Journal of Cartilage & Joint Preservation® 4 (2024) 100191

Contents lists available at ScienceDirect

Journal of Cartilage & Joint Preservation®

journal homepage: www.elsevier.com/locate/jcjp

Original Research

Osteochondral autograft and allograft for knee cartilage injuries—an international Delphi consensus statement☆

Frederic Baker Mills IV[a,*], Eoghan T. Hurley[a], Richard M. Danilkowicz[a], Robert H. Brophy[b], Brian J. Cole[c], Fares S. Haddad[d], Laszlo Hangody[e], Gilbert Moatshe[f], Riley J. Williams III[g], Rachel M. Frank[h] and International Knee Cartilage Injury Delphi Consensus Study Group[1]

[a] Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC, USA
[b] Department of Orthopaedic Surgery, Washington University, Chesterfield, MO, USA
[c] Rush University Health System, Midwest Orthopaedics at RUSH, Chicago, IL, USA
[d] University College London Hospitals NHS Foundation Trust, Institute of Sport, Exercise and Health, London, England, United Kingdom
[e] Orthopeadic & Trauma Department, Uzsoki Hospital, Budapest, Hungary
[f] Oslo Sports Trauma Research Center, Oslo, Norway
[g] Hospital for Special Surgery, New York, NY, USA
[h] Department of Orthopaedic Surgery, University of Colorado, Denver, CO, USA

ARTICLE INFO

Keywords:
Consensus
Delphi
Knee cartilage
Osteochondral allograft
Osteochondral autograft

ABSTRACT

Introduction: Articular cartilage injuries of the knee are a complex and challenging clinical pathology.
Objectives: The purpose of this study was to establish consensus statements via a Delphi process on osteochondral autograft (OATS) and osteochondral allograft (OCA) in the setting of cartilage defects in the knee.
Methods: A consensus process on knee cartilage injuries utilizing a modified Delphi technique was conducted. Seventy-nine surgeons across 17 countries participated in these consensus statements. Twenty-seven questions were generated on OATS and OCA, with 3 rounds of questionnaires and final voting occurring. Consensus was defined as achieving 80% to 89% agreement, whereas strong consensus was defined as 90% to 99% agreement, and unanimous consensus was defined as 100% agreement with a proposed statement.
Results: Of the 27 total questions and consensus statements on OATS and OCA developed from 3 rounds of voting, 0 achieved unanimous consensus, 11 achieved strong consensus, 7 achieved consensus, and 9 did not achieve consensus.
Conclusions: The statements that achieved strong consensus pertained to the contraindications of OATS and OCA, the preferred site for harvest, storage conditions and timeframe for grafting, site preparation, surgical approach, graft step-off, impact of multiple grafts on clinical outcome, and ways to minimize complications. The statements that did not reach consensus regarded indications for OATS, locations for OATS and OCA, backfilling, sizing, supplemental fixation, marrow venting, and the use of orthobiologics for OCA.

☆ Eoghan T. Hurley and Richard M. Danilkowicz served as Guest Editors for this article in a special issue of JCJP. They, as well as Editor-in-Chief Rachel M. Frank, were not involved in the final editorial decision for this article.

* Frederic Baker Mills IV, Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC.
Email address: baker.mills@duke.edu (F.B. Mills).

[1] See Appendix A for International Knee Cartilage Injury Delphi Consensus Study Group.

https://doi.org/10.1016/j.jcjp.2024.100191
Received 12 March 2024; Revised 27 April 2024; Accepted 30 April 2024
Available online 10 May 2024

Introduction

Cartilage lesions are a common source of pain and disability, impacting the quality of life for millions of individuals worldwide. Chondral injuries are identified in > 60% of arthroscopic knee procedures; however, not all lesions are symptomatic.[1–4] These lesions are often the result of trauma, degenerative changes, and congenital anomalies and can manifest as pain, swelling, catching, and locking. The human body possesses limited intrinsic capacity to regenerate such lesions due to low chondrocyte turnover rates and avascularity, leading to dysfunction affecting daily life and potentially generalized osteoarthritis later in life.[1,2,5–9] Treatment options for symptomatic lesions range from less-invasive options, including arthroscopic debridement with or without bone marrow stimulation, to more invasive replacement options, including osteochondral autograft (OATS) or osteochondral allograft (OCA) transplantation, among others.[10] Treatment for focal lesions remains a topic of debate, and their functional impact can be significant, prompting a search for improved restorative techniques and standardized approaches.

When properly indicated, osteochondral transplantation seeks to restore the native topography of the articular surface and address subchondral pathology with a single-stage procedure.[11,12] Using autograft tissue, OATS involves the transplantation of native and healthy cartilage from non–weight-bearing and nonarticulating or minimally articulating portions of the joint to the damaged area with generally high success rates.[13,14] Good-to-excellent results have been observed at the 10-year follow-up in 92% of patients who underwent treatment for femoral condyle chondral defects, 87% of patients with tibial defects, 79% of patients with patellar and/or trochlear defects, and 94% of patients treated with talar defects.[15] A meta-analysis demonstrated a 93% rate of return-to-play (RTP) following OATS while offering a fast RTP timeframe in the management of osteochondral defects sustained by 2549 patients. Comparatively, OCA offered an RTP rate of 88%, which took a mean of 4 months longer.[16] OATS affords the opportunity to minimize the potential for an immunologic response, does not require a waiting period for graft availability or matching, and is typically indicated for smaller lesions.[3,15,17] However, there remains a lack of consensus regarding ideal lesion size as the amount of potential autograft can be limited. In contrast, OCA involves the placement of grafts harvested from a cadaveric donor into the damaged area and is typically utilized for larger defects.[18] The use of OCA also eliminates the possibility for donor-site morbidity, which is of concern with OATS. Additionally, OCAs offer an opportunity to select a donor site that more closely resembles the defective articular surface.

Previously, several societies have developed both national and international consensus statements on a variety of topics utilizing the Delphi method.[19–26] The Delphi method requires multiple rounds of questionnaires to encompass expert opinion on a topic, ultimately leading to defined consensus statements. Therefore, the International Knee Cartilage Injury Delphi Consensus Study Group was created with a mandate to establish clinical guidelines for key aspects of the treatment of this pathology. The purpose of this study was to establish consensus statements via a Delphi process on OATS and OCA for knee cartilage injuries. Our hypothesis was that there would be consensus in the majority of statements on the use of and indications for OATS and OCA in the knee.

Methods

Consensus working group

Eighty-four orthopaedic sports medicine and knee surgeons participated in these consensus statements on knee cartilage injuries, with 79 completing the consensus voting. The participants were members of The International Cartilage Regeneration & Joint Preservation Society (ICRS), Arthroscopy Association of North America (AANA), American Orthopaedic Society for Sports Medicine (AOSSM), Asia-Pacific Knee, Arthroscopy and Sports Medicine Society (APKASS), European Society for Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA), International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS), and Latin American Society of Knee Arthroscopy and Sports Medicine (SLARD), from 19 countries. They were invited due to their active interest and research on the topic of knee cartilage surgery. The participants were instructed to answer the questionnaires with what they considered the best answer, regardless of their personal bias concerning the answer. Experts were assigned to 1 of 10 working groups defined by specific subtopics of interest within knee cartilage surgery, including (1) diagnosis, (2) nonoperative management, (3) cartilage fixation, (4) bone marrow stimulation, (5) osteochondral autograft/allograft, (6) chondrocyte-based approaches and scaffolds, (7) concomitant procedures, (8) management of failed knee cartilage surgery, (9) rehabilitation and return-to-play, and (10) clinical and research follow-up. This study represents 1 of the working groups' topics, and 9 separate companion manuscripts focus on the other topics. Working groups were kept geographically balanced to prevent bias and ensure the groups were representative of the field at large. Thus, each working group was assigned surgeons from at least 2 different continents. A liaison (E.T.H.) served as the primary point of contact and facilitated communication and the distribution of surveys to ensure consistency across the working groups. Additionally, they formulated each subsequent round of questionnaires based on the prior round's responses. To reduce the potential for bias in the data analysis and/or literature review, the liaison did not submit answers to the questionnaires or partake in the voting process.

Delphi consensus method

The questions were generated by the 10 members of the steering committee based on areas of controversy in the experts' opinions as well as on questions identified through several systematic reviews of the literature. The Delphi method was used to generate consensus statements, with groups completing 3 initial rounds of questionnaires, amendments, and, last, a final vote. All the questionnaire responses and voting were anonymous. Questions progressed from an open-ended to a more structured format and were designed to elucidate areas of agreement and disagreement between group members. Once a preliminary consensus statement was

Table 1
Osteochondral autograft transfer system (OATS) consensus statements.

