MRI evaluation of symptomatic total knee arthroplasty

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Abstract

Introduction: Symptomatic total knee arthroplasty with normal studies come as a challenge for the orthopedists. Magnetic resonance imaging (MRI) could be an alternative to get to diagnosis. The objective of this study is to evaluate the value of optimized MRI in symptomatic total knee arthroplasty, and also that of carrying out an inter-observer analysis to determine what anatomic structures can be evaluated.

Materials and methods: We evaluated retrospectively 15 patients with total knee arthroplasty operated on between 2007 and 2012, with peri-prosthetic pain and normal X-ray, scintigraphy and lab tests, subject to MRI. We carried out inter-observer analysis using intraclass correlation and kappa coefficients between four professionals—one resident in imaging diagnosis, one resident in orthopedics and two 20-year experience doctors (one specialist in imaging diagnosis and one specialist in knee surgery).

Results: We found an increase in synovial fluid in 14 patients, synovitis in four, and infrapatellar ossicle in one; on the other hand, we did not detect osteolysis in any case. In seven patients, it was possible to evaluate collateral ligaments correctly. Gastrocnemius muscles, subcutaneous tissues and the extensor apparatus were evaluated without difficulty. MRI found causes of pain in 12 cases. The intraclass correlation coefficient showed agreement on medial collateral ligament, extensor apparatus, gastrocnemius muscles and subcutaneous tissues.

Conclusion: This study proves the value of MRI in the decision making process. Inter-observer agreement was statistically significant for assessment of medial collateral ligament, gastrocnemius muscles, and subcutaneous tissues.

Key words: Magnetic resonance imaging; total knee arthroplasty; artifact.
Level of evidence: III

Evaluación con resonancia magnética de artroplastias totales de rodilla sintomáticas

Resumen

Introducción: Las artroplastias totales de rodilla sintomáticas con estudios normales resultan un desafío para el ortopedista. La resonancia magnética podría ser una alternativa para arribar al diagnóstico. El objetivo de este estudio fue evaluar la utilidad de la resonancia magnética con secuencias optimizadas en artroplastias totales de rodilla sintomáticas y también realizar un estudio interobservador para determinar qué estructuras anatómicas son evaluables.

Materiales y Métodos: Se evaluaron retrospectivamente 15 pacientes con artroplastias totales de rodilla operados entre 2007 y 2012, con dolor periprotésico, y radiografía, centellograma y análisis de laboratorio normales, sometidos a una resonancia magnética. Se realizó un análisis interobservador utilizando los coeficientes de correlación intraclase y kappa

Conflict of interests: The authors have reported none.

entre cuatro profesionales, un residente de diagnóstico por imágenes y otro de Ortopedia, y dos médicos con 20 años de experiencia, uno en diagnóstico por imágenes y el otro en rodilla.
Resultados: Se halló líquido articular aumentado en 14 pacientes, sinovitis en cuatro, un osículo infrarrotuliano y no se detectó osteólisis en ningún caso. En siete pacientes, fue posible evaluar correctamente los ligamentos colaterales. Los gemelos, el tejido celular subcutáneo y el aparato extensor se evaluaron sin dificultad. La resonancia magnética encontró causas de dolor en 12 casos. El coeficiente de correlación intraclase mostró concordancia para el ligamento colateral medial, el aparato extensor, los gemelos y el tejido celular subcutáneo.
Conclusión: Este estudio demuestra la utilidad del método en la toma de decisiones. La concordancia interobservador fue estadísticamente significativa para el análisis del ligamento colateral medial, los gemelos y el tejido celular subcutáneo.

Palabras clave: Resonancia magnética; prótesis total de rodilla; artefacto.
Nivel de Evidencia: III

Introduction

The study of symptomatic total knee arthroplasty (TKA) with normal X-rays and lab tests comes as a challenge for the specialist in joint degenerative diseases. Magnetic resonance imaging (MRI) could be a diagnostic alternative to evaluate theses cases.

Conventional radiology allows evaluators to assess the alignment of the prosthesis components and the bone-prosthesis interface, but it offers limitations when it comes to evaluating anomalies in soft tissues.[1,2] Arthrography is an invasive method for the patient and, similarly to nuclear medicine, abnormal findings usually are unspecific.

