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Interobserver Reliability of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) Classification of Meniscal Tears

Allen F. Anderson,^{*†} MD, Jay J. Irrgang,[‡] PT, PhD, ATC, FAPTA, Warren Dunn,[§] MD, MPH, Philippe Beaufils,^{||} MD, Moises Cohen,[¶] MD, PhD, Brian J. Cole,[#] MD, MBA, Myles Coolican,^{**} MD, Mario Ferretti,^{¶¶} MD, PhD, R. Edward Glenn Jr,[†] MD, Robert Johnson,^{††} MD, Philippe Neyret,^{‡‡} MD, Mitsuo Ochi,^{§§} MD, PhD, Ludovico Panarella,^{|||} MD, PhD, Rainer Siebold,^{¶¶¶} MD, PhD, Kurt P. Spindler,^{###} MD, Tarik Ait Si Selmi,^a MD, Peter Verdonk,^b MD, PhD, Rene Verdonk,^c MD, PhD, Kazu Yasuda,^d MD, PhD, and Deborah A. Kowalchuk,^e MD, MS
Investigation performed at the Tennessee Orthopaedic Alliance, Nashville, Tennessee

Background: Consistency of arthroscopic evaluation and documentation in meniscal tears between investigators is essential to the validity of multicenter studies. A group of experts developed a classification of meniscal tears that may be used internationally.

Hypothesis: The International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) classification of meniscal tears provides sufficient interobserver reliability for pooling of data from international clinical trials designed to evaluate the outcomes of treatment for meniscal tears.

Study Design: Cohort study (diagnosis); Level of evidence, 1.

Methods: A pilot study was performed by having 8 members of the committee grade 10 arthroscopic videos for classification of tear depth, rim width, location, tear pattern, and quality of the tissue. The results of the pilot study were used to change the instruction sheet and evaluation form. International interobserver reliability was determined by having 8 orthopaedic surgeons who practice in different countries evaluate 37 arthroscopic videos selected to represent different meniscal tear characteristics. The Spearman ρ correlation coefficient was used to compare the area of the meniscus excised, as drawn on the diagram, with the numeric percentage of meniscus excised.

Results: There was an 87% agreement for anterior-posterior location of the tear ($\kappa = .65$); 79% agreement for tear pattern ($\kappa = .72$); 88% agreement for tear depth ($\kappa = .52$); 68% agreement for anterior, middle, and posterior location of the tear ($\kappa = .46$); and 72% agreement for tissue quality ($\kappa = .47$). There was 54% agreement for the rim width ($\kappa = .25$) and 67% agreement if the tear was central to the popliteal hiatus ($\kappa = .36$). Based on the Landis and Koch criteria for κ coefficients, there was substantial agreement for anterior-posterior location of the tear and tear pattern; moderate agreement for tear depth, anterior, middle, and posterior location of the tear, and tissue quality; and fair agreement for rim width and if the tear was central to the popliteal tear. Interobserver reliability based on the intraclass correlation coefficient (ICC) was good for tear length (ICC = .83) and moderate for percentage of meniscus that was excised (ICC = .65). The mean ρ for all raters was .92 (95% confidence interval [CI], .89-.94) comparing the values for percentage of meniscus excised with the area on the diagrams.

Conclusion: The ISAKOS classification of meniscal tears provides sufficient interobserver reliability for pooling of data from international clinical trials designed to evaluate the outcomes of treatment for meniscal tears.

Keywords: meniscus; arthroscopy; multicenter; reliability

Basic science and clinical studies have substantiated the crucial role of the menisci in maintaining knee joint homeostasis.^{6,7,11,17,19,29} Biomechanical studies have shown that the menisci have important functions of load

transmission,^{1,5,12,24,25,26} shock absorption,^{17,30} joint lubrication,^{2,6} and stability.^{16,19,20} Clinical studies have clearly demonstrated that loss of meniscal function causes early osteoarthritis.^{6,9,11,17,19,21,29} Consequently, it is important to know the outcomes of different treatments for meniscal tears that may include neglect, partial meniscectomy, meniscal repair, or transplantation.

