Incidence Rates of Surgery After Knee MRI

Association According to Referring Physician Type and Patient's Age and Sex

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Background: The utility of magnetic resonance imaging (MRI) in the primary care setting is uncertain, with a perception that there is less likelihood for surgery after MRI ordered by general practitioners (GPs) when compared with orthopaedic surgeons and sports medicine physicians. Additionally, the influence of patient age and sex on subsequent surgical intervention is currently unknown.

Purpose/Hypothesis: The purpose of this study was to compare surgical incidence after MRI referrals by orthopaedic surgeons, GPs, and sports medicine physicians, including a subset analysis for GP patients based on type of approval given by the radiologist. The authors also wanted to explore the association of age and sex on subsequent surgical intervention. They hypothesized that surgical incidence after MRI ordered by orthopaedic surgeons and sports medicine physicians would be higher than after MRI ordered by GPs.

Study Design: Cohort study; Level of evidence, 3.

Methods: Knee MRI referrals by the 3 physician cohorts during May to December 2017 were assessed. For GP patients, the types of approval or recommendation from a radiologist were categorized. Subsequent surgical intervention status was then compared among referral groups up to 2 years after MRI. Associations of age and sex with surgical occurrence were also assessed. Chi-square test, analysis of variance, and univariate/multivariable logistic regression were used for statistical analysis.

Results: Overall, 407 referrals were evaluated (GP, n = 173; orthopaedic, n = 176; sports medicine, n = 58). Surgical incidence was not significantly higher for orthopaedic and sports medicine than GP referrals at 3 months (10%, 3%, and 6%, respectively; $P = .23$), 6 months (20%, 17%, and 15%; $P = .49$), and 2 years (30%, 35%, and 24%; $P = .25$). Surgical incidence for GP patients was higher after discussion with a radiologist or when evaluating specific pathology on prior imaging versus less defined reasons (30.4% vs 15.7%, respectively; $P = .03$). Surgical incidence was lower for older patients (11% vs 31% for >60 years vs all other age groups combined; $P = .002$), and women were less likely to undergo surgery than men (22% vs 35%, respectively; $P = .008$).

Conclusion: Surgical incidence after MRI was likely appropriately lower for older patients. Lower incidence for female patients is of uncertain cause and warrants further study.

Keywords: knee; magnetic resonance imaging; orthopaedic surgeons; general practitioners; physicians; family; referral and consultation

Knee pain accounts for >10 million primary care outpatient visits annually in the United States.[23] Although most of these concerns are due to osteoarthritis,[6,14] many patients present with acute injuries. In patients with acute injuries, approximately 9% to 10% have meniscal tears, 7% have collateral ligament injury, and about 4% have a cruciate ligament injury.[5,12,14] Many of these patients require magnetic resonance imaging (MRI) to diagnose internal derangement of the knee. Currently in the Saskatoon Health Region,

direct access to ordering knee MRI is limited to specialists—namely, orthopaedic surgeons, sports medicine physicians, and rheumatologists. This is not unique to our health region and has some overlap with payer systems where access to MRI is limited. Sports medicine physicians are general practitioners (GPs) with board-certified additional training in sports medicine who have MRI-ordering privileges similar to those of orthopaedic surgeons in our health region. However, general GPs, which include primary care physicians and family doctors, can order knee MRI only with a radiologist's approval or by following up on a radiologist's recommendations from prior knee radiographs and/or ultrasonography.

