



# The use of magnetic resonance imaging (MRI) of the knee in current clinical practice: A retrospective evaluation of the MRI reports within a large NHS trust

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## ABSTRACT

**Background:** Magnetic resonance imaging (MRI) is one of the most widely used investigations for knee pain as it provides detailed assessment of the bone and soft tissues. The aim of this study is to report the frequency of each diagnosis identified on MRI scans of the knee and explore the relationship between MRI results and onward treatment.

**Methods:** Consecutive MRI reports from a large NHS trust performed in 2017 were included in this study. The hospital electronic system was consulted to identify whether a patient underwent x-ray prior to the MRI, attended an outpatient appointment or underwent surgery.

**Results:** 4466 MRI knees were performed in 2017 with 71.2% requested in primary care and 28.1% requested in secondary care. The most common diagnosis was signs of arthritis (55.2%), followed by meniscal tears (42.8%) and ACL tears (8.3%). 49.4% of patients who had an MRI attended outpatients and 15.6% underwent surgery.

The rate of knee surgery was significantly higher for patients who had their scans requested in secondary care (32.9% vs 8.9%,  $p < 0.001$ ).

**Conclusion:** The rate of surgical intervention following MRI is low and given these results it seems unlikely that the scan changes practice in most cases. The rate of surgery and outpatient follow up was significantly higher in scans requested by secondary care. We urge clinicians avoid wasteful use of MRI and recommend the use of plain radiography prior to MRI where arthritis may be present.

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## 1. Introduction

Knee pain is caused by a multitude of pathologies, affects people of all ages and contributes a substantial amount to the clinical workload of healthcare professionals [1,2]. Knee pain has been shown to affect 26.9% of the general population [3]. Trauma to the knee has been shown to have the highest burden of all sports injuries leading to lower quality of life in young

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and active patients [4]. Following a clinical examination, magnetic resonance imaging (MRI) of the knee provides a detailed assessment of the soft tissues of the knee in addition to the bone [5]. This allows diagnosis of a range of pathologies including ligament injuries, arthritis and infection. Although MRI is a useful imaging tool for soft tissue issues especially for young patients following trauma, its role in detecting arthritis is less clear [6]. The sensitivity of MRI for detecting arthritis has been shown to be lower than clinical examination and plain radiography [6]. MRI can be useful in detecting additional features of arthritis, e.g. meniscal tears and bone marrow lesions, however, the clinical relevance of these findings in the context of arthritis is not understood [5,7].

When first introduced MRIs of the knee were predominantly requested in secondary care by orthopaedic surgeons to determine whether surgery was needed [8,9]. However, over the last decade, MRIs have increasingly been requested in primary care, where MRIs of the knee are now the second most commonly requested body part [10]. One reason for this is that primary care doctors often see patients with knee pain at first presentation and may consider a MRI scan to be part of the clinical work up, without necessarily considering the impact on ongoing treatment options.

As MRIs come at a significant cost to the healthcare service with only a limited number of scanners per trust, it is important that scans are only requested when truly indicated and where the outcome will influence treatment decisions such as surgery [9,11,12]. Previous work has suggested that MRI scans in secondary care are more likely to be requested for patients who would benefit from surgery, for example younger patients with acute symptoms and history of trauma [8]. Additionally, the rate of 'normal' MRI scans is significantly higher following primary care requests compared to secondary care requests [9]. Previous work has also attempted to estimate the frequency of different pathologies from MRI scans with meniscal tears being the most frequent, although these are relatively small studies [13,14].

Given that MRI is a resource which needs to be shared amongst all specialities, we need to understand the current frequency of diagnosis for knee pain in the UK. Following this, we can then explore the intervention rates for each diagnosis and the need for subsequent surgery. This will help inform referring clinicians as to whether an MRI is required based on the history and the examination findings, especially if the intervention rate for a particular diagnosis is low. It will also allow care providers to streamline the use of MRI to patients where it is indicated, reducing the burden on the health service and improving the quality of care for all patients.

