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OSTEOARTHRITIS and CARTILAGE

# Inter-observer reliability of the arthroscopic quantification of chondropathy of the knee

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## Summary

Background: Several scoring systems have been proposed in order to quantify the degree of cartilage damage observed by arthroscopy of the knee in patients with osteoarthritis.

Objective: To evaluate the inter-observer reliability of five different scoring systems of arthroscopic evaluation for chondropathy in osteoarthritis of the knee and to evaluate the utility of a training session between different observations on these scoring systems.

Methods: Videotapes of knee arthroscopies on five patients with osteoarthritis demonstrating different levels of severity of cartilage damage of the medial tibiofemoral compartment were analyzed by nine observers prior to (pre-training evaluation) and 2 months after a 6 h training session (post-training evaluation) by the following scoring systems: (1) cartilage deterioration by a 100 mm visual analogue scale (VAS), (2) overall assessment of degeneration in the entire medial compartment (cartilage, meniscus, osteophyte) using a 100 mm VAS, (3) French Society of Arthroscopy (SFA) Scoring System, (4) SFA Grading System, (5) American College of Rheumatology (ACR) Scoring System.

Results: At the pre-training evaluation, the SFA grading system produced the highest coefficient of reliability ($r = 0.94$), the other systems recording levels of $\leq 0.80$. At the post-training evaluation, the coefficient of reliability was $r > 0.80$ for four of the five scoring systems, with lack of improvement in the ACR Scoring System.

Conclusion: There was an improved and acceptable inter-observer reliability for at least 2 months follow-up in four of five evaluated scoring systems of arthroscopically graded osteoarthritis of the knee following a training session. A scoring system using a 100 mm VAS may produce the best inter-observer reliability. These results show that scoring chondropathy is possible and demonstrate the importance of training in the analysis of articular cartilage breakdown.

Key words: Osteoarthritis, Knee, Arthroscopy, Outcome measure.

## Introduction

The primary uses of arthroscopy of the knee have been for diagnosis of unexplained rheumatological symptoms [1, 2], and as a therapeutic tool to evaluate particular rheumatic diseases [3]. More recently, the results of arthroscopy of the knee have been considered as an outcome measure of articular damage, particularly in osteoarthritis [4, 5]. The value of arthroscopy is that it provides a direct magnified view of cartilage surface integrity, detecting cartilage surface defects that are characteristic of osteoarthritis. Alternative but less sensitive methods of evaluating joint

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surface integrity involve imaging techniques, such as plain radiographs, computerized tomography and magnetic resonance imaging [6, 7].

The use of arthroscopy for prospective studies of osteoarthritis of the knee would be enhanced by selecting and validating a scoring system. Arthroscopic classification and scoring systems have been devised that evaluate specific characteristics of cartilage lesions, specifically 'location' and 'depth' [8, 9] or location, depth and 'size' [10–13].

For 'location', the consensus is that the assessment should separate the evaluations of each compartment of the knee: medial tibiofemoral compartment, lateral tibiofemoral compartment and patellofemoral compartment.

Evaluation of 'depth' includes a description of the lesion with staging from normal appearance of the cartilage to full disruption of the cartilage and exposure of the subchondral bone. The classification of chondropathy proposed by Beguin and Locker [8] includes five grades in which 0 indicates normal cartilage, grade I swelling and/or softening, grade II superficial fibrillations or erosions, grade III deep fibrillations down to bone or deep erosions without exposed bone and grade IV exposure of subchondral bone. A variant of the classification of Noyes and Stabler [14] has been proposed by Klashman *et al*. [15], in which grade Ia indicates intact but dull articular surface, grade Ib swelling and/or softening, grade IIa and IIb superficial or deep fissures or erosions, respectively, and grade IIIa and IIIb exposed bone without or with bone cavitation, respectively.

'Size' of the lesions can be assessed in millimeters (diameter of the most severe chondropathy) [14] or in percentage of the whole articular surface [4].

Composite indices of size and depth of cartilage lesions have been proposed by the French Society of Arthroscopy (SFA for Société Française d'Arthroscopie) based on a multivariate analysis of the results on a clinical study of 750 patients. Two systems were proposed: the SFA Scoring System [16, 17], which records a number from a continuous variable with a range from 0 to 100 and the SFA Grading System [16] which assigns five categories of severity of chondropathy to each of the tibiofemoral compartments.