Strong consensus
The relative contraindications for OATS are (1) > 4 cm^2 (ie, 20 mm by 20 mm), (2) patients older than 60 years of age, (3) patients with uncorrected asymmetric malalignment (coronal $>$ 5 degrees), (4) patients with uncorrected ligamentous injury, (5) patients with uncontrolled diabetes, (6) patients with a history of inflammatory arthritis or crystalline arthropathy, and (7) patients who are unable to comply with postoperative restrictions.
Preferrable harvesting sites for OATS include the non–weight-bearing portions of the knee, including the superomedial and superolateral portions of the femoral trochlea.
Both open and arthroscopic approaches are acceptable for OATS/OCA as long as the defect can be approached perfectly perpendicular during reaming and graft insertion.
Prior to OATS/OCA transplantation, osteochondral lesions should be debrided in their entirety unless debridement would result in loss of containment. Additionally, healthy cartilage resection should be $<$ 5 mm on any border unless it results in a violation of the cortical rim or requires overlapping plugs. Ultimately, single plugs with the sacrifice of healthy cartilage are preferred over the use of overlapping plugs unless the sacrifice of healthy cartilage is $>$ 5 mm on any one side.
Graft congruency (perfectly flush when possible) is of paramount importance. When congruency cannot be obtained, then $<$ 1 mm of step-off is acceptable and it is better to be recessed than proud.
The number of grafts required for OATS or OCA affects the clinical outcome as increasing the number of grafts increases the risk of failure.
The following steps should be taken to minimize complications in those undergoing OATS or OCA: (1) ensure compliance with rehabilitation/return-to-play timeline, (2) address concomitant issues regarding alignment, menisci, and ligaments preoperatively and intraoperatively, (3) maximize contour and congruency, (4) avoid step-offs intraoperatively, (5) ensure reaming and graft preparation are completely perpendicular to the condylar surface, (6) minimize heat while reaming and irrigate liberally, (7) avoid overlapping plugs except when required by graft geometry, (8) avoid perforation of graft during preparation, (9) avoid using screw fixation and/or pins unless absolutely necessary, and (10) avoid loading the joint and weight-bearing early.
Consensus
The optimal drill depth and length of graft harvest is 8-10 mm for OATS and 6-8 mm for OCA.
Generally, the occurrence of postoperative cysts and/or bone marrow edema 9 mo after OATS and 12 mo after OCA is concerning.
OATS should not be washed prior to transplantation, but OCA should be washed with a minimum of 3 L of pulsatile lavage on the bone (without antibiotics).
Currently, orthobiologics do not have an established role alongside OATS.
No consensus
The relative indications for OATS are (1) full-thickness, isolated osteochondral lesions, and (2) between 2.25 cm^2 and 4 cm^2 (ie, up to 20 mm by 20 mm).
OATS may not be suitable for the trochlea, patella, and tibial plafond.
OATS may be preferable over OCA when used for full-thickness, isolated osteochondral lesions $\leq$1.44 cm^2 (ie, up to 12 mm by 12 mm).
OATS donor sites should be backfilled whenever possible.
Graft diameter should be slightly oversized by 1 mm to allow for a tighter press-fit of the OATS/OCA.
Headless compression screw(s) are preferred when fixation is necessary for OATs or OCA.
Marrow venting should not be done for the recipient site or for the donor plug for OATS or OCA.
It may be beneficial for OCA to be presoaked in concentrated bone marrow aspirate (ie, BMAC), for a minimum of 3 min.

Abbreviations: BMAC, bone marrow aspirate concentrate; OCA, osteochondral allograft.

generated within a working group, the liaison polled the participants as to whether they “agreed” or “disagreed” with the statement. If the agreement was not unanimous within a group, these questions were subject to further discussion by members of the entire consensus group, with statements being amended where there was agreement with the proposed change. The final voting process allowed all study participants to assess the consensus statements generated by the other working groups and vote on whether they “strongly disagree,” “disagree,” “agree,” “strongly agree,” or were “neutral” with them; thus, all statements were voted on by the 79 participants. Surveys were distributed in a blinded fashion using the Research Electronic Data Capture internet-based application.[27,28]

Final voting

After the final votes for each question occurred, the degree of agreement was expressed using a percentage rounded to the nearest whole number. Consensus was defined as 80% to 89%, strong consensus as 90% to 99%, and unanimous consensus was indicated by receiving 100% of the votes in favor of a proposed statement.[19–21,29–32]

Results

Overall consensus

Of the 27 total questions and consensus statements on OATS and OCA developed from 3 rounds of voting, 0 achieved unanimous consensus, 11 achieved strong consensus, 7 achieved consensus, and 9 did not achieve consensus. The consensus statements for OATS and OCA are shown in Tables 1 and 2, respectively.

Consensus statements

Q1: What are the relative indications for OATS?

A1: The relative indications for OATS are (1) full-thickness, isolated osteochondral lesions and (2) between 2.25 cm^2 and 4 cm^2 (ie, up to 20 mm by 20 mm).

Table 2
Osteochondral allografts (OCA) consensus statements.

Strong consensus
The relative contraindications for OCA are (1) lesions < 1 cm^2 (ie, 10 mm by 10 mm), (2) patients older than 60 years of age, (3) patients with a body mass index greater than 35, (4) patients with uncorrected asymmetric malalignment (coronal $>$ 5 degrees), (5) patients with uncorrected ligamentous injury, (6) patients with uncontrolled diabetes, (7) patients with a history of inflammatory arthritis or crystalline arthropathy, (8) patients with a history of infection, and (9) patients who are unable to comply with postoperative restrictions.
The preferred sites for harvesting OCAs are the donor medial femoral condyle and lateral femoral condyle grafts, which can be used for any lesion of any size of either femoral condyle. However, trochlea lesions should be treated with grafts harvested from the donor trochlea and patella lesions should be treated with grafts harvested from the donor patella.
Fresh (not frozen) is the ideal storage method for OCA. The ideal fluid medium has not been defined but needs to be maintained in a fluid medium that supports cell health, including an energy source, antibiotics, and other stabilizing medium.
The optimal and acceptable timeframe for OCA use is < 4 wk.
Prior to OATS/OCA transplantation, osteochondral lesions should be debrided in their entirety unless debridement would result in loss of containment. Additionally, healthy cartilage resection should be < 5 mm on any border unless it results in a violation of the cortical rim or requires overlapping plugs. Ultimately, single plugs with the sacrifice of healthy cartilage are preferred over the use of overlapping plugs unless the sacrifice of healthy cartilage is > 5 mm on any one side.
Graft congruency (perfectly flush when possible) is of paramount importance. When congruency cannot be obtained, then < 1 mm of step-off is acceptable and it is better to be recessed than proud.
The number of grafts required for OATS or OCA affects the clinical outcome as increasing the number of grafts increases the risk of failure.
The following steps should be taken to minimize complications in those undergoing OATS or OCA: (1) ensure compliance with rehabilitation/return-to-play timeline, (2) address concomitant issues regarding alignment, menisci, and ligaments preoperatively and intraoperatively, (3) maximize contour and congruency, (4) avoid step-offs intraoperatively, (5) ensure reaming and graft preparation are completely perpendicular to the condylar surface, (6) minimize heat while reaming and irrigate liberally, (7) avoid overlapping plugs except when required by graft geometry, (7) avoid perforation of graft during preparation, (8) avoid using screw fixation and/or pins unless absolutely necessary, and (9) avoid loading the joint and weight-bearing early.
Consensus
The relative indications for OCA are (1) full-thickness isolated osteochondral lesion, (2) $\geq$1.2 cm^2 (ie, $>$ 11 mm by 11 mm), (3) revision cartilage restoration lesion of any size, and (4) bipolar cartilage restoration lesion(s).
OCA can be performed for an uncontained lesion if there is $>$ 50% to 75% circumferential containment.
Radiographs can be beneficial, but MRI is necessary to procure a size-matched OCA.
Both open and arthroscopic approaches are acceptable for OATS/OCA as long as the defect can be approached perfectly perpendicular during reaming and graft insertion.
The optimal drill depth and length of graft harvest is 8-10 mm for OATS and 6-8 mm for OCA.
Generally, the occurrence of postoperative cysts and/or bone marrow edema 9 mo after OATS and 12 mo after OCA is concerning.
OATS should not be washed prior to transplantation, but OCA should be washed with a minimum of 3 L of pulsatile lavage on the bone (without antibiotics).
No consensus
OCA is suitable for all locations.
OATS may be preferable over OCA when used for full-thickness, isolated osteochondral lesions $\leq$1.44 cm^2 (ie, up to 12 mm by 12 mm).
Graft diameter should be slightly oversized by 1 mm to allow for a tighter press-fit of the OATS/OCA.
Headless compression screw(s) are preferred when fixation is necessary for OATS or OCA.
Marrow venting should not be done for the recipient site or for the donor plug for OATS or OCA.

Abbreviations: MRI, magnetic resonance imaging; OATS, osteochondral autograft transfer system.

No consensus—59% agreement (21% strongly agree, 38% agree, 13% neutral, 23% disagree, and 5% strongly disagree).

Q2: What are the relative indications for OCA transplantation?

A2: The relative indications for OCA are (1) full-thickness isolated osteochondral lesion, (2) $\geq$1.2 cm^2 (ie, $>$ 11 mm by 11 mm), (3) revision cartilage restoration lesion of any size, and (4) bipolar cartilage restoration lesion(s).

Consensus—86% agreement (30% strongly agree, 56% agree, 12% neutral, 3% disagree, and 0% strongly disagree).

Q3: What are the relative contraindications for OATS?

A3: The relative contraindications for OATS are (1) $>$ 4 cm^2 (ie, 20 mm by 20 mm), (2) patients older than 60 years of age, (3) patients with uncorrected asymmetric malalignment (coronal $>$ 5 degrees), (4) patients with uncorrected ligamentous injury, (5) patients with uncontrolled diabetes, (6) patients with a history of inflammatory arthritis or crystalline arthropathy, and (7) patients who are unable to comply with postoperative restrictions.

Strong consensus—90% agreement (34% strongly agree, 56% agree, 8% neutral, 1% disagree, and 1% strongly disagree).

Q4: What are the relative contraindications for OCA?

A4: The relative contraindications for OCA are (1) lesions $<$ 1 cm^2 (ie, 10 mm by 10 mm), (2) patients older than 60 years of age, (3) patients with a body mass index greater than 35, (4) patients with uncorrected asymmetric malalignment (coronal $>$ 5 degrees), (5) patients with uncorrected ligamentous injury, (6) patients with uncontrolled diabetes, (7) patients with a history of inflammatory arthritis or crystalline arthropathy, (8) patients with a history of infection, and (9) patients who are unable to comply with post-operative restrictions.

Strong consensus—91% agreement (38% strongly agree, 53% agree, 4% neutral, 5% strongly disagree, and 0% strongly disagree).

Q5: Are there any specific locations in which OATS cannot be used?

A5: OATS may not be suitable for the trochlea, patella, and tibial plafond.

No consensus—51% agreement (20% strongly agree, 31% agree, 16% neutral, 30% disagree, and 4% strongly disagree).

Q6: Are there any specific locations in which OCA cannot be used?

A6: No, OCA is suitable for all locations.

No consensus—79% agreement (40% strongly agree, 39% agree, 9% neutral, 10% disagree, and 1% strongly disagree).

Q7: Can an OCA be performed for an uncontained lesion?

A7: OCA can be performed for an uncontained lesion with > 50% to 75% circumferential containment.