Perhaps the best-established appropriateness criteria for imaging the acutely injured and chronically painful knee are from the American College of Radiology (ACR). In the recommendations for acute knee injury, MRI is often listed as "usually appropriate" as a secondary or tertiary study, with justification for its use being the ability to detect occult fractures and soft tissue injuries (including ligament or menisci), many of which may be of surgical interest.[28] For chronic knee pain, MRI is listed as "usually appropriate" in the setting of joint effusion and "may be appropriate" in the setting of degenerative change, with justification reinforcing that meniscal tears are often incidental in older patients.[9] Additionally, the bone marrow, cartilage, and soft tissue findings listed as justification for MRI in chronic knee pain are not usually of surgical interest.[9]

The clinical impact of knee MRI ordered by GPs is uncertain, with a perception that they may be less likely to affect clinical outcome. Concerns have been raised regarding GP patients having a lower likelihood of orthopaedic surgical intervention. Although the reasons for GPs ordering MRI are diverse and likely vary by patient and practitioner, looking for a lesion amenable to surgery is a common cause for them to request knee imaging. However, there are potential patient and system benefits to obtaining MRI, with a goal of avoiding surgery.

During the past decade, there has been debate over the utility of MRI in the primary care setting. A few retrospective studies[1,3,22,25,26] have compared the efficacy of knee MRI ordered by orthopaedic surgeons and GPs based on cost-effectiveness and surgical outcomes. Some studies[10,22,24,29] have shown that orthopaedic surgeons obtain knee MRI with more discretion than nonorthopaedic providers. However, some studies[1,3] demonstrated benefits of providing MRI access to GPs: reduction of unnecessary orthopaedic referrals and costs, provision of timely diagnosis for patients, less patient anxiety, and improved patient satisfaction. Yet, such access could result in (1) overutilization of an expensive and limited imaging resource, (2) higher health care costs and longer wait times, and (3) potentially inappropriate treatment of patients, owing to a lack of familiarity with how to address the MRI findings.[10,30]

The purpose of this study was to compare the frequency of surgical intervention for patients who receive MRI referred by orthopaedic surgeons, sports medicine physicians, and GPs. We also aimed to analyze the frequency of surgical intervention among GP patients who obtain knee MRI because of various types of recommendations from radiologists based on previous radiographs and/or ultrasonography. Secondary objectives were to determine whether older patient age and sex are associated with different incidences of surgery after MRI. We hypothesized that patients with MRI ordered by orthopaedic surgeons and sports medicine physicians would have a higher rate of subsequent surgical intervention than patients with MRI ordered by GPs.

METHODS

Study Design and Population

This retrospective cohort study was performed in Saskatoon, Saskatchewan. We reviewed the records of patients who received knee MRI in Saskatoon from May 28 to December 31, 2017. The presence or absence of surgical intervention was determined at 3 months, 6 months, and 2 years after MRI for all patients. The study protocol received an exemption from ethics approval by our institutional review board.

During the given period, a total of 943 knee MRI scans were requested and performed from these 3 groups: 204 from GPs, 681 from orthopaedic surgeons, and 58 from sports medicine physicians. To have a balanced sample to compare with GPs, only a subset of orthopaedic-referred MRI scans was selected for analysis. This selection was performed by including the orthopaedic-referred MRI immediately after each GP-referred MRI, typically within 2 to 3 days. Since some sports medicine–referred MRI scans were initially included in this sample, the number of orthopaedic-referred MRI scans do not perfectly match the GP-referred MRI scans. This selection process ensured that the GP- and orthopaedic-referred MRI followed a similar chronological pattern across the study period while minimizing the potential for clustering of MRI scans ordered by individual surgeons because of clinic scheduling. However, given the relatively limited number of sports medicine–referred MRI scans, all were included. Two GP patients were excluded because of incomplete data. Six MRI scans (4 from GPs, 2 from orthopaedic surgeons) were excluded as they were followed by knee replacements. This resulted in 198 MRI scans in the GP cohort, 184 in the orthopaedic cohort, and 58 in the sports medicine cohort. Upon further analyzation of the cohorts, we excluded MRI obtained as part of a claim with the workers' compensation board, as its rate of surgical intervention could have been influenced by other factors. Ultimately, 173 knee MRI scans remained in the GP cohort, 176 in the orthopaedic cohort, and 58 in the sports medicine cohort (Figure 1).

