

# COMPARISON OF ARTHROSCOPY AND MR IMAGING FOR GRADING OF KNEE CHONDROMALACIA

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## INTRODUCTION

As treatment options for osteochondral defects and earlier intervention for osteoarthritis become more readily available, the need for a less invasive diagnostic tool has increased. The combination of plain radiographs and clinical correlation remain the current mainstays of evaluating osteoarthritis severity. It is not uncommon for arthroscopy to be used for additional diagnostic evaluation because of the potential for associated therapeutic effects including debridement, microfracture, synovectomy, and osteochondral implants. Previous studies have shown that experience can contribute to both the accuracy and reproducibility of the arthroscopic Outerbridge articular grading system, but the classification is highly subjective and inexact. The addition of MR imaging to patient evaluation has shown significant promise as an augmentation to the understanding of articular injury, but correlations between MR results and arthroscopic grading are not fully defined.

The goal of this study was to assess consistency of knee osteoarthritis grading procedures between observers using arthroscopy and those using MR images, and to test for accuracy by comparing results to observations following arthrotomy.

## MATERIALS AND METHODS

- Seven human cadaveric knees from five subjects (2 males/3 females, average age 80) were transversely sectioned mid femur and mid tibia/fibula. The skin and subcutaneous tissues were then removed and the knees were stored frozen.
- The knees were allowed to thaw for 36 hours before they underwent MR imaging.

### MAGNETIC RESONANCE IMAGING

- The knees were slightly flexed and imaged using a four element phased array surface coil.
- Four MR sagittal image sequences were obtained:
  - 3D gradient recall echo (GRE), no fat suppression (TR:29.0, TE: 15.0, flip angle: 40°, slice thickness 1.5mm)
  - 3D gradient recall echo with fat suppression (TR: 47.0, TE: 15.0, flip angle: 40°, slice thickness 1.5mm)
  - 3D spoiled gradient recall (SPGR) with fat suppression (TR: 39.0, TE: 7.0, flip angle: 20°, slice thickness 1.5mm)
  - Dual echo fast spin echo with fat suppression (TR: 4000, TE: 14.2/85.1, flip angle: 90°, slice thickness 2mm)
- All sequences used a 256 x 256 matrix with a 12 cm field of view, resulting in an in-plane resolution of 0.469 mm/pixel

### ARTHROSCOPY

- Following imaging, a standard diagnostic arthroscopy was performed on each knee and videotaped.
- The knees were scoped in the same sequence with a 30° arthroscope and a 5 mm arthroscopic probe used to characterize size of defects and to assess cartilage surfaces.

### ARTHROTOMY

- An arthrotomy was performed on each knee to separate tibia, femur, patella and menisci.
- Photographs of the articular surfaces were obtained and caliper measurements of any defects were recorded.

### GRADING

- Cartilage surfaces were graded using the Outerbridge scoring system, with scores 0-IV assigned to the following regions: patella, femoral trochlea, medial tibia, lateral tibia, medial femoral condyle, and lateral femoral condyle.
- Comparisons between operators were based on the worst scores recorded for each region
- The arthroscopy video was independently viewed and scored by a fellowship trained sports medicine orthopaedic surgeon and two orthopaedic residents (PGY 5 and PGY 3).
- MR images were scored by three musculoskeletal radiologists, none of whom had used the Outerbridge scoring system in the past.
- None of the observers had access to the arthrotomy information prior to grading.

### STATISTICAL ANALYSIS

- A weighted kappa statistical analysis was used to test for reproducibility and agreement between observers, between techniques, and for accuracy by comparison to the arthrotomy as the gold standard.
- Weighting factors of  $(r1-r2)^2$  were applied to disagreements between ratings (r).
- A weighted kappa value of less than 0.00 indicates poor agreement, a value of 0.00 to 0.20 indicates slight agreement, a value of 0.21 to 0.40 indicates fair agreement, a value of 0.41 to 0.60 indicates moderate agreement, a value of 0.61 to 0.80 indicates substantial agreement, a value of 0.81 to less than 1.00 indicates excellent agreement, and a value of 1.00 indicates perfect agreement

## RESULTS

The knees exhibited wide ranges of articular defects, with numerous osteochondral lesions, diffuse thinning of cartilage, surface fibrillation, regions of denuded bone, subchondral bone cysts, and osteophytes. However, there were areas of intact cartilage without signs of chondromalacia (Figure 1).

