TRAUMATIC KNEE EVALUATION WITH 0.2T MRI

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SUMMARY – The possibilites of MR diagnosing knee pathology on high field scanners of 1T and 1.5T are well known. A sensitivity of 87%-100% and specificity of 64%-100% in diagnosing meniscal pathology are quoted in the literature. The aim of this work was to define the sensitivity and specificity of evaluation of meniscal lesions and cruciate ligament tears with a 0.2T permanent magnet of low field strength, as well as of other associated lesions of the bone, cartilage and collateral ligaments. We wished to estimate the value of particular sequences and projections of scanning chosen for certain pathology, and to recommend the type of scanning. MR findings were correlated with arthroscopy as the "gold standard method" in evaluating knee pathology. Two radiologists of different clinical experience interpreted MR findings by the principle of "interobserver difference". A total of 40 patients were examined, 32 men and 8 women, aged 17-46, mean age 27±5 years. The following sequences were used always in three projections: SE 1500/38; SE 1500/25; SE 1700/40; SE 200/38; SR 550/25; SR 550/38; GE 100/23/45; GE 100/23/60; and GE 500/23/40. We conclude that low field MRI is as sensitive and specific as diagnostic arthroscopy for traumatic meniscal lesions, yet better due to its noninvasiveness. MRI 0.2 T is of a lower specificity and sensitivity in detecting anterior cruciate ligament and chondral lesions in comparison with arthroscopy.

Introduction

The aim of this paper is to present diagnostic possibilities of 0.2T MRI as a noninvasive examination in evaluating traumatic conditions of the knee joint in comparison with arthroscopy, an invasive method. The goal is to look upon the sensitivity and specificity of MR in examining the menisci and cruciate ligaments, chondral disorders, bone traumatic changes and collateral ligaments; also, to assess the value of certain sequences and planes of projection. The results were correlated with arthroscopy, which still represents the "gold standard" examination technique in our country, and were interpreted by two radiologists (resident and specialist) in order to assess the interobserver difference.

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Patients and methods

Forty patients, 32 men and 8 women, aged 17-46, mean age 27±5 years, were examined with 0.2 MRI. The criterion of including patients into the study was a positive clinical finding by orthopedic surgeon. Each patient was introduced into the study in detail, and an informed consent was obtained. Arthroscopy was performed within 30 days from initial MR examination. In each patient, meniscal pathology, cruciate ligament tear, chondral lesions and bone changes were analyzed. The following sequences were used in sagittal and coronal projections, and axial and other projections were included as necessary: SE 1500/38, SE 1500/25, SE 1700/40, SE 200/38, SR

550/25, SR 550/38, GE 100/23/45, GE 100/23/60, and GE 500/23/40. Standard 5-mm sections were done.

Statistical analysis was performed by χ^2-test, χ^2-test as modified by Yates, McNemars and Fisher methods.

Results

Our results showed a 95% sensitivity and 91% specificity for both interpreteurs, without statistically significant differences between them in the evaluation of medial meniscal tears. For the lateral meniscal tears, the interpreteurs showed an 85% sensitivity but different specificity, 100% and 50% (taking into account the different levels of education of the interpreteurs), i.e. a statistically significant difference occurred due to the first interpreteur's reporting less negative findings. In the analysis of body tear with definite medial meniscal tear, a sensitivity of 85% and 86%, and specificity of 50% were found for both interpreteurs.

The first interpreteur identified grade III in 71.42%, grade II in 25%, and grade I in 3.5% of patients. The second interpreteur produced identical results for grade III and I meniscal tears, however, he reported on grade II meniscal lesion in 21.42% of patients. Arthroscopy pointed to 92.85% of meniscal tears and identified none of grade I and grade II lesions. Both interpreteurs diagnosed lateral meniscal tear in 53.85% of patients, whereas arthroscopy confirmed rupture in 69.23% of patients. The first interpreteur recorded lateral meniscal lesions of grade I in 15.38% and grade II in 26.92% of patients. The second interpreteur recored lateral meniscal lesions grade I in 11.54% and grade II in 19.23% of patients. Arthroscopy did not verify any grade I or grade II meniscal lesion. Both interpreteurs differed significantly from arthroscopy in grade I and grade II interpretations.

It is also very important not to mistaken the popliteal tendon with a vertical rupture of the lateral meniscus. We had 2 (5%) false positive interpretations in this series.

Our findings showed the majority of medial meniscal tears to be oblique and complex. The findings of the second interpreteur correlated well with arthroscopy for 16.67% of complex and 30.56% of oblique tears. The sensitivity and specificity in defining tear course in relation to arthroscopy were 95% and 92%, for the first interpreteur, and 97% and 94% for the second interpreteur, respectively.

The majority of diagnosed tears of the lateral meniscus were also oblique and complex. A significantly greater number of anterior horn tears were observed on arthroscopy. These were patients with a concomitant anterior cruciate ligament (ACL) tear. A number of these tears were defined by the arthroscopist as contusion of the anterior horn rather than a true tear. The sensitivity and specificity in defining tear course in relation to arthroscopy were 89% and 93% for the second interpreteur, and 95% and 91% for the first interpreteur, respectively.

Our results classified bucket handle tear as definite in 2.5%, and arthroscopy in 7.5% of cases.

