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COST EFFECTIVENESS OF MAGNETIC RESONANCE IMAGING OF THE KNEE

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The history and physical examination of the knee in patients with knee complaints are known to be nonspecific in determining the cause of internal derangement. In a recent comprehensive study, physical evaluation of the knee was performed in 161 patients with knee pain of at least 1-year duration.[8] The predictive value of five common clinical tests (McMurray, flexion pinch test, Apley grind test, joint line tenderness, extension block) for the detection of meniscal tears was evaluated in a prospective fashion and compared to athroscopic findings. The authors found a correlation between joint line tenderness and meniscal pathology in 68 of 80 patients with a proven meniscal tear. Overall the sensitivity was 85.5% and the specificity only 29.4%. Sixty-five patients had pain in forced flexion for a sensitivity of only 50% and a specificity of 68.2%. McMurray test and extension block were insensitive in predicting meniscal tears. In patients with anterior cruciate ligament (ACL) tears, only the presence of block to extension showed predictive value for meniscal tear. The authors concluded that clinical diagnosis has considerable limitations when used to confirm meniscal lesions of the knee.

In patients in whom the clinical diagnosis is uncertain, physicians must therefore turn to other diagnostic techniques to determine the appropriate treatment. Prior to the advent of MR imaging, plain radiography, arthrography, CT arthrography, and diagnostic arthroscopy were employed. Plain radiography is clearly insensitive, whereas arthrography is invasive although considerably more accurate when performed by the most skilled of users.[8,16,23] CT arthrography may be accurate[17] but is expensive and invasive and exposes the patient to ionizing radiation. These factors, among others, have led to the use of arthroscopy as the diagnostic procedure of choice of orthopedic surgeons.[14]

Although diagnostic arthroscopy is expensive and invasive, proponents point to its accuracy and to the surgeon's ability to diagnose and treat pathology with a single procedure.[2] Unfortunately, diagnostic arthroscopy sometimes demonstrates no abnormality, clinically insignificant lesions such as plicae or chondromalacia patellae, or a totally different diagnosis.[15] Consequently, patients may be subjected to an unnecessary operative procedure with its associated risks and potential morbidity.

Magnetic resonance imaging, a relatively new imaging technique for the knee, has been shown in multiple studies to have excellent

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sensitivity and specificity.[4,5,17,20,24] The wide range of reported accuracies can be attributed partly to scanner type, imaging technique, radiologist's experience, and choice of gold standard. For example, accuracy in diagnosing medial meniscus tears increased from 86% to 93%, sensitivity increased from 84% to 97%, and negative predictive value increased from 86% to 96% when comparisons were drawn between a mobile 0.35-T and a stationary 1.5-T machine.[7] Variables in this study were minimized through the use of the same technique and radiologist. Using the same patient for both scanners would be ideal but has yet to be reported. Using a 1.5-T magnet, Mink et al[18] reported an overall MR imaging accuracy of 93%. They observed that the false-positive MR imaging rates varied from 6% to 16% among 37 general orthopedic surgeons, but was only 6% for the knee subspecialist arthroscopist.

Arthroscopy is usually used as the gold standard for determining MR imaging accuracy but in actuality, the accuracy rates of arthroscopy and MR imaging are not dissimilar. Each is highly dependent on the surgeon's operative expertise and the radiologist's technical and interpretive expertise, respectively.

Quinn and Brown[19] reported that some MR imaging false-positive findings as measured against arthroscopic findings may be attributed to inadequate visualization of the meniscus at arthroscopy. They conducted a study of 254 consecutive patients who underwent both knee MR imaging and arthroscopy. All the arthroscopic procedures were videotaped. There were 17 false-positive MR imaging findings as determined by the results of the operative report or the statement of the surgeon. Fifty-three percent (9 of 17) represented high signal lines that extended to the articular surface of the posterior horn which were visualized incompletely when the arthroscopic videotapes were reviewed. In 11.8% (2 of 17), postmeniscectomy irregularities were found but were not considered clinically significant by the arthroscopist. Forty-one percent (7 of 17) were high signal abnormalities involving the free edge or the entire meniscus that did not correlate with clinically significant tears. Of 32 false-negative findings, 46.7% (15 of 32) were small tears not necessitating meniscectomy. Seventeen of 32 of the false-negative findings were treated with a partial meniscectomy, and 9 of these were radial tears or abnormalities of the inner third of the meniscus. Considering only significant tears missed, the false-negative rate was 3% (17 of 508).

The authors conclude that false-positive findings on MR imaging studies involving the posterior horn may actually indicate the inability of the arthroscopist to adequately visualize the meniscus.[19] Not all segments of the posterior horn can be visualized easily. False-positive MR imaging scans may also reflect the subjectivity with which postsurgical appearances and free edge irregularities are labeled. False-negative MR imaging scans often represent small tears diagnosed by compression or probing at arthroscopy, most of which are managed nonsurgically and hence not a retrospective justification for arthroscopy.