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Measurements

For each patient, the following information was collected from the radiology picture archiving and communication system: examination indication, type of recommendation (including previous imaging modality for GP-referred MRI), and patient age and sex. The presence or absence of surgical intervention within 2 years of the MRI was based on a search of medical records (consultation and operative notes) for the Saskatchewan Health Authority. For GP-referred MRI, the type of radiologist approval/recommendation was categorized as "verbal discussion" of the

case or by comment on previous imaging as 1 of 3 types: follow-up of a specific structure, follow-up of a nonspecific finding such as joint effusion, or general statement to get MRI "if concerned."

Statistical Analysis

Basic descriptive statistics, including characteristics and the proportion of patients with subsequent surgical intervention, were undertaken for all 3 cohorts, with comparisons made by analysis of variance or chi-square test as appropriate. The surgical proportions among GP-referred MRI subgroups, imaged under direct radiologist approval or by type of prior imaging follow-up recommendation, were also determined; these GP-referred MRI scans were stratified by prior imaging type (ultrasonography vs radiograph). Where testing results were significant across categories overall, pairwise comparisons were made with Bonferroni-corrected alpha ($0.05/3 = 0.018$) using the chi-square test or t test. Where >20% of expected cell sizes were <5, the Fisher exact test was used in place of chi-square. This was followed with univariate and multivariable logistic regression, adjusting the primary association between physician type and surgical outcome for possible influential cohort differences in age and sex. Analysis was performed using SPSS Version 26 (IBM Corp).
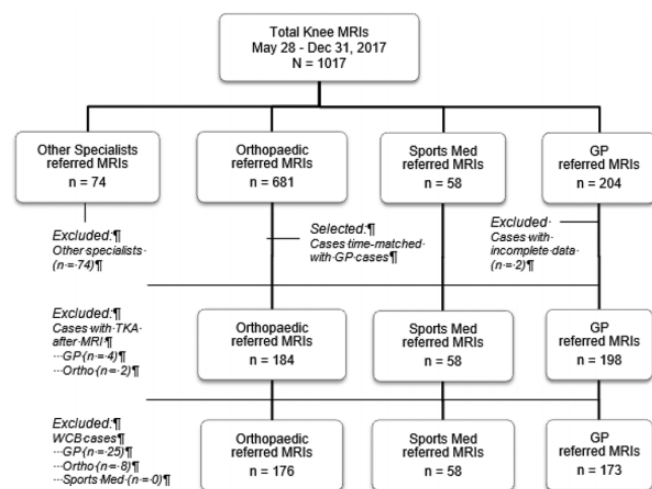
Figure 1. Flowchart of the study sample. GP, general practitioner; MRI, magnetic resonance imaging; Ortho, orthopaedic surgeon; Sport Med, sports medicine physician; TKA, total knee arthroplasty; WCB, workers' compensation board.

RESULTS

Patient Characteristics

A total of 407 patients were included in the study, referred from GPs (n = 173), orthopaedic surgeons (n = 176), and sports medicine physicians (n = 58). Referrals were from 141 physicians: 113 GPs, 24 orthopaedic surgeons, and 4

TABLE 1
Patient Characteristics and Surgical Intervention Proportions Based on Referring Specialty

	General Practitioners (n = 173)	Orthopaedic Surgeons (n = 176)	Sports Medicine Specialists (n = 58)	P^a
Age, y, mean ± SD	46 ± 17	38 ± 17	34 ± 14	$<.0001^b$
Sex, No. (%)				.3
Male	76 (43.9)	86 (48.9)	32 (55.2)	
Female	97 (56.1)	90 (51.1)	26 (44.8)	
Time to surgery, No. (%)				
Within 3 mo				.23
Yes	11 (6.4)	17 (9.7)	2 (3.4)	
No	162 (93.6)	159 (90.3)	56 (96.6)	
Within 6 mo				.49
Yes	26 (15.0)	35 (19.9)	10 (17.2)	
No	147 (85.0)	141 (80.1)	48 (82.8)	
Within 2 y^c				.25
Yes	42 (24.3)	53 (30.1)	20 (34.5)	
No	131 (75.7)	123 (69.9)	38 (65.5)	

$^a P$ value for overall comparison of values across groups.
$^b P$ values for pairwise comparisons: general practitioners vs surgeons, $P < .0001$; surgeons vs sports medicine specialists, $P = .06$; general practitioners vs sports medicine specialists, $P < .0001$.
^{c} When orthopedic surgeons and sports medicine groups were combined, proportions were 31.2% for orthopedic and sports medicine groups combined vs 24.3% for general practitioners, $P = .13$.