Thanks to the progress made in transducers, ultrasound looks quite promising at the time of evaluating soft tissues, but it is an operator-dependant method and the bone component cannot be assesses in deep correctly.[1,2]

There are reports that suggest numerous resorts to improve imaging quality and reduce artifacts in MRI. Increasing RF bandwidth and reducing magnetic field strength are some of them; reducing voxel size, orienting the frequency in the direction of the long axis of the prosthesis and using Turbo-Spin Echo sequences instead of Multi-Spin Echo sequences are some of the strategies to reduce signal loss in the vicinity of the implant; likewise, the use of STIR sequences instead of FAT-SAT sequences is associated with better visualization.[3,4]

In turn, there is development in applicable commercial programs that combine these strategies and get great quality images for the visualization of elements so far impossible to evaluate with traditional sequences.

Objective

To evaluate the value of MRI with optimized sequences in patients with symptomatic TKA. Moreover, to carry out an inter-observer analysis to determine what anatomic structures can be evaluated in these patients.

Materials and methods

We evaluated retrospectively 15 patients with TKA, operated on between 2007 and 2012 and with persistent post-operative pain, who were first studied with X-ray, total body bone scintigraphy and lab tests, and were subject to knee MRI with the aim of diagnosing their condition.

We included those patients with three-compartmental prosthesis where the femoral component was made up of a chromium, cobalt and molybdenum alloy and, the tibial component, of a titanium and aluminum alloy. All the patients were operated on for knee osteoarthritis and showed persistent post-operative pain. We revised MRI in 15 patients with TKA performed between March 2013 and February 2014 at the health center we work at (Table 1).

We excluded patients with uni-compartmental prosthesis, history of fracture that required osteosynthesis, revision prosthesis or spacers and prosthesis made up of other materials such as zirconium, or only- polyethylene tibial components, so as to define the impact of the metallic artifact on the images. On the other hand, we excluded MRI made at other health centers.

Table 1. Population characteristics

Age		74 ± 7
Sex		4 males 11 females
Main symptom		
	Anterior pain	33%
	Medical pain	26%
	External pain	20%
	Unspecific pain	20%

We used a 1.5 resonator (Avanto-Siemens® or Achieva Philips®). The knee was bent in minimal flexion (15-20º), with posterior bulge in all the cases, and we used an 8-canal MRI coil for knee surface. Optimized sequences and parameters were identical in the two equipments and for all the patients (Figures 1, 2 and 3).