A composite index, the American College of Rheumatology (ACR) Scoring System, is based on the results of a consensus meeting (personal communication). In this system, cartilage damage is reported in a global score ranging from 0 to 350 [15].

A successful scoring system for clinical trials would fulfill in the criteria for outcome measures of simplicity, accuracy, sensitivity to change and reliability [18]. Accuracy, simplicity and sensitivity to change have been evaluated for some of the proposed arthroscopy systems [4, 19]. For reliability, differences are expected between observers in the evaluation of severity of chondropathy. In addition, there are differences in the routine systems used by arthroscopists (mostly the classification proposed by Noyes and Stabler in United States and the classification proposed by Beguin and Locker in Europe). There are differences in the grading of severity of findings observed in daily practice by different arthroscopists (e.g., mild chondropathy often seen in sports medicine clinics vs severe disease often seen in patients from a rheumatology clinic).

A workshop was convened by the Osteoarthritis Research Society to evaluate existing scoring systems in order to standardize the language and findings on the evaluation of severity of chondropathy among arthroscopists, facilitate the analysis of arthroscopy results derived from clinical epidemiological studies and/or clinical trials, and create a training session and test inter-observer reliability.

## Materials and Methods

### PATIENTS

Five patients fulfilling ACR criteria for the classification of knee osteoarthritis [20] from the Department of Rheumatology of Cochin Hospital, Paris, France, underwent knee arthroscopy with concomitant videotape recordings. Patients were selected for findings that represent different aspects of cartilage lesions and different stages of severity of chondropathy in the medial tibiofemoral compartment of the knee.

### OBSERVERS

The study included nine senior arthroscopists, each having extensive experience in osteoarthritis (five from the U.S.A., two from France, one from Italy and one from Sweden).

### EVALUATED ARTICULAR SURFACE

Videotape recordings were only evaluated for the medial tibiofemoral compartment.

### SCORING SYSTEMS

The forms used during this session contained the contents of five scoring systems:

(1) Investigator's Overall Assessment of Chondropathy using a 100 mm VAS in which '0' indicates the absence of chondropathy and '100' the most severe chondropathy [4]. A VAS is used for each articular surface of the medial compartment, i.e., medial femoral condyle and medial tibial plateau. The VAS score of chondropathy of the medial compartment is obtained by calculating the average value of the VAS of the two corresponding articular surfaces of the compartment.
(2) Investigator's Overall Assessment of Degeneration of the medial compartment using a 100 mm VAS [15]. This differs from Investigator's Overall Assessment of Chondropathy by addition of the meniscus and osteophytes to the evaluation.
(3) The SFA Scoring System [16, 17]. The observed chondropathy is reported on an articular diagram of the knee with baseline variables of 'location' (medial femur and medial tibia, 'depth' (based on the classification of chondropathy proposed by Beguin and Locker [8]) and 'size'. The size of each lesion is estimated as a percentage of the whole articular surface and the sum of the lesions of different grades for each articular surface equals 100%.
The SFA score is a continuous variable recorded as between '0' and '100', in which 0 indicates the absence of chondropathy and 100 the total exposure of bone. The score is obtained for each compartment as follows:

SFA score = A + B + C + D, where:
A = size (%) of grade I lesions × 0.14
B = size (%) of grade II lesions × 0.34
C = size (%) of grade III lesions × 0.65
D = size (%) of grade IV lesions × 1.00

Size (%) = average percent of surface for the medial femoral condyle and medial tibial plateau combined.
(4) The SFA Grading System [16] is a categorical variable. The above numbers (size percent of grade 0 to IV lesions) are included in a formula to provide a summary grade (or category of chondropathy severity) for each compartment of the knee. There are five categories (five SFA grades) for the medial tibiofemoral compartment where category 0 indicates the absence of chondropathy and category IV indicates a severe chondropathy.
(5) The ACR Scoring System [15] records location, depth and size of chondral lesions. Lesions are recorded on a knee diagram. Depth of each lesion is based on the classification proposed by Klashman *et al*. [15]. Size of each lesion is evaluated on a 100 mm VAS in which '100' represents the entire size of the articular surface. A point scaling system is applied to obtain an overall score, called 'damage score' [15]. The damage score is a continuous variable between '0' and '350', in which 0 indicates the absence of chondropathy and 350 the total exposure of bone. The score is obtained for each compartment as follows:

ACR score = A + B + C + D + E + F, where:
A = size (mm) of grade Ia lesions × 1.0
B = size (mm) of grade Ib lesions × 1.5
C = size (mm) of grade IIa lesions × 2.0
D = size (mm) of grade IIb lesions × 2.5
E = size (mm) of grade IIIa lesions × 3.0
F = size (mm) of grade IIIb lesions × 3.5

Size (mm) = average value of size for the medial femoral condyle and medial tibial plateau combined.

It should be noted that the arthroscopic exploration of the tibiofemoral compartment recorded on the videotapes was only visual without any probing of the articular cartilage at the time of arthroscopy. Thus, the assessment of early stage of the disease, i.e., pure chondromalacia, was based on detection of local swelling (grade I or Ib in the classification proposed by Beguin/Locker or Klashman, respectively) or change in color of the cartilage (grade Ia in Klashman's classification).

### STUDY DESIGN

This design of the study comprised three steps:
(1) Pre-training evaluation: in a general session, videotapes were presented to the observers after a brief explanation on use of the five sets of case record forms without information on interpretation or description of the lesions to be visualized. All observers simultaneously visualized each tape in a classroom and independently recorded the cartilage surfaces and lesions based on their prior experience of arthroscopy. The case record forms were collected and information collated.
(2) Training session: in a general session, the videotapes were carefully reviewed in a classroom. Discrepancies in the interpretation of findings from the videotapes were discussed among the participants in a 6 h open and highly interactive session. Agreement was reached on the interpretation and recording of findings.
(3) Post-training evaluation: in the participants' own centers, the same videotapes were reviewed 2 months after the training session. Each participant independently reviewed the videotapes and recorded their findings for a second time.

Pre-training evaluations had not been returned to the participants and this assessment was without knowledge of their pre-training evaluation. The case record forms were the same as those used in the pre-training evaluation.

### STATISTICAL ANALYSIS

Inter-observer reliability between the pre-training and post-training evaluations was calculated for a coefficient of reliability [21]. The reported range of value in this technique is 0–1.00. Higher values, particularly those of $\geq 0.80$, are usually regarded as acceptable [21].

## Results

The arthroscopic findings selected demonstrated moderate osteoarthritic changes in patients #1 and #2 with more advanced changes in patients #3, #4 and #5 (Table I).

Results from the pre-training assessment [Table I(a)] demonstrated wide variation among the nine arthroscopists in the interpretation of four of the five scales (Table II) with reliability coefficients ranging from 0.27 to 0.73. Evaluation using the categorical SFA Grading System was more consistent, particularly in the patients with more severe cartilage breakdown (reliability coefficient 0.94).

Results of the post-training assessment [Table I(b)] demonstrate consistently lower readings using all scales with less variation in the reliability coefficients in three of the five scales (Table II). Interpretation of the arthroscopic findings were lower but the reliability coefficient unchanged with the SFA Grading System. Interpretation by the Investigator's Overall Assessment of Chondropathy, the Investigator's Overall

Table I
*Mean values of the different arthroscopic findings of five osteoarthritic patients evaluated by nine observers using different scoring systems of chondropathy*

(a) Pre-training

| | Patients | | | | |
|---|---|---|---|---|---|
| Parameters* | 1 | 2 | 3 | 4 | 5 |
| Investigator's overall assessment of chondropathy | 35 ± 14† (16–53) | 50 ± 20 (22–74) | 61 ± 20 (43–98) | 68 ± 19 (38–94) | 57 ± 15 (30–73) |
| Investigator's overall assessment of degeneration | 39 ± 13 (14–56) | 52 ± 16 (28–73) | 65 ± 16 (48–89) | 77 ± 13 (58–96) | 64 ± 19 (34–90) |
| SFA Scoring System | 25 ± 18 (7–64) | 36 ± 20 (11–68) | 51 ± 21 (30–84) | 61 ± 22 (40–95) | 52 ± 17 (29–72) |
| SFA Grading System | | | | | |
| I | 1 | 0 | 0 | 0 | 0 |
| II | 4 | 0 | 0 | 0 | 0 |
| III | 2 | 4 | 0 | 0 | 0 |
| IV | 2 | 5 | 9 | 9 | 9 |
| ACR Scoring System | 99 ± 56 (12–202) | 164 ± 108 (21–339) | 179 ± 96 (38–354) | 208 ± 98 (44–347) | 191 ± 100 (25–365) |