Determining which of these methods of treatment is best for a specific tear and how the treatment correlates

with long-term results is not easy or straightforward. Research published in the surgical literature is the most important factor in determining the best method of treatment. The literature, unfortunately, is often contradictory, leading to different treatment recommendations. Some of the variation in the literature is due to the low level of study quality. Reliance on small case series in the literature on the treatment of meniscal tears has led to uncertainty and many unresolved questions. In evaluating and comparing case series, surgeons are uncertain whether the patients in the different series have the same type of meniscal tear, whether the studies were conducted in the same way, whether the outcomes were evaluated with the same outcomes measures, or any number of other biases, which make it difficult to determine the best method of treatment for meniscal tears.

Now that our field is embracing evidence-based medicine, the methodological standards for publication in the orthopaedic literature have become increasingly more rigorous. Pooling of resources between investigators who may practice at different institutions and even in different countries may be necessary to obtain large enough sample sizes to adequately power statistical analysis. Consistency of arthroscopic evaluation and documentation of meniscal tears between these investigators is essential to avoid measurement error and improve the validity of results. Inconsistent classification of meniscal tears among surgeons could introduce enough measurement error to invalidate the findings of even the most rigorously conducted clinical trial.

Sensitive to these issues, the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) Knee Committee formed a Meniscal Documentation Subcommittee in 2006 with the objective of developing a reliable, international meniscal evaluation and documentation system to facilitate outcomes assessment. The members of the ISAKOS Meniscal

Documentation Subcommittee were selected by the leadership of the American Orthopaedic Society for Sports Medicine (AOSSM), the Asian Pacific Orthopaedic Society for Sports Medicine (APOSSM), the European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA), the ISAKOS, and the Latin American Society of Knee Arthroscopy and Sports Medicine (SLARD).

At the initial meeting, the committee discussed 3 types of forms that may be used to evaluate and document meniscal tears: a patient-reported (subjective) outcomes form, knee examination form, and surgical documentation form. The committee believed the development of a meniscus-specific patient-reported outcomes form was not necessary. The committee unanimously agreed to adopt the International Knee Documentation Committee (IKDC) Current Health Assessment and IKDC Subjective Knee Form. This form has shown to be valid and responsive for the evaluation of meniscal treatment outcomes.^{8,13,14} Additionally, the IKDC Subjective Knee Form includes items that were rated to be frequent and important to patients with meniscus lesions.²⁸

The committee placed a low priority on development of a knee examination form. Interobserver differences, including how tests are performed and interpreted, make it impossible to validate the objective metrics of meniscal examination. Thus, the primary focus of the initial meeting was to develop a surgical documentation form to classify meniscal tears.

The purpose of this study was to report the consensus of the ISAKOS Meniscal Documentation Subcommittee and to document interobserver reliability of the ISAKOS classification of meniscal tears. Our hypothesis was that the ISAKOS classification of meniscal tears provides sufficient interobserver reliability for pooling of data from international clinical trials designed to evaluate outcomes of treatment for meniscal tears.

*Address correspondence to Allen F. Anderson, MD, Tennessee Orthopaedic Alliance, St Thomas Medical Plaza East, 4230 Harding Road, #1000, Nashville, TN 37205 (e-mail: andersonaf@toa.com).

†Tennessee Orthopaedic Alliance, Nashville, Tennessee.

‡Department of Orthopaedic Surgery, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania.

§Department of Orthopaedic Surgery and Rehabilitation, Center for Health Services Research, Vanderbilt University Medical Center, Nashville, Tennessee.

||Versailles Hospital, Le Chesnay, France.

*Department of Orthopaedic Surgery, Federal University of Sao Paulo, Sao Paulo, Brazil.

#Division of Sports Medicine, Departments of Orthopaedics and Anatomy and Cell Biology, Cartilage Restoration Center, Rush University Medical Center, Chicago, Illinois.

