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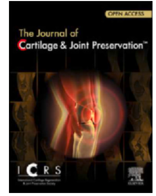

Original Research

Diagnosis of knee cartilage injuries—an international Delphi consensus statement☆

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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 the diagnosis of knee cartilage injuries.
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. Eleven questions were generated on the diagnosis of knee cartilage injuries, 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 11 total questions and consensus statements regarding the diagnosis of knee cartilage injuries developed from 3 rounds of voting, 0 achieved unanimous consensus, 8 achieved strong consensus, and 3 achieved consensus.
Conclusions: The majority of the statements regarding diagnosis achieved strong consensus, which related to aspects of the physical exam and history, imaging and documentation, and assessment of concomitant injury or bony malalignment that aid in surgical decision-making. The statements that did not achieve strong consensus were determining when a lesion is symptomatic, documentation of imaging, and when a diagnostic arthroscopy is indicated.

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Zachary S. Aman and Allen A. Champagne did equal work on this study and should be considered co-first authors.

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Introduction

The management of cartilage lesions involving the femoral condyles and patellofemoral joint has remained a challenge given the poor healing nature of articular cartilage, variability in lesion size and location, and association with concomitant meniscal and ligamentous pathology.[1–4] Cartilage lesions are highly prevalent in patients undergoing arthroscopy, and full-thickness defects may be encountered in up to 36% to 59% of athletic populations involved in repetitive ground impact sports as a result of direct trauma, overuse, or malalignment.[5–10] Although there is uncertainty regarding the natural history of asymptomatic lesions, untreated symptomatic lesions have been associated with a declining level of performance, quality of life, and progression to osteoarthritis.[9–12]

While novel grafting and cell-based techniques have emerged over the last 2 decades to surgically address cartilage lesions of the patellofemoral and tibiofemoral joint,[8] a detailed preoperative diagnostic workup that includes thoughtful history, physical examination, and correlation of lesion characteristics is essential in guiding treatment choice to optimize patient outcomes undergoing cartilage restoration procedures.[1,2,13] Additionally, failure to identify and address concomitant ligamentous injury, meniscal injury, and the presence of malalignment has been associated with high failure rates for cartilage restoration procedures due to unrelieved and increased compartmental contact stresses.[1,2,14–17]

Altogether, the complex spectrum of patient-specific factors, as well as the critical effect of early clinical diagnosis in facilitating successful cartilage restoration procedures,[14,18–20] necessitate an organized systematic approach to patients presenting with suspected cartilage lesions.[21] However, to date, there remains a lack of global consensus regarding the choice and utility of preoperative imaging modalities, measurement and documentation of lesion size, and indications for diagnostic arthroscopy, in order to ensure optimal preoperative assessment.[22–24]

Previously, several societies have developed both national and international consensus statements on a variety of topics utilizing the Delphi method.[25–32] 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 the diagnosis of knee cartilage injuries.

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 one 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 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

Table
Diagnosis consensus statements.