(b) Post-training

| | Patients | | | | |
|---|---|---|---|---|---|
| Parameters* | 1 | 2 | 3 | 4 | 5 |
| Investigator's overall assessment of chondropathy | 30 ± 12† (14–47) | 35 ± 11 (20–57) | 57 ± 13 (41–85) | 62 ± 15 (41–93) | 53 ± 11 (36–73) |
| Investigator's overall assessment of degeneration | 29 ± 12 (14–50) | 40 ± 9 (28–56) | 61 ± 14 (42–82) | 73 ± 13 (50–92) | 63 ± 17 (40–96) |
| SFA Scoring System | 18 ± 6 (9–30) | 20 ± 6 (13–31) | 41 ± 19 (24–86) | 50 ± 18 (33–91) | 39 ± 7 (28–48) |
| SFA Grading System | | | | | |
| I | 0 | 0 | 0 | 0 | 0 |
| II | 4 | 2 | 0 | 0 | 0 |
| III | 5 | 4 | 0 | 0 | 1 |
| IV | 0 | 3 | 9 | 9 | 8 |
| ACR Scoring System | 88 ± 40 (18–140) | 88 ± 47 (8–182) | 149 ± 62 (65–271) | 140 ± 62 (72–266) | 134 ± 46 (60–220) |

*See methods section for details.
†Values given are mean ± S.D. (first row) and range (second row).

Table II
*Inter-observer reliability of different arthroscopic scoring systems of severity of chondropathy (nine observers)*

| Parameters† | First analysis* reliability coefficient | Second analysis* reliability coefficient |
|---|---|---|
| Investigator's overall assessment of chondropathy | 0.49 | 0.98 |
| Investigator's overall assessment of degeneration | 0.73 | 0.91 |
| SFA Scoring System | 0.44 | 0.87 |
| SFA Grading System | 0.94 | 0.94 |
| ACR Scoring System | 0.27 | 0.44 |

*Second analysis of the same videotapes was performed 2 months after the first one by all the observers without knowledge of their own previous results.
†See methods section for details.

Assessment of Degeneration and the SFA Scoring System improved to the 0.87 to 0.98 level of reliability coefficient. The ACR Scoring System improved but only to a 0.44 level of reliability coefficient.

The ACR Scoring System used a 100 mm VAS for scoring the size of the lesions. In the pre-training evaluations, seven of 45 femoral condyles or tibial plateaus were graded over 100 mm when adding the size of the various chondral lesions. The post-training evaluation had no sum of lesions graded as over 100 mm, accounting for some of the improved reliability coefficient.

## Discussion

This study evaluated five methods of scoring the degree of osteoarthritis in the medial tibiofemoral compartment of the knee as performed by nine experienced arthroscopists. Arthroscopy permits the exploration of the three compartments of the knee joint. However, in this study, the evaluation of inter-observer reliability focused on the medial tibiofemoral compartment because most clinical studies in knee osteoarthritis using weight-bearing X-rays [22] or arthroscopy [23] as outcome measures focus on this compartment. Inter-observer reliability prior to training was rather poor, but was markedly improved by a training session. Only one method, the SFA Grading System, showed acceptable inter-reader reliability before training and did not change afterwards. With the training session, the Investigator's Overall Assessment of Chondropathy, the Investigator's Overall Assessment of Degeneration and the SFA Scoring System improved to acceptable levels of inter-observer reliability. The ACR Scoring System improved, but not to an acceptable level. The importance of the training session was apparent 2 months after the single training session.

The technique of evaluating the reliability of an outcome variable and interpretating the obtained results are not yet well established. However, in accordance with recent proposed methodology guidelines, we used the coefficient of reliability (using analysis of variance techniques) for this study [21]. The possible range of values of this technique is 0–1.00. Higher values, particularly those of $\geq 0.80$ are usually regarded as acceptable.