**Royal North Shore Hospital and Sydney Orthopaedic Research Institute, Sydney, Australia.

††Department of Orthopaedic Surgery, University of Vermont College of Medicine, Burlington, Vermont.

‡‡Department of Orthopaedic Surgery, Centre Medico Sportif Albert Trillat-Centre Livet, University of Lyon, Lyon, France.

§§Department of Orthopaedic Surgery, Hiroshima University School of Medicine, Hiroshima, Japan.

|||Department of Orthopaedic Surgery, Valle Giulia Clinic of Rome, University of Rome Tor Vergata, Rome, Italy.

¶¶Center for Knee and Ankle Surgery and Sports Traumatology, ATOS Hospital Heidelberg, Heidelberg, Germany.

##Department of Orthopaedic Surgery and Rehabilitation, Vanderbilt Sports Medicine and Orthopaedic Patient Care Center, Vanderbilt University, Nashville, Tennessee.

^aDepartment of Orthopaedic Surgery, Centre Livet, Hôpital de la Croix-Rousse, Lyon, France.

^bDepartment of Orthopaedic Surgery, Ghent University Hospital, Ghent, Belgium, and Department of Orthopaedic Surgery, Stedelijk Ziekenhuis Roeselare, Roeselare, Belgium.

^cDepartment of Orthopaedics and Traumatology, Ghent University Hospital, Ghent, Belgium.

^dDepartment of Sports Medicine and Joint Surgery, Hokkaido University School of Medicine, Sapporo, Japan.

^eDepartment of Orthopaedic Surgery, University of Massachusetts Medical Center, Worcester, Massachusetts.

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MATERIALS AND METHODS

The first step was to agree on standard terminology. The committee agreed on the following terms. Tear length indicates the length of the meniscal tear that reaches the surface of the meniscus. Intermeniscal degeneration or contained tears, that is, those that do not reach the surface of the meniscus, are not included in the definition of tear length. Tear depth mirrors the magnetic resonance imaging (MRI) meniscal classification scheme of 0 to 3. A 3A tear is a partial tear that extends through either the superior or inferior surface of the meniscus. A horizontal tear may also be a partial tear. A 3B tear is a tear that extends through both the superior and inferior surfaces of the meniscus.

The committee evaluated 2 radial location classifications, the anterior-posterior classification, which divides the menisci in half, and the anterior, middle, and posterior classification, which divides the menisci into thirds. Rim width (circumferential) locations include zone 1 (tears of the meniscosynovial junction or a tear with a rim of <3 mm), zone 2 (tears with a rim of 3 to <5 mm), and zone 3 (rim width of 5 mm or greater). The committee discouraged the use of the terms red-red, red-white, and white-white because the vascular supply of the menisci varies and cannot be precisely determined by rim width alone.

The committee agreed to the following terms for tear patterns: longitudinal-vertical (extension of this tear is a bucket-handle tear), horizontal, radial, vertical flap, horizontal flap, and complex (see Figure 1). The quality of the tissue may be nondegenerative, degenerative, or undetermined. The committee discouraged the use of the terms acute, subacute, and chronic in preference to the time since onset of symptoms. Patients may not be aware of when the tear occurred, particularly in circumstances involving degenerative tears.

Pilot Study

The next step in developing the meniscal documentation form was to perform a pilot study to quantify interobserver agreement for grading of meniscal tear characteristics. Eight members of the committee independently evaluated ten 45-second arthroscopic videos demonstrating the probing of meniscal tears. The videos demonstrated a variety of medial and lateral meniscal tears.

Each observer was given a 1-page instruction sheet (Figure 1A), without any additional coaching, and a scoring sheet containing diagrams of the classification schemes. The videos were evaluated for meniscal tear depth, location, tear pattern, quality of tissue, length of the tear, and the amount of tissue excised (Figure 1B). Interobserver reliability for categorical variables was assessed using the unweighted κ statistic for multiple raters.¹⁸

Results of the pilot study showed substantial agreement ($\kappa = .61-.80$) for tear pattern and moderate agreement ($\kappa = .41-.60$) for tear location, quality of tissue, and tear length. There was slight agreement ($\kappa = .0-.2$) for tear length and rim width. The reliability of estimating the amount of meniscus excised was not calculated because the

instructions were confusing to some committee members. Hence, the instruction sheet and evaluation form were changed based on these pilot data.