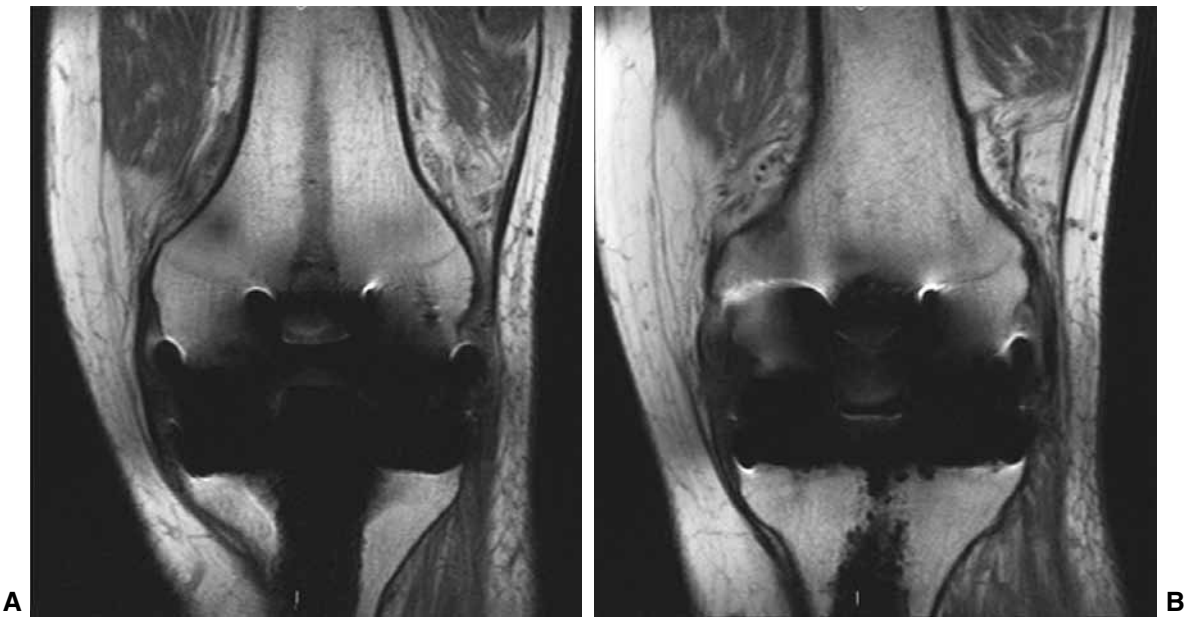

Figure 1. MRI in a 71-year-old patient with vague knee pain. Coronal sections that show feasible evaluation of collateral ligaments without osteolysis signs.

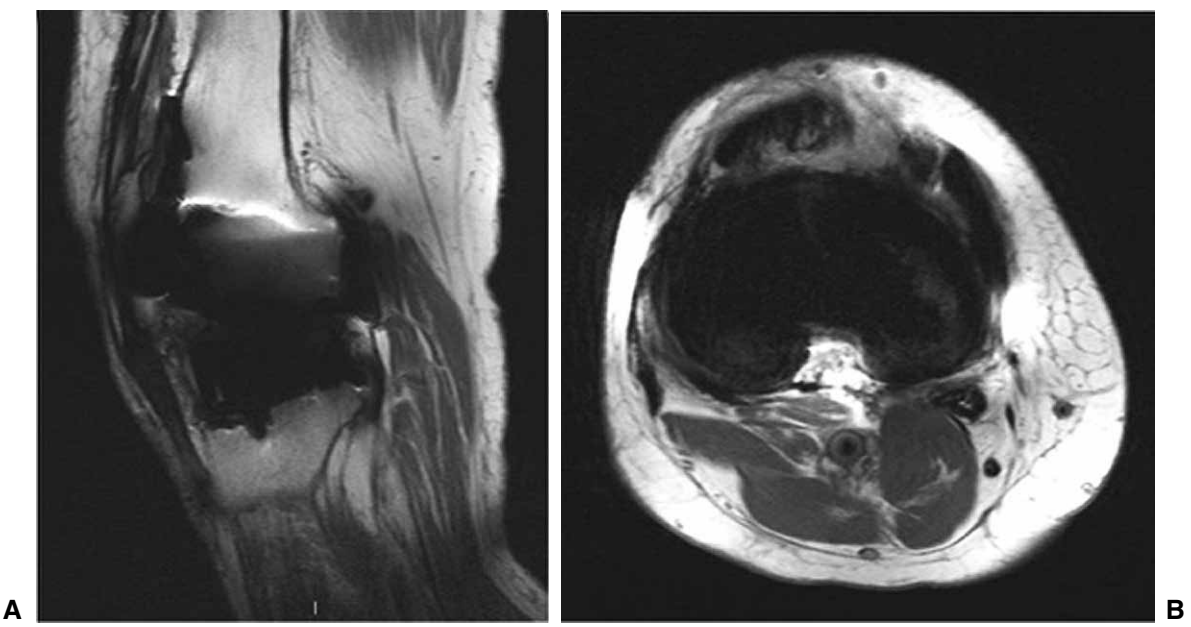

Figure 2. MRI in a 68-year-old patient with pain at final extension and lateral pain. **A**. PD sagittal section showing complete visualization of quadriceps tendon and patellar tendon, and infra-patellar synovitis **B.** Transverse section showing popliteous tendon without difficulty.