Based on comparisons to arthrotomy, the arthroscopic procedure was more accurate than MR image analysis, with the average weighted kappa ( $\kappa$ ) coefficients of 0.77 vs 0.55, respectively. In addition, the arthroscopy grading showed excellent reproducibility ( $\kappa = 0.85$ )

MR image analysis showed good agreement with  $\kappa = 0.46$

Comparisons between radiologists and arthroscopy resulted in an average kappa coefficient of 0.56 (Table 1).

FIGURE 1: Examples of the same knee's articular surface as visualized by MR imaging, arthroscopy, and arthrotomy.

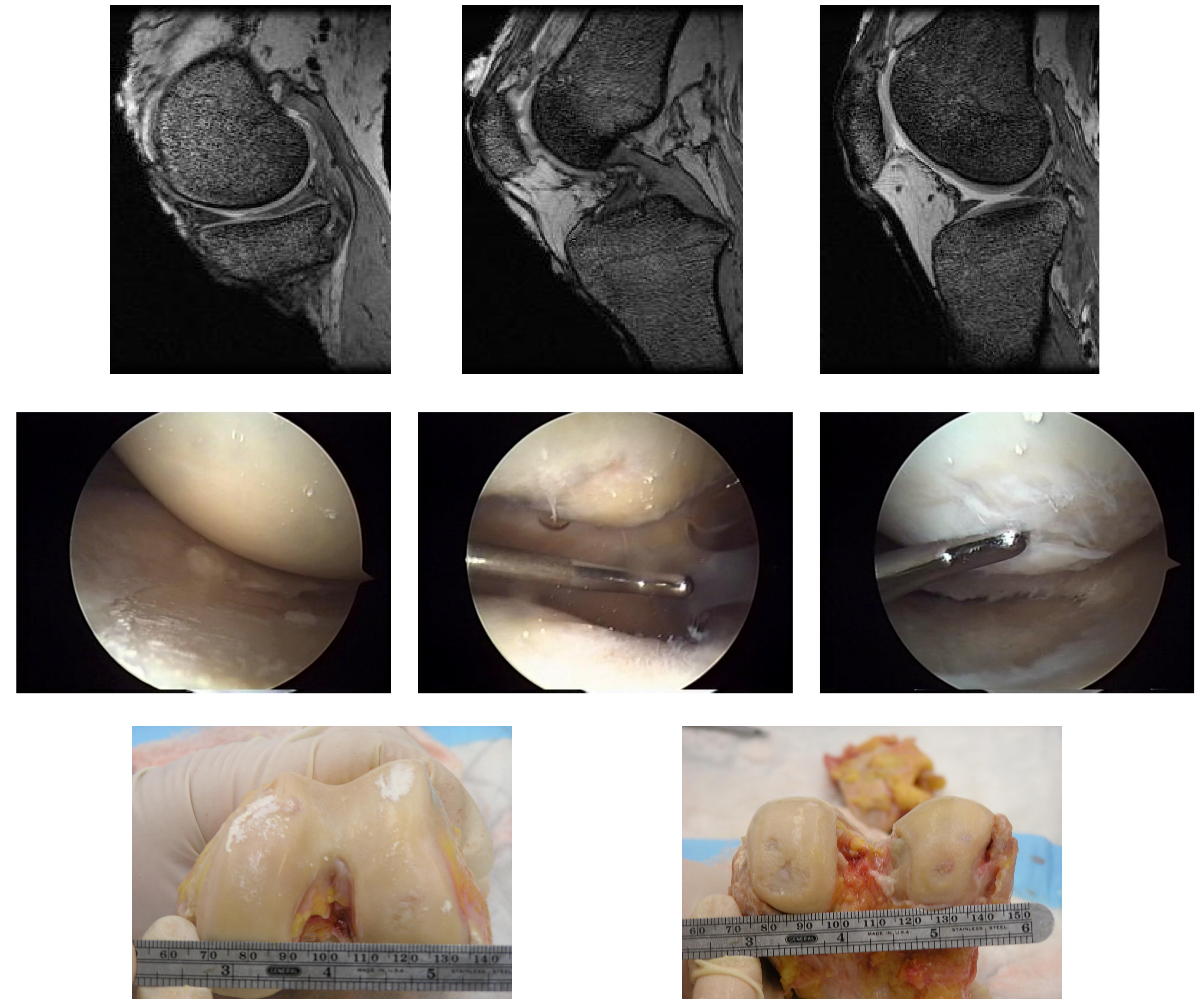


TABLE 1: Weighted Kappa statistics for comparison between surgeons (OS), radiologists (R) and observations on arthrotomy