Consensus—86% agreement (30% strongly agree, 56% agree, 9% neutral, 5% disagree, and 0% strongly disagree).

Q8: When is OATS preferred over OCA?

A8: OATS may be preferable over OCA when used for full-thickness, isolated osteochondral lesions ≤ 1.44 cm^2 (ie, up to 12 mm by 12 mm).

No consensus—76% agreement (17% strongly agree, 59% agree, 17% neutral, 5% disagree, and 3% strongly disagree).

Q9: What is the preferred site (compartment and area) for OATS harvesting?

A9: Preferrable harvesting sites for OATS include the non–weight-bearing portions of the knee, including the superomedial and superolateral portions of the femoral trochlea.

Strong consensus—91% agreement (45% strongly agree, 46% agree, 5% neutral, 3% disagree, and 1% strongly disagree).

Q10: Should OATS donor sites be backfilled?

A10: OATS donor sites should be backfilled whenever possible.

No consensus—75% agreement (29% strongly agree, 46% agree, 17% neutral, 8% disagree, and 1% strongly disagree).

Q11: What is the preferred site (compartment and area) for harvesting OCA?

A11: The preferred site for harvesting OCAs are the donor medial femoral condyle and lateral femoral condyle grafts, which can be used for any lesion of any size of either femoral condyle. However, trochlea lesions should be treated with grafts harvested from the donor trochlea, and patella lesions should be treated with grafts harvested from the donor patella.

Strong consensus—95% agreement (40% strongly agree, 55% agree, 3% neutral, 3% disagree, and 0% strongly disagree).

Q12: Is there an ideal storage method for OCA?

A12: Fresh (not frozen) is the ideal storage method for OCA. The ideal fluid medium has not been defined but needs to be maintained in a fluid medium that supports cell health, including an energy source, antibiotics, and other stabilizing medium.

Strong consensus—99% agreement (51% strongly agree, 48% agree, 1% neutral, 0% disagree, and 0% strongly disagree).

Q13: Is there an optimal and acceptable timeframe for OCA use?

A13: The optimal and acceptable timeframe for OCA use is < 4 weeks.

Strong consensus—95% agreement (43% strongly agree, 52% agree, 3% neutral, 3% disagree, and 0% strongly disagree).

Q14: What measurement and imaging method of the knee is necessary to procure a size-matched OCA?

A14: Radiographs can be beneficial, but magnetic resonance imaging is necessary to procure a size-matched OCA.

Consensus—84% agreement (46% strongly agree, 38% agree, 7% neutral, 5% disagree, and 5% strongly disagree).

Q15: Should OATS/OCA be performed via an open or arthroscopic approach?

A15: Both open and arthroscopic approaches are acceptable for OATS/OCA as long as the defect can be approached perfectly perpendicular during reaming and graft insertion.

Strong consensus—91% agreement (52% strongly agree, 39% agree, 4% neutral, 4% disagree, and 1% strongly disagree).

Q16: How much lesion should you remove prior to OATS/OCA, how much can be left untreated, and how much healthy cartilage can be removed?

A16: Prior to OATS/OCA transplantation, osteochondral lesions should be debrided in their entirety unless debridement would result in loss of containment. Additionally, healthy cartilage resection should be < 5 mm on any border unless it results in a violation of the cortical rim or requires overlapping plugs. Ultimately, single plugs with the sacrifice of healthy cartilage are preferred over the use of overlapping plugs unless the sacrifice of healthy cartilage is > 5 mm on any one side.

Strong consensus—95% agreement (39% strongly agree, 56% agree, 1% neutral, 4% disagree, and 0% strongly disagree).

Q17: How should the lesion and the OATS/OCA be sized intraoperatively to the defect?

A17: Graft diameter should be slightly oversized by 1 mm to allow for a tighter press-fit of the OATS/OCA.

No consensus—70% agreement (23% strongly agree, 47% agree, 18% neutral, 7% disagree, and 5% strongly disagree).

Q18: How important is graft congruency? Is there an acceptable amount of step-off after graft placement? If yes, is it better to be proud or recessed?

A18: Graft congruency (perfectly flush when possible) is of paramount importance. When congruency cannot be obtained, then < 1 mm of step-off is acceptable, and it is better to be recessed than proud.

Strong consensus—92% agreement (53% strongly agree, 39% agree, 5% neutral, 3% disagree, and 0% strongly disagree).

Q19: If supplemental fixation is required for OATS or OCA, what fixation device is preferred?

A19: Headless compression screw(s) are preferred when fixation is necessary for OATS or OCA.
No consensus—78% agreement (38% strongly agree, 40% agree, 17% neutral, 5% disagree, and 0% strongly disagree).
Q20: What is the optimal depth to drill the lesion site and optimal length of the graft to harvest for OATS or OCA?

A20: The optimal drill depth and length of graft harvest is 8 to 10 mm for OATS and 6 to 8 mm for OCA.
Consensus—87% agreement (35% strongly agree, 52% agree, 7% neutral, 5% disagree, and 1% strongly disagree).
Q21: Does the number of grafts required for OATS or OCA affect clinical outcome?

A21: The number of grafts required for OATS or OCA affects the clinical outcome, as increasing the number of grafts increases the risk of failure.
Strong consensus—91% agreement (38% strongly agree, 53% agree, 7% neutral, 3% disagree, and 0% strongly disagree).
Q22: What time point are postoperative cysts and/or bone marrow edema a concern after OATS or OCAs?

A22: Generally, the occurrence of postoperative cysts and/or bone marrow edema 9 months after OATS and 12 months after OCA is concerning.
Consensus—86% agreement (26% strongly agree, 60% agree, 10% neutral, 3% disagree, and 1% strongly disagree).
Q23: Which of the following steps should be taken to minimize complications in those undergoing OATS or OCA?

A23: The following steps that should be taken to minimize complications in those undergoing OATS or OCA are (1) ensure compliance with rehabilitation/RTP timeline, (2) address concomitant issues regarding alignment, menisci, and ligaments preoperatively and intraoperatively, (3) maximize contour and congruency, (4) avoid step-offs intraoperatively, (5) ensure reaming and graft preparation are completely perpendicular to the condylar surface, (6) minimize heat while reaming and irrigate liberally, (7) avoid overlapping plugs except when required by graft geometry, (8) avoid perforation of graft during preparation, (9) avoid using screw fixation and/or pins unless absolutely necessary, and (10) avoid loading the joint and weight-bearing early.
Strong consensus—96% agreement (53% strongly agree, 43% agree, 1% neutral, 3% disagree, and 0% strongly disagree).
Q24: Should marrow venting be performed during OATS or OCA?

A24: Marrow venting should not be done for the recipient site or for the donor plug for OATS or OCA.
No consensus—70% agreement (23% strongly agree, 47% agree, 14% neutral, 12% disagree, and 4% strongly disagree).
Q25: Should the donor plug for OATS or OCA be washed/prepared prior to transplantation?

A25: OATS should not be washed prior to transplantation, but OCA should be washed with a minimum of 3 L of pulsatile lavage on the bone (without antibiotics).
Consensus—85% agreement (46% strongly agree, 39% agree, 16% neutral, 0% disagree, and 0% strongly disagree).
Q26: Should orthobiologic(s) be utilized for OATS?

A26: Currently, orthobiologics do not have an established role alongside OATS.
Consensus—89% agreement (38% strongly agree, 51% agree, 7% neutral, 4% disagree, and 1% strongly disagree).
Q27: Should orthobiologic(s) be utilized for OCA?

A27: It may be beneficial for OCA to be presoaked in concentrated bone marrow aspirate (ie, bone marrow aspirate concentrate [BMAC]) for a minimum of 3 minutes.
No consensus—59% agreement (12% strongly agree, 47% agree, 30% neutral, 10% disagree, and 1% strongly disagree).

Discussion

There are varying indications for the use of OATS. Current literature focuses on patient selection, which has previously been recommended for use in the treatment of younger patients (< 45 years of age) with focal and smaller lesions.[3,33] However, there remains a lack of consensus regarding optimal age and physical activity for OATS in the literature. OATS may be used in settings requiring multiple plugs or grafts.[3] However, patients with global arthrosis are not typically indicated.[33] This study reached consensus with the recommendation of OATS for full-thickness, isolated osteochondral lesions measuring between 2.25 cm^2 and 4 cm^2 (ie, up to 20 mm by 20 mm) and found OATS may be preferable over OCA in the treatment of full-thickness, isolated lesions measuring up to 1.44 cm^2 (ie, up to 12 mm by 12 mm) and smaller. However, it should be noted that allograft may not be as freely accessible in all parts of the world, and some surgeons may not be able to use OCA.[34] This may cause surgeons in certain regions to alter their indications and may lead to some challenges in coming to a consensus as there can be multiple right options with overlapping indications.

It is important to consider lesion locations as OATS may not be suitable for the trochlea, patella, and tibial plafond due to incongruity at the articular surface and the underlying tidemark, making topographical matching challenging.[33,35,36] Notably, when harvesting OATS grafts, it should be from non–weight-bearing portions of the knee, including the superomedial and superolateral aspects of the femoral trochlea, which have been shown to have low donor-site morbidity.[37–41] Although there is currently no consensus on backfilling donor sites following harvesting, complications such as overfilling of donor sites with hypertrophic fibrocartilage leading to knee pain and locking have been described.[42] OCA eliminates all considerations of donor-site morbidity and

presents the unique opportunity to select a transplant region that more closely resembles the recipient's native contour.[43] OCA has typically been recommended for patients not indicated for OATS by the aforementioned criteria and those with symptomatic, full-thickness osteochondral defects measuring ≥2 cm^2.[37,40,44–46]

This consensus recommends the use of OCA for full-thickness, isolated osteochondral lesions 1.2 cm^2 (ie, > 11 mm by 11 mm) or larger, revision cartilage restoration lesions of any size, and bipolar cartilage restoration lesions. Whereas the majority of prior literature utilizes size recommendations > 2.0 cm^2 to 3.0 cm^2, there was a strong consensus that OCA may be appropriate for use in all locations.[35,39,40,46,47] Additionally, OCA may be performed for uncontained lesions if there is > 50% to 75% circumferential containment. When considering OCA graft selection, it is strongly recommended to select a graft that was harvested from the most anatomically similar location and advanced imaging in the form of a magnetic resonance imaging may be beneficial in procuring a size-matched OCA.[9,15,38,48,49] For instance, trochlear and patellar lesions should be treated with grafts harvested from the donor trochlea and patella, respectively. In other cases, harvesting from the donor medial and lateral femoral condyles is preferred, although there is research to suggest more flexibility in the harvesting of condylar allografts.[50] Specifically, Mologne et al[51] found excellent OCA surface match with either a medial or lateral femoral donor graft into medial femoral condyle recipient sites, with no significant difference in graft height mismatch or step-off. Following harvesting, it is recommended fresh (never-frozen OCA) be used when possible, and OCA should be maintained in a fluid medium that supports cell health with an energy source, antibiotics, and stabilization when preserved.[52] There was also a strong consensus that OCA should be implanted within 4 weeks of harvesting and washed with 3 L of pulsatile lavage, without antibiotics, on the bone prior to implantation.