Strong consensus
The following aspects of the patient history should be documented: (1) age; (2) medications; (3) duration and onset of symptoms; (4) pain characteristics (ie, location, severity, character, and aggravating factors); (5) presence of mechanical symptoms (ie, catching, locking); (6) activity-related swelling; (7) previous history of trauma to ipsilateral knee (with mechanism); (8) prior treatments attempted (nonoperative and/or surgical); (9) history of known osteochondritis dissecans; (10) other associated joint pain; (11) history of inflammatory arthropathy; (12) history of patellar instability; (13) history of malalignment or treatment of malalignment; and (14) impact on ADLs.
The following aspects of the physical exam should be evaluated and documented: (1) BMI, (2) alignment, (3) localization of tenderness to palpation (including palpation of chondral surfaces and joint line), (4) range of motion, (5) presence of crepitus or clicking, (6) stability, (7) meniscal testing, and (8) patellar inhibition testing.
Standing AP weight-bearing, lateral, and full-length standing lower-extremity plain radiographs should be obtained to evaluate a suspected or known cartilage lesion.
Long-leg (hip-to-ankle) radiographs should always be obtained in the evaluation of chondral defects.
Advanced imaging should be obtained if the patient is unresponsive to nonoperative regimens that include physical therapy, activity modification, or injections.
Documentation of lesion location should include the joint compartment (ie, medial vs lateral), bone surface involved (ie, femoral vs tibial vs patellofemoral), specific localizers (ie, patella facets, proximal/mid/distal, and anterior/posterior as it applies), whether or not the lesion is contained or uncontained, position relative to weight-bearing surface of joint, and lesion size in millimeters within the sagittal and coronal planes.
Using advanced imaging, the width, depth, and length in millimeters should be measured in the sagittal and coronal axis for tibiofemoral lesions and in the sagittal and axial axis for patellofemoral lesions. ICRS or Outerbridge grading should be performed and documented arthroscopically.
The relative indications for nonoperative management of knee cartilage injuries include (1) asymptomatic, small lesions (< 1 cm), (2) ICRS grade 1 or 2, (3) lesion in non–weight-bearing area, (4) found incidentally on MRI/arthroscopy, (5) inability to comply with post-op rehabilitation, (6) global chondral wear, and (7) stable osteochondritis lesions in skeletally immature patients.
The following should be concomitantly evaluated in the setting of suspected or known cartilage lesion: (1) ligamentous pathology (ie, ACL, PCL, MCL, and LCL) on physical exam, MRI and/or examination under anesthesia; (2) malalignment (coronal or sagittal) on standing radiographs; (3) meniscal pathology on MRI and/or arthroscopically; (4) subchondral bone integrity on MRI and/or arthroscopically; (5) adjacent articular surfaces on MRI and/or arthroscopically; (6) relation between the degree of flexion and contact of opposing surfaces involving the lesion arthroscopically; and (7) the synovium evaluated arthroscopically with or without biopsy.
Consensus
Cartilage lesions can be described as symptomatic if patients have pain localization to the chondral surface or radiographic location of the defect, present or activity-related intra-articular effusion, symptomatic crepitus, or history of mechanical symptoms (ie, locking, catching).
The following imaging findings should be assessed and documented: (1) localization, size, and depth of the lesion; (2) morphology of the lesion (ie, chondral or osteochondral); (3) ICRS grading; (4) presence of arthritic signs (ie, joint space narrowing, subchondral cysts, osteophyte formation, and subchondral sclerosis); (5) presence of the underlying bone marrow edema; (6) condition of opposing surface (ie, contained or uncontained lesion); (7) ligament and meniscus integrity; (8) presence of intra-articular effusion; and (9) the presence of a loose body.
Diagnostic arthroscopy is a helpful tool in assessing the known or suspected cartilage lesion to determine eligibility for cartilage repair.

Abbreviations: ACL, anterior cruciate ligament; ADLs, activities of daily living; AP, anterior-posterior; BMI, body mass index; ICRS, International Cartilage Regeneration & Joint Preservation Society; LCL, lateral collateral ligament; MCL, medial collateral ligament; MRI, magnetic resonance imaging; PCL, posterior cruciate ligament.

participants. Surveys were distributed in a blinded fashion using the Research Electronic Data Capture internet-based application.[33,34]

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.[25–28,35–37]

Results

Overall consensus

Of the 11 total questions and consensus statements on the diagnosis of knee cartilage injuries developed from 3 rounds of voting, 0 achieved unanimous consensus, 8 achieved strong consensus, and 3 achieved consensus. There were no statements that did not reach consensus. The consensus statements are shown in the Table.

Consensus statements

Q1: Which aspect(s) of the patient history should be documented in the setting of suspected/known cartilage lesion (ie, a focal chondral/osteochondral defect)?

A1: The following aspects of the patient history should be documented: (1) age; (2) medications; (3) duration and onset of symptoms; (4) pain characteristics (ie, location, severity, character, and aggravating factors); (5) presence of mechanical symptoms (ie, catching, locking); (6) activity-related swelling; (7) previous history of trauma to ipsilateral knee (with mechanism); (8) prior treatments attempted (nonoperative and/or surgical); (9) history of known osteochondritis dissecans; (10) other associated joint pain;

(11) history of inflammatory arthropathy; (12) history of patellar instability; (13) history of malalignment or treatment of malalignment; and (14) impact on activities of daily living.

Strong consensus—99% agreement (71% strongly agreed, 27% agreed, and 1% strongly disagreed).

Q2: Which aspect(s) of the physical examination should be performed/documented in the setting of suspected/known cartilage lesion?

A2: The following aspects of the physical exam should be evaluated and documented: (1) body mass index, (2) alignment, (3) localization of tenderness to palpation (including palpation of chondral surfaces and joint line), (4) range of motion, (5) presence of crepitus or clicking, (6) stability, (7) meniscal testing, and (8) patellar inhibition testing.