TABLE 2
Characteristics Related to MRI Scans With and Without Subsequent Surgery Intervention[a]

| | Surgery, No. (%) | | | |
	Yes	No	Odds Ratio (95% CI)	P [b]
Age, y				
≤30	47 (35.1)	87 (64.9)	4.41 (1.76-11.06)	**.002**
31-45	30 (32.3)	63 (67.7)	3.89 (1.50-10.08)	**.005**
46-60	32 (25.6)	93 (74.4)	2.81 (1.10-7.18)	**.03**
>60	6 (10.9)	49 (89.1)	Reference	
Sex				
Female	48 (22.5)	165 (77.5)	0.55 (0.36-0.85)	**.008**
Male	67 (34.5)	127 (65.5)	Reference	
Physician type				
General practitioner	42 (24.3)	131 (75.7)	0.74 (0.46-1.20)	.22
Sports medicine specialist	20 (34.5)	38 (65.5)	1.22 (0.65-2.29)	.53
Orthopaedic surgeon	53 (30.1)	123 (69.9)	Reference	

[a]MRI, magnetic resonance imaging.
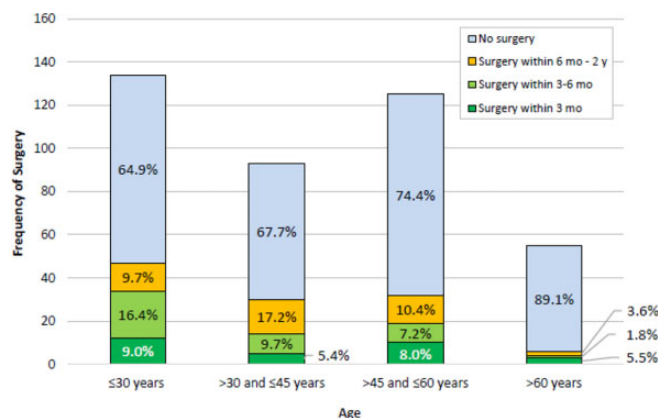[b]From univariate logistic regression. Bold values indicate $P < .05$.

Figure 2. Surgical intervention by age group. There was a significantly lower surgical incidence after MRI for patients >60 years of age vs all other age groups combined ($P = .002$).

TABLE 3
Multiple Logistic Regression Modeling of Surgical Intervention

	Odds Ratio (95% CI)	P [a]
Age, y		
≤30	3.81 (1.48-9.83)	**.006**
31-45	3.30 (1.24-8.80)	**.02**
46-60	2.62 (1.01-6.77)	**.047**
>60	Reference	
Sex		
Female	0.61 (0.39-0.95)	.03
Male	Reference	
Physician type		
General practitioner	0.91 (0.55-1.49)	.70
Sports medicine specialist	1.09 (0.57-2.07)	.79
Orthopaedic surgeon	Reference	

[a]Bold values indicate $P < .05$.

sports medicine physicians. The mean patient age was highest in GP referrals (Table 1).

Surgical Interventions

Surgical incidence was not significantly higher for orthopaedic and sports medicine than GP referrals at 3 months (approximately 10%, 3%, and 6%, respectively; $P = .23$), 6 months (20%, 17%, and 15%; $P = .49$), and 2 years (30%, 35%, and 24%; $P = .25$). There was no statistical difference in 2-year surgical intervention rates even when sports medicine and orthopaedic surgeons were combined and compared with GPs (73 of 245 [31%] of sports medicine and orthopaedic surgeons vs 42 of 173 [24%] of only GPs; $P = .13$).

