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CLINICAL RESEARCH

Magnetic Resonance Imaging of the Hip: Poor Cost Utility for Treatment of Adult Patients With Hip Pain

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Abstract

Background Although MRI is frequently used to diagnose conditions affecting the hip, its cost-effectiveness has not been defined.

Questions/purposes We performed this retrospective study to determine for patients 40 to 80 years old: (1) the differences in hip MRI indications between orthopaedic and nonorthopaedic practitioners; (2) the clinical indications that most commonly influence treatment decisions; (3) the likelihood that hip MRI influences treatment decisions separate from plain radiographs; and (4) the cost of obtaining hip MRI studies that influence treatment decisions (impact studies).

Methods We retrospectively assessed 218 consecutive hip MRI studies (213 patients) at one institution over a 5-year interval. Medical records, plain radiographs, and MRI studies were reviewed to determine how frequently individual MRI findings determined treatment recommendations (impact study). The cost estimate of an impact study was calculated from the product of institutional MRI unit cost (USD 436) and the proportion of impact studies relative to all studies obtained either for a specific indication or by an orthopaedic/nonorthopaedic clinician.

Results Nonorthopaedic clinicians more frequently ordered hip MRI without a clinical diagnosis (72% versus 30%, $p < 0.01$), before plain radiographs (29% versus 3%, $p < 0.001$), and with less frequent impact on treatment (6% versus 15%, $p < 0.05$). Hip MRI most frequently influenced treatment when assessing for a tumor (58%, $p < 0.001$) or infection (40%, $p < 0.001$) and least frequently when assessing for pain (1%, $p < 0.002$). Hip MRI impacted a treatment decision independent of plain radiographic findings in only 7% of studies (3% surgical, 4% nonsurgical). Hip MRI cost was least when assessing for a neoplasm (USD 750) and greatest when assessing undefined hip pain (USD 59,000). The cost of obtaining an impact study was also less when the ordering clinician was an orthopaedic clinician (USD 2800) than a nonorthopaedic clinician (USD 7800).

Conclusions Although MRI can be valuable for diagnosing or staging specific conditions, it is not cost-effective as a screening tool for hip pain that is not supported by history, clinical examination, and plain radiographic findings in patients between 40 and 80 years of age.

Level of Evidence Level IV, economic and decision analysis study. See Instructions for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
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Introduction

MRI can be useful in the diagnosis and treatment of conditions affecting the hip. Over the past two decades, it has become an accepted modality for assessing occult fractures of the femoral neck [2, 5, 8, 18, 21] and staging osteonecrosis of the femoral head [3, 15, 23]. More recently, it has emerged as a modality for the assessment of hip deformity [1, 12], articular cartilage disease [9, 11, 14], acetabular labral pathology [4, 6, 10, 19, 20], inflammatory or infectious disease [13, 16], and reactions to metal-on-metal THAs [7]. Although MRI may be valuable in answering specific diagnostic questions, it is not clear that current patterns of hip MRI use are cost-effective for the surgical evaluation and treatment of hip pain in adult patients at an age when osteoarthritis is most prevalent. We performed this retrospective study to determine among patients between 40 and 80 years of age: (1) What differences exist in study indications between orthopaedic and nonorthopaedic practitioners? (2) What clinical indications for hip MRI most commonly influence treatment decisions? (3) What is the likelihood that a hip MRI would influence a treatment decision beyond what could already be determined by plain radiographs? (4) What is the estimated cost of obtaining an MRI study that influenced a treatment decision (impact study) with respect to the study indication and the ordering provider?

Patients and Methods

After obtaining institutional review board approval, we conducted a retrospective review of 218 consecutive hip MRI studies performed on 213 patients aged between 40 and 80 years during a 5-year interval (January 2006 to December 2010).