Strong consensus—98% agreement (84% strongly agreed, 14% agreed, and 1% strongly disagreed).

Q3: How can it be discerned that the cartilage lesion is symptomatic?

A3: Cartilage lesions can be described as symptomatic if patients have pain localization to the chondral surface or radiographic location of the defect, present or activity-related intra-articular effusion, symptomatic crepitus, or history of mechanical symptoms (ie, locking, catching).

Consensus—75% agreement (57% strongly agreed, 38% agreed, 3% neutral, and 3% disagreed).

Q4: Which plain radiographic views should be obtained to evaluate suspected/known cartilage lesion?

A4: Standing anterior-posterior weight-bearing, lateral, and full-length standing lower-extremity plain radiographs should be obtained to evaluate a suspected or known cartilage lesion.

Strong consensus—96% agreement (75% strongly agreed, 21% agreed, 3% neutral, and 1% disagreed).

Q5: Should long-leg (hip-to-ankle) radiographs be obtained in the evaluation of chondral defects?

A5: Long-leg (hip-to-ankle) radiographs should always be obtained in the evaluation of chondral defects.

Strong consensus—93% agreement (62% strongly agreed, 31% agreed, 3% neutral, and 4% disagreed).

Q6: When should advanced imaging (magnetic resonance imaging [MRI]/computed tomography) be performed in a patient presenting with suspected/known cartilage injury?

A6: Advanced imaging should be obtained if the patient is unresponsive to nonoperative regimens that include physical therapy, activity modification, or injections.

Strong consensus—91% agreement (70% strongly agreed, 21% agreed, 5% neutral, 3% disagreed, and 1% strongly disagreed).

Q7: Which radiographic/imaging findings can be assessed/documented in the setting of a cartilage lesion of the knee?

A7: The following imaging findings should be assessed and documented: (1) location, size, and depth of the lesion; (2) morphology of the lesion (ie, chondral or osteochondral); (3) ICRS grading; (4) presence of arthritic signs (ie, joint space narrowing, subchondral cysts, osteophyte formation, and subchondral sclerosis); (5) presence of the underlying bone marrow edema; (6) condition of opposing surface (ie, contained or uncontained lesion); (7) ligament and meniscus integrity; (8) presence of intra-articular effusion; and (9) the presence of a loose body.

Consensus—88% agreement (66% strongly agreed, 22% agreed, 7% neutral, 3% disagreed, and 3% strongly disagreed).

Q8: How should the lesion location be documented?

A8: Documentation of lesion location should include the joint compartment (ie, medial vs lateral), bone surface involved (ie, femoral vs tibial vs patellofemoral), specific localizers (ie, patella facets, proximal/mid/distal, and anterior/posterior as it applies), whether or not the lesion is contained or uncontained, position relative to weight-bearing surface of joint, and lesion size in millimeters within the sagittal and coronal planes.

Strong consensus—97% agreement (70% strongly agreed, 27% agreed, and 3% disagreed).

Q9: How should the lesion size be measured/graded?

A9: Using advanced imaging, the width, depth, and length in millimeters should be measured in the sagittal and coronal axis for tibiofemoral lesions and in the sagittal and axial axis for patellofemoral lesions. ICRS or Outerbridge grading should be performed and documented arthroscopically.

Strong consensus—91% agreement (55% strongly agreed, 36% agreed, 4% neutral, 4% disagreed, and 1% strongly disagreed).

Q10: When is diagnostic arthroscopy a helpful tool in assessing a known or suspected cartilage lesion?

A10: Diagnostic arthroscopy is a helpful tool in assessing a known or suspected cartilage lesion to determine eligibility for cartilage repair.

Consensus—85% agreement (42% strongly agreed, 43% agreed, 8% neutral, and 8% disagreed).

Q11: What associated pathology should be evaluated concomitantly and how?

A11: The following should be concomitantly evaluated in the setting of a suspected or known cartilage lesion: (1) ligamentous pathology (ie, anterior cruciate ligament, posterior cruciate ligament, medial collateral ligament, and lateral collateral ligament) on physical exam, MRI, and/or examination under anesthesia; (2) malalignment (coronal or sagittal) on standing radiographs; (3) meniscal pathology on MRI and/or arthroscopically; (4) subchondral bone integrity on MRI and/or arthroscopically; (5) adjacent articular surfaces on MRI and/or arthroscopically; (6) relation between the degree of flexion and contact of opposing surfaces involving the lesion arthroscopically; and (7) the synovium evaluated arthroscopically with or without biopsy.