The characteristics of patients who underwent surgery versus those who did not are presented in Table 2 with univariate odds ratios. As illustrated in Figure 2, older patients (>60 years) had a lower proportion of surgical intervention versus the other age groups combined (cumulative 2-year proportions, 10.9% vs 31.0%, respectively; $P = .002$). Thus, when adjusted for age in the multivariable model (Table 3), the strength of the association between GPs and surgery, in comparison with orthopaedic surgeons, was reduced from an odds ratio of 0.74 to 0.91, with P value significance decreasing from .22 to .70. The inclusion of sex as a covariate in the model had no effect on this key relationship; it was, however, an independent predictor of surgical intervention in univariate and multivariable models, with women 39% less likely to undergo surgery even after adjustment for type of referring specialist and patient age ($P = .03$).

GP-referred knee MRI scans were generated either by direct conversation with a radiologist or by following up on a radiologist's recommendations on prior ultrasonography/

TABLE 4
GP-Referred MRI Scans With Subsequent Surgery, Stratified by Approval or Recommendation Type
and Prior Imaging Modality[a]

	Ultrasonography	Radiographs	Other Modality	Total	Surgical Intervention, No. (%)
Direct conversation with radiologist	—	—	—	48	14 (29.2)
Radiologist recommendations					
"Specific structure"	31	22	1[b]	54	17 (31.5)
"Nonspecific finding"	26	13	1[c]	40	7 (17.5)
"If concerned"	7	23	0	30	4 (13.3)
Total	64	58	2	172[d]	42 (24.4)

[a]GP, general practitioner; MRI, magnetic resonance imaging; —, not applicable.
[b]Bone scan.
[c]CT, computed tomography.
[d]One referral missing indication.

TABLE 5
Surgical Intervention Post MRI Among GP Patients
Referred on the Recommendations of Prior
Ultrasonography and Radiographic Imaging Reports[a]

Recommendation	Prior Ultrasonography Imaging		Prior Radiographic Imaging	
	No.	Surgical Intervention, No. (%)	No.	Surgical Intervention, No. (%)
"Specific structure"	31	12 (38.7)	22	5 (22.7)
"Nonspecific finding"	26	4 (15.4)	13	3 (23.1)
"If concerned"	7	1 (14.3)	23	3 (13.0)
Overall[b]	64	17 (26.6)	58	11 (19.0)

[a]GP, general practitioner; MRI, magnetic resonance imaging.
[b]For comparison of overall proportions undergoing surgery by prior imaging method, $P = .32$.

radiographs (Table 4). Differences in rates of subsequent surgery among the GP referral reasons did not reach statistical significance ($P = .16$). However, when "stronger" reasons (discussion-based approval or follow-up of specific pathology) were combined and compared against the less well-defined indications combined (follow-up of nonspecific findings or ongoing concern), referrals based on the former were significantly more likely to be associated with eventual surgical management (30.4% vs 15.7%; $P = .03$). This association held when referral reasons were restricted to those related to previous imaging (follow-up of a specific finding vs a nonspecific finding/concern, 31.5% vs 15.7%, respectively; $P = .04$).

For ultrasonography (Table 5), the rate of surgical intervention was highest at about 39% when radiologists recommended MRI to follow up specific pathology, although surgery occurred too infrequently among recommendation types for statistical comparison. On radiographs, the rate of surgical intervention was almost equivocal within the specified subcategories but slightly higher when joint effusion

was seen (3 of 13 [23%]). Two MRI recommendations were based on computed tomography and bone scan; neither case resulted in subsequent surgery. In our sample, the proportion with surgical intervention was also higher after recommendations based on ultrasonography than radiographs (27% vs 19%; $P = 0.32$).