The primary aim of this study was to describe the frequencies of each diagnoses identified during an MRI of the knee. The secondary aim of this study was to explore the current intervention rates for each diagnosis identified during an MRI of the knee. As this is an exploratory study of incidences of each diagnosis, the authors did not perform formal hypothesis testing for the primary aim. The authors did hypothesize that the majority of MRI scans will be requested by general practitioners and the operative rate will be significantly higher following MRIs requested by secondary care compare to general practice.

## 2. Methods

### 2.1. Study design and ethical approval

This study is reported in accordance with the Strengthening The Reporting of Observational studies in Epidemiology (STROBE) Guidelines for Observational Studies and Statistical Analyses and Methods in the Published Literature guidelines [15]. The study, which used routinely collected pseudonymised data only, was registered at the UHCW research and development team as a service evaluation project (ref. SE0168). In addition, ethical approval was granted by the University of Warwick Biomedical and Scientific Research Ethics Committee (ref. BSREC 09/19–20) on the 11th October 2019.

A single centre retrospective study was undertaken at University Hospital Coventry and Warwickshire (UHCW) NHS trust, which includes both University Hospital Coventry and Rugby St Cross hospital. MRI reports from 4466 patients which met the following eligibility criteria were included in this study. The inclusion criteria were all MRI knee scans performed for patients of any age for any indication. Scan taken between 1st January 2017 and 31st December 2017 were eligible for inclusion. The year 2017 was chosen to ensure at least a two-year data collection period was allowed to account for waiting lists for potential surgery. The authors excluded scans which were not accompanied by a written report produced by a radiologist and any scans performed outside of the study period.

### 2.2. Data collection

Clinical codes were identified and the radiology database was searched to identify all MRI knee reports which were performed over a one year period were reviewed. All reports were authored or approved by a consultant radiologist at the trust. Three authors (IA, WC, CE) reviewed the available MRI reports, over a six-month period from October 2019 to April 2020. From the MRI report, the following data were collected: patient age, sex, right/left knee, referral source and diagnosis. The report was explored in detail to identify the presence of meniscal tears, anterior cruciate ligament (ACL) tears, other ligament tears, fractures, presence of signs of arthritis, infection, tumours or masses and the presence of spontaneous osteonecrosis. Where a report was described as normal this was also documented. Any report which used one the following terms: degeneration within the knee joint, tricompartmental arthritis, patellofemoral arthritis, patellofemoral degeneration, osteoarthritis within the knee, chondral thinning or loss was deemed to report 'signs of arthritis'. Signs of arthritis was reported as a binary measure as either being present or not. The authors did not report incidences of different types of arthri-

tis as the reports were produced by multiple radiologists and differing language was used to describe similar findings. Electronic hospital records were then interrogated by two authors (HM and IA) to collect data on whether an x-ray was performed prior to the MRI, the number of orthopaedic outpatient appointments the patient attended and any surgical procedures undertaken following the MRI. One author (IA) then cross checked all the reports to ensure accuracy of data collection.

### 2.3. Outcomes of interest

The outcomes of interest in this study were to identify the frequency of each diagnosis identified on MRI reports and to identify the proportion of patients with each diagnosis who attended outpatient appointments and underwent knee surgery.

### 2.4. Data analysis

Patient characteristics were summarised by calculating means and standard deviations for continuous outcomes (e.g. age) and tabulations to show frequencies for categorical outcomes (e.g. sex and diagnosis). We explored the relationships between variables (e.g. diagnosis and outcomes such as attendance to outpatients or undergoing a surgical procedure) using chi-squared for categorical data or t-tests for continuous outcome data with significance set at the 5% level ( $P < 0.05$ ). Where appropriate and clinically relevant, we explored relationships between combined variables; e.g. patients with both a meniscal tear and ACL injury or patients with a meniscal tear and presence of arthritis with outcomes such as outpatients and surgery. The analysis allowed frequencies and intervention rates for each diagnosis to be summarised concisely. All analyses were carried out using R (R Core team (2013) R Foundation for statistical computing, Vienna, Austria) [16].

