%) were incorporated into host bone
Fresh Osteochondral Allografts for Posttraumatic Knee Defects
Long-term Followup

A. E. Gross MD, FRCSC, O.Ont, W. Kim MD, F. Las Heras MD,
D. Backstein D, MD, MEd, FRCSC, O. Safir MD, FRCSC, K. P. H. Pritzker MD, FRCPC

Table 1. Articular cartilage allograft histologic findings

<table>
<thead>
<tr>
<th>Tissue examined</th>
<th>Early retrieval (&lt;1 year)</th>
<th>Midterm retrieval (2-5 years; average, 2.9 years) (11 cases)</th>
<th>Long-term retrieval (&gt;5 years; average, 12 years) (24 cases)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartilage</td>
<td>Normal thickness and architecture</td>
<td>Normal thickness and architecture</td>
<td>Matrix staining normal except for superficial layer and upper mid zone</td>
</tr>
<tr>
<td></td>
<td>Retention of matrix and proteoglycan staining</td>
<td>Loss of matrix staining in the superficial and upper mid zones</td>
<td>Mostly visible chondrocytes with chondrocyte clusters and loss of chondrocyte polarity</td>
</tr>
<tr>
<td></td>
<td>Viable chondrocytes</td>
<td>Multiple chondrocytes within chondrons and some loss of chondrocyte polarity</td>
<td></td>
</tr>
<tr>
<td>Bone</td>
<td>Graft bone structurally intact</td>
<td>Host bone extends to subchondral plate with orderly resorption of graft bone by host bone</td>
<td>Host bone extends to and is apposed to calcified cartilage zone but variable remnants of dead bone surrounded by live bone persist</td>
</tr>
<tr>
<td></td>
<td>No osteocytes in lacunae</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Union of graft with host bone by 6 months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Allogenic cartilage grafts consist of the cartilage phase only, without attached bone. Therefore, they should be seen as a cell carrier, rather than structural graft.

1. Morcellized cartilage allograft
2. Allogenic chondrocyte implants
Morcellized cartilage allograft (1 mm³ cubes of hyaline cartilage obtained from juvenile donor, resulting in a chondrocyte density 100-fold higher than that of adult cartilage (De Novo NT))


7 patients with more than 1-year follow-up improved over baseline scores
**Allogenic chondrocyte implants** (cartilage is harvested and digested to release the cells contained within. The chondrocytes are isolated and mixed with alginate to form beads that are implanted into the cartilage defect


21 patients

follow up 36 months

mean age 33 years (12–47)

All lesions were focal: 15 on the MFC

ICRS grade III–IV mean size of 2.6 cm²

VAS pain and WOMAC scores improved significantly
Meniscal transplantation can be considered in case of massive/total meniscal resection. Meniscal replacement using scaffolds and meniscal allografts after partial and total meniscectomy, respectively, provides an important treatment option.
Meniscal scaffolds

- > 25% loss of meniscal tissue due to trauma or surgical intervention
- no or minimal chondral damage
- Menaflex or Actifit
Monllau JC, Gelber PE, et al. Tey M) **Outcome after partial medial meniscus substitution with the collagen meniscal implant at a minimum of 10 years’ follow-up.** Arthroscopy 2011:27:933–943

22 patients after a minimum of 10 years

Results were good or excellent in 83%

Radiographic evaluation showed either minimal or no narrowing of the joint line.

MRI was read as nearly normal in 64% of cases and normal in 21%.
At 3 months postimplantation, early evidence of tissue ingrowth was observed on MRI in 86% of patients.

MRI findings at 12 months postimplantation showed stable or improved cartilage scores in the index compartment compared to baseline.

No evidence of necrosis or cell death, was observed in all biopsies taken at the 1-year second-look arthroscopy
Meniscal allograft transplantation

1. Young patients with a history of meniscectomy who have pain localized to the meniscus-deficient compartment, particularly after *lateral* meniscectomy.

2. ACL-deficient patients who have had previous medial meniscectomy with concomitant ACL reconstruction

3. In an effort to avert early joint degeneration, some also consider young, athletic patients who have had total meniscectomy as candidates for meniscal transplantation prior to symptom onset.
Meniscal allografts are matched side- and size specific based on preoperative radiographs as small as a 10% size mismatch has been found to have major effects.

Open or arthroscopic technique

Radiographical analysis revealed no further joint narrowing in 13/32 knees (41%). MRI analysis showed no progression of degeneration in 6/17 knees (35%).
Osteotomy

Indications

Malalignment associated with unicompartmental OA, cartilage or meniscal lesions, and ligament instability

Preoperative MRI or concomitant arthroscopy to assess the articular surface and meniscus of the contralateral compartment.

Contraindications

- Meniscal lesion in the contralateral compartment
- Decreased < 90 degrees of flexion or more than 15 degrees of flexion contracture
- Tibial subluxation greater than 1 cm
- Obesity, smoking and compromised bone stock
Medial opening-wedge HTO

A medial opening HTO is usually performed when a severe varus deformity is present with proximal tibial malrotation,

Also when we need to correct tibial slope in case of associated ligament laxity.

preservation of the tibiofibular joint, no risk of injury to the peroneal nerve, no loosening of posterolateral structures, no limb shortening and easier adjustment of the tibial slope.
Lateral closing-wedge HTO

Performed for OA patients with no morphotype alterations and with light or moderate deformity. However, it is more difficult to change the tibial slope.

Does not require bone, grafting, allows earlier weight-bearing, has less risk of nonunion, and loss of correction.

The need for fibular osteotomy increases the risk of nonunions and peroneal nerve palsy.
For the varus-producing osteotomies, we aim to move the mechanical axis to a point 48–50% across the width of the tibial plateau from lateral to medial, mostly by means of a DFO and only in select cases by a medial closing-wedge HTO.
At 5 years, 70–90% of patients report satisfactory outcomes, which decreases to 50–70% at 15 years.


Saragaglia D, Blaysat M, Inman D, Mercier N. *Outcome of opening wedge high tibial osteotomy augmented with a Biosorb wedge and fixed with a plate and screws in 124 patients with a mean of ten years follow-up*. Int Orthop 2010 35:1151–1156.
30 patient with medial compartment OA and patellofemoral OA

open wedge HTO was combined with 1- to 1.5-cm Maquet-like tibial tuberosity anteriorisation

70% of patients experienced no pain
This combined procedure provides a safe treatment option for younger patients with medial knee OA and varus alignment with significant clinical improvement at 5 years.

However, overall graft survival and cartilage infill were poor (MRI study).
Young patients with early OA represent a challenging population due to a combination of high functional demands and limited treatment options.

Conservative measures such as injection and physical therapy can provide short-term pain relief but are only palliative in nature.
Joint replacement, a successful procedure in the older population, is controversial in younger patients, who are less satisfied and experience higher failure rates.

Specifically patients younger than 40 can only expect a 50\% chance of good and excellent Knee Society function scores and a revision rate of 12.5\% at 8 years.
Cartilage repair techniques with/or without osteotomy therefore, appears as a potentially promising treatment alternative for the young patient with disabling symptoms from early knee OA.