DISCUSSION

Main Findings

Our hypothesis was that patients with MRI ordered by orthopaedic surgeons and sports medicine physicians have a higher rate of subsequent surgical intervention when compared with patients with MRI ordered by GPs. Although model estimates were in the direction of this hypothesis, differences among the groups were less than expected and did not reach statistical significance. Surgical incidence was not significantly higher for orthopaedic and sports medicine than GP referrals at 3 months (10%, 3%, and 6% respectively; $P = .23$), 6 months (20%, 17%, and 15%; $P = .49$), and 2 years (30%, 35%, and 24%; $P = .25$).

Furthermore, in our sample, the somewhat lower intervention rate in the GP cohort and higher intervention rate in the sports medicine cohort, relative to orthopaedic patients, appear partly attributable to older and younger patient ages, respectively, as adjustment for age differences resulted in odds ratios that were closer to 1. With regard to radiologists' recommendations on ultrasonography/radiographs, we found that nonspecific findings, such as joint effusion or general follow-up statements on normal examination findings (eg, "obtain MRI if concerned about internal derangement"), resulted in MRI with a lower rate of surgical intervention in comparison with following up a specific pathology (30.4% vs 15.7%; $P = .03$). We also noted a statistically lower incidence of surgery after MRI for older patients (11% vs 31% for >60 years vs all other age groups combined; $P = .002$) and female patients (22% for female patients vs 35% for male patients; $P = .008$) even after adjusting for each other and differences in referring physician group.

Comparison With Existing Literature

Two other retrospective studies[22,29] have compared the rate of surgical intervention after MRI ordered by orthopaedic surgeons versus GPs, both of which were from Albany, New York. Roberts et al[22] demonstrated that orthopaedic surgery–referred MRI resulted in more arthroscopic procedures than that referred by primary care physicians (41.2% vs 31.4%) based on 1592 patients from 2010 to 2011 (845 patients referred by orthopaedic surgeons and 747 by primary care physicians). Similarly, Uppal et al[29] reported that orthopaedic-referred MRI resulted in higher rate of surgical evaluation than that ordered by GPs (39% vs 28%) based on 439 patients from 1996 to 1997 (328 referred by orthopaedic surgeons and 111 by other physicians). In both these studies, the surgical intervention rates in both cohorts were higher than ours (30% for orthopaedic surgeons and 24% for GPs in our study), which may relate to different practice patterns because of local/system-related factors or time-related evolution of practice. However, GPs were able to directly order knee MRI without obtaining approval from a radiologist in both these studies, and age- and sex-specific statistical evaluation was not performed.[22,29] Our study results are contrary to theirs, with only a nonstatistically significant difference between the orthopaedic and GP patients, which was partly attributable to patient age.

There have been no prior studies to our knowledge on the impact of radiologists' reporting of non-MRI and post-MRI surgical intervention. Knowing this impact may provide additional insight for institutions or payer systems where GP-referred MRI requires a radiologist's recommendations on ultrasonography/radiographs, which could result in a relative enrichment of the cases from GPs, where an additional hurdle of recommendation based on prior imaging or a direct conversation with the radiologist is needed. In such cases, if the radiologist suggests MRI to assess a specific abnormality (ligamentous tear or meniscal tear), the rate of surgical intervention is essentially equivalent to that of the MRI arranged by orthopaedic surgeons (32% vs 30%), although the small sample size precludes meaningful statistical assessment. Knowing the association between reasons for recommending knee MRI and subsequent surgery may also influence how or when radiologists make recommendations for MRI on radiographs and ultrasonography. This could be particularly relevant in health regions or payer systems where radiologists' recommendations influence access for reimbursed MRI. Additionally, the findings of this study may play a role in discussing access to knee MRI for GPs, particularly when the goal of MRI is to help select patients for potential surgery.

Our study additionally adds data regarding surgery after MRI ordered by sports medicine physicians, similar to the other groups. We believe that no prior studies have examined the surgical intervention rates after sports medicine–referred knee MRI.