Preferential surgical technique and approach varies between surgeons. Both open and arthroscopic approaches are appropriate if the defect is approached perfectly perpendicular during reaming and insertion, which had a strong consensus. In cases in which prior OATS/OCA has been performed, the osteochondral lesions should be debrided in their entirety unless it may result in loss of containment. Additionally, healthy cartilage resection should be minimized (ie, < 5 mm) unless there is a violation of the cortical rim or overlapping of plugs is required. Single plugs with the sacrifice of healthy cartilage had strong consensus over the use of overlapping plugs unless the sacrifice of > 5 mm of healthy cartilage on any border is required, which is supported in the literature.[15,38–40,42,47] During implantation, there is a lack of consensus regarding intraoperative sizing and whether grafts should be oversized by 1 mm to allow for a tighter press-fit, but there was consensus that optimal drill depth and length of graft harvest is 8 to 10 mm for OATS and 6 to 8 mm for OCA. It is paramount to obtain graft congruency (< 1 mm of step-off) or leave the graft slightly recessed as opposed to proud when applicable, as biomechanical studies have shown the deleterious effects of grafts left proud.[53–56] In cases in which supplemental fixation is necessary, headless compression screws may be used, but there was no consensus among our authors regarding various methods.

Regarding adjunctive procedures as a means to increase local biology, there was no consensus regarding the potential role of marrow venting or the role and potential use of orthobiologics for OATS and OCA. While there is some limited evidence to support the use of orthobiologics in such cases, there remains a lack of consensus in the literature as well. A prior suggested that orthobiologic augmentation and graft-recipient microfracture preparation during OATS of the medial femoral condyle may improve allograft incorporation and decrease revision rates.[57] In 1 study, the use of BMAC prior to OCA implantation to treat large femoral condylar defects demonstrated superior radiographic integration, leading to decreased sclerosis during the postoperative period.[58] However, this finding was contested by Ackermann et al,[59] who found no improvement in radiographic integration. A systematic review of platelet-rich plasma and BMAC as augmentation in the treatment of chondral defects with OCA concluded no difference in radiographic features.[60] Similarly, Wang et al[61] did not find a correlation between OCA augmented with BMAC and improved osseous integration or decreased rates of sclerosis compared with OCA alone at 6 and 12 months postoperatively.[61] Rather, they suggested several influencing factors in the creeping substitution process, such as BMAC harvest and preparation, patient age, and a prior or current history of tobacco use.[61]

Several factors were considered regarding clinical outcome and prognosis following OATS and OCA. An increasing number of grafts required for OATS and OCA is felt to negatively impact clinical outcomes and increase the likelihood of failure, which has been established in the literature.[35,62,63] There is concern for postoperative cysts and/or bone marrow edema in the initial 9 months following OATS and 12 months following OCA.[64] However, postoperative imaging and the clinical significance of its findings are still under investigation.[48,52,63,65,66] Last, in order to minimize complications in those undergoing OATS and OCA, the following recommended steps should be taken: ensure patient compliance, address concomitant issues intraoperatively, maximize contour and congruency, avoid step-offs, ensure perpendicular reaming and graft preparation, minimize heat with liberal irrigation during reaming, avoid overlap, avoid graft perforation, avoid supplemental fixation unless necessary, and avoid early loading of the joint.

Limitations

This study has several potential limitations. First, consensus statements are considered to be level V data as they represent expert opinion, which makes them susceptible to inherent biases in the selection and allocation of participants. However, we sought to include surgeons who have an active interest and level of expertise in this area, as evidenced by their clinical and academic achievements on the topic. Furthermore, the questions and topics addressed may represent a potential source of bias as there was no standardized process for generating them. Instead, they were each selected and agreed upon by the group leaders. During the process, all the included authors had the opportunity to contribute to the manuscript and raise points for discussion. This was done in a blinded fashion in an effort to further reduce potential sources of bias. While attrition rates were low, participant dropout can also introduce a potential source of bias. Finally, there are some limitations with the Delphi process itself as it may represent the lowest common denominator of expert opinion with less ownership of ideas, ultimately representing level V data.

Conclusion

The statements that achieved strong consensus pertained to the contraindications of OATS and OCAs, the preferred site for harvest, storage conditions and timeframe for grafting, site preparation, surgical approach, graft step-off, impact of multiple grafts on clinical outcome, and ways to minimize complications. The statements that did not reach consensus regarded indications for OATS, locations for OATS and OCA, backfilling, sizing, supplemental fixation, marrow venting, and the use of orthobiologics for OCA.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethics approval

Informed consent was not required due to no patient data being used.

Declaration of Competing Interest

Richard Danilkowicz, Zachary Aman, Allen Champagne, Fintan Shannon, Jacob Torrey, Chanell Brown, Rodrigo Guiloff, Safa Gursoy, Alex Meyer, Kendall Bradley, Crystal Perkins, Bryan Crook, Grant Cabell, Mats Brittberg, Stefan Marlovits, Lars Peterson, F. Baker Mills, Zoe Hinton, Lucy Meyer, Joao Espregueria-Mendes, Sam Lorentz, Isabel Prado, Tom Doyle, Daniel Stokes, Andrew Hughes, and Ian Savage-Elliott have nothing to disclose. The other authors report the following disclosures:

Eoghan T. Hurley: SECEC: Board or committee member, Arthroscopy: Editorial or governing board, Journal of Cartilage and Joint Preservation: Editorial or governing board. Drew Lansdown: AlloSource: Paid consultant, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Other financial or material support, Arthroscopy: Editorial or governing board, Arthroscopy Association of North America: Board or committee member, Convergence Medical: Stock or stock options, Journal of Cartilage & Joint Preservation: Editorial or governing board, Vericel: Paid consultant. Francisco Figueroa: International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member. Iain Murray: Arthrex, Inc: Paid consultant, Bone and Joint Research: Editorial or governing board, Journal of Bone and Joint Surgery - British: Editorial or governing board, Stryker: Paid consultant. Kristofer J. Jones: Aesculap/B.Braun: Research support, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Paid consultant, Journal of Bone and Joint Surgery (Am): Board or committee member, Joint Restoration Foundation (JRF) Ortho: Paid consultant, Musculoskeletal Transplant Foundation: Research support, NFL Musculoskeletal Injury Committee: Board or committee member, Organogenesis: Research support, Sparta Biopharma: Stock or stock options, Vericel Corporation: Paid consultant; Research support. Laith M Jazrawi: Arthrex, Inc: Research support, Bulletin for the Hospital for Joint Diseases: Editorial or governing board, JBJS Reviews: Editorial or governing board, Lazurite: Stock or stock options, Mitek: Research support, Smith & Nephew: Research support, Wolters Kluwer Health - Lippincott Williams & Wilkins: Publishing royalties, financial or material support. Michael G. Ciccotti: Major League Baseball Team Physicians Association: Board or committee member, Orthopaedic Learning Center: Board or committee member. Michael T. Hirschmann: AGA: Board or committee member, BMC Sports Medicine, Arthroscopy, Rehabilitation, Therapy & Technology: Editorial or governing board, DePuy, A Johnson & Johnson Company: Paid consultant; Paid presenter or speaker, European Society for Sports Traumatology, Knee Surgery and Arthroscopy: Board or committee member, European Knee Associates (EKA): Board or committee member, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Knee Surgery, Sports Traumatology, Arthroscopy: Editorial or governing board, Lima: Paid consultant; Paid presenter or speaker, Muscle Ligament Tendon Journal (MLT): Editorial or governing board, Smith & Nephew: Paid consultant; Paid presenter or speaker, Symbios: Paid consultant; Paid presenter or speaker. Kirk Campbell: AAOS: Board or committee member, Arthroscopy Association of North America: Board or committee member, Stryker: Research support, David Figueroa: CONMED Linvatec: Paid consultant, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Revista Artroscopia: Editorial or governing board, revista Chilena de Ortopedia y Traumatologia: Editorial or governing board, Latin American Society of Knee Arthroscopy and Sports Medicine: Board or committee member, Smith & Nephew: Paid consultant, Stryker: Paid consultant. Laurie Hiemstra: Banff Sport Medicine Foundation: Board or committee member, Canadian Orthopaedic Association: Board or committee member, CONMED Linvatec: Paid presenter or speaker; Research support, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Patellofemoral Foundation: Board or committee member, Pendopharm: Paid presenter or speaker; Research support, Pendopharm Canada: Paid consultant, Precision OS: Stock or stock options, Sanofi-Aventis: Paid consultant; Paid presenter or speaker, Smith & Nephew: Paid presenter or speaker; Research support. Bogdan Matache: Arthrex, Inc: Paid consultant, Arthroscopy Association of North America: Board or committee member, Pendopharm: Paid presenter or speaker, Kenneth Zaslav: Arcuro: Paid presenter or speaker, Arcuro Inc: Stock or stock options, Arthroscopy Association of North America: Board or committee member, BIOLOGIC ASSOCIATION: Board or committee member, Cartiheal Inc: Stock or stock options, International Cartilage Regeneration & Joint Preservation Society (ICRS): Board or committee member, Lipogems: Research support, Novartis: Research support, Organogenesis: Research support, Smith & Nephew: Paid consultant. Jorge Chahla: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Paid consultant, Arthroscopy Association of North America: Board or committee member, CONMED Linvatec: Paid consultant, International Society of Arthroscopy, Knee