Strong consensus—99% agreement (62% strongly agreed, 36% agreed, and 1% neutral).

Discussion

While full-thickness cartilage lesions are highly prevalent in athletic populations, identification and clinical decision-making remains complex.[38] Standard evaluation begins with a detailed history, physical exam, and correlation with findings on radiographic and advanced imaging. There should be a high level of suspicion for these injuries in patients who present with pain accompanied by swelling, mechanical symptoms, or in the context of trauma, concomitant ligamentous injury. Variables obtained through the history of presenting illness, including age, activity level, and chronicity, have all been demonstrated to affect patient treatment and outcomes.[39] Similarly, evidence from basic science has suggested that delayed cartilage repair is associated with poorer histologic and biochemical profiles, which has been associated with poor clinical outcomes,[39,40] further reinforcing the need for prompt, accurate diagnosis and treatment.

In studies investigating prognostic factors between differing cartilage restoration or repair techniques, the quality of cartilage repair tissue after microfracture and cell-based techniques may be less effective than bone-based repair surgical methods.[41–43] Moreover, patients with high-activity levels participating in sports may receive a greater benefit from cell-based or bone-block techniques over microfracture alone, emphasizing the importance of patient-specific decision-making with respect to the management of such pathology.[44] While patient-specific variables extracted through clinical history may help predict outcomes based on surgical technique, it remains difficult to fully elucidate their independent impact on outcomes in correlation with lesion size, location, and concomitant pathology. Overall, the findings of this study demonstrate strong consensus in obtaining a thorough clinical history, aided by radiographic and advanced imaging, with the objective of optimizing guidance for the diagnosis and clinical management of cartilage injury.

More often than not, patients who are found to have knee cartilage injuries present with vague symptoms, which can be difficult to identify on physical exam and clinical history alone, especially in the setting of concomitant ligamentous or meniscal injury. In contrast, previously assumed "asymptomatic" cartilage lesions incidentally found on MRI or arthroscopy further convolute the indication for cartilage restoration. This is overall reflected in the findings of this study, as a strong consensus for discerning symptomatic lesions was not obtained. Therefore, it is recommended that imaging be carefully correlated with symptomatology, while also considering other potential pain generators such as under-rehabilitation and associated meniscal tears. This study reached strong consensus for indications to obtain MRI and the necessary associated documentation required for anatomical lesion characterization. Specifically, lesion size and location have generally been well-recognized as critical for predicting the natural progression of knee cartilage lesions, correlating symptoms, and driving current treatment algorithms.[8,45–47] The findings on MRI, such as loose bodies, bipolar lesions, arthritic changes, containment, and ligamentous/meniscal pathology may also help guide treatment indications.

There was strong consensus for measuring length, depth, and width on advanced imaging, and subsequently grading lesions using Outerbridge or ICRS scoring arthroscopically. However, the measurement accuracy of both MRI and arthroscopic grading has been shown to be variable with larger lesions, owing to 2-dimensional measurements on 3-dimensional defects, technique, and intra-observer reliability, which may underestimate or overestimate lesion size.[48]

There was strong consensus for assessing concomitant bony, ligamentous, and meniscal pathology using long-leg plain radiographs and advanced imaging. Pathology that results in compartment overload and increased stress on cartilage repair has been well-demonstrated to result in treatment failure and poor postoperative outcomes and should be critically evaluated prior to indicating patients for surgical intervention.[49] While plain knee radiographs alone can help assess compartment narrowing, long-leg radiographs provide a more accurate evaluation of mechanical malalignment, which is supported by the strong consensus found in this study. Furthermore, unaddressed patholaxity and meniscal deficiency results in greater compartment contact pressures placed on repair sites leading to the progression of cartilage defects and failure of graft incorporation and healing. Therefore, these associated pathologies are considered relative contraindications to cartilage restoration unless adequately identified and addressed.[1]

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 majority of the statements regarding diagnosis achieved strong consensus, which related to aspects of the physical exam and history, imaging and documentation, and assessment of concomitant injury or bony malalignment that aid in surgical decision-making. The statements that did not achieve strong consensus were determining when a lesion is symptomatic, documentation of imaging, and when a diagnostic arthroscopy is indicated.

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Ethics approval

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

Declaration of Competing Interest

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Appendix A

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