The first interpreteur diagnosed ACL tear in 75%, and the second in 66.67% of patients. Arthroscopy verified 100% of ACL tears (in 12 of 40 patients). The second interpreteur differed significantly from arthroscopy due to more negative results. The first interpreteur showed a 60% and the second 70% sensitivity, whereas both showed a specificity of 83%. This could be explained by the introduction of the method, and as yet inadequate experience in the traumatic knee positioning in these patients, as well as by the observation that incomplete tears were not definitely interpreted, i.e. partial tears may have become complete by the time of arthroscopy was done.

Our results showed the first interpreteur to have diagnosed chondral lesions in 37.50%, and second interpreteur in 75% of patients, whereas arthroscopy detected chondral lesions in 100% of patients (eight of 40 patients). There was a statistically significant difference in the findings of the first interpreteur *versus* arthroscopy due to more negative results. The sensitivity was 24% for the first interpreteur and 57% for the second interpreteur, whereas the specificity was 100% due to no false negative findings. However, only osteochondral fractures and major full thickness chondral tears were detected with MR, whereas arthroscopy revealed partial thickness tears and cartilage softening, i.e. lower grade chondral lesions.

Discussion

The diagnostic value of MR imaging of the knee joint has been very well known for the last 15 years. This technique is highly sensitive and specific, and has supplemented diagnostic arthrography in defining meniscal lesions[1-8]. In addition to differentiating well meniscal tears and other meniscal pathology, synovitis and cruciate ligament lesions can also be clearly demonstrated[9-12]. Most of the literature present reports from high field strength resonators[1-13] or intermediate field strength resonators[14-18]. Only a few papers have indicated that diagnostically appropriate images can be obtained with low field resonators[14-19]. Advances in hardware and software technology, with the development of dedicated pulse sequences, have improved the results of viewing and diagnosis with low field resonators. Recent studies, mostly in Italy, on a larger population of patients with Arthroscan, a dedicated MR system for the extremities, have been presented. Riel *et al.*[20] demonstrated a 93% sensitivity and 97% specificity for lesions of medial meniscus, and 82% sensitivity and 96% specificity for lateral meniscus tears. Kreitner *at al.*[21] evaluated their results according to the clinical experience of the interpreteur, and demonstrated an 81%-92% sensitivity and 74%-92% specificity for medial meniscus tears, and 61%-83% sensitivity, and 86%-93% specificity for lateral meniscus tears. Fischer *et al.*[5] showed that 17% of MR grade II meniscal lesions were found to have true meniscal tears on arthroscopy. Crues *et al.22* also found that 17 tears in 154 menisci (11%) were prospectively graded as I or II on MR. These data indicate a relatively low reliability for negative MR examination. This could also be explained either by the progression of small or intrasubstance tears to complete ones by the time when arthroscopy was performed, or by underestimation of grade III signal intensity. Underestimation may occur if tears are oriented parallel to the plane of the image and are seen as abnormal morphology without changes in signal intensity. Some comparative studies show that the analysis with 1.5 T machines is more reliable than with lower field strength machines. However, a lower level of accuracy for the 1.5 T system has also been reported[5]. At a very low field strength (0.064T), a 79% agreement between MR and arthroscopy was found in diagnosing meniscal tears[23].

The understanding of the meniscal tear morphology may be of practical value for the surgeon's view and prognosis. Tears are divided into vertical, horizontal and complex. Vertical tears are further divided into simple vertical, peripheral, meniscocapsular separation and bucket-handle ruptures. Horizontal tears are divided into cleavage, radial, oblique and parrot-beak tears. Numerous classifications have been advocated for meniscal tears on the basis of surgical findings, mechanism, and other factors. Horizontal cleavage tears of the posterior medial meniscus are most frequent, commonly occurring in the elderly as the result of degeneration. Vertical tears occur slightly more often in the lateral meniscus as the result of trauma. Using arthroscopy findings as the gold standard reference, the accuracy of MR in the evaluation of meniscal tear is between 72%-94%. About 80%-94% of tears graded as MR signal III have a rupture verified arthroscopically.

False positive MR results, seen in about 10% of cases, are often in direct relationship with misinterpretation of MR findings. However, neither is arthroscopy a perfect gold standard in the evaluation of meniscal tears. Literature reports vary from 69.8% to 98.0% of accuracy[22]. Correlating MR results with arthroscopy, we found a 95% sensitivity and 91% specificity for both interpreteurs, showing high reliability for MR findings even on low-field strength scanners, having in mind close evaluation with clinical findings of the orthopedic surgeon. It is well known that without extensive probing, arthroscopists may often underestimate tears in the periphery and inferior surface of the posterior medial meniscus.

Nearly 70% of so-called false positive MR imaging results are found in the posterior medial meniscus. This may indicate that false positive MR findings actually represent false negative arthroscopic findings.

Bucket handle tears often involve medial meniscus and represent a vertical or oblique tear with full thickness longitudinal extension that propagates within the meniscus. The inner fragment frequently is displaced into the intercondylar notch in a way that resembles a handle, and the peripheral nondisplaced fragment is the "bucket". Keeping in mind that no change in the intrameniscal signal intensity must be seen, MR shows abnormality of the meniscal morphology: the nondisplaced fragment shows a truncated triangular appearance or reduced height, with nonvisualization of the meniscal body (absence of the bow tie). A "double posterior cruciate ligament" sign indicated the displaced fragment of the meniscus on sagittal and coronal images.

Meniscal lesions can be visualized on a number of projections. Routinely, sagittal projections may be sufficient and diagnostic. Coronal scans are often used as second confirmation of the location and morphology. Only occasionally, axial scans may define tear morphology. Peripheral posterior coronal scan may imitate discoid meniscus. The diagnosis of discoid meniscus