Interobserver Reliability Study

The next step was to determine international interobserver reliability among 8 experienced orthopaedic surgeons who were not members of the committee. These surgeons practiced in 8 countries (Australia, Belgium, Brazil, France, Germany, Italy, Japan, and the United States), and they were members of the 4 continental sports medicine societies: AOSSM, APOSSM, ESSKA, and SLARD.

Thirty-seven arthroscopic videos, 45 seconds in length, were made by a single surgeon. This number of videos was evaluated to ensure adequate statistical analysis of the different types of meniscal tears. The meniscal tears were defined by correlating preoperative MRI with the surgeon's thorough arthroscopic assessment. According to this method of assessment, there were 22 medial and 15 lateral meniscal tears. Ten of the tears were longitudinal-vertical, 10 flap, 10 complex, 5 radial, and 2 horizontal. The videos were edited to show arthroscopic probing of the meniscal tear and the residual meniscus remaining after meniscectomy with a calibrated probe. The thirty-seven videos were saved onto a compact disc (CD) and distributed to the 8 orthopaedic surgeons. An instruction sheet, explaining the definitions of the standard terminology and a questionnaire (Figure 1B), was included with the CD. The questionnaire included grading of the following meniscal tear characteristics: whether the tear was partial or complete; the rim width location; location of the tear using both the anterior, middle, and posterior and anterior-posterior classification schemes; tear pattern; quality of the tissue; length of the tear; and amount of meniscus excised. For rim width, the surgeons were instructed that tears should be graded based upon how far the tear extended into the meniscus. For example, a complete radial tear that extends through zones 3, 2, and 1 should be graded as a zone 1 tear. For location, posterior, mid body, and anterior classifications of the tears were graded according to all the zones in which the tear was located. A complete bucket-handle tear of the medial meniscus would be in the posterior, mid body, and anterior zones. In the posterior-anterior location classification, a radial tear in the middle of the lateral meniscus from anterior to posterior would be graded radial tear mid body. Tears of the lateral meniscus that extended partially or completely in front of the popliteal hiatus were graded as central to the popliteal hiatus. Tear patterns were graded based on the predominant pattern. A complex tear included 2 or more tear patterns. Degenerative tears have characteristics, including cavitation, multiple tear patterns, softening of meniscal tissue, fibrillation, or other degenerative changes. The length of the tear was measured with an arthroscopic ruler in millimeters. The length of a radial tear is the distance the tear extended into the meniscus. The amount of meniscus excised was estimated as a percentage of the surface area of the meniscus. The amount of meniscal tissue excised was also drawn on a diagram and cross-hatched.

