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Is Knee Magnetic Resonance Imaging Overutilized in Current Practice?

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Purpose: To determine what proportion of patients visiting a tertiary knee clinic had pre-obtained knee magnetic resonance imaging (MRI) and to assess the impact of pre-obtained knee MRI on the selection of treatment plans.
Materials and Methods: Six hundred and eighty patients were enrolled from patients who visited our knee clinic during a 6-month period. The proportion of patients with pre-obtained knee MRI was calculated, and associations of sociodemographic factors, disease category, and finally selected treatment options with knee MRI pre-obtainment were investigated. A utility assessment panel of five orthopaedic surgeons was formed and established utility assessment criteria. Two rounds of utility assessment (before and after MRI review) were performed.
Results: Of the 680 patients, 185 (27%) had pre-obtained knee MRI. In the first round of utility assessment, 39%, 18%, and 43% of the 185 knee MRIs were evaluated as useful, equivocal, and arguably useless, respectively, and almost identical results were obtained in the second round. The proportion of assessed 'useful MRI' was higher in sports related injury (84%) and other conditions (91%) than in degenerative joint disease (18%) and nonspecific knee pain (31%). Utility assessment results among panels varied little for practice patterns and education duration.
Conclusions: This study suggests clinicians should reconsider and counsel patients the expected utility of knee MRI acquisition.

Keywords: **Knee, Magnetic resonance imaging, Overuse**

Introduction

Healthcare spending is growing at an explosive rate and accordingly cost-containment is a major goal in healthcare at present. Given the heavy financial burden and social expectations, healthcare reform has also become a major economic and political issue. In the midst of this, advanced diagnostic imaging modalities, especially noninvasive ones, namely, computed tomography and magnetic resonance imaging (MRI) have been among the fastest growing medical expenditures over the past decade. Although access to such diagnostics is beneficial for patients, the impact on healthcare cost is substantial. Indeed, US Medicare reported an increase from $3.6 to $7.6 billion between 2000 and 2006 in the cost of advanced imaging services[1)]. Approximately a 5-fold increase was recorded in total MRI cost, and MRI equipment totals doubled in the national collection of data by the Health Insurance Review and Assessment Service in South Korea from 2005 to 2011. Recent MRI usage in the orthopedic discipline has climbed rapidly, sparking criticism of MRI overutilization in multiple specialties[2-4)]. For example, a recent study reported over half of lumbar spinal MRIs done at university hospitals were inappropriate or of questionable value for treatment purposes[5)].

Knee MRI has the distinct advantage of being a highly accurate yet noninvasive diagnostic tool for patients with knee ailments, typically involving bone and soft tissue elements including meniscus, cartilage, ligament, and muscles. However, pathologic

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conditions unrelated to patient symptoms may also be identified. For example, many MRI findings in elderly patients may have no clinical significance due to aging process[6,7] and may mislead a clinician in making diagnosis and weighing treatment options[8,9]. Nonetheless, given that most primary care centers are now equipped with MRI units, it is tempting for the primary care physician to obtain knee MRI prior to tertiary care center referral. One previous study reported 24% of knee MRIs obtained even in patients younger than 40 years of age were ordered inappropriately by primary care physicians[10]. Echoing this concern over potential overutilization of knee MRI, it has been our impression that patients increasingly visit the knee clinic with knee MRI obtained at primary or secondary care facilities, but unfortunately the practical value of the knee MRI in selecting treatment options is uncertain.

Although the appropriateness of current knee MRI utilization clearly warrants scrutiny, there is a paucity of data with regard to the utilization level and the utility of knee MRI. This study was conducted to determine what proportion of patients visiting a tertiary knee clinic had obtained knee MRI before they visited the clinic and to assess the impact of pre-obtained knee MRI on the selection of treatment plans. We hypothesized that a substantial proportion of patients had pre-obtained knee MRI prior to their visitations and pre-obtainment rate of knee MRI would differ by sociodemographic features and disease types. It was also hypothesized that overall, a considerable proportion of pre-obtained knee MRIs would have doubtful utility in making a correct diagnosis and selecting treatment options and the utility of knee MRI would vary with disease category.