Multiple studies[10,18,21,22,25] have assessed the appropriateness of MRI ordered by GPs and orthopaedic surgeons. Although, admittedly, many studies on knee MRI utility are from orthopaedic surgeons, which may introduce bias, many of the recommendations aim to identify patients likely to benefit from surgery. Similarly, many of the justifications for best use of knee MRI by the ACR include reference to lesions of surgical interest.[7,23]

These studies showed that (1) 45% of knee MRI scans from primary care physicians were inappropriate by ACR criteria,[10] (2) family physicians were more likely than orthopaedic surgeons to inappropriately order knee MRI for chronic knee pain and osteoarthritis,[22] and (3) 43% of knee MRI scans ordered by GPs were categorized as "arguably useless" by a panel of orthopaedic surgeons.[25] Two studies evaluated appropriateness of knee MRI ordered by GPs in older patients, showing that only 12% of MRI scans in patients aged ≥40 years were deemed appropriate by orthopaedic surgeons[21] and that 76% in patients aged ≥55 years were considered not useful.[18] Many of these studies used appropriateness criteria, but adherence may be difficult for GPs because of the guidelines' accessibility and patients' expectations, symptoms, and repeated visits to the clinic.[11] It should be remembered that surgical intervention is not the only possible benefit after MRI, as MRI can provide appropriate triage to surgical and nonsurgical interventions, potentially optimizing early treatments while decreasing management costs.[20] Some studies[1,3] have highlighted benefits of providing MRI access to GPs, such as improved "knee-related quality of life measures" and reduced "orthopaedic referrals," but those were not explored in our study given its retrospective nature. There is currently a large multicenter randomized controlled trial underway in the Netherlands that is evaluating the diagnostic value and cost-effectiveness of direct GP access to knee MRI for patients with traumatic knee complaints.[26]

On the clinical side, more studies are emerging that demonstrate limited to no benefit from arthroscopic surgery for degenerative conditions of the knee (osteoarthritis and degenerative meniscal tears) and for older patients. Some of this evidence comes from the high incidence of meniscal tears and relatively poor association with symptoms in older patients with and without osteoarthritis.[2,8] A study of 180 patients with knee osteoarthritis showed no difference in outcomes after arthroscopic surgery, arthroscopic lavage, or a placebo procedure.[19] A recent meta-analysis[27] on arthroscopic surgery for middle-aged to older patients with and without osteoarthritis showed a minor short-lived decrease in pain, with no functional improvement after surgery when compared with control interventions, at a cost of potential complications such as deep venous thrombosis, pulmonary embolus, infection, and death. Findings such as these have led to a call to curtail arthroscopy for knee pain in middle-aged and older patients.[17] The impact of these data on surgical practices is illustrated by the 39% decrease in recent years in arthroscopic knee surgery among Australian patients aged >50 years.[16] It has also been postulated that knee MRI early in the disease course for middle-aged and older patients may reveal meniscal lesions and subsequently increase the likelihood of arthroscopic surgery irrespective of the relevance of the lesion.[17] Our study showed a significantly lower incidence of surgery after MRI for older patients, which is appropriate given the

documented little benefit of arthroscopic surgery in older patients, despite that there may have been lesions of surgical temptation on those scans.

The age difference between the GP cohort and the specialist cohort in our study was just 8 years (mean ± SD, 46 ± 17 vs 38 ± 17 years, respectively). Not only did it reach statistical significance, but some may argue that it is of great clinical importance. This age discrepancy is similar to that seen by Roberts et al,[22] where patients referred for MRI by GPs were on average 10 years older than those referred by orthopaedic colleagues. This age difference may have contributed to their observed lower incidence of knee arthroscopy after MRI ordered by GPs.