Magnetic resonance imaging is useful to discern between those patients without significant internal derangements of the knee and those who would benefit from therapeutic arthroscopy.[5,11,17] In addition to guiding treatment, MR imaging further aids the surgeon in terms of preoperative planning. Plans for meniscal repair can be made in appropriate patients based on the MR imaging scan. Isolated ACL injuries, based on instability patterns, can be treated electively whereas young patients with combined meniscal tears and ACL disruption can be treated with meniscal repair and ACL reconstruction.

A limitation of many of the studies comparing MR imaging to arthroscopy is a failure to use the final outcome of the patient as the standard of comparison.[9,22] The success of MR imaging can be judged by two criteria: patient outcome and cost effectiveness. If MR imaging can preclude an unnecessary arthroscopy, it should be judged as beneficial. Furthermore, if it helps a significant number of patients avoid the cost of diagnostic arthroscopy, MR imaging in all patients may also save money, that is, be cost effective. A few recent studies have attempted to determine if MR imaging in all patients with suspected internal derangement is cost effective compared to diagnostic arthroscopy in diagnosing internal derangement of the knee. Boden et al[2] concluded on the basis of a cost analysis formula that diagnostic arthroscopy would be more cost effective than MR imaging if 78% of the patients underwent arthroscopy. The study cohort consisted of a select population that excluded patients who were older, had no history of a specific injury, had surgery, or had knee complaints of greater than 6 months' duration. In their study, MR

imaging was not cost effective because 87% of the patients underwent arthroscopy. However, this study had several limitations.[25] First, the final outcome of the patients was not ascertained, that is, did the patient benefit from arthroscopy? The authors provided no information on the clinical course for the 47 patients who received arthroscopy. Patients who failed to improve following arthroscopy would hardly be a triumph for arthroscopy. Second, the authors failed to define MR imaging criteria. Third, no criteria for avoiding a diagnostic arthroscopy were stated. It is not clear why or how the surgeons used MR imaging and if the decision to use arthroscopy was made before and despite the MR imaging findings.

Gelb et al[10] recently reported the results of their study in which 67 consecutive patients who had previously undergone MR imaging of the knee were evaluated prospectively in their sports medicine clinic.[10] Thirty-seven percent of the MR imaging scans were ordered by health care personnel other than orthopedic surgeons. Sixty-four percent of patients had their MR imaging study ordered on initial presentation, 6 patients without having a physical examination, and 21% had the MR imaging scan prior to obtaining plain films of the affected knee.

Thirty-five patients underwent arthroscopic evaluation and treatment. Based on these patients, the authors reported by clinical examination a sensitivity and specificity of 100% for the diagnosis of ACL injury, and 90% for isolated meniscal injury. For MR imaging the authors reported a 94% sensitivity and 82% specificity for ACL injury and an 82% and 83% respective sensitivity and specificity for meniscal lesions.

Their specificity of 90% for meniscal lesions is among the highest reported in the literature[1,6,8,13] and dramatically higher than that reported by Fowler and Lubliner.[8] The authors conclude that based on their experience, MR imaging is not cost effective.[10]

In a recent study attempting to determine if MR imaging is cost effective and reduces the need for diagnostic knee arthroscopy, only 43% of patients underwent immediate therapeutic arthroscopy based on MR imaging findings.[22] During a 9-month period, 103 consecutive patients with knee complaints sufficient to warrant a diagnostic arthroscopy and compatible with the diagnosis of internal knee derangement underwent a 1.5-T MR imaging examination. The criteria for inclusion were persistent knee pain, recurrent knee effusions, repeated episodes of giving-way, a positive McMurray test, a positive flexion pinch test, or significant acute trauma. Patients with a normal MR imaging scan or MR imaging diagnoses of isolated ligament tears or intrasubstance meniscal changes did not receive immediate therapeutic arthroscopy. These patients were evaluated at a minimum of 17 months after the MR imaging scan by questionnaire or phone interview.

Patients were classified as successes if they had not had a subsequent positive diagnostic arthroscopy and were functionally normal without significant activity limitation, had received a subsequent negative arthroscopy, or had received ligament reconstruction for known chronic instability (and had no other treatable lesion in the knee). Patients were classified as failures if they received a subsequent positive arthroscopy or had persistent complaints limiting activity. Cost effectiveness was based on the estimated costs of $1000 per knee MR imaging scan for all patients and a savings of $3900 for each patient not receiving a diagnostic arthroscopy (Fig. 1). The cost effectiveness of all patients with knee complaints receiving MR imaging was calculated as follows: the cost of all patients receiving an MR imaging scan, plus the cost of all patients who received an immediate therapeutic ar-

(103 x 3900) - [(103 x 1000) + (44 x 3900) + (6 x 3900)] = 103,000

All patients Surgery	All patients MRI	Surgery Patients	Failures	Savings

Figure 1. Formula used to calculate cost effectiveness of MR imaging versus diagnostic arthroscopy at the Yale University Sports Medicine Center.

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