Surgery, and Orthopaedic Sports Medicine: Board or committee member, Ossur: Paid consultant, Smith & Nephew: Paid consultant; Paid presenter or speaker. James L. Carey: Arthrex, Inc: Paid consultant, Bioventus: Paid consultant, ICRS: Board or committee member, JRF Ortho: Paid consultant, Ossur: Research support, Smith & Nephew: Other financial or material support, The American Journal of Sports Medicine: Editorial or governing board, Vericel Corporation: Paid consultant; Research support. Benton E. Heyworth: Allosource: Other financial or material support, Imagen Technologies, Inc: Stock or stock options, Pediatric Orthopaedic Society of North America: Board or committee member, Pediatric Research in Sports Medicine (PRISM): Board or committee member, Springer: Publishing royalties, financial or material support, Vericel: Other financial or material support. Adnan Saithna: Arthrex, Inc: Paid consultant, Arthroscopy: Editorial or governing board, Arthroscopy Association of North America: Board or committee member, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, OJSM: Editorial or governing board, SANTI Study Group: Board or committee member. Daniel B. F. Saris: Cartilage: Editorial or governing board, JRF: Research support, NewClip: Paid consultant. Nicholas A. Sgaglione: Regen Biologics: Research support, Sports Medicine Arthroscopy Review: Editorial or governing board, Wolters Kluwer Health - Lippincott Williams & Wilkins: Publishing royalties, financial or material support, Zimmer: IP royalties; Paid consultant; Research support. Dean C. Taylor: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Other financial or material support, Breg: Other financial or material support, DePuy, A Johnson & Johnson Company: IP royalties, DJOrtho: Other financial or material support, Mitek: Other financial or material support, OJSM: Editorial or governing board, Smith & Nephew: Research support, Smith and Nephew: Other financial or material support. Brandon Erickson: AAOS: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, American Shoulder and Elbow Surgeons: Board or committee member, Arthrex, Inc: Paid consultant; Research support, DePuy, A Johnson & Johnson Company: Research support, Linvatec: Research support, PLOS One: Editorial or governing board, Smith & Nephew: Research support, Stryker: Research support. Alberto Gobbi: Anika Therapeutics USA: Research support, ICRS: Board or committee member, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member. Deepak Goyal: ICRS: Board or committee member, Indian Cartilage Society: Board or committee member, Asian Cartilage Repair Society: Board or committee member, American Journal of Sports Medicine: Editorial or governing board, Journal of Cartilage Repair and Joint Preservation: Editorial or governing board. Cassandra Lee: AAOS: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthroscopy Association of North America: Board or committee member, CONMED Linvatec: Paid presenter or speaker, Genzyme: Paid presenter or speaker, Smith & Nephew: Paid presenter or speaker. Elizabeth Matzkin: Arthrex, Inc: Other financial or material support, Arthroscopy: Editorial or governing board. Sabrina Strickland: American Journal of Sports Medicine: Editorial or governing board, Arthroscopy Association of North America: Board or committee member, Engage: Stock or stock options, JRF: Research support, Moximed: Paid consultant, Organogenesis: IP royalties; Paid presenter or speaker, Smith & Nephew: Paid consultant, Stryker: Stock or stock options, Vericel: Paid presenter or speaker; Research support. Robert Parisien: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Other financial or material support, Arthroscopy: Editorial or governing board, Arthroscopy Association of North America: Board or committee member, Eastern Orthopaedic Association: Board or committee member, Journal of Cartilage & Joint Preservation: Editorial or governing board, Journal of Sport Rehabilitation: Editorial or governing board, New England Orthopaedic Society: Board or committee member, Society of Military Orthopaedic Surgeons: Board or committee member. Betina Hinckel: Arthrex, Inc: Other financial or material support, Smith & Nephew: Other financial or material support, Stryker: Other financial or material support. Robert H. Brophy: AAOS: Board or committee member, American Journal of Sports Medicine: Editorial or governing board, American Orthopaedic Association: Board or committee member, Journal of the American Academy of Orthopaedic Surgeons: Editorial or governing board. Brian J. Cole: Aesculap/B.Braun: Research support, American Journal of Sports Medicine: Editorial or governing board, Arthrex, Inc: IP royalties; Paid consultant; Research support, Arthroscopy Association of North America: Board or committee member, BandGrip Inc: Stock or stock options, Elsevier Publishing: IP royalties, Journal of the American Academy of Orthopaedic Surgeons: Editorial or governing board, JRF Ortho: Other financial or material support, National Institutes of Health (NIAMS and NICHD): Research support, Operative Techniques in Sports Medicine: Publishing royalties, financial or material support, Ossio: Stock or stock options. Fares Sami Haddad: Corin: IP royalties, ISTA: Board or committee member, Journal of Bone and Joint Surgery - British: Editorial or governing board, Mathys Ltd: Paid presenter or speaker, MatOrtho: IP royalties, Orthopedics Today: Editorial or governing board, Smith & Nephew: IP royalties; Paid consultant; Research support, Stryker: IP royalties; Paid consultant; Paid presenter or speaker; Research support. Laszlo Hangody: Anika Therapeutics: Research support. Buru Gilbert Moatshe: Arthroscopy: Editorial or governing board, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Journal of Bone and Joint Surgery - American: Editorial or governing board, Smith & Nephew: Paid consultant. Riley Joseph Williams: Arthrex, Inc: IP royalties; Paid consultant, BICMD: Stock or stock options, CyMedica: Stock or stock options, Engage Surgical: Stock or stock options, Gramercy Extremity Orthopedics: Stock or stock options, HistoGenetics: Research support, JRF Ortho: Paid consultant, Lipogems: Paid consultant, Pristine Surgical: Stock or stock options, RecoverX: Stock or stock options. Rachel M. Frank. AAOS: Board or committee member, Allosource: Paid consultant; Paid presenter or speaker, American Orthopaedic Society for Sports Medicine: Board or committee member, American Shoulder and Elbow Surgeons: Board or committee member, Arthrex, Inc: Paid consultant; Paid presenter or speaker; Research support, Arthroscopy Association of North America: Board or committee member, Elsevier: Publishing royalties, financial or material support, International Cartilage Restoration Society: Board or committee member, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Journal of Shoulder and Elbow Surgery: Editorial or governing board, JRF: Paid consultant; Paid presenter or speaker, Orthopedics Today: Editorial or governing board, Ossur: Paid presenter or speaker, Smith & Nephew: Research support. David Flanigan: Aesculap/B.Braun: Research support, American Orthopaedic Society for Sports Medicine: Board or committee member, Anika Therapeutics: Research support, Arthrex, Inc: Research support, Arthroscopy Association of North America: Board or