FIGURE 1
Instruction Sheet and Questionnaire

A. INSTRUCTION SHEET

1. Tear depth: The partial tear extends through either the superior or inferior surface of the meniscus. A horizontal tear may also be a partial tear. The complete tear extends through both the superior and inferior surfaces of the meniscus.
2. Rim width:
 - a. In the zone classification, tears may involve more than one zone. The tears should be graded based on how far the tear extends into the meniscus. For example, a complete radial tear that extends through zones 3, 2, and 1 should be graded as a zone 1 tear.
 - Zone 1 tears have a rim width of <3 mm.
 - Zone 2 tears have a rim width of 3 to <5 mm.
 - Zone 3 tears have a rim width of ≥5 mm.
3. Radial location: The committee is evaluating the reliability of 2 different methods of documenting tear locations. The results of this study will determine which method is chosen.
Please grade location of the tear with 2 formats:
 - a. Indicate whether the tear is posterior, mid body, or anterior in location. Tears should be graded according to all the zones in which they are located. For example, a complete bucket-handle medial meniscus tear would be in the posterior, mid body, and anterior zones.
 - b. The posterior-anterior classification is demonstrated on the diagram. Indicate whether the tear is anterior, posterior, or both. A radial tear in the middle lateral meniscus from anterior to posterior should be marked as radial tear mid body.
4. A tear of the lateral meniscus that extends partially or completely in front of the popliteal hiatus should be graded as central to the popliteal hiatus.
5. Tear pattern: The tear should be graded according to the patterns that are demonstrated in the drawing. Tears should be graded on the predominant tear pattern. Complex tears include 2 or more tear patterns. **A tear in the lateral meniscus that extends partially or completely in front of the popliteal hiatus should be graded as central to the popliteal hiatus.**
6. Quality of the tissue: Degenerative characteristics include cavitations, multiple tear patterns, softened meniscal tissue, fibrillation, or other degenerative changes.
7. Length of tear: This should be measured from the arthroscopic ruler in millimeters. The length of a radial tear is the distance the tear extends into the meniscus.
8. Please indicate the amount of meniscal tissue that has been excised by drawing on the diagram and cross-hatching the part of the meniscus that was removed.
9. Indicate the percentage of meniscus (surface area) that was excised.

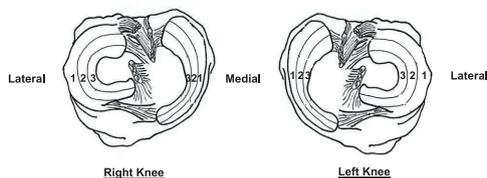
B. QUESTIONNAIRE

1. Tear Depth:

- Partial
 Complete

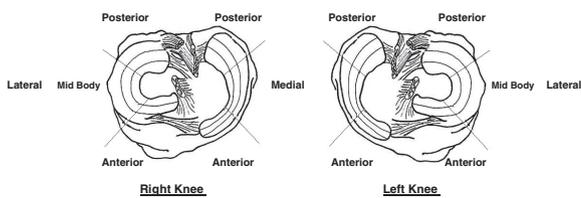
2. Location (refer to diagram for description)

Rim Width (circumferential location): Zone 1 Zone 2 Zone 3

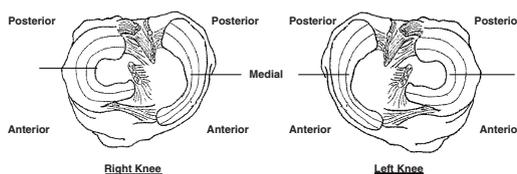


3. Radial Location

a. Posterior-Mid body-Anterior Location: Posterior Mid body Anterior



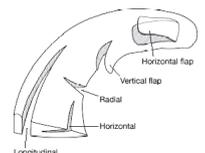
b. Posterior-Anterior Location: Posterior Anterior Radial tear mid body



4. Central to the popliteal hiatus? Yes No

5. Tear Pattern (refer to diagram for description)

- Longitudinal-vertical: extension is a bucket handle tear
 Horizontal
 Radial
 Vertical flap
 Horizontal flap
 Complex



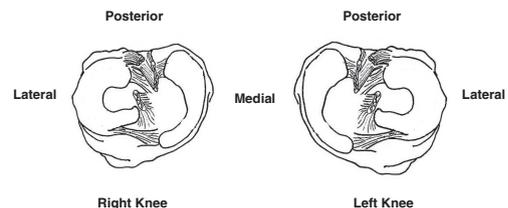
6. Quality of Tissue:

- Nondegenerative
 Degenerative
 Undetermined

7. Length of Tear:

mm

8. Indicate the amount of meniscus that was excised by drawing on the diagram and crosshatching the part that was removed.