	OS-1	OS-2	OS-3	R-1	R-2	R-3
Arthrotomy	0.77	0.75	0.78	0.41	0.54	0.69
OS-1		0.85	0.87	0.50	0.63	0.56
OS-2			0.82	0.54	0.55	0.52
OS-3				0.53	0.64	0.63
R-1					0.43	0.54
R-2						0.41
R-3						

## DISCUSSION

- The Outerbridge chondromalacia classification system, originally used to evaluate patellar chondromalacia is the most frequently used clinical grading system for orthopaedists. Surgeons are taught this system early in training and use it throughout their careers with arthroscopy. However, this system is not perfect due to observer subjectivity and has been shown to not have good intraobserver and interobserver reliability.
- We found arthroscopy to have excellent reproducibility and very good accuracy when compared to open arthrotomy, even with different experience levels. Reproducibility may have been influenced by the use of a consistent video tape by all observers. The observed differences were most common in grades for moderate chondromalacia resulting in scores of II or III, in other words, those defects which are not at the extremes of normal or pathologic.
- Radiologists also evaluate the severity of chondromalacia within joints. Plain radiographs show loss of joints space, osteophytes, subchondral cysts and sclerosis but these signs do not readily correlate to a specific Outerbridge grade. MR imaging is advantageous because it allows visualization of articular cartilage thickness, subchondral changes and measurement of defects, including those that may difficult to assess by arthroscopy.
- Since the Outerbridge system is not frequently used by radiologists, it was not surprising that reproducibility scores were lower for the grading of MR images. In particular, signal changes corresponding to fibrillation of the articular cartilage are not yet fully understood.
- Supplementing this subjective scoring system with more quantitative and semi-automated assessments of cartilage thickness, volume, and surface area would be beneficial to fully characterize chondromalacia in a non-invasive manner. In addition, studies which allow radiologists to compare MR findings to histological based evidence of chondromalacia will provide needed validation of these advanced techniques. These findings have direct clinical relevance with regards to non-invasive assessment follow-up of cartilage treatment and decisions on whether to proceed with unicompartmental joint arthroplasty.

## ACKNOWLEDGEMENTS

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## REFERENCES

- Alford JW, Cole BJ. Cartilage restoration, part 1: basic science, historical perspective, patient evaluation, and treatment options. Am J Sports Med 2005;33:295-306.
- Alford JW, Cole BJ. Cartilage restoration, part 2: techniques, outcomes, and future directions. Am J Sports Med 2005;33:443-60.
- Baysal O, Baysal T, Alkan A, et al. Comparison of MRI graded cartilage and MRI based volume measurement in knee osteoarthritis. Swiss Med Wkly 2004;134:283-8.
- Brismar BH, Wredmark T, Movin T, et al. Observer reliability in the arthroscopic classification of osteoarthritis of the knee. J Bone Joint Surg Br 2002;84:42-7.
- Browne JE, Branch TP. Surgical alternatives for treatment of articular cartilage lesions. J Am Acad Orthop Surg 2000;8:180-9.
- Cameron ML, Briggs KK, Steadman JR. Reproducibility and reliability of the outerbridge classification for grading chondral lesions of the knee arthroscopically. Am J Sports Med 2003;31:83-6.
- Cohen J. Weighted kappa: Nominal scale agreement with provision for scaled disagreement or partial credit. Psychological Bulletin 1968;70:213-20.
- Drape JL, Pessis E, Sarazin L, et al. [MRI and articular cartilage]. J Radiol 1998;79:391-402.
- Galli M, De Santis V, Tafuro L. Reliability of the Ahlback classification of knee osteoarthritis. Osteoarthritis Cartilage 2003;11:580-4.
- Koch GG, Landis JR, Freeman JL, et al. A general methodology for the analysis of experiments with repeated measurement of categorical data. Biometrics 1977;33:133-58.
- Landis JR, Koch GG. An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. Biometrics 1977;33:363-74.
- Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159-74.
- Mintz DN, Tashjian GS, Connell DA, et al. Osteochondral lesions of the talus: a new magnetic resonance grading system with arthroscopic correlation. Arthroscopy 2003;19:353-9.
- Outerbridge RE. The etiology of chondromalacia patellae. J Bone Joint Surg Br 1961;43-B:752-7.
- Outerbridge RE, Dunlop JA. The problem of chondromalacia patellae. Clin Orthop Relat Res 1975:177-96.
- Potter HG, Linklater JM, Allen AA, et al. Magnetic resonance imaging of articular cartilage in the knee. An evaluation with use of fast-spin-echo imaging. J Bone Joint Surg Am 1998;80:1276-84.