committee member, Cartiheal: Research support, CartiLife: Research support, Ceterix: Research support, CONMED Linvatec: Paid consultant, DePuy, A Johnson & Johnson Company: Paid consultant, Episurf: Research support, Hyalex: Paid consultant, Moximed: Research support, Musculoskeletal Transplant Foundation: Paid consultant; Research support, Smith & Nephew: Paid consultant; Research support, Stryker: Research support, Vericel: Paid consultant; Research support, Zimmer: Research support. Elizaveta Kon: American Journal of Sports Medicine: Editorial or governing board, BMC Musculoskeletal Disorders: Editorial or governing board, Cartiheal: Research support, Cartiheal (Israel): Paid consultant; Stock or stock options, Fidia (Italy): Paid presenter or speaker, Fidia Farmaceutici: Research support, Fidia Farmaceutici Spa: Paid consultant, Geistlich Biosurgery: Paid consultant, ICRS: Board or committee member, International Orthopaedics: Editorial or governing board, Joints: Editorial or governing board, Journal of Experimental Orthopedics: Editorial or governing board, Mastelli: Paid consultant; Research support, SIAGASCOT: Board or committee member, Terra Quantum: Paid consultant, Zimmer: Paid presenter or speaker; Research support. Bert Mandelbaum: AJSM, Cartilage: Editorial or governing board, Arthrex, Inc: IP royalties; Paid consultant, Biologic Association: Board or committee member, ICRS: Board or committee member, Kerlan Jobe Institute: Board or committee member. Nori Nakamura: American Journal of Sports Medicine: Editorial or governing board, Cell Source: Paid consultant; Research support, ICRS: Board or committee member, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Journal of Experimental Orthopaedics (Springer): Editorial or governing board, Journal of International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (JISAKOS): Editorial or governing board, Journal of Orthopaedic Science (Springer): Editorial or governing board, Sage (Cartilage): Editorial or governing board, Two Cells Ltd: Research support. Alison Toth: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Other financial or material support, Breg: Other financial or material support, Mitek: Other financial or material support, Smith & Nephew: Other financial or material support, Stryker: Other financial or material support. Jocelyn Wittstein: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Paid presenter or speaker, Arthroscopy Association of North America: Board or committee member, Geistlich: Paid consultant, Ortho Info: Editorial or governing board, Vericel: Paid presenter or speaker, ViewFi: Stock or stock options. Brian Forsythe: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Research support, Elsevier: Publishing royalties, financial or material support, i-BrainTech: Stock or stock options, Smith & Nephew: Paid consultant; Research support, Sparta Biopharma: Stock or stock options, Stryker: Paid consultant; Research support, Video Journal of Sports Medicine: Editorial or governing board, Zuno Medical: Stock or stock options. Andreas H. Gomoll: Arthroscopy Association of North America: Board or committee member, Bioventus: Paid presenter or speaker, Cartiheal: Research support, Cartilage: Editorial or governing board, ICRS: Board or committee member, JRF: Paid consultant; Research support, Knee Surgery, Sports Traumatology, Arthroscopy: Editorial or governing board, Moximed: Paid consultant; Paid presenter or speaker; Research support, Organogenesis: Paid presenter or speaker; Research support, Orthopaedic Journal of Sports Medicine: Editorial or governing board, Smith & Nephew: Paid consultant; Paid presenter or speaker, Vericel: Paid consultant; Paid presenter or speaker; Research support. Simon Goertz: Icarus Medical: Unpaid consultant, ICRS: Board or committee member, JRF: Other financial or material support; Paid consultant, Vericel: Other financial or material support. Christian Lattermann: Biologic Association: Board or committee member, Cartilage J Sports Physiology The Knee Orthopaedic Journal of Sports Medicine: Editorial or governing board, ICRS: Board or committee member, JRF: Paid consultant; Research support, Samumed: Paid consultant, Vericel: Paid consultant. David Parker: ACL Study Group: Board or committee member, AJSM: Editorial or governing board, Asia-Pacific Knee Arthroscopy and Sports Medicine Society: Board or committee member, Asia-Pacific Knee Society: Board or committee member, Ganymed Robotics: Stock or stock options; Unpaid consultant, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, OJSM, JISAKOS: Editorial or governing board, Personalised Surgery: Stock or stock options, SMARTT Journal: Editorial or governing board, Smith & Nephew: Paid consultant; Paid presenter or speaker, Zimmer: Research support. Tim Spalding: Arthroscopy Committee at European Society for Sports Traumatology, Knee Surgery and Arthroscopy: Board or committee member, CONMED Linvatec: IP royalties; Paid presenter or speaker, Episurf: Paid consultant; Paid presenter or speaker, Joint Operations UK: Paid presenter or speaker, Knee Surgery, Sports Traumatology, Arthroscopy: Editorial or governing board, Smith & Nephew: Paid presenter or speaker, Stryker: Paid presenter or speaker. Brian R. Waterman: AAOS: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, American Shoulder and Elbow Surgeons: Board or committee member, Arthrex, Inc: Other financial or material support; Paid presenter or speaker, Arthroscopy: Editorial or governing board; Publishing royalties, financial or material support, Arthroscopy Association of North America: Board or committee member, Elsevier: Publishing royalties, financial or material support, FH Ortho: Paid consultant, Kaliber AI: Stock or stock options; Unpaid consultant, Musculoskeletal Transplant Foundation: Other financial or material support, Smith & Nephew: Other financial or material support, Sparta: Paid presenter or speaker; Stock or stock options; Unpaid consultant, Vericel: Paid presenter or speaker, Video Journal of Sports Medicine: Editorial or governing board, Vivorte: Stock or stock options. Annunziato Amendola: American Journal of Sports Medicine: Editorial or governing board, Arthrex, Inc: IP royalties, Bone Solutions Inc: Stock or stock options, JISAKOS: Editorial or governing board, Miach Orthopedics Inc: Stock or stock options, Springer: Publishing royalties, financial or material support, Stryker: Research support, Wolters Kluwer Health - Lippincott Williams & Wilkins: Publishing royalties, financial or material support. Adam Yanke: AlloSource: Paid consultant, Arthrex, Inc: Research support, Icarus Medical: Stock or stock options, JRF Ortho: Paid consultant, Organogenesis: Research support, PatientIQ: Unpaid consultant, PatientIQ: Stock or stock options, Sparta Biomedical: Stock or stock options; Unpaid consultant, Stryker: Paid consultant; Paid presenter or speaker. Seth Sherman: ACL Study Group: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Paid consultant, Arthroscopy Association of North America: Board or committee member, Biologics Alliance: Board or committee member, CONMED Linvatec: IP royalties; Paid consultant, Current Reviews in Musculoskeletal Medicine: Editorial or governing board, Enovis: Paid consultant, Epic Bio: Stock or stock options. ICRS: Board or committee member, International Society of Arthroscopy, Knee Surgery,

and Orthopaedic Sports Medicine: Board or committee member, International Sports Medicine Fellows Conference: Board or committee member, JRF: Research support, Kinamed: Paid consultant, LifeNet: Paid consultant, Ossio: Research support, Reparel: Stock or stock options, Sarcio: Stock or stock options, Smith & Nephew: Paid consultant, Vericel: Paid consultant, Video Journal of Sports Medicine: Editorial or governing board, Vivorte: Stock or stock options. Lutul Farrow: American Journal of Sports Medicine: Editorial or governing board, American Orthopaedic Association: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthroscopy Association of North America: Board or committee member, Orthopaedic Journal of Sports Medicine: Editorial or governing board, Video Journal of Sports Medicine: Editorial or governing board. Alan Getgood: ACL Study Group: Board or committee member, Aesculap/B.Braun: Research support, American Journal of Sports Medicine: Editorial or governing board, Arthrex, Inc: Research support, DePuy, A Johnson & Johnson Company: Research support, Eupraxia Pharmaceuticals Inc: Research support, Graymont Inc: IP royalties, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Knee Surgery, Sports Traumatology, Arthroscopy: Editorial or governing board, LinkX Robotics: Stock or stock options, Musculoskeletal Transplant Foundation: Research support, Ossur: Research support, Ostesys Robotics: Stock or stock options, Precision OS: Stock or stock options, Smith & Nephew: Paid consultant; Paid presenter or speaker; Research support, Spring Loaded Technologies Inc: Stock or stock options. Jon Dickens: AAOS: Board or committee member, American Journal of Sports Medicine: Editorial or governing board, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthroscopy Association of North America: Board or committee member, Society of Military Orthopaedic Surgeons: Board or committee member. Michael Alaia: AAOS: Board or committee member, Arthroscopy: Editorial or governing board, Arthroscopy Association of North America: Board or committee member, BodyCad: Paid consultant, Journal of Cartilage and Joint Preservation: Editorial or governing board, JRF Ortho: Paid consultant, Mitek: Paid consultant, Orcosa, Inc: Research support, Springer: Publishing royalties, financial or material support. Volker Musahl: ACL Study Group: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Other financial or material support, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, JISAKOS: Board or committee member, Knee Surgery, Sports Traumatology, Arthroscopy: Editorial or governing board, Newclip: Paid consultant, Ostesys: Stock or stock options, Smith & Nephew: Other financial or material support; Paid consultant, Springer: Publishing royalties, financial or material support. Olufemi Rolland Ayeni: Canadian Orthopaedic Association: Board or committee member, International Society for Hip Arthroscopy: Board or committee member, International Society of Arthroscopy, Knee Surgery, and Orthopaedic Sports Medicine: Board or committee member, Stryker: Paid presenter or speaker. Jason L. Dragoo: AAOS: Board or committee member, American Journal of Sports Medicine: Editorial or governing board, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Paid consultant, Arthroscopy Association of North America: Board or committee member, Biomet: Paid consultant, Bioventus: Paid consultant, Breg: Paid consultant, CONMED Linvatec: Paid consultant; Research support, DJ Orthopaedics: Paid consultant, EmCyte: Other financial or material support, Flexion Therapeutics: Paid consultant, Genzyme: Paid consultant, Harvest Technologies: Other financial or material support; Paid consultant, JRF: Paid consultant, KCRN Research: Paid consultant, Linvatec: Research support, Moximed: Paid consultant, Ossur: Paid consultant; Paid presenter or speaker; Research support, PAC 12 Athletic Conference: Board or committee member, Regeneration Technologies, Inc: Paid consultant, RNL Bio: Paid consultant, RTI: Other financial or material support; Research support, Sideline Sports Docs, LLC: Paid consultant, Zimmer: Paid consultant; Research support. Brian Lau: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Research support, Arthroscopy Association of North America: Board or committee member, DePuy, A Johnson & Johnson Company: Paid consultant, Miach: Paid consultant, Wright Medical Technology, Inc: Research support. Mary K. Mulcahey: Arthrex, Inc: Paid consultant. Joan C. Monllau: CONMED Linvatec: Paid presenter or speaker. Clayton William Nuelle: AAOS: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, AO Foundation: Other financial or material support, Arthrex, Inc: Paid presenter or speaker, Arthroscopy: Editorial or governing board; Publishing royalties, financial or material support, Arthroscopy Association of North America: Board or committee member. Guidepoint Consulting: Paid consultant, Vericel Inc: Paid presenter or speaker. Scott Alan Rodeo: Ortho RTI: Stock or stock options, Teladoc: Paid consultant. Asheesh Bedi: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthrex, Inc: Paid consultant, SLACK Incorporated: Publishing royalties, financial or material support, Springer: Publishing royalties, financial or material support. Alexander Golant: AAOS: Board or committee member, Arthrex, Inc: Unpaid consultant, Arthroscopy: Editorial or governing board, Arthroscopy Association of North America: Board or committee member. John Andrew Grant: Aesculap/B.Braun: Research support, Arthrex, Inc: Research support, Journal of Bone and Joint Surgery - American: Editorial or governing board, JRF Ortho: Paid presenter or speaker; Research support, Tactile Orthopaedics: Paid consultant, Vericel: Paid presenter or speaker. Aaron John Krych: Aesculap/B.Braun: Research support, American Journal of Sports Medicine: Editorial or governing board, Arthrex, Inc: IP royalties; Paid consultant, Arthroscopy Association of North America: Board or committee member, ICRS: Board or committee member, Springer: Editorial or governing board. Mike McNicholas: ICRS: Board or committee member. Matthew J. Salzler: American Orthopaedic Society for Sports Medicine: Board or committee member, Arthroscopy: Editorial or governing board, Arthroscopy Association of North America: Board or committee member, Journal of Bone and Joint Surgery - American: Editorial or governing board.