9. What percentage of the medial meniscus was excised?

%

TABLE 1
Interobserver Reliability of the ISAKOS Classification of Meniscal Tears

Variable	Observations (n = 296)	Average No. of Raters	Observed Agreement, %	Reliability Coefficient ^a	95% Confidence Interval
Tear depth	281	7.59	88	.52	.27-.74
Rim width	294	7.95	54	.25	.18-.33
Location					
Method 1:					
anterior, middle, and posterior regions	296	8.00	68	.46	.33-.59
Method 2:					
anterior and posterior regions	294	7.95	87	.65	.44-.82
Popliteal hiatus	107	7.64	67	.36	.21-.55
Tear pattern	294	7.95	79	.72	.63-.81
Tissue quality	292	7.89	72	.47	.35-.60
Length, mm	292	7.89	—	.83	.75-.90
Percentage excised	259	7.85	—	.63	.52-.78

^aUnweighted κ for categorical data and intraclass correlation coefficient (ICC) using a 2-way random effects model for continuous data.

Statistical Analysis

Interobserver reliability for categorical data was determined by calculating κ coefficients for multiple raters.²⁷ Observed agreement is the probability that 2 participants would provide the same response to a question for a specific case. κ is the amount of observed agreement that is beyond the agreement expected because of chance alone. A κ of .0 represents agreement that is equal to chance, and a κ of 1.0 represents perfect agreement. A κ of 0 to .2 represents slight agreement, .21 to .40 is fair agreement, .41 to .60 is moderate agreement, .61 to .80 is substantial agreement, and .81 to 1.0 is almost perfect agreement.¹⁸ The bootstrap method in Stata (release 10, StataCorp, College Station, Texas) with 1000 replications was used to generate the confidence intervals for the κ coefficients. For continuous data, including tear length and percentage of meniscus excised, the intraclass correlation coefficient (ICC) using a 2-way random effects model was calculated to estimate interobserver reliability.²⁷ Intraclass correlation coefficients range from 0 to 1.0, with 1.0 indicating perfect agreement. Intraclass correlation coefficients greater than .75 are indicative of good interobserver reliability.²²

The diagrams indicating the amount of meniscal excision were scanned and saved as image files. These images were opened in ImageJ,²³ and volume measurements were made by manually outlining the entire meniscus as well as the cross-hatched portion representing the amount excised. These area measurements were used to calculate the percentage of meniscus excised based on the diagrams. Using free, open-source R statistical software (www.r-project.org), the Spearman ρ correlation coefficient was used to compare the area of the meniscus excised, as drawn on a diagram with the numeric percentage of meniscus excised.

RESULTS

The results are presented in Table 1. The observed agreement for all categorical variables was above that expected by chance alone. Based on the Landis and Koch criteria¹⁸

for κ coefficients, there was substantial agreement for anterior-posterior location of the tear ($\kappa = .65$) and tear pattern ($\kappa = .72$); moderate agreement for tear depth ($\kappa = .52$), anterior, middle, and posterior location of the tear ($\kappa = .46$), and tissue quality ($\kappa = .47$); and fair agreement for rim width ($\kappa = .25$) and if the tear was central to the popliteal hiatus ($\kappa = .36$). Interobserver reliability based on the ICC was good for tear length (ICC=.83) and moderate for percentage of the meniscus excised (ICC=.65).

The Spearman ρ was used to compare the estimation of the percentage of meniscus excised with the area of the meniscus excised as drawn on the diagrams. The mean ρ was .92 for all 8 raters; the median (interquartile range) was .91 (.88-.95). The upper and lower bounds of the 95% confidence interval (CI) of the correlation between the percentage of meniscus excised and the area of the meniscus excised in the drawings were .89 and .94, respectively.

DISCUSSION

The results of this study show that interobserver reliability between investigators who practice at different institutions and different countries was acceptable for grading tear depth, location, tear pattern, length, quality of the tissue, and percentage of the meniscus excised. Consistency in documentation is essential for valid assessment of the treatment for meniscal tears. Disagreement between surgeons on meniscal tear grading may invalidate clinical trials designed to evaluate the outcomes of treatment for meniscal tears and bias trials designed to evaluate the treatment of other knee conditions.

