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Article

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Appropriateness of magnetic resonance imaging requested by primary care physicians for patients with knee pain

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Abstract

Objective: To evaluate the appropriateness of magnetic resonance imaging (MRI) of the knee requested by primary care physicians.
Design: Retrospective observational study.
Setting: Six primary care centres in the Elche Department of Health of the Valencian Community, Spain.
Participants: Three hundred patients with knee pain who were prescribed MRI.
Main Outcome Measures: Data were collected from the electronic clinical history, which allowed us to assess the appropriateness and inappropriateness of the MRI requests for the knee based on the American College of Radiology (ACR) criteria. A multivariate logistic regression model was used to identify factors associated with an inappropriate request.
Results: About 45% (41–49%) of knee MRI prescriptions were assessed as inappropriate. The frequency was higher in female patients (odds ratio, OR = 1.96; $P = 0.03$). A history of knee trauma and urgent use of MRI were associated with a lower frequency of inappropriate requests (OR = 0.14, $P < 0.001$ and OR = 0.32, $P = 0.03$, respectively). In 82% of cases, the request for MRI was deemed inappropriate because it was used as the initial imaging test. The availability of a previous radiograph of the knee significantly reduced the rate of inappropriate requests (OR = 0.05, $P < 0.001$); only 47% of the patients had a previous radiograph.
Conclusions: The percentage of inappropriate knee MRI prescriptions is high. Protocols should be put in place to improve the appropriateness of MRI requests by promoting understanding of the appropriate use of MRI among primary care physicians.

Key words: appropriateness, knee jointmagnetic resonance imaging, primary healthcare, Spain

Introduction

Knee pain represents a frequent reason for consultation in primary care because of the large number of conditions (acute, chronic, traumatic and non-traumatic) that can affect this articulation, one of the largest, most complex and overloaded joints in the body. The prevalence of knee pain has been reported as 15–33% in various populations [1–6].

Radiography remains the first-choice imaging test for most patients with knee pain, although one study [7] has noted a progressive increase in the number of requests for magnetic resonance imaging (MRI) of the knee and a parallel decrease in the use of radiography. Given the importance of ligamentous and cartilaginous components in the structure and function of the knee, it is not surprising that MRI is a frequently ordered imaging technique.

Knee MRI is a sensitive and non-invasive imaging test that provides an easy and accurate diagnosis of different anatomical abnormalities. However, the findings may cause confusion when they do not correlate with radiography, results of exploration or the patient's clinical history [8]. MRI sometimes identifies incidental pathology unrelated to the symptoms, which can lead to unnecessary referral and treatment [9]. A recent review of the available evidence attributes little or no benefit to the use of routine MRI in the diagnosis of knee pathology [10].

Knee MRI is one of the most frequently performed tests in our health department and is exceeded in frequency only by MRI of the lumbar spine. Given the diversity of clinical practice, the progressive increase in the use of MRI in the last decade [11–14] and the low rate of appropriate requests for MRI observed for other musculoskeletal conditions [15], it is possible that this test is becoming a standard before a rigorous evaluation of its use has been published [16]. Furthermore, inappropriate requests for MRI represent a high cost for the health system and can lead to unnecessary interventions [17], which are even more costly and risky for patients.

All Spaniards have access to the country's universal healthcare system called the Spanish National Health System. It covers most healthcares free of charge. Unlike in other health systems, Spanish doctors are not financially incentivised to prescribe expensive prescriptions and treatments, so they are accustomed to recommending the cheapest course of action. However, family doctors can freely prescribe MRI in our region.

We found no studies that have investigated the appropriateness of requests for MRI in the Spanish population and we chose to investigate this issue. The objectives of this study were to quantify the percentage of appropriate requests for knee MRI in primary care according to the American College of Radiology (ACR) criteria [18, 19] and to identify the variables associated with inappropriate requests.

Methods

During 2015, the Elche Health Department (Alicante, Spain) provided coverage to 163 583 people. Any physician from its six primary care centres can order knee MRI, which are performed on a Philips Intera 1.5T device (Koninklijke Philips NV, Amsterdam, the Netherlands) at the Department's University General Hospital.