All MRI scans were accomplished during the study interval using an MRI scanner with a 1.5-T magnet. Imaging studies focused on the requested hip and not the entire pelvis. All studies had a written report submitted by one of several staff radiologists at our institution. MRI reports were assessed to determine patient age at the time of the study, clinician ordering the MRI, indication for the MRI, and reported MRI diagnosis. Radiology records were assessed to determine whether plain radiographs had been obtained before the hip MRI and the resulting radiographic diagnosis. The electronic medical record was reviewed to determine whether the patient was referred for additional treatment, had received an operative or nonoperative recommendation for treatment, or had any documentation that delineated clinical use of information obtained from the MRI study. The composite MRI and plain radiographic findings were used to determine whether the MRI study findings were integral to directing a course of treatment that could not have been advised on the basis of the findings from the plain radiographs alone (impact study).

The mean patient age was 60 years (SD, 11 years). Primary care, emergency room, or other nonorthopaedic clinicians ordered 179 hip MRI studies (82%). The remaining 39 studies (18%) were obtained by either an orthopaedic surgeon (14%) or orthopaedic physician assistant (4%). Seventy-two percent of MRI studies (157 MRI studies) demonstrated either no structural disease (85 hips [39%]) or osteoarthritis (72 hips [33%]). The remaining 61 studies (28%) demonstrated a variety of clinical or incidental diagnoses (Table 1). Among the 54 MRIs (25%) obtained before obtaining plain radiographs, only three studies (2%) identified a specific abnormal condition. Plain radiographs had been obtained for 164 of the 213 patients (77%) before the MRI with a normal study documented for 66 patients (31%) and diagnostic findings for 97 patients (46%). Fifty-five of the 213 patients (26%) had moderate or advanced osteoarthritis on plain radiographs, an additional 14 patients (7%) had Ficat Stage II or more advanced osteonecrosis, and 28 patients (13%) had other specific processes that were visualized on plain radiographs and supported by clinical history (eg, tumor, infection, fracture, femoroacetabular impingement, acetabular dysplasia). Overall, there were 34 patients (16%) who underwent surgical treatment. Twenty-three patients (67%) had diagnostic plain imaging studies before surgery. THA or resurfacing arthroplasty accounted for 24 procedures (71%), including one patient with an impact study MRI diagnosing femoral head osteonecrosis.

We used our institutional fixed unit cost for lower-extremity MRI (USD 436) to calculate a procedural cost utility for both the ordering clinician and study indication with the following formula:

Table 1. Indications for hip MRI among patients 40 to 80 years of age

Study indication	Hips (N = 218)	Surgery	No surgery	MRI-directed treatment selected
Pain	136	15 (11.0%)	121 (89.0%)	1 (0.7%)
AVN	30*	11 (36.7%)	19 (62.3%)	3 (10%)
Labral tear	11	1 (9.1%)	10 (90.9%)	0 (0%)
Infection	10	3 (30%)	7 (70%)	4 (40%)
Tumor	12	2 (16.7%)	10 (83.3%)	7 (58.3%)
Fracture	9	1 (11.1%)	8 (88.9%)	1 (11%)
OA	5	1 (20.0%)	4 (80.0%)	0 (0%)
Other diagnosis	5	0 (0%)	5 (100.0%)	0 (0%)

* Nine hips also had osteoarthritis on plain radiographs; AVN = avascular necrosis; OA = osteoarthritis.

$$\text{Institutional MRI unit cost (USD 436)} \times \frac{\text{number of total studies performed}}{\text{number of impact studies}}$$

The ratio of total studies performed divided by the number of impact studies provides a proportional estimate of the number of studies required to yield a single MRI study that impacted a treatment decision (impact study). When this proportional quotient is then multiplied by the MRI unit cost, it provides an estimate of the total cost required to produce each impact study. Therefore, the costs reported in this study are the total costs for all MRIs performed before one study impacts the treatment plan for a patient; and this cost estimate is reported for both the indications cited in the study request and the categorical physician type (orthopaedic versus nonorthopaedic clinician).

Categorical variables were assessed using either the chi square test or Fisher's exact test and continuous variables were assessed using a two-tailed Student's t-test.

Results

Nonorthopaedic clinicians were more likely than orthopaedic clinicians to obtain a hip MRI to assess for pain rather than a specific suspected diagnosis (72% versus 30%, $p < 0.01$). Nonorthopaedic clinicians were also substantially more likely than orthopaedists to obtain an MRI before completion of plain radiographs (29% versus 3%, $p < 0.0001$) or to request an MRI when a plain radiograph indicated moderate to severe osteoarthritis (13% versus 3%, $p < 0.001$). The MRI more frequently contributed to the treatment decision when ordered by an orthopaedic surgery provider compared with a nonorthopaedic provider (15% versus 6%, $p < 0.05$) (Table 2). Twenty-eight patients had simultaneous MRIs of their hip and either their knee or spine ordered by a nonorthopaedic clinician. All 28 hip MRI studies (100%) had a normal interpretation.

The most common indications for the hip MRI were the assessment of pain (136 studies [69%]), femoral head osteonecrosis (30 studies [14%]), tumor (12 studies [6%]), acetabular labral tear (11 studies [5.0%]), infection (10 studies [5%]), and fracture (nine studies [4%]) (Table 2). Of these indications, the hip MRI was more likely to guide a treatment decision when the study was performed to assess a specific diagnosis (15 of 82 studies [18%]) rather than hip pain without a diagnosis (one of 136 studies [1%], $p < 0.002$). A statistically significant benefit for the study was noted when assessing for a tumor (58%, $p < 0.001$), infection (40%, $p < 0.01$), or femoral head osteonecrosis (10%, $p < 0.02$). The other clinical diagnoses did not impact a decision toward treatment within a level of statistical significance.

The hip MRIs in this series rarely influenced treatment decisions. Although a clinical diagnosis that might have influenced a treatment decision was present for 34 patients (16%), only 16 patients (7%) were directed toward either surgical or nonoperative treatment.

The cost estimates reflect the yield of impact studies based on diagnosis and ordering practitioner (Table 3). When hip pain alone was the indication for the hip MRI, the cumulative institutional cost of obtaining a single study that positively impacted a treatment decision was USD 59,296. In contrast, when an MRI was obtained for a specific diagnosis, the average cumulative cost for obtaining an impactful study was USD 2383. MRI was the most cost-effective when used to evaluate a neoplasm (USD 747). The cost for obtaining an impactful study was three times greater when the ordering practitioner was a nonorthopaedist (USD 7804) in comparison with an orthopaedic surgeon (USD 2834).

Table 2. Results by category of practitioner ordering study

Ordering practitioner	Number	Mean age (years)	Indication pain:specific diagnosis	Radiographs not ordered	Moderate-severe OA	MRI contributed to surgical decision
Nonorthopaedist	179 (82%)	61.7	138:41 (73%)	52 (29%)	24 (13%)	10 (6%)
Primary/emergency department physician	165 (76%)	61.8	125:41 (70%)	42 (25%)	21 (13%)	10 (6%)
Other subspecialist	14 (7%)	60.2	13:0 (100%)	10 (71%)	3	0 (0%)
Orthopaedic practitioner	39 (18%)	54.7 ($p < .001$)	12:27 (30.8%)	1 (2.6%)	1 (2.6%)	6 (15.4%)
Orthopaedic surgeon	30 (14%)	54.6	9:21 (30%)	0	1 (3%)	5 (17%)
Orthopaedic physician assistant	9 (4%)	54.8	3:6 (33%)	1 (11%)	0	1 (11%)
Total	218	60.4	15:68 (69%)			16 (7%)

OA = osteoarthritis.

Table 3. Estimated cost of obtaining an impact study

Study indication	Hips (N = 218)	MRI-directed treatment selected	Impact study cost (USD)
Pain	136	1 (1%)	59,296
Specified diagnosis (any)	82	15 (18%)	2383
AVN	30	3 (10%)	4360
Fracture	9	1 (11%)	3924
Infection	10	4 (40%)	1090
Tumor	12	7 (58%)	747
Labral tear	11	0 (0%)	4796
OA	5	0 (0%)	2180
Other diagnosis	5	0 (0%)	2190
Ordering practitioner	**Hips (N = 218)**	**MRI-directed treatment selected**	**Impact study cost (USD)**
Orthopaedic surgeon	39	6 (15%)	2834
Nonorthopaedic practitioner	179	10 (6%)	7804

AVN = avascular necrosis; OA = osteoarthritis.

Discussion

MRI of the hip can be useful in the detection of specific conditions affecting the hip. When a clinical diagnosis is supported by history, examination, and radiographic studies, the MRI can be effective in confirming a diagnosis and assisting in preoperative surgical planning. However, our results suggest that MRI is a poor tool when used in the assessment of patients presenting with pain without a strong clinical suspicion for a specific diagnosis and for instances in which pain cannot be delineated between adjacent anatomic regions (eg, lumbar spine and knee).

There are several notable study limitations of this retrospective observational study: (1) There is some inherent selection bias because the majority of patients evaluated were predominantly male, with a mean age of 60 years, and the study findings may not accurately reflect patterns of hip MRI evaluations in communities with a balanced sex representation or a younger age demographic. (2) The majority of studies were obtained by primary care clinicians before consideration of a subspecialty referral and it is possible that a subset of patients who were not referred for subspecialty evaluation after their MRI study could have had an imaging study ordered by an orthopaedic specialist after referral. (3) Our selection of a positive treatment decision as the primary outcome measure of value may undervalue the consideration that negative treatment decisions may benefit individual patients or reduce systemic costs of healthcare delivery. A decision against referral for potentially costly operative or nonoperative interventions after a normal hip MRI could have a cost-benefit that we were unable to delineate from our study. Our cost analysis only accounts for the direct costs of the imaging study and does not assess for indirect costs of care, including opportunity costs from time away from employment or additional physician office visits to discuss the results of diagnostic testing or orthopaedic subspecialty consultant assessment. (4) Other indirect costs, including potential opportunity costs related to positive economic behavior for patients (eg, return to employment), after the outcome of either a positive or negative study outcome can also be difficult to quantify and were not assessed. (5) Cost estimates can be imprecise for other reasons including the use of different cost measurements (eg, billing charges, collected charges, and direct costs of care), regional variability in procedure costs, and variability in reimbursement based on payor status. Because this study was accomplished within a federal facility, the fixed costs of obtaining an MRI study reflect basic costs of the technology maintenance and operation. Although we anticipate that these would project lower than actual costs, this may not be an accurate impression.

Nonorthopaedic clinicians were more likely than orthopaedic clinicians to obtain a hip MRI to assess for pain rather than a specific suspected diagnosis before completion of plain radiographic imaging or when plain radiographs had indicated moderate to severe osteoarthritis. Although orthopaedic clinicians were three times more likely to obtain a hip MRI study that had a positive impact on treatment decision-making and their study requests cited indications that were for a specified diagnosis in 69% of cases, the yield of a study that impacted a surgical decision still was less than 13%. There is limited available literature reviewing the use of hip MRI. Lee et al. [17] reported no significant differences in the indications and outcomes of knee MRI when ordered by orthopaedists and nonorthopaedists when the majority of

studies were being obtained by orthopaedic surgeons. Although knee MRI use in the past may have reduced systemic healthcare costs by limiting the use of knee arthroscopy, proposed cost savings for an MRI when performed instead of diagnostic arthroscopy do not reflect contemporary clinical practice. With respect to hip MRI use in this study, the substantial majority of studies were obtained on patients before referral to an orthopaedic surgeon for evaluation. In addition, orthopaedists and nonorthopaedic practitioners differed in their indications for obtaining a hip MRI study.

Our study findings suggest that evaluation to confirm or define severity of a specified condition was more likely to result in a positive decision for operative or nonoperative treatment after the study. Hip MRI procedures performed to assess for pain without a specified clinical diagnosis were exceptionally unlikely to yield study findings that affected a treatment decision. The delineation of pathology with the use of MRI alone does not always necessitate operative intervention. Several publications have indicated the value of MRI in determining the presence of occult hip fractures, which have frequently resulted in a recommendation for surgical stabilization [8, 19, 22]. However, it could be argued that a nondisplaced fracture of the hip that cannot be visualized on plain radiographs may not require operative intervention and the direct costs of nonoperative management may be less than those of operative intervention. In the current study, only one of nine proximal femur fractures identified with MRI (11%) was treated with surgery. This fracture was visible on plain radiographs; therefore, no patient with a fracture had a treatment recommendation that was influenced by the MRI findings exclusive of plain radiographic findings. Although the decision for protected weightbearing for each of these patients did not require the MRI study, it is recognized that medicolegal considerations still direct the practice of obtaining an MRI to exclude an occult hip fracture for these patients. Moreover, the limited number of patients assessed for this indication does not afford clinically or statistically significant observations. Although MRI can be useful in the staging of osteonecrosis for nonarthroplasty surgical options, the majority of patients between 40 and 80 years of age were treated with arthroplasty at our institution, because MRI was often advocated to assess for the presence of osteonecrosis when the hip already had postcollapse disease. Although MRI effectively confirms the presence of labral tears identified at arthroscopy, our study infrequently identified acetabular labral tears without concurrent degenerative articular changes [6, 11, 20]. When acetabular labral tears are identified on MRI, they are commonly associated with structural, osseous deformity of the acetabulum or femoral neck [10, 22].

The hip MRIs in this series rarely influenced treatment decisions. Only 16 patients (7%) of patients received a treatment recommendation after their hip MRI study. Our observations suggest that our institutional mechanism for ordering a hip MRI did not require either the identification of an expected diagnosis in advance of the MRI or a review of plain radiographs before obtaining the MRI study. Essentially one-third of patients who were referred for a hip MRI study had diagnostic plain radiographs that indicated the presence of at least moderate osteoarthritis or postcollapse osteonecrosis. In this age group, the majority of surgical procedures performed were hip arthroplasties and a decision to move forward with this surgical approach was not contingent on the results of the MRI study. Although this observation is most likely related to the average patient age (60 years), it highlights the importance of obtaining plain radiographic images before MRI, because the majority of commonly occurring and clinically significant conditions affecting patients between 40 and 80 years of age is more likely to be treated with arthroplasty than joint preservation procedures. For ambulatory patients presenting with hip pain, conventional plain radiographs should be obtained before consideration of MRI to assess for structural deformity, osteoarthritis, or advanced osteonecrosis. Although other studies have demonstrated increased sensitivity with MRI for the assessment of pathological conditions affecting the femoral neck and potentially could guide prognosis and management of stress conditions affecting the hip, there have been few studies that have directly compared the effectiveness of MRI and plain radiographic imaging among adult patients with hip pain. Although this study does not directly compare the two imaging modalities, the findings of this study reflect that the institutional practice during the years of the study (before 2010), the majority of identified conditions could have been diagnosed with plain imaging studies before the use of a more advanced and more costly imaging study.

Hip MRI was most cost-effective when used to confirm a diagnosis with substantial severity to warrant intervention. For the 135 patients who had MRI to assess hip pain and had a normal study, the cost of the MRI for our institution was USD 59,000. Extrapolation of the study findings would suggest that selective use of hip MRI for older adult patients could result in substantial cost reduction on a national scale. Hip radiographs are substantially less expensive than MRI and may identify structural deformity of the hip that would obviate the need for soft tissue assessment. Hip MRI is most cost-effective when a specific diagnosis is suspected–but cannot be confirmed–based on history, clinical examination, and plain radiographic findings. To our knowledge, this is the first study that has assessed the relative costs of obtaining advanced imaging studies for adult patients with a suspected hip condition of interest.

Although MRI can be a valuable tool for staging the severity of hip disease for some conditions among patients at an age appropriate for a nonarthroplasty procedure, it is not a cost-effective tool for the diagnosis of radiographically silent hip pain among middle-aged adult patients. Protocols to develop a process for obtaining hip MRI will be helpful to improve utilization approaches and help to control costs of care, particularly for use among patients older than 50 years, who are unlikely to benefit from hip surgery other than arthroplasty.

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