## 3. Results

### 3.1. Patient demographics

Between the 1st of January and the 31st of December 2017 4095 patients underwent 4466 MRIs of the knee at UHCW NHS trust; 2302 (51.5%) on males and 2164 (48.5%) on female patients. The mean age of patients undergoing an MRI scan was 45.38 ( $\pm$ SD 17.07) years old. Of the 4466 scans, 3180 (71.2%) were requested by a primary care doctor, 1257 (28.1%) were requested in secondary care with the remainder (0.7%) requested via an integrated musculoskeletal service. The integrated musculoskeletal service is a predominantly physiotherapist led service where patients are reviewed and managed if operative management is not deemed necessary. Previous surgery to the index knee was reported in 341 (7.6%) patients, the most common previous surgery was an ACL reconstruction (114;33.4%) followed by a meniscectomy (88;25.8%).

### 3.2. Frequency of each diagnosis

The most common MRI finding was the presence of signs of arthritis; 2465 (55.2%) patients had signs of arthritis on their MRI report, the mean age of these patients was 52.9 ( $\pm$ SD 14.0) years. Within this group, 941 (38.1%) had an x-ray before an MRI compared to 1524 (61.9%) who did not have an x-ray before MRI. In comparison 866 (43.3%) of patients without signs of arthritis had an x-ray before an MRI (chi-squared test,  $p < 0.001$ ). Of the patients undergoing an MRI of the knee, 1910 (42.8%) were found to have a meniscal tear and of these 621 (32.5%) had no signs of arthritis on their MRI report. The most frequently reported ligament injuries were an ACL tear (371; 8.3%), 200 (53.9%) of which had a combined meniscal tear. All other ligament injuries combined totalled 404 (9%) patients (see Table 1).

Fractures around the knee joint were reported in 82 (1.8%) patients, the tibia being the most common site of fractures (44, 0.99%), followed by the femur (19, 0.43%), patella (14, 0.31%) and fibula (5, 0.11%).

Less common diagnoses identified on MRI included infection (12, 0.27%), patella dislocation (41, 0.9%), patella alta (95, 2.15%), spontaneous osteonecrosis of the knee (SONK) (13, 0.3%) and a tumour or mass (67, 1.5%). A completely normal scan was reported in 259 (5.8%) patients.

**Table 1**

A summary of the frequency of additional ligament injuries diagnosed on the MRI scan and the proportion of patients who underwent surgery.

Other ligament injury	Number (%)	Surgery (%)	No surgery (%)
No other ligament injury	4062 (91)	625 (15.4)	3437 (84.6)
Medial Collateral ligament (MCL)	265 (5.9)	38 (14.3)	227 (85.7)
Lateral Collateral Ligament (LCL)	74 (1.7)	17 (23.0)	57 (77.0)
Posterior Cruciate Ligament (PCL)	30 (0.7)	8 (25.8)	23 (74.2)
MCL and LCL	18 (0.4)	4 (21.1)	15 (78.9)
MCL and PCL	6 (0.1)	3 (50)	3 (50)
Patella tendon	2 (0.09)	0 (0)	2 (100)
Quadriceps tendon	3 (0.07)	0 (0)	3 (100)

### 3.3. Outpatient attendance

Following an MRI scan, 2208 (49.4%) patients attended an outpatient appointment. When comparing the source of referral with attendance to outpatient clinics, we found 1060 out of 3180 (33.7%) patients from primary care and 8 out of 29 (27.6%) patients referred from integrated musculoskeletal requests were followed up in orthopaedic outpatients compared to 1140 out of 1257 (90.7%) patients from secondary care were followed up in outpatients. This difference was statistically significant (chi-squared test,  $p < 0.001$ ). There was no statistically significant difference in male versus female attendance to orthopaedic outpatient appointments following MRI (49.6% of males vs 49.3% of females; chi-squared test,  $p = 0.067$ ).