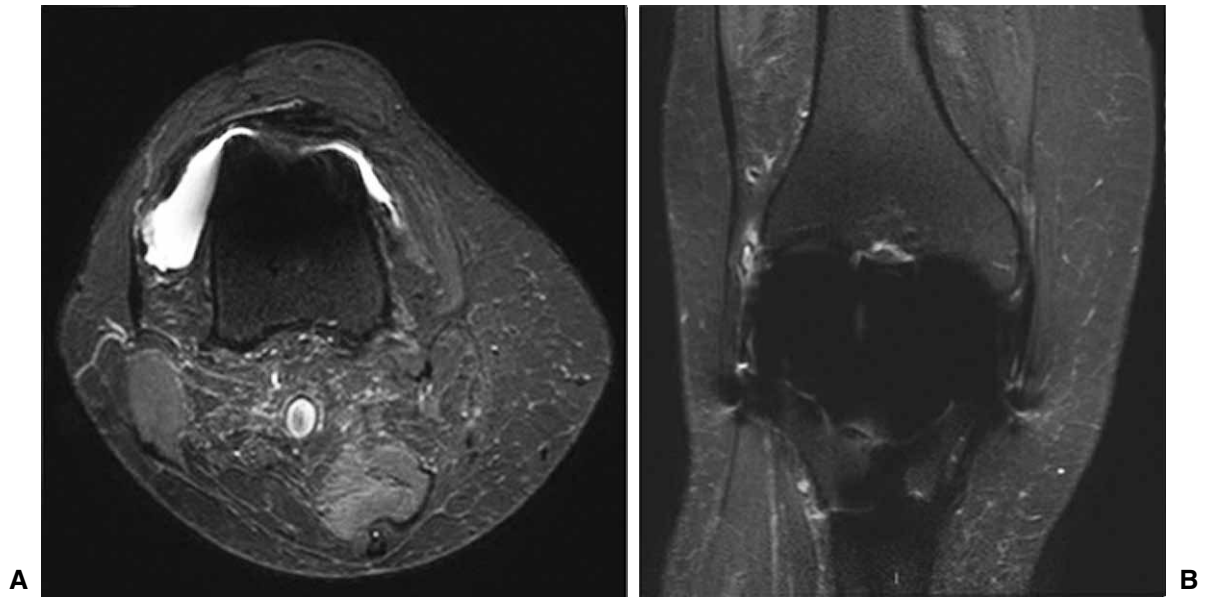

Figure 3. MRI in a 70-year-old patient with knee medial pain and hydrarthrosis one year after the surgery.
A. STIR transverse section showing moderate synovial fluid without interference by metallic material.
B. STIR coronal section showing partial vision in the proximal sector of the medial collateral ligament.

We carried out an inter-observer agreement analysis between four professionals: two advanced medical residents—one in imaging diagnosis and the other one in orthopedics, and two doctors with more than 20-year experience—one specialized in imaging diagnosis and the other one, an orthopedist specialized in knee surgery. We used the Likert's classification that ranges from 0 to 3 to define possibility of visualization of the anatomic structures evaluated in every patient (Table 2).

With the aim of defining the correlation of the MRI findings between the observers, we used the intraclass correlation coefficient (ICC) and a kappa agreement analysis. Moreover, we evaluated the percentage of agreement for the same patient conveyed as the average of agreement percentages.

The ICC describes how similar to each other values are within every group, as compared to the other groups. It is used to estimate the degree of correlation of several values

Table 2. Elements assessed by the observer

Assessed anatomic elements	Lickert's classification
Medial collateral ligament	0: Impossible to evaluate.
Lateral collateral ligament	1: It can be evaluated with difficulty.
Popliteus tendon	2: It can be evaluated, but it is suboptimal.
Quadriceps tendon	3: It can be evaluated as if there was no prosthesis.
Patellar tendon	
Ostoelysis	
Loose bodies	
Synovial membrane	
Synovial fluid	
Gastrocnemius muscles	
Subcutaneous tissue	
Tensor fasciae latae	

in different groups. It considers values from 1 (extremely high correlation within every group) to 0 (null correlation within every group). Landis and Koch set out the following scale of evaluation of degree of agreement for the ICC, which has since been widely used: <0.00 represents poor degree of agreement; >0.00-0.20, mild degree; 0.21-0.40, acceptable degree; >0.41-0.60, moderate degree; 0.61-0.80, considerable degree; 0.81-1.00, almost perfect degree of agreement.