Appendix A

International Knee Cartilage Injury Delphi Consensus Study Group includes Eoghan T. Hurley MB MCh PhD, Richard M. Danilkowicz MD, Zachary S. Aman MD, Allen A. Champagne MD PhD, Michael G. Ciccotti MD, Michael T. Hirschmann MD, Francisco Figueroa MD, Kristofer J. Jones MD, Iain R. Murray FRCS, Fintan J. Shannon FRCS, Laith M. Jazrawi MD, Jacob S. Torrey MD,

Chanell R. Brown MD MPH, Kirk A. Campbell MD, David Figueroa MD, Rodrigo Guiloff MD, Safa Gursoy MD PhD, Laurie A. Hiemstra MD PhD, Bogdan Matache MD, Kenneth R. Zaslav MD, Jorge Chahla MD PhD, Alex M. Meyer MD, James L. Carey MD MPH, Benton E. Heyworth MD, Crystal Perkins MD, Adnan Saithna MD, Daniel B.F. Saris MD PhD, Nicholas A. Sgaglione MD, Kendall E. Bradley MD, Dean C. Taylor MD, Bryan S. Crook MD, Brandon J. Erickson MD, Alberto Gobbi MD, Deepak Goyal MBBS MS DNB MNAMS, Cassandra A. Lee MD, Elizabeth G. Matzkin MD, Sabrina M. Strickland MD, Robert L. Parisien MD, Betina B Hinckel MD, F. Baker Mills IV MD, MS, Robert H. Brophy MD, Brian J. Cole MD, MBA, Fares S. Haddad FRCS, Laszlo Hangody MD, PhD, DSc, Gilbert Moatshe MD, PhD, Riley J. Williams III MD, Rachel M. Frank MD, Grant H. Cabell, MD, Mats Brittberg MD PhD, David C. Flanigan MD, Elizaveta Kon MD, Bert R. Mandelbaum MD, Stefan Marlovits MD MBA, Nori Nakamura MD, Jocelyn R. Wittstein MD, Alison P. Toth MD, Lucy E. Meyer MD, Michael J. Alaia MD, Jonathan F. Dickens MD, Joao Espregueria-Mendes MD, Alan Getgood MD, FRCS (Tr&Orth), Lutul D. Farrow MD, Volker Musahl MD, Adam Yanke MD, Seth L. Sherman MD, Zoe W. Hinton MD, Brian Forsythe MD, Andreas H. Gomoll MD, Simon Görtz MD, Christian Lattermann MD, David Parker MBBS BMedSc FRACS FAOrthA, Tim Spalding MBBS FRCS, Brian R. Waterman MD, Annunziato Amendola MD, Samuel G. Lorentz MD, Olufemi R. Ayeni MD PhD MSc, Jason L. Dragoo MD, Brian C. Lau MD, Mary K. Mulcahey MD, Joan C. Monllau MD PhD, Clayton W. Nuelle MD, Scott A. Rodeo MD, Isabel P. Prado MD MS, Tom R. Doyle MB MCh, Daniel J. Stokes MD, Asheesh Bedi MD, Alexander Golant MD, John A. Grant MD PhD, Andrew J. Hughes FRCS MCh, Mike McNicholas MD, Matthew J. Salzler MD, Ian Savage-Elliott MD, Aaron J. Krych MD.

References

1. Familiari F, Cinque ME, Chahla J, et al. Clinical outcomes and failure rates of osteochondral allograft transplantation in the knee: a systematic review. *Am J Sports Med.* 2018;46(14):3541–3549. https://doi.org/10.1177/0363546517732531
2. Hjelle K, Solheim E, Strand T, Muri R, Brittberg M. Articular cartilage defects in 1,000 knee arthroscopies. *Arthroscopy.* 2002;18(7):730–734. https://doi.org/10.1053/jars.2002.32839
3. Trofa DP, Hong IS, Lopez CD, et al. Isolated osteochondral autograft versus allograft transplantation for the treatment of symptomatic cartilage lesions of the knee: a systematic review and meta-analysis. *Am J Sports Med.* 2023;51(3):812–824. https://doi.org/10.1177/03635465211053594
4. Chahal J, Gross AE, Gross C, et al. Outcomes of osteochondral allograft transplantation in the knee. *Arthroscopy.* 2013;29(3):575–588. https://doi.org/10.1016/j.arthro.2012.12.002
5. Andrade R, Nunes J, Hinckel BB, et al. Cartilage restoration of patellofemoral lesions: a systematic review. *Cartilage.* 2021;13(1_suppl):57s–73s. https://doi.org/10.1177/1947603519893076
6. Brophy RH, Wojahn RD, Lamplot JD. Cartilage restoration techniques for the patellofemoral joint. *J Am Acad Orthop Surg.* 2017;25(5):321–329. https://doi.org/10.5435/jaaos-d-15-00447
7. Davies-Tuck ML, Wluka AE, Wang Y, et al. The natural history of cartilage defects in people with knee osteoarthritis. *Osteoarthr Cartil.* 2008;16(3):337–342. https://doi.org/10.1016/j.joca.2007.07.005
8. Hinckel BB, Pratte EL, Baumann CA, et al. Patellofemoral cartilage restoration: a systematic review and meta-analysis of clinical outcomes. *Am J Sports Med.* 2020;48(7):1756–1772. https://doi.org/10.1177/0363546519886853
9. Mall NA, Harris JD, Cole BJ. Clinical evaluation and preoperative planning of articular cartilage lesions of the knee. *J Am Acad Orthop Surg.* 2015;23(10):633–640. https://doi.org/10.5435/jaaos-d-14-00241
10. Haunschild ED, Gilat R, Aghogho E, et al. Functional outcomes and survivorship of distal femoral osteotomy with cartilage restoration of the knee. *J Cartil Jt Preserv.* 2021;1(1):100004.
11. Medina G, Görtz S. Osteochondral techniques: where are we now? *J Cartil Jt Preserv.* 2023;3(1):100105.
12. García JR, Acuña AJ, Villareal JB, et al. New horizons in cartilage repair: update on treatment trends and outcomes. *J Cartil Jt Preserv.* 2024;4(2) https://doi.org/10.1016/j.jcjp.2024.100179
13. Keszég M, Hangody L, Egyed Z, Tóth G, Pánics G. Long-term (10-25 years) outcomes of knee osteochondral autologous transplantation in soccer players. *J Cartil Jt Preserv.* 2022;2(2):100062.
14. Fernandes TL, SantAnna JPC, Boff MS, et al. Age-related surgical management of chondral and osteochondral lesions. *J Cartil Jt Preserv.* 2024;4(2) https://doi.org/10.1016/j.jcjp.2024.100172
15. Hangody L, Füles P. Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints: ten years of experimental and clinical experience. *J Bone Jt Surg Am.* 2003;85-A(suppl 2):25–32. https://doi.org/10.2106/00004623-200300002-00004
16. Krych AJ, Pareek A, King AH, Johnson NR, Stuart MJ, Williams 3rd RJ. Return to sport after the surgical management of articular cartilage lesions in the knee: a meta-analysis. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(10):3186–3196. https://doi.org/10.1007/s00167-016-4262-3
17. Lynch TS, Patel RM, Benedick A, Amin NH, Jones MH, Miniaci A. Systematic review of autogenous osteochondral transplant outcomes. *Arthroscopy.* 2015;31(4):746–754. https://doi.org/10.1016/j.arthro.2014.11.018
18. Wang T, Bugbee WD. Osteochondral allograft transplantation in the football player (knee and ankle). *J Cartil Jt Preserv.* 2022;2(2):100052.
19. Hurley ET, Matache BA, Wong I, et al. Anterior shoulder instability part I-diagnosis, nonoperative management, and Bankart repair-an international consensus statement. *Arthroscopy.* 2022;38(2):214–223.e7. https://doi.org/10.1016/j.arthro.2021.07.022
20. Hurley ET, Matache BA, Wong I, et al. Anterior shoulder instability part II-Latarjet, remplissage, and glenoid bone-grafting-an international consensus statement. *Arthroscopy.* 2022;38(2):224–233.e6. https://doi.org/10.1016/j.arthro.2021.07.023
21. Matache BA, Hurley ET, Wong I, et al. Anterior shoulder instability part III-revision surgery, rehabilitation and return to play, and clinical follow-up-an international consensus statement. *Arthroscopy.* 2022;38(2):234–242.e6. https://doi.org/10.1016/j.arthro.2021.07.019
22. Hurley ET, Sherman SL, Stokes DJ, et al. Experts achieve consensus on a majority of statements regarding platelet-rich plasma treatments for treatment of musculoskeletal pathology. *Arthroscopy.* 2024;40(2):470–477.e1. https://doi.org/10.1016/j.arthro.2023.08.020
23. Murawski CD, Hogan MV, Thordarson DB, Stone JW, Ferkel RD, Kennedy JG. Editorial. *Foot Ankle Int.* 2018;39(1_suppl):1S–2S. https://doi.org/10.1177/1071100718779395
24. Flanigan DC, Sherman SL, Chilelli B, et al. Consensus on rehabilitation guidelines among orthopedic surgeons in the united states following use of third-generation articular cartilage repair (MACI) for treatment of knee cartilage lesions. *Cartilage.* 2021;13(1_suppl):1782S–1790S. https://doi.org/10.1177/1947603520968876
25. Garrigues GE, Zmistowski B, Cooper AM, Green A. Proceedings from the 2018 International Consensus Meeting on Orthopedic Infections: rationale and methods of the shoulder subgroup. *J Shoulder Elbow Surg.* 2019;28(6S):S4–S7. https://doi.org/10.1016/j.jse.2019.03.041
26. Tokish JM, Kuhn JE, Ayers GD, et al. Decision making in treatment after a first-time anterior glenohumeral dislocation: a Delphi approach by the Neer Circle of the American Shoulder and Elbow Surgeons. *J Shoulder Elbow Surg.* 2020;29(12):2429–2445. https://doi.org/10.1016/j.jse.2020.08.011
27. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform.* 2019;95:103208.
28. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JGA. Metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377–381.
29. Erickson BJ, Hurley ET, Mojica ES, Jazrawi LM. Ulnar Collateral Ligament – Delphi Consensus Group (UCL-DCG). Elbow ulnar collateral ligament tears: a modified consensus statement. *Arthroscopy.* 2023;39(5):1161–1171. https://doi.org/10.1016/j.arthro.2022.12.033