Given the availability of an electronic medical record (EMR) for every MRI performed, we decided to conduct a retrospective cross-sectional study. Initially, the data for all MRI of the knee performed during 2015 were collected. After discarding those requested by specialists, we found 598 cases of knee MRI that had been requested by primary care physicians. Based on this population size and assuming a rate of 40% inappropriate requests based on a recent study conducted in a similar setting [20], a confidence interval (CI) of ±4% and a confidence level of 95%, a sample size of 300 patients was calculated as necessary. All patients were over 17 years old and there were no pregnant women in the sample.

Simple random sampling was performed among all registered MRIs to select the sample. The EMR for each patient was reviewed, and a team member (Medical Doctor, Master in Public Health, General Practitioner for 7 years) collected the independent variables that were considered necessary to assess the appropriateness of MRI according to the ACR criteria: age; duration of knee pain (chronic if ≥3 months, acute if <3 months and indeterminate if unclear in the EMR); existence of patellofemoral symptoms; antecedent of a previous knee injury in the form of a fall, twist injury or traffic accident with suspected dislocation of the knee; ability to walk and support the body weight and knee radiography performed in the 3 months before the MRI request. Other details recorded included whether the patient had sustained a fracture or exhibited joint effusion, degenerative signs, crystals, avascular necrosis, inflammatory signs or any evidence of internal disarray of the joint. In addition, other independent variables not needed to evaluate the MRI request according to the ACR criteria were recorded to check whether they were related to inappropriate request for knee MRI, such as sex, MRI priority (normal or urgent), primary care centre originating the request, number of referrals for every patient and surgical indications. With the exception of age, all variables were categorical. Cases with missing values were discarded.

To evaluate the appropriateness of each MRI request, the same team member who collected the data compared the values for the variables for every patient against the ACR criteria for both traumatic [18] and non-traumatic knee [19] injury.

The quantitative variable age is expressed as median and interquartile range (IQR, in P_{25}–P_{75} format). The Shapiro–Wilk test showed that age and sex were non-normally distributed, and these variables were analysed using the Mann–Witney *U* test. Bivariate analysis was performed, followed by multivariate analysis using backward stepwise regression. Significance was accepted at $P < 0.05$. The results are expressed as the odds ratio (OR) with respect to a reference group. To evaluate the adjustment of the model developed, Pearson's chi-square test and the Hosmer–Lemeshow test were used. Collinearity was assessed using the variance inflation factor. Statistical analysis was performed in STATA (Version 14, StataCorp, College Station, TX, USA).

Results

We included 300 patients: 144 (48%) women and 156 (52%) men. Their median age was 53 years (IQR = 39, 66) for women and 46 years (IQR = 31, 57) for men. The difference in age between men and women was significant ($P = 0.002$).

Table 1 shows the frequencies and percentages of each ACR variant in the sample, grouped according to the appropriateness and inappropriateness of the request for MRI and according to the type of injury—traumatic and non-traumatic. Overall, the MRI prescription was assessed as inappropriate in 135 of cases (45%) and as appropriate in 165 cases (55%).

The main causes of inappropriateness were the use of MRI as the initial imaging technique when it was not indicated. For example, in the initial evaluation of non-traumatic and non-localised knee pain (inappropriate use of MRI for variant 3 of ACR for non-traumatic knee injury, comprising 39% of inappropriate requests), initial study of patellofemoral symptoms (inappropriate use of MRI for variant 2 of non-traumatic ACR, 32% of inappropriate requests) and pain after a fall or twist without spill or focalised pain (use MRI for ACR variant 1 for traumatic knee, 11% of inappropriate requests). Another important reason was the inappropriate use of MRI for ACR variant 9 for non-traumatic knee injury when not considering surgery (13%).