The proportion of patients with each diagnosis who attended outpatient appointments can be seen in [table 2](#). Patients with meniscal tears were significantly more likely to be seen in outpatient clinics compared to patients without a meniscal tear (51.9% of patients with meniscal tears vs 34.2% without meniscal tears, chi squared test  $p < 0.001$ ). Similarly patients with ACL tears were significantly more likely to be seen in outpatients compared to patients without ACL tears (65% vs 48.1%, chi squared test  $p < 0.001$ ). The presence of signs of arthritis on the scan was associated with significantly lower attendance to outpatients compared to patients without arthritis (46.1% vs 53.5%, chi-squared test  $p < 0.001$ ).

Patients with a reported infection, tumour or mass or patella dislocation were significantly more likely to be reviewed in orthopaedic outpatients compared to those without these diagnoses, see [table 2](#).

### 3.4. Surgery

Out of the 4466 MRI knee scans performed in 2017, 697 patients (15.6%) subsequently underwent knee surgery. Of those patients who attended an outpatient appointment ( $n = 2208$ ), 693 (31.8%) underwent surgery. There was a significantly higher proportion of surgery in the patients who had their MRI requested in secondary care compared to primary care, 282 out of 3180 patients (8.9%) underwent surgery following primary care requests compared to 414 (32.9%) patients from 1257 secondary care requests (chi-squared test,  $p < 0.001$ ). Male patients were also more likely to undergo surgery compared to female patients (17.4% vs 13.7%, chi-squared test  $p < 0.001$ ).

The proportion of patients with each diagnosis who subsequently underwent surgery is demonstrated in [table 3](#) and [Table 1](#) provides a summary of the rate of surgery for additional ligament ruptures. Patients with a meniscal tear had a significantly higher rate of surgery compared to those without a meniscal tear (19.7% of patients with a meniscal tear underwent surgery compared to 12.6% of patients without a meniscal tear, chi-squared test  $p < 0.001$ ). Similarly, patients with an ACL tear had a significantly higher rate of surgery compared to patients without these diagnoses (36.4% vs 13.7%, chi-squared test  $p < 0.001$ ). The presence of arthritis suggested patients were significantly less likely to undergo surgery compared to patients without arthritis (13.6% vs 18%, chi-squared test  $p < 0.001$ ). The rate of surgery was significantly higher for patients with an infection (41.7% vs 15.5%, chi-squared test  $p = 0.012$ ) (see [table 3](#)). There was also no difference in rates of surgery for patients with patella dislocation (22% vs 15.5%, chi-squared test  $p = 0.261$ ), patella alta (12.6% vs 15.8%, chi-squared test  $p = 0.420$ ) or for patients with a tumour or mass (9% vs 15%, chi-squared test  $p = 0.130$ ).

**Table 2**

Frequency of each diagnosis for patients attending outpatients clinics. Percentages are reported as the percentage of patients with each diagnosis attending outpatients clinics., and the p values report results of chi-squared tests. \* indicates a significant p value ( $<0.05$ ). No p value possible for infection as 100% if patients with an infection presented to outpatients.

Presence or absence of each diagnosis (Y indicates report identified the presence of diagnosis in question)		Number of patients attending outpatients (% of patients with each diagnosis that attended outpatients) ( $n = 4466$ )	p-value (Chi-squared test)
Meniscal tear	Y	992 (51.9)	0.004*
	N	1216 (34.2)	
ACL tear	Y	241 (65.0)	<0.001*
	N	1967 (48.1)	
Signs of arthritis	Y	1137 (46.1)	<0.001*
	N	1071 (53.5)	
Patella dislocation	Y	27 (65.9)	0.035*
	N	2181 (48.6)	
Patella alta	Y	47 (49.5)	0.994
	N	2161 (49.4)	
SONK	Y	8 (37.9)	0.382
	N	2200 (49.4)	
Infection	Y	12 (100)	No value
	N	2196 (49.3)	
Tumour/mass	Y	44 (65.7)	0.007*
	N	2164 (49.2)	

**Table 3**

The frequency of each diagnosis subsequently undergoing surgery and the p value (based on chi squared test). Percentages are reported as the percentage of patients with each diagnosis attending outpatients. \* indicates a significant p value (<0.05). No p value possible for SONK as no patients with SONK underwent surgery.