Results during the first evaluation were obtained prior to any discussion between or among the arthroscopists. The consistency of the SFA Grading System, even under these conditions, suggests an acceptable reliability. Some differences in the evaluation of the different scoring methods can be explained by mathematical reasoning: the mathematical characteristic of the variable, i.e., categorical or continuous variables may produce different results. The best inter-observer reliability of the SFA Grading System prior to the training session is probably due to its categorical characteristic. In the ACR Scoring System, a 100 mm VAS was used for scoring the size of each sub-grade. In several instances this resulted in recording a total chondral involvement (grade Ia to grade IIIb) exceeding 100 mm, suggesting that chondropathy can be observed in more than 100% of the articular surface under evaluation. This prompted the committee of the ACR to modify the method of recording this information. The proposal is to record the size in percentage of the studied articular surface (similar to the SFA Scoring System) [15]. Separation of subtype a or b for grade I and III in the ACR Scoring System appears to produce a more accurate number, but complicates the methodology, perhaps contributing to the lower inter-observer reliability. Additional inter-observer reliability of the ACR Scoring System appears needed. Future evaluations should emphasize

the training session with particular emphasis on the method of evaluation of the size of each lesion.

Inter-observer reliability is one of the characteristics of an outcome measure but is cross-sectional. Longitudinal evaluations are needed to determine if the methods have the ability to detect change. In prospective longitudinal study, the SFA grading system permits classification of a population of osteoarthritic patients into homogeneous categories of chondropathy severity and permits investigation of specific subgroups of osteoarthritic patients [19]. Since this system is a categorical variable, it seems unlikely to show much sensitivity to change. At variance, Investigator Overall Assessment of Chondropathy or Degeneration and SFA or ACR scores are more appropriate to detect minimal changes in severity of chondropathy over time, as they represent continuous variables. In a previous study, Investigator Overall Assessment of Chondropathy and SFA score have demonstrated their ability to detect and quantify a statistically significant worsening of cartilage breakdown of the medial tibiofemoral compartment between two arthroscopic evaluations performed 1 year apart in 41 patients, even though the changes assessed by the SFA Grading System did not reach statistical significance [19]. At this time, both continuous variables, i.e., global assessment and the more analytic score, are used in clinical trials. One could argue that Investigator's Overall Assessment of Chondropathy or Degeneration seems preferable to the more complicated SFA or ACR Scoring Systems, since they show good reproducibility, particularly after training, and are likely to be sensitive to change. Further longitudinal studies are required to answer this question.

The utility of the training session was determined by comparing results on inter-observer reliability before and after this session. Four of the five methods showed improvement (the fifth was already at 0.94 reliability). There was concern that any training would be retained only for a short time and therefore would produce only short-term results. The second evaluation was made 2 months after the training session, when one might expect most short-term learning to have dissipated. The usefulness of such training is illustrated by the improvement of the coefficients of inter-observer reproducibility of all scoring and grading systems, reaching the level of 0.80 for most of the evaluated variables. Nevertheless, one could argue that these results are explained by reviewing the same videotapes after 2 months, with a worringly small number of arthroscopic examinations (only five) and that the improvement of the second evaluation may be due not only to training, but also to some recall or indeed quirks of the sample population. These criticisms are undeniable and should be taken into account in the interpretation of the results. Moreover, it could have been preferable for the inter-observer evaluation to select patients with more variation in the degree of chondropathy, as assessed by global scores, although the analytic aspects of chondral lesions (depth and size) leading to the global scores were quite different among the five patients.

Despite the limits of this study, this workshop convened by the Osteoarthritis Research Society was a first attempt to discuss and evaluate existing systems for scoring chondropathy. It suggests that scoring chondropathy is possible and points out the importance of training in the analysis of articular cartilage breakdown, which remains essentially a subjective observation of depth and size of the lesions. Further studies are required in order (1) to evaluate inter-observer reliability of the arthroscopic quantification of chondropathy in larger samples of patients with different patients at re-evaluation, (2) to compare other characteristics of the scoring systems, i.e., simplicity, validity, sensitivity to change and (3) to evaluate whether additional training sessions could further enhance homogenization of interpretation of results and therefore improve communication in this field.

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