30. Hurley ET, Hughes AJ, Savage-Elliott I, et al. A modified Delphi consensus statement on patellar instability: part I. *Bone Jt J.* 2023;105-B(12):1259–1264. https://doi.org/10.1302/0301-620X.105B12.BJJ-2023-0109.R1
31. Hurley ET, Sherman SL, Chahla J, et al. A modified Delphi consensus statement on patellar instability: part II. *Bone Jt J.* 2023;105-B(12):1265–1270. https://doi.org/10.1302/0301-620X.105B12.BJJ-2023-0110.R1
32. Hurley ET, Sherman SL, Stokes DJ, et al. Experts achieve consensus on a majority of statements regarding platelet-rich plasma treatments for treatment of musculoskeletal pathology. *Arthroscopy.* 2024;40(2):470–477. https://doi.org/10.1016/j.arthro.2023.08.020
33. Miller DJ, Smith MV, Matava MJ, Wright RW, Brophy RH. Microfracture and osteochondral autograft transplantation are cost-effective treatments for articular cartilage lesions of the distal femur. *Am J Sports Med.* 2015;43(9):2175–2181. https://doi.org/10.1177/0363546515591261
34. Husen M, Custers RJ, Hevesi M, Krych AJ, Saris DB. Size of cartilage defects and the need for repair: a systematic review. *J Cartil Jt Preserv.* 2022;2(3):100049.
35. Frank RM, Lee S, Levy D, et al. Osteochondral allograft transplantation of the knee: analysis of failures at 5 years. *Am J Sports Med.* 2017;45(4):864–874. https://doi.org/10.1177/0363546516676072
36. Solheim E, Hegna J, Inderhaug E. Long-term survival after microfracture and mosaicplasty for knee articular cartilage repair: a comparative study between two treatments cohorts. *Cartilage.* 2020;11(1):71–76. https://doi.org/10.1177/1947603518783482
37. Sherman WF, Patel AH, Kale NN, Freiberger CM, Barnes CL, Lee OC. Surgeon decision-making for individuals with obesity when indicating total joint arthroplasty. *J Arthroplast.* 2021;36(8):2708–2715.e1. https://doi.org/10.1016/j.arth.2021.02.078
38. Vellios EE, Jones KJ, Williams RJ. Osteochondral autograft transfer for focal cartilage lesions of the knee with donor-site back-fill using precut osteochondral allograft plugs and micronized extracellular cartilage augmentation. *Arthrosc Tech.* 2021;10(1):e181–e192. https://doi.org/10.1016/j.eats.2020.09.025
39. Rodriguez-Merchan EC, Encinas-Ullan CA, Liddle AD. Osteochondral allografts for large osteochondral lesions of the knee joint: indications, surgical techniques and results. *Arch Bone Jt Surg.* 2022;10(3):245–251. https://doi.org/10.22038/abjs.2021.51810.2555
40. Cavendish PA, Everhart JS, Peters NJ, Sommerfeldt MF, Flanigan DC. Osteochondral allograft transplantation for knee cartilage and osteochondral defects: a review of indications, technique, rehabilitation, and outcomes. *JBJS Rev.* 2019;7(6):e7. https://doi.org/10.2106/jbjs.Rvw.18.00123
41. Cook JL, Stannard JP, Stoker AM, et al. Importance of donor chondrocyte viability for osteochondral allografts. *Am J Sports Med.* 2016;44(5):1260–1268. https://doi.org/10.1177/0363546516629434
42. LaPrade RF, Botker JC. Donor-site morbidity after osteochondral autograft transfer procedures. *Arthroscopy.* 2004;20(7):e69–e73. https://doi.org/10.1016/j.arthro.2004.06.022
43. Seow D, Koh JH, Cheang HL, et al. Noninferiority meta-analysis of autologous vs allogeneic osteochondral transplantation for the treatment of osteochondral defects of the knee confounded by defect size differences. *J Cartil Jt Preserv.* 2023;3(4) https://doi.org/10.1016/j.jcjp.2023.100130
44. Nielsen KP, Amundsen A, Olsen BS, Rasmussen JV. Good long-term patient-reported outcome after shoulder arthroplasty for cuff tear arthropathy. *JSES Int.* 2022;6(1):40–43. https://doi.org/10.1016/j.jseint.2021.08.002
45. De Caro F, Bisicchia S, Amendola A, Ding L. Large fresh osteochondral allografts of the knee: a systematic clinical and basic science review of the literature. *Arthroscopy.* 2015;31(4):757–765. https://doi.org/10.1016/j.arthro.2014.11.025
46. Wagner KR, DeFroda SF, Sivasundaram L, et al. Osteochondral allograft transplantation for focal cartilage defects of the femoral condyles. *JBJS Essent Surg Tech.* 2022;12(3):e21.00037. https://doi.org/10.2106/jbjs.St.21.00037
47. Pisanu G, Cottino U, Rosso F, et al. Large osteochondral allografts of the knee: surgical technique and indications. *Joints.* 2018;6(1):42–53. https://doi.org/10.1055/s-0038-1636925
48. Meric G, Gracitelli GC, McCauley JC, et al. Osteochondral allograft MRI scoring system (OCAMRISS) in the knee: interobserver agreement and clinical application. *Cartilage.* 2015;6(3):142–149. https://doi.org/10.1177/1947603515573987
49. Savage-Elliott I, Hughes AJ, Triana J, Li ZI, Alaia MJ, Alaia EF. Magnetic resonance imaging–arthroscopic correlation for chondral pathology in commonly imaged joints: a narrative review. *J Cartil Jt Preserv.* 2024;4(1) https://doi.org/10.1016/j.jcjp.2023.100154
50. Salka N, Grant JA. Contralateral lateral femoral condyle allografts provide an acceptable surface match for simulated classic osteochondritis dissecans lesions of the medial femoral condyle. *Orthop J Sports Med.* 2020;8(1):2325967119898413. https://doi.org/10.1177/2325967119898413
51. Mologne TS, Cory E, Hansen BC, et al. Osteochondral allograft transplant to the medial femoral condyle using a medial or lateral femoral condyle allograft: is there a difference in graft sources? *Am J Sports Med.* 2014;42(9):2205–2213. https://doi.org/10.1177/0363546514540446
52. Williams 3rd RJ, Ranawat AS, Potter HG, Carter T, Warren RF. Fresh stored allografts for the treatment of osteochondral defects of the knee. *J Bone Jt Surg Am.* 2007;89(4):718–726. https://doi.org/10.2106/jbjs.F.00625
53. Koh JL, Kowalski A, Lautenschlager E. The effect of angled osteochondral grafting on contact pressure: a biomechanical study. *Am J Sports Med.* 2006;34(1):116–119. https://doi.org/10.1177/0363546505281236
54. Johnson MR, LaPrade RF. Tibial plateu "Kissing Lesion" from a proud osteochondral autograft. *Am J Orthop (Belle Mead NJ).* 2011;40(7):359–361.
55. Harris JD, Solak KK, Siston RA, Litsky A, Richards J, Flanigan DC. Contact pressure comparison of proud osteochondral autograft plugs versus proud synthetic plugs. *Orthopedics.* 2011;34(2):97. https://doi.org/10.3928/01477447-20101221-06
56. Manjunath AK, Pendola M, Hurley ET, et al. Does the tidemark location matter in osteochondral allograft transplantation? A finite element analysis. *J Cartil Jt Preserv.* 2023;3(2):100092.
57. Gwosdz J, Rosinski A, Chakrabarti M, et al. Osteochondral allograft transplantation of the medial femoral condyle with orthobiologic augmentation and graft-recipient microfracture preparation. *Arthrosc Tech.* 2019;8(3):e321–e329. https://doi.org/10.1016/j.eats.2018.11.008
58. Oladeji LO, Stannard JP, Cook CR, et al. Effects of autogenous bone marrow aspirate concentrate on radiographic integration of femoral condylar osteochondral allografts. *Am J Sports Med.* 2017;45(12):2797–2803. https://doi.org/10.1177/0363546517715725
59. Ackermann J, Mestriner AB, Shah N, Gomoll AH. Effect of autogenous bone marrow aspirate treatment on magnetic resonance imaging integration of osteochondral allografts in the knee: a matched comparative imaging analysis. *Arthroscopy.* 2019;35(8):2436–2444. https://doi.org/10.1016/j.arthro.2019.03.033
60. Chona DV, Kha ST, Minetos PD, et al. Biologic augmentation for the operative treatment of osteochondral defects of the knee: a systematic review. *Orthop J Sports Med.* 2021;9(11):23259671211049756. https://doi.org/10.1177/23259671211049756
61. Wang D, Lin KM, Burge AJ, Balazs GC, Williams 3rd RJ. Bone marrow aspirate concentrate does not improve osseous integration of osteochondral allografts for the treatment of chondral defects in the knee at 6 and 12 months: a comparative magnetic resonance imaging analysis. *Am J Sports Med.* 2019;47(2):339–346. https://doi.org/10.1177/0363546518813915
62. Cotter EJ, Hannon CP, Christian DR, et al. Clinical outcomes of multifocal osteochondral allograft transplantation of the knee: an analysis of overlapping grafts and multifocal lesions. *Am J Sports Med.* 2018;46(12):2884–2893. https://doi.org/10.1177/0363546518793405
63. Anderson DE, Bogner EA, Schiffman SR, Rodeo SA, Wiedrick J, Crawford DC. Evaluation of osseous incorporation after osteochondral allograft transplantation: correlation of computed tomography parameters with patient-reported outcomes. *Orthop J Sports Med.* 2021;9(8):23259671211022682. https://doi.org/10.1177/23259671211022682
64. Stewart ZE, Joseph Simeone F, Guermazi A, Berkson E, Price M, Chang CY. Postoperative imaging of cartilage: where are we in 2023? *J Carti Jt Preserv.* 2024;4(1):100150. https://doi.org/10.1016/j.jcjp.2023.100150
65. Nemec SF, Marlovits S, Trattnig S. Persistent bone marrow edema after osteochondral autograft transplantation in the knee joint. *Eur J Radiol.* 2009;71(1):159–163. https://doi.org/10.1016/j.ejrad.2008.04.007
66. Palhares GM, Vaswani R, Fletcher C, et al. Increased host bone marrow edema on 6-month MRI is a risk factor for osteochondral allograft failure. *Arthroscopy.* 2024. https://doi.org/10.1016/j.arthro.2024.01.008 online ahead of print.