Presence or absence of each diagnosis (Y indicates report identified the presence of diagnosis in question)		Number of patients undergoing surgery (% of patients with each diagnosis that had surgery)	P value (Chi-squared test)
Meniscal tear	Y	376 (19.7)	<0.001*
	N	321 (12.6)	
ACL tear	Y	135 (36.4)	<0.001*
	N	562 (13.7)	
Signs of arthritis	Y	336 (13.6)	<0.001*
	N	361 (18.0)	
Patella dislocation	Y	9 (22.0)	0.261
	N	688 (15.5)	
Patella alta	Y	12 (12.6)	0.420
	N	685 (15.8)	
SONK	Y	0 (0)	No value
	N	697 (15.7)	
Infection	Y	5 (41.7)	0.012*
	N	692 (15.5)	
Tumour/mass	Y	6 (9.0)	0.130
	N	691 (15.7)	

#### 4. Discussion

Over a one year period 4466 MRI knee scans were performed at this large trust with the over 71% of scans being requested in primary care, compared to 28% requested in secondary care. The most common diagnosis was the presence of the arthritis, followed by meniscal tears and ACL tears. 49% of all patients with an MRI knee performed were seen in outpatients and in particular patients with a meniscal tear, ACL tear, patella dislocation, infection and tumour or mass were significantly more likely to be seen in outpatients than patients without these diagnoses. Patients with signs of arthritis were significantly less likely to be referred to secondary following the MRI scan. 15% of patients subsequently underwent surgery following their MRI scan. Patients with a meniscal tear, ACL tear and infection were significantly more likely to undergo surgery than patients without these diagnoses. Again, patients with signs of arthritis were significantly less likely to undergo surgery than patients with arthritis.

The rate of meniscal tear diagnosis found in this study (42%) was higher than previous work which had found the rate to be between 30–31% [16], although this study reported the rate in asymptomatic uninjured patients only. A reason for the higher rate in our study is that we included symptomatic patients who had scans requested by both primary and secondary care. Signs of arthritis were found in 55.2% of patients included in this study compared to 62% of scanned knees in previous literature [16]. The rate of ACL ligament rupture found in this study was lower than previously reported (8% vs 17%) [14]. The rate of SONK was much lower in this study compared to previous literature (0.3% vs 3.4%) [17]. A reason for this is the range of patients included in this study was 1–98 and SONK has been found to be more common in older patients [17]. As a result, the overall rate is expected to be lower in this study as we included patients of all ages, whereas the previous study only included patients above 50 years old.

The rate of outpatient referrals for MRIs requested in secondary care was significantly higher than the rate of outpatient referrals for MRI requested by the General Practitioner (GP) (90.7% vs 33.3%,  $p < 0.001$ ). This is unsurprising, however, of particular interest is that only 1060 out of 3180 (33.7%) patients who had an MRI request in primary care required a secondary care review suggesting that the majority of scans do not change practice and are therefore unnecessary requests. The rate of subsequent surgery for MRIs requested in secondary care was also significantly higher than the MRIs requested in primary care (32.9% vs 8.9%,  $p < 0.001$ ). This is similar to previous work which reported that MRI scans requested by orthopaedic surgeons resulted in significantly more arthroscopic interventions compared to scans requested by primary care physicians (39.3% versus 22.2%;  $p < 0.001$ ) [8]. These findings raise the question as to whether a knee MRI and in particular a MRI request in primary care changes practice, in particular as over 2000 MRIs were requested in primary care that did not require further review in secondary care. This study also found that orthopaedic surgeons were significantly less likely to request MRIs for patients with signs of arthritis [8]. This is agreement with the results of our study where we found 62% of the MRIs requested by a GP had signs of arthritis compared to 38% of MRIs requested in secondary care having signs of arthritis ( $p < 0.001$ ).

The knee is one of the most common sites for an MRI scan, however, as evidenced by this study the intervention rate in terms of operations is low. In addition, we found 55% of patients had signs of arthritis, only 38% of these patients had an X-ray before a MRI. The use of plain radiography is the investigation of choice for arthritis [18], therefore the use of radiographs could have prevented the need for an MRI. In addition, research has questioned the effectiveness of surgery for meniscal

tears in the context of arthritis [19]. The identification of degeneration on plain radiographs combined with clinical examination could avoid the need for a MRI scan and a referral to secondary care in general. This study has shown that although primary care doctors are responsible for requesting the majority of MRI knees, the rate of arthroscopic intervention was significantly higher for secondary care requested MRIs. It could be argued that to ease the burden on radiology services, MRIs should be requested in secondary care only. However, previous work has shown although it is more costly for primary care doctors to request the scans, the study reported the probability of early MRI being cost effective at £20,000 per Quality-adjusted life year (QALY) gained is 0.93 [20]. This randomised controlled trial (RCT) only included 553 patients and was performed in 2002. All patients all had orthopaedic outpatient appointments which factored into the costs so not representative of current practice where only one third of primary care requests are seen in an outpatient clinic.

The implementation of shared decision making with patients could have an important role in reducing unnecessary MRIs. Patients expectations may be that an MRI is needed to assess for internal derangement of the knee and that tears may be managed operatively. This could lead to an increase in requests for MRIs as clinicians respond to patient expectations [21]. However, it is important to note almost a third of patients will have a meniscal tear with the majority being asymptomatic and not requiring surgery [22]. Research has also suggested conservative management options are favoured for meniscal tears [23,24]. It is important that after responding to patient emotions, clinicians should deliberate with patients about the available evidence [21]. This could lead to a shared decision to avoid requesting a MRI and moving on to conservative management.

This study reported the diagnosis and outcome of all MRIs performed at a large NHS trust. By using the radiology clinical codes we are certain all consecutive MRIs performed over the year were included in this study. Hospital electronic records were consulted at least 1 year after the MRI scan to ensure appropriate time to account for waiting lists for subsequent operations. Two authors reviewed all MRI reports to ensure accuracy of the data collection and to our knowledge this is the largest series of consecutive MRIs reviewed and associated with clinical outcomes such as outpatient attendance and knee surgery. Weaknesses of this study include we did not include clinical findings such as symptoms, duration of symptoms and examination findings in our results. In particular, this impacts the findings regarding intervention rate as the presence or absence of certain clinical features could influence treatment decisions. In addition, many of the primary care referrals could be due to repeated attendances to the primary care physician. Although this is a large sample of over 4000 patients the reports were produced by multiple radiologists at the trust, this could lead to potential biases as each radiologist may be subjective in their assessment of certain secondary diagnosis. However, the aim of this study was to describe the incidences of each diagnosis in current clinical practice. By using a sample from a large NHS trust employing multiple radiologists it allows the authors to provide incidences which are representative of current clinical practice. Another weakness of this study is patients could have been referred to NHS or private hospitals outside this trust. As a result the outcomes would not be included in our intervention rate. This is particularly true for tumours or masses as all suspected cases are managed at a specialist bone tumour centre, nonetheless, for all other diagnoses we believe our rates are a true reflection of the intervention rates. Another limitation of this study is the absence of reporting incidences of different types of arthritis, this was due to the study including reports produced by multiple radiologists who used different terms to describe signs of arthritis.

## 5. Conclusion

MRI is a widely used investigation for knee pain with 4466 scans performed at a single large NHS trust. Despite its use only 50% of patients attend an outpatient clinic following the scan and 15% undergo subsequent surgery. The most common diagnosis is signs of arthritis, despite this a small proportion have a radiograph performed before an MRI. Over 70% of MRI scan are requested by primary care doctors, however, MRI scans requested in secondary care had significantly higher rates of outpatient attendance and subsequent surgery compared to MRIs requested in primary care. We urge clinicians to be more vigilant in their use of MRI scans, to implement shared decision making to reduce unnecessary requests and to consider the use of plain radiographs prior to requesting a MRI. Further research is needed to explore the clinical and cost effectiveness of MRIs requested in primary care versus MRIs requested in secondary care.

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Level of Evidence: Retrospective case series, Level IV.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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