As shown in Table 2, the bivariate analysis of the association between inappropriate requests and independent variables found no

Table 1 Knee MRI appropriateness and inappropriateness causes in our sample[a]

	Description	ACR variant	*N* (%)
Appropriateness causes			
Non-traumatic knee pain	Adult: non-trauma and non-localised pain. Initial knee radiographs are negative or demonstrate a joint effusion	6	52 (31.5)
	Child or adult: patellofemoral (anterior) symptoms. Initial knee radiographs are negative or demonstrate a joint effusion	5	40 (24.2)
	Adult: Initial knee radiographs demonstrate inflammatory, crystalline or degenerative joint disease (uni- to tri-compartmental sclerosis, hypertrophic spurs, joint space narrowing and/or subchondral cysts)	9[b]	19 (11.5)
Acute trauma to the knee	Adult or child >1-year-old. Fall or twisting injury with either no fracture or a Segond fracture seen on a radiograph, suspect internal derangement. Next study	3	32 (19.4)
	Adult or child >1-year-old. Injury to knee, mechanism unknown. Focal patellar tenderness, effusion, able to walk	5	14 (8.5)
	Adult or child >1-year-old. Fall or twisting injury, with one or more of the following: focal tenderness, effusion, inability to bear weight. First study	2	4 (2.4)
	Adult or child >1 year old. Significant trauma to the knee from motor vehicle accident, suspect knee dislocation	6	4 (2.4)
Inappropriateness causes			
Non-traumatic knee pain	Adult: non-trauma and non-localised pain. Initial examination	3	52 (38.5)
	Child or adult: patellofemoral (anterior) symptoms. Initial examination	2	43 (31.9)
	Adult: Initial knee radiographs demonstrate inflammatory, crystalline or degenerative joint disease (uni- to tri-compartmental sclerosis, hypertrophic spurs, joint space narrowing and/or subchondral cysts)	9[b]	18 (13.3)
	Adult: patellofemoral (anterior) symptoms. Initial knee radiographs demonstrate degenerative joint disease and/or chondrocalcinosis	8	4 (3.0)
Others[c]			3 (2.2)
Acute trauma to the knee	Adult or child >1-year-old. Fall or twisting injury, no focal tenderness, no effusion; able to walk. First study	1	15 (11.1)

[a]American College of Radiology. ACR appropriateness criteria.
[b]ACR variant 9 considers MRI usually not appropriate, except when preoperative assessment is involved.
[c]MRI prescriptions not matching any ACR criteria.

significant differences in sex, age, clinical signs (meniscal, arthrosis, blockage or spills) or priority of the MRI request. By contrast, there were significant differences in cases for which a knee radiograph was available before the MRI request (OR = 0.08; $P < 0.001$), when there was evidence of previous trauma (OR = 0.26, $P < 0.001$), when the duration of symptoms was not accurately determined (OR = 2.27; $P = 0.03$) and when the MRI request came from a specific primary care centre (OR = 0.28, $P = 0.005$).

Logistic regression analysis was performed on all collected variables to identify those that were independently associated with the inappropriate request for MRI after adjusting for possible confounding factors. The results are shown in Table 3. One variable, female sex, was associated with a higher percentage of inappropriate requests (OR = 1.96; $P = 0.03$). Three variables were associated with a lower percentage of inappropriate requests: previous knee radiograph (OR = 0.05; $P < 0.001$), knee trauma (OR = 0.14; $P < 0.001$) and urgent MRI request (OR = 0.32; $P = 0.03$).

The model based on these four variables could explain 32.3% of the variance (calculated using pseudo R^2) and was found to provide a satisfactory fit with both Pearson's chi-square test ($P = 0.63$) and the Hosmer–Lemeshow test ($P = 0.50$ with six quantiles). To evaluate collinearity, the variance inflation factor showed a mean value of 1.34.

The 300 patients with knee pain included in the sample were associated with 232 referrals to other services. The most frequent were directed to the Orthopaedic Surgery and Traumatology Service ($n = 202$, 87%) and Rehabilitation Services ($n = 28$, 12%). Of all referrals, the MRI request was considered appropriate for 147 (i.e. 0.89 per each inappropriate MRI) and 85 referrals were considered inappropriate. In 72 (36%) of the referrals to the Orthopaedic Surgery and Traumatology Service, a surgical solution to the knee pain was proposed: the MRI request was assessed as appropriate for 51 (71%) and as inappropriate for the other 21 (29%).