There is no doubt a distinction between the young, injured, but otherwise normal knee and the "aging" knee, with multiple findings that are largely degenerative or secondary to minor trauma. While chronologic age is a poor guide, it is suspected that at approximately age 40 years, a division begins to appear, with older patients much less likely to have MRI findings that could lead to surgical intervention.[7] In this way, age may be acting as a poor surrogate for degenerative change/osteoarthritis; however, it was beyond the scope of this study to evaluate the degree of osteoarthritis on patient radiographs or MRI. Regardless, benefits of arthroscopic surgery in an older population are limited, with or without osteoarthritis.[27] This potentially explains the trend toward orthopaedic surgeons and sports medicine physicians having lower-aged patients receive MRI in our study. Referral of older patients from family physicians as compared with orthopaedic surgeons may be due to multiple factors. There are certainly times when a normal or minimally abnormal MRI finding is the expected or desired outcome to reassure patients and facilitate their activity and rehabilitation progression. Patients' expectations for imaging, as well as a desire to document disease or absence of disease, can also be drivers for ordering MRI by GPs.[11]

In our study, we found that women were 39% less likely than men to undergo surgery after MRI. Although there is no prior published literature on differences in rates of arthroscopic knee surgery by sex, there is a body of evidence showing that symptomatic female patients are less likely to undergo knee arthroplasty.[4,13] The potential causes for this sex-related discrepancy in knee arthroplasty are uncertain but may involve patients' preferences, social network differences, and potential physician bias.[4,13] Determining the cause for a sex-related difference in surgical incidence after MRI is beyond the scope of this study but may be an avenue for further research.

Strengths and Limitations

The strengths of this study include relatively well-balanced cohorts and minimization of selection bias. We were blind to subsequent surgical intervention at the time of patient selection. The knee MRI was ordered by several physicians with various types of practices in Saskatchewan, Canada.

There are, however, limitations to this study. First, our study considered surgery as potential patient treatment after MRI acquisition. There are other interventions to orthopaedics that were not feasible to assess, such as physical therapy, patient reassurance, and nonreferral. Second, we excluded MRI obtained directly by rheumatologists and other specialists, but it was not possible to exclude patients with rheumatologic background or queries from the GP cohort. Such patients within the GP cohort could have lowered this group's rate of surgical intervention. Third, the surgical incidence differences were lower than expected, and as such, our study was potentially underpowered, possibly leaving smaller but meaningful differences in surgical management among the physician groups undetectable. A post hoc power evaluation (R statistical software version 4.0.2); R Foundation for Statistical Computing) revealed respective power values of 0.39 and 0.46 when comparing our orthopaedic and sports medicine proportions against our GP proportion.

A fourth limitation was that, although we did find a correlation between older age and lower rate of surgery, this difference is likely secondary to a combination of age- and osteoarthritis-related factors. This is in keeping with the minimal benefits of arthroscopic knee surgery in degenerative conditions, which have been found to be limited regardless of the degree of osteoarthritis and has led to calls for decreasing the knee surgery and even MRI evaluation of these patients.[15,17-19,21] Fifth, our study consisted of patients with acute and chronic knee pain. Since there are no centralized medical records for clinic visits in our health region, it was not possible to accurately determine the exact duration of symptoms for each patient. Sixth, this study does not reflect an entirely true referral pattern of GPs, as they did not have complete independence to order knee MRI as they deemed fit. This may actually represent a relatively enriched population of GP patients, as the requirements for ordering MRI is higher, but this is not a situation unique to our health region. Seventh, we did not analyze specific pathologies, such as ligamentous or meniscal tear, and their associated surgical correlation. Additionally, although expected to be infrequent at our institution, some orthopaedic surgeons may influence the ordering practices of referring physicians if they were to require having MRI performed before consultation. Last, given the relatively small sample size of the subgroups explored, our subset comparisons may have generally been underpowered. Future work should take these aspects into consideration and explore the revealed associations between surgery and both age and sex.

CONCLUSION

Surgical intervention after MRI was not significantly different among the 3 referral groups of orthopaedic surgeons, sports medicine physicians, and GPs in our practice setting. Decreased surgical incidence after MRI for older patients is in keeping with current best practices. The revealed lower incidence of surgery after MRI for female patients is a novel finding for which further investigation is needed.

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