Materials and Methods

1. Study Design and Subjects

With institutional review board approval, a retrospective review of medical records and radiologic data was conducted, examining all patients referred to the Division of Knee Surgery and Sports Medicine at our facility between January 1, 2012 and June 30, 2012. External radiographic images were loaded into the electronic database system and time-stamped. Inclusion requirements were as follows: 1) knee clinic visitation, 2) medical information disclosure, 3) electronic medical record of sufficient nature, and 4) radiographic knee series in standing (anteroposterior, lateral, and 45° posteroanterior) and Merchant views. After excluding 39 cases (5.4% of all eligible patients) lacking adequate medical records or radiographic knee series or those objecting to disclosure of information, 680 patients were finally included in this study.

2. Assessment of Knee MRI Utility

To assess the utility of knee MRI, a panel of five orthopaedic surgeons was formed, and the panel established criteria to assess the utility of knee MRI through several consensus meetings. To prevent bias originating from practice patterns or education duration, the panel was formed with surgeons with different practice patterns (three academic faculties, one private-practice physician, and one orthopedic fellow trainee). The panel had two consensus meetings to establish the criteria for the assessment of knee MRI utility. The agreed criteria were as follows. Knee MRIs were considered useful for all young patients with sports injury, patients slated for high tibial osteotomy (HTO) or first seen after a traffic accident, and those with intra-articular fracture or tumorous conditions, persistent pain after knee surgery, or degenerative joint disease (DJD) with mechanical symptoms (locking, popping, etc.) or specific physical examination (Lachman test, McMurray test, etc.). Knee MRI was considered useful in sports related injury to evaluate the soft tissue status that may be missed on clinical examination or unable to diagnose by plain radiography. Similarly, knee MRI in patients posted for HTO was considered useful to rule out any cartilage loss and ligament and meniscal injury. Conversely, a knee MRI was considered useless for those advised to seek total knee arthroplasty, for patients >60 years old with moderate-to-severe DJD but no mechanical symptoms, and for patients <50 years old without a history of trauma or abnormal physical examination.

To determine the utility of knee MRI, two rounds of assessment were performed. In the first round without knee MRI review, a moderator (Kim, the senior author and one of the five panel members) presented a brief history, physical findings, laboratory findings and plain radiographs of each case with knee MRI to the other four panel members. The panel members were requested to classify the utility of knee MRI into three categories: useful, equivocal, and arguably useless. The category of "useful" was defined as knee MRIs assessed to play a crucial role in making correct diagnosis or selecting treatment options. The category of "equivocal" was defined as knee MRIs assessed to play a potentially helpful role in making correct diagnosis or selecting treatment options. The category of "arguably useless" was defined as knee MRIs assessed to play minimal or no role in making correct diagnosis or selecting treatment options. In the second round, knee MRIs were presented, and the panel members were requested to classify the utility into the three categories. Each member was blinded to the assessment of other panel members.

The assessment results were collected for analyses by an independent investigator (Song, one of the author) who was not a panel member.

3. Statistical Analysis

All statistical analyses were performed using the IBM SPSS ver. 21.0 (IBM Co., Armonk, NY, USA). To determine what proportion of patients had knee MRI before they visited the knee clinic of tertiary referral center, the proportion of patients who visited the authors' clinic with knee MRI was calculated. In addition, to identify factors for obtaining knee MRI, patients with knee MRI were compared with patients without knee MRI with regard to sociodemographic factors, disease category and finally selected treatment modalities. Age, gender, and residential area were included in sociodemographic data. Residential areas were dichotomized as urban versus rural based on patient's address. Diagnoses were classified into four categories: DJD, sports-related injury, nonspecific knee pain, and other conditions. DJD was diagnosed by plain X-ray as typical changes seen as joint space narrowing, subchondral sclerosis, subchondral cyst formation, or osteophytes. Sports related injury was defined as injuries that occur in athletic activities or acute trauma without evidence of degenerative changes in patients who were under 55 years old; nonspecific knee pain was defined as knee pain with no radiological abnormality and no concomitant history of trauma; and other knee conditions were categorized as disease other than the above mentioned conditions including fractures, tumors and persistent pain after surgery. Finally selected treatment options were classified into three categories: non-pharmacologic, pharmacologic, and surgical. Statistical comparisons between the patients with knee MRI and the patients without knee MRI were performed using chi-square or Fisher's exact test for categorical variables and student t-test or Mann-Whitney U test for continuous variables.