The kappa analysis evaluates the degree of agreement between evaluators, or accuracy in classifying in one evaluator in him/ herself or among evaluators. The kappa index shows the remaining proportion of agreement after excluding random agreement. This index is conservative (i.e., it tends to underestimate agreement, according to some criticism). It was analyzed in the same way, using the Landis and Koch's scale.

The Ethics Committee at the institution we work at accepted carrying out this piece of research.

Results

The analysis of the collected data showed an increase in synovial fluid in 14 cases, synovitis in four cases and a loose body in only one patient that was actually an infrapatellar ossicle. We did not find osteolysis in this group of patients.

As regards tendons and collateral ligaments, in half cases it was possible to evaluate them as if there was no implant, although with some difficulty, whereas in the other half, metallic artifacts did not allow us to evaluate clearly their continuity. Gastrocnemius muscles, subcutaneous tissue and the extensor apparatus showed excellent results in the Likert's classification (Table 3).

MRI helped in pain diagnosis in 12 of the 15 patients: tensor fasciae latae tendinitis (7 cases), anterior pain due to patellar necrosis (one case), patellar tendinopathy (three cases), and there was also removal of neuroma in the saphenous nerve which showed acute pain and compatible image. No patient was subject to prosthesis revision on the grounds of these results. The analysis of osteolysis was very difficult with MRI, which did not help to make decisions. Two patients received infiltration, and the rest of them, physiotherapy (Figures 1, 2 and 3).

The analysis of inter-observer agreement showed considerable agreement on the evaluation of the medial collateral ligament, the quadriceps tendon, the patellar tendon and the gastrocnemius muscles; and almost perfect agreement on the evaluation of subcutaneous tissues. When it came to comparing agreement and the Likert's classification, we found that agreement is only good with acceptable image evaluation in the quadriceps tendon, the patellar tendon and the gastrocnemius muscles; and also in the evaluation of subcutaneous tissue, in which case it was as if the patient had not had any prosthesis. Agreement on the evaluation of lateral collateral ligament, synovial membrane, synovial fluid and tensor fasciae latae was moderate and, on average, it was associated with difficult evaluation by images (Table 3).

The statistical analysis of the ICC showed favorable results for ICC in the medial collateral ligament and acceptable results in the lateral collateral ligament, but results in the rest of the variables were poor. In the case of gastrocnemius muscles and subcutaneous tissues, the ICC is very low, since scores do not vary much in the patients (homogeneous sample); the ICC tends to be low, because it compares variance among patients to total variance, which includes variance in patients, variance in methods or observers, and random error.

We should interpret theses results as unsuitability of the Likert's classification for evaluation amonb observers when agreement is high.

Likewise, the kappa analysis showed mild agreement for collateral ligaments (medial collateral ligament, p= 0.0460) and poor agreement for the rest of the assessed variables (p= NS) (Table 4).

Table 3. Results of inter-observer agreement

Patient	Medial collateral ligament	Lateral collateral ligament	Popliteous tendon	Quadriceps tendon	Patellar tendon	Osteolysis	Loose body	Synovial membrane	Synovial fluid	Gastrocnemius muscles	Subcutaneous tissue	Tensor fasciae latae
Average Likert	1.81	1.81	1.63	2.70	2.62	1.93	1.65	2.03	2.45	2.45	2.88	2.20
Average **agreement among observers**	0.62	0.56	0.38	0.73	0.70	0.32	0.35	0.48	0.56	0.70	0.88	0.50
Agreement strength	Considerable	Moderate	Acceptable	Considerable	Considerable	Acceptable	Acceptable	Moderate	Moderate	Considerable	Al most perfect	Moderate

Table 4. Statistical results

	Medial collateral ligament	Lateral collateral ligament	Popliteous tendon	Quadriceps tendon	Patellar tendon	Osteolysis	Loose body	Synovial membrane	Synovial fluid	Gastrocnemius muscles	Subcutaneous tissue	Tensor fasciae latae
ICC	0.48	0.22	0.10	0.17	0.18	0.01	0.08	0.03	0.00	0.00	0.00	0.02
ICC Agreement Strength	Moderate	Acceptable	Mild	Mild	Mild	Poor	Poor	Poor	Poor	Considerable	Considerable	Poor
Kappa	0.1753 (p = 0.004)	0.0460 (p = 0.26)	0 (p = NS)	0.018 (p = NS)	0.09 (p = NS)	0 (p = NS)	0 (p = NS)	0 (p = NS)	0 (p = NS)	0 (p = NS)	0 (p = NS)	0 (p = NS)
Kappa Agreeement Strength	Mild	Mild	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Considerable	Considerable	Poor

CCIC = coeficiente de correlación intraclase.