Finally, we analysed the relationship between the MRI findings and the appropriateness of the request. There was some pathological finding in 102 (76%) of the cases for which MRI was considered inappropriate and in 144 (87%) of those for which MRI was considered appropriate. No pathological findings were observed in 15 (11%) of the group for which MRI was considered appropriate and in 17 (10%) of the group for which MRI was considered inappropriate.

Discussion

About 45% (41–49%) of the knee MRI requested in this primary care setting did not seem justified from the viewpoint of their fulfilling the ACR criteria. Comparison of our results with those reported by others is difficult because there are few studies of the appropriateness of knee MRI and no reports on this in the Spanish population. A recent study by Solivetti *et al.* [20] from Italy reported a rate of 40% inappropriate requests for MRI, which is similar to that found in our study. In that study, most of the requests for knee MRI came from orthopaedic surgeons (44.3%) or other specialists (19.5%), and only 36.3% of the knee MRI requests came from primary care physicians. The study by Solivetti *et al.* is consistent with other studies [21, 22] in attributing the higher percentage of appropriate MRI requests to those requested by orthopaedic surgeons, which may explain why their rates are slightly lower than that found in our

Table 2 Knee MRI Inappropriateness: bivariate analysis

		Inappropriateness			
	Appropriate MRI (*N*)	Inappropriate MRI (*N*)	Odds ratio	CI 95%	*P*-value
Patient sex					
Men	90	66	1 (ref)		
Women	75	69	1.25	0.80–1.98	0.33
Patient age (years)					
<24	16	15	1 (ref)		
25–44	47	40	0.91	0.40–2.06	0.82
45–64	69	54	0.83	0.38–1.84	0.65
65–74	25	16	0.68	0.27–1.75	0.43
>75	8	10	1.33	0.42–4.28	0.63
Patellofemoral symptoms					
No	122	110	1 (ref)		
Yes	43	25	0.64	0.37–1.12	0.12
Degenerative joint disease					
No	150	118	1 (ref)		
Yes	15	17	1.44	0.69–3.00	0.33
Joint blockages					
No	156	128	1 (ref)		
Yes	9	7	0.95	0.34–2.62	0.92
Joint efussion					
No	147	125	1 (ref)		
Yes	18	10	0.65	0.29–1.47	0.3
Duration of symptoms					
Acute	99	80	1 (ref)		
Chronic	54	35	0.75	0.45–1.28	0.3
Undetermined	12	20	2.27	1.06–4.86	0.035
MRI priority					
Normal	151	124	1 (ref)		
Urgent	14	11	0.96	0.42–2.18	0.92
Previous radiograph					
No	32	102	1 (ref)		
Yes	133	33	0.08	0.04–0.13	<0.001
Previous trauma					
No	111	120	1 (ref)		
Yes	54	15	0.26	0.14–0.48	<0.001
Primary care centre					
1	35	41	1 (ref)		
2	48	43	0.76	0.42–1.41	0.39
3	17	13	0.65	0.28–1.53	0.33
4	18	16	0.76	0.34–1.71	0.51
5	20	13	0.55	0.24–1.27	0.17
6	27	9	0.28	0.12–0.69	0.005
GP sex					
Men	80	58	1 (ref)		
Women	87	75	1.19	0.75–1.88	0.46
GP age (years)[a]					
<45	48	39	1 (ref)		
45–54	28	15	1.52	0.71–3.23	0.28
55–64	76	54	0.89	0.53–1.52	0.68

[a]GP age was unknown in 23 cases.

study. Vedjani *et al.* [23] estimated a rate of 46.7% for the inappropriate use of knee MRI in an Iranian hospital, which is also similar to the rate found in our study, even though their criteria were different, their sample was smaller and MRI was requested by a specialist in 98.7% of cases. Oikarinen *et al.* [24] reported a 10% rate of inappropriate MRI requests in one Finnish hospital, but their sample included only 30 knee MRI cases. Petron *et al.* [25] found that only 12 of 100 MRIs ordered by primary care providers in Utah (USA) would have been ordered by an orthopaedist given the documented data.

In our study, the main reason for considering the MRI request inappropriate was its use as the initial imaging test, which accounted for 82% of the requests considered inappropriate. This result suggests that using MRI as the initial imaging mode increases the chance of the request being inappropriate according to the ACR criteria, which recommend radiography as the most appropriate initial imaging mode in patients with knee pain without a history of trauma. If the radiograph demonstrates deposits of crystals or an inflammatory or degenerative pathology of the joint, no further imaging

Table 3 Factors associated to knee MRI inappropriateness

	N	Odds ratio	CI 95%	P-value
Previous radiograph				
No	134	1 (ref)		
Yes	166	0.05	0.026–0.097	<0.001
Previous trauma				
No	231	1 (ref)		
Yes	69	0.14	0.06–0.31	<0.001
Sex				
Men	156	1 (ref)		
Women	144	1.96	1.07–3.57	0.028
MRI priority				
Normal	275	1 (ref)		
Urgent	25	0.32	0.11–0.91	0.033

tests are indicated. MRI is indicated only when a possible surgical intervention is being considered or when the findings cannot explain the patient's symptoms. For traumatic knee pathology, the ACR also recommends radiology as the initial mode, with the sole exception of significant trauma—such as that received in motor vehicle accidents—for which MRI is considered appropriate as the initial mode for assessing the extent of damage to ligaments and other support structures. Despite this recommendation, 47% of our patients did not have any previous radiograph. This percentage is double that observed in another study [26], and this indicates a clear opportunity for improvement in our environment. Roberts *et al.* [22] already pointed out the concern among the orthopaedic surgical community about an increasing number of knee MRIs being ordered in the primary care setting without prior radiographs.

Although requesting a knee MRI before performing other tests and examinations may be an inappropriate request, the primary care physician may be tempted to do so at an early stage in the evolution of the knee pain to provide the specialist doctor the results at the patient's first visit, usually several weeks after the referral is made. MRI requests are frequently made by specialists in the private healthcare sector, so the patient may pressure the primary care physician to receive this service at no cost through the public health system.

Our observations agree with those of some studies [20, 27, 28], but further studies are needed to assess the role of these and other factors in the prescribing physician's decision to request an MRI for patients with knee pain. We consider that the high percentage of inappropriate requests for MRI may be a starting point for assessing the costs associated with inappropriate prescription and considering the number of referrals.

Other data obtained from the EMR were also associated with a higher percentage of inappropriate requests for knee MRI. However, some of these are not modifiable, such as female sex and the existence of previous trauma. Regarding the female sex, in our sample there were no pregnant women, so we considered that the decision to prescribe MRI was not influenced by the fear of radiation. A lower percentage of inappropriate MRI requests was observed when the request was urgent, but it seems likely that such a priority would be reserved for the most serious cases. Other significant and non-modifiable factors associated with higher percentages of inappropriate MRI requests were knee pain whose duration could not be established from the EMR or history that did not generate any referral and that did not eventually lead to a surgical indication.

A limitation of this study is the choice of the ACR criteria for assessing the appropriateness of knee MRI requests. The US health system encourages the use of diagnostic procedures, which may introduce some laxity in other countries in terms of their criteria for determining appropriateness [29] and could increase the inappropriate use of MRI, as observed in this study.

Measures to reduce the over-prescription of MRI for knee injury include reassessment of the knee MRI prescription procedure, development of clear guidelines and protocols, improving the training of primary care physicians to encourage their adherence to these guidelines, meetings for case discussion and providing individualised feedback to professionals.

Conclusions

Our study shows, for the first time in Spain that a high percentage of knee MRI requests by primary care physicians are inappropriate. These findings suggest that having a radiograph of the knee available before the MRI request may reduce the number of inappropriate requests for MRI because the risk is greatly reduced when a previous knee radiograph is available; this happened in only 47% of the sample reported here. However, these results should be interpreted within the context of the specific circumstances of our health system: freedom of MRI prescription, without incentives for prescribers and at no cost for patients.

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