Vascularity of the menisci has important implications for healing of meniscal repairs. Cooper et al⁷ described a circumferential zone classification for meniscal tears that has gained acceptance.^{16,30} In this classification, zone 0 is the meniscosynovial junction, zone 1 includes the outer third of the meniscus, zone 2 includes the middle third, and zone 3 is the central third of the meniscus. In the meniscus of adults, capillaries penetrate no deeper

than 10% to 25% of the width of the lateral meniscus and 10% to 30% width of the medial meniscus.^{3,4} The committee adopted a modification of the Cooper classification system that was based on the evidence of vascularity extending up to 3 mm into the menisci. Unfortunately, the observed agreement for estimation of the rim width in this study was only 54%. Dunn et al¹⁰ reported the interobserver reliability for grading of rim width, which divided the meniscus into 3 circumferential zones: central, middle, and peripheral. The observed agreement was 46% in their study. To account for meniscal tears that involve more than one zone, 6 combinations are possible, which may explain why the observed agreement was low. The fact that 2 studies reach the same conclusions lends greater credence to the idea that caution should be used when interpreting the results of meniscal repair based on rim width.

Two radial classifications have been used to correlate the location of meniscal tears to outcome. In one system, the medial meniscus was divided into radial thirds A (posterior), B (middle), and C (anterior), and the lateral meniscus was divided into D (anterior), E (middle), and F (posterior)⁷ (Figure 1B). The committee recommended using the descriptors anterior, middle, and posterior for the medial and lateral menisci rather than the A-to-F classification because this method was thought to be more intuitive. The observed agreement was 68%, and the κ was .46 (moderate) using this system.

Another radial classification divided the menisci into anterior and posterior halves.¹⁰ The observed agreement and κ statistic, as expected, were higher for the anterior-posterior classification than the anterior, middle, and posterior classification. The observed agreement (87%) and κ (.65, substantial) for the anterior-posterior classification were the same as those reported by Dunn et al.¹⁰ Despite the lower interobserver reliability, the consensus of the committee was that having 3 radial zones was better for descriptive purposes because certain tears reside in specific zones. Consequently, the historic standard anterior, middle, and posterior classification was recommended.

Javed et al¹⁵ evaluated interobserver reliability of meniscal tear grading using arthroscopic videos. They found disagreement between 17% and 21% among 2 trainees and a senior surgeon. The variation in experience of the surgeons was the primary determinant of disagreement in their study. This factor should not have contributed to disagreement in our study because all 8 surgeons were experienced.

Dunn et al¹⁰ determined interobserver reliability by having 7 fellowship-trained orthopaedic surgeons from the United States grade 18 arthroscopic videos. They found 80% agreement ($\kappa = .46$) on depth of tear, 72% agreement ($\kappa = .44$) on the presence of degeneration of the tear, 71% agreement ($\kappa = .42$) on whether the tears were central to the popliteal hiatus, 73% agreement ($\kappa = .63$) on the type of tear, and 87% agreement ($\kappa = .61$) on location of the tear. The results of this study were similar to those reported by Dunn et al.¹⁰ This consistency

verifies the reliability and generalizability of meniscal tear grading.

This study, like all others, has strengths and weaknesses. The strengths of this study include an international panel of experts who developed the form. The participants did not discuss the meniscal tear grading or the ISAKOS classification of meniscal tears before this study. This study also included the largest number of arthroscopic videos used to evaluate interobserver agreement. In addition, the results should be generalizable to location because the 8 surgeons who participated in the study lived in 8 countries and on 4 continents.

The weaknesses of this study include the fact that participating surgeons had to grade meniscal tears after viewing brief arthroscopic videos. They did not have the advantages of tactile sensation provided by probing or more time to personally evaluate the meniscal tears. It is impossible to know how this technique of evaluating meniscal tears affected interobserver reliability. The potential limitation caused by grading arthroscopic videos may have been offset by viewing the "best cases" that did not include real-world conditions that may limit visibility. In conclusion, these data demonstrate that the ISAKOS classification of meniscal tears provides sufficient interobserver reliability for pooling of data from international clinical trials designed to evaluate the outcomes of treatment for meniscal tears.

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