Discussion

Conventional protocols for the knee generate images that are very difficult to interpret, even for very experienced people, due to the great metallic artifact caused by the prosthesis; the change in protocols has reduced this artifact to some extent and, this way, quality improves and, therefore, images are more useful, what allows recognition—partial in some cases, and total in other cases—of anatomic structures with the purposes we are interested in.

The limitations of this study have to do with the low number of cases analyzed with a protocol of recent technical application. However, it is an original work about a topic hardly approached in orthopedic literature.

Raphael et al.'s study shows an inter-observer analysis to compare recognition of collateral ligaments, patellar tendon and quadriceps tendon in seven zirconium prosthesis and 14 chromium-cobalt prosthesis, and variability among observers was lower at analyzing the zirconium prosthesis.[1] Our study only analyzed prosthesis with chromium-cobalt alloys, and also considered non-ligament structures such as synovial membrane, the contents of the articular cavity, gastrocnemius muscles, subcutaneous tissues, tensor fascia latae and the popliteous tendon.

The main theoretical objective of MRI in this group of patients is to evaluate the interface early enough, trying to detect osteolysis that cannot be evaluated using other imaging tests. In the Raphael et al.'s study, 48% of the patients, assessed under similar MRI technical circumstances, showed osteolysis, although it is worth mentioning that the material the prosthesis were made up of was not specified at any time, and if osteolysis was found in other lower complexity studies is not detailed. This study also showed that observation was much simpler using MAVRIC sequences. Moreover, they report that osteolysis in the tibial component can be found using the optimized protocol and special sequences for prosthesis, but osteolysis in the femoral component cannot be found this way, because they can only be visualized with MAVRIC sequences. Although no patient in our series showed osteolysis, evaluation here was somehow difficult.[1-3]

Authors such as Sofka et al. used MRI to evaluate rotation of the components with great correlation among observers. They considered distal femur intercondyle line as reference with the cut line at condyle level, and even though CT scan could be used with the same aim, this study also contributed with information about synovitis and the interface status. This is a motivation for MRI use in these patients, because although we do not routinely evaluate rotation using MRI, such assessment is possible and can be carried out as easily as it can with CT scan. This was not the aim or our analysis, though, because the rotation of the components was almost always evaluated with CT scan if medical status made us to.[4]

In the analyzed bibliography, results coincide with those in our series regarding ligaments and tendons—these are structures that usually can be seen totally or partially in spite of the artifact and that, undoubtedly, can be assessed to rule out reasons of pain. 93% of the tendons and ligaments that were included in the analysis of the images could be visualized using optimized protocol, no matter if visualization was incomplete, good or excellent.[5-7]

Finally, and as our utmost, we showed that by means of MRI findings it was possible to to find a likely explanation for post-operative pain in 12 cases, and that they generated changes in medical behavior in four of them. Compared to bibliography, other studies report a higher percentage of change in medical behavior, although total figures are not clearly informed. This difference stems

mainly from the fact that, in that study, they found more osteolysis than us. In several patients (15%) they also detected a dense infrapatellar scar that they chose to manage with arthroscopy.[7-11]

We believe that MRI is a study with great inter-observer agreement on peri-prosthetic structures, feasible, with no drawbacks for the patient and useful for diagnosis in symptomatic TKA.

Conclusions

Our study shows the value of MRI in the decision making process. The evaluation of patellar tendon, quadriceps tendon, gastrocnemius muscle and subcutaneous tissue was highly accurate. Inter-observer agreement was statistically significant on the analysis of the medial collateral ligament, gastrocnemius muscles and subcutaneous tissues.

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