To determine the impact of pre-obtained knee MRI on the selection of treatment plans, the proportions of knee MRIs assessed to be useful, equivocal, and arguably useless were calculated separately for the four disease categories (DJD, sports related injury, nonspecific knee pain and others) as well as in total. In addition, the effects of practice pattern or education duration on the assessment of knee MRI utility were evaluated by comparing utility assessment results among the five panel members and assessing inter-observer reliabilities. Inter-observer reliabilities were assessed by the Kappa statistics. The kappa values generated for panel agreement were interpreted via guidelines of Landis and Koch 9 as follows: slight agreement (range, 0.01 to 0.20), fair agreement (range, 0.21 to 0.40), moderate agreement (range, 0.41 to 0.60), substantial agreement (range, 0.61 to 0.80), or almost perfect agreement (range, 0.81 to 0.99). Zero value denoted no agreement beyond that expected by chance alone, with total disagreement at –1.00 values and perfect agreement at 1.00.

Results

Of 680 patients visiting our tertiary knee clinic, 185 (27%) had obtained knee MRI prior to their visitations, and younger age and the category of sports related injury were associated with more frequent pre-obtainment of knee MRI (Table 1). Of the 185 patients with knee MRI, 112 were in the category of DJD (61%), 43 in the category of sports related injury (23%), 19 in the category of nonspecific knee pain (10%), and 11 in the category of others (6%). The proportion of patients with pre-obtained knee MRI was highest in the category of sports related injury (43/61, 71%) followed by the categories of others (11/29, 38%), DJD (112/490, 23%), and nonspecific knee pain (19/100, 19%). Gender, residential area, and finally selected treatment options were not associated with knee MRI pre-obtainment (p>0.05).

Table 1. Comparisons of Sociodemographics, Disease Category, and Selected Treatment Options between Patients with and without Pre-Obtained Knee MRI

Variable	With knee MRI (n=185)	Without knee MRI (n=495)	p-value
Sociodemograhics			
Age (yr)			
Mean (standard deviation)	54.7 (14.7)	61.2 (15.8)	<0.001
Gender (F)	125 (68)	370 (75)	0.061
Residence			
Urban	146 (79)	413 (83)	0.171
Rural	39 (21)	82 (17)	
Disease category			
Degenerative joint disease	112 (61)	378 (76)	<0.001
Sports related injury	43 (23)	18 (4)	<0.001
Nonspecific knee pain	19 (10)	81 (16)	0.046
Others	11 (6)	18 (4)	0.185
Selected treatment option			
Non-pharmacologic	73 (39)	225 (45)	0.161
Pharmacologic	53 (29)	142 (29)	0.992
Surgical	59 (32)	128 (26)	0.117

Values are presented as number (%).
MRI: magnetic resonance imaging.

Approximately 40% of pre-obtained knee MRIs were assessed arguably useless both in the first and second rounds. The utility assessment results varied with the disease category, but little with practice pattern or education duration. Of the 185 pre-obtained knee MRIs, 73 were assessed useful (39%), 35 equivocal (18%), and 77 arguably useless in the first round assessment (43%), and 76 useful (41%), 33 equivocal (18%), and 76 arguably useless in the second round (41%) (Table 2). There were no significant differences in the utility assessment results between the panel members and between the first and second round assessments ($p>0.05$ in all comparisons). Knee MRIs pre-obtained for patients in the categories of sports related injury and others were largely deemed useful: sports related injury, 84% in the first round and second round; and others, 91% in the first round and second round (Table 3). In contrast, knee MRIs pre-obtained for patients in the categories of DJD and nonspecific knee pain were assessed useful much less frequently: DJD, 18% in the first round and 21% in the second round; and nonspecific knee pain, 31% in the first round and second round. Inter-observer reliabilities were substantial or higher ($k\geq0.61$) between most panel members in both rounds, and no significant differences were noted in the utility assessment results between the panel members ($p>0.05$).

Discussion

Considering the current nationwide trend of rapidly growing health care cost, the development of reasonable guidelines for a more efficient use of expensive medical modalities is highly recommended. The current study was conducted to investigate the possibility that knee MRI, an expensive diagnostic modality frequently obtained in patients with knee symptoms, is overutilized in current practice. We determined what proportion of patients visiting our tertiary knee clinic had obtained knee MRI prior to their visitations and the utility of pre-obtained knee MRI in selecting treatment options.

Our findings support the hypothesis that a considerable proportion of patients visited our clinic with pre-obtained knee MRI and knee MRI obtainment varied with disease type. Approximately one-quarter (27%) of patients had knee MRI prior to their visitations, and younger age and the disease categories of sports related injury and others (fractures, tumors, and persistent pain after surgery) were associated with more frequent pre-obtainment of knee MRI. These associations of younger age and the two disease categories appear to be intuitively reasonable. Patients who sustained sports related injury or are suspected to have other condi-

Table 2. Utility Assessment Results of the 185 Pre-Obtained Knee Magnetic Resonance Imaging Scans by the Five Panel Members in the First and Second Rounds

Variable	First round			Second round			p-value[a]
	Useful	Equivocal	Arguably useless	Useful	Equivocal	Arguably useless	
Academic faculty A	39 (73)	13 (24)	48 (88)	42 (77)	11 (21)	47 (87)	0.855
Academic faculty B	34 (62)	17 (32)	49 (91)	37 (69)	17 (31)	46 (85)	0.743
Academic faculty C	39 (72)	16 (30)	45 (83)	39 (73)	19 (36)	41 (76)	0.650
Private physician	44 (82)	26 (48)	30 (55)	43 (80)	25 (46)	32 (59)	0.901
Fellowship trainee	41 (76)	21 (39)	38 (70)	44 (82)	17 (31)	39 (72)	0.557
Average	39 (73)	18 (35)	43 (77)	41 (76)	18 (33)	41 (76)	

Values are presented as percentage (number).

[a]The statistical significance of the proportional changes between the first and second rounds was determined using the chi-squared test.

Table 3. Utility Assessment Results of the 185 Pre-Obtained Knee Magnetic Resonance Imaging Scans according to the Four Disease Categories

Variable	First round			Second Round		
	Useful	Equivocal	Arguably useless	Useful	Equivocal	Arguably useless
Degenerative joint disease (n=112)	18 (20)	21 (24)	61 (68)	21 (24)	21 (23)	58 (65)
Sports related injury (n=43)	84 (36)	9 (4)	7 (3)	84 (36)	12 (5)	4 (2)
Nonspecific knee pain (n=19)	31 (6)	31 (6)	38 (7)	31 (6)	26 (5)	42 (8)
Others (n=11)	91 (10)	9 (1)	0	91 (10)	9 (1)	0
Average	56	18	26	57	17	26

Values are presented as percentage (number).

tions such as tumorous conditions or persistent pain after surgery would naturally be inclined to obtain knee MRI. Our findings of the associations of the age and the disease category implicitly suggest that the proportion of patients with pre-obtained knee MRI varies with patient population characteristics in a particular tertiary knee clinic.

This study also supports our hypothesis that a considerable proportion of pre-obtained knee MRIs would have doubtful utility in making a correct diagnosis and selecting treatment options and the utility of knee MRI would vary with disease category. Only about 40% of pre-obtained knee MRIs was identified as 'useful' in both the first and second rounds. Particularly, the utility of pre-obtained knee MRIs seemed remarkably low in patients in the disease categories of DJD and nonspecific knee pain. However, this finding should be interpreted with serious caution. As the utility varies considerably with disease category, the overall utility of pre-obtained knee MRIs can also change substantially. For example, if the majority of patients of a clinic are in the sports-related injury or others category, the proportion of useful pre-obtained knee MRIs would be higher than 80%. Our literature review identified three previous studies reporting overutilization rates of knee MRI (Table 4). The 40% of 'arguably useless' in the current study was higher than the reported rates, 10%, 14%, and 24% in the previous studies[10-12]. This overutilization issue of MRI, an accurate yet expensive diagnostic modality, was raised in other specialties[3,5,13]. A previous study reported 90% overutilization of shoulder MRI[3] and another study reported 56% overutilization rate of spine MRI[5]. In contrast, Martin et al.[13] reported a very low rate of overutilization of MRI in patients referred to an oncologic clinic.

Our findings in the comparisons of utility assessment results among panel members indicate that the utility assessment would not be influenced by practice patterns or education duration. The utility assessment results were remarkably similar across the panel both in the first and second rounds, and inter-observer reliabilities remained high between the private practice surgeon and academic faculty members and between the fellowship trainee and faculty members. These findings may suggest that it is a plausible task to establish practice guidelines for the use of knee MRI. Future efforts are expected to be made in relevant societies.

The findings of the current study should be interpreted with consideration of the following limitations. First, our study was not free from inherent bias and restriction by its retrospective study design. We had no access to the original medical records of primary clinics and could not ask additional questions of patients, which hindered completeness and accuracy of charting at initial visits. Second, fair assessment of knee MRI utility in a particular patient might not be as straightforward as in theory, and the utility assessment criteria used in this study might not have addressed multiple and complex aspects of the issue. For example, despite the apparent absence of the need for knee MRI based on the criteria, patients may insistently demand a knee MRI for confirmation of the diagnosis or treatment option reasonably or correctly offered based on clinical assessments and plain radiographs. Furthermore, although the authors endeavored to establish the utility assessment criteria as objective and scientifically sound as possible, the criteria were not validated or endorsed by a relevant society. Therefore, caution should be taken not to draw a hasty conclusion that knee MRI is over-utilized in current practice. Finally, this study was conducted in a cohort recruited from patients visiting the authors' clinic, which is a knee clinic of a tertiary referral hospital. Our patient population might be different in terms of socio-demographic features and disease patterns from other patient populations visiting other tertiary knee clinics, which could be a confounding factor to consider. In theory, the utility of knee MRI can vary with the diagnosis, and the proportion of useful knee MRIs is expected higher in a clinic where sports injury patients are the majority than in a clinic where DJD is the most common. In addition, knee MRI obtainment patterns may depend partly on the practice patterns of primary or secondary care physicians. This study does not contain any information about the practice patterns of referring physicians of the patients. Therefore, caution is advised in applying our findings to other patient populations or to a nationwide level. Future nationwide

Table 4. Summary of 6 Previous Studies Reporting on Overutilization of Magnetic Resonance Imaging (MRI) in Musculoskeletal Practice

Author	Year	Country	MRI type	Overutilization (%)
Bradley et al.[3]	2005	U.S.	Shoulder MRI	90
Emery et al.[5]	2013	U.S.	Spine MRI	56 (557/1,000)
Petron et al.[10]	2010	U.K	Knee MRI	24 (24/100)
Lehnert et al.[11]	2010	U.S.	Knee MRI	14 (5/36)
Oikarinen et al.[12]	2013	Finland	Knee MRI	10 (3/30)
Martin et al.[13]	2012	U.S.	All referred MRIs to oncologic clinic	3 (8/320)

studies are warranted to scrutinize the possibility of knee MRI overutilization suggested in this study.

Conclusions

In conclusion, we found that approximately one-quarter of patients visiting a tertiary knee clinic had pre-obtained knee MRI and more than 40% of the pre-obtained knee MRI were deemed arguably useless in selecting treatment options. In particular, knee MRI was less likely to be useful in patients with DJD or nonspecific knee pain. This study suggests clinicians need to reconsider and consult with patients the expected utility of knee MRI in making correct diagnosis and selecting proper treatment options before acquisition of knee MRI. Future studies are warranted to scrutinize possible overutilization of knee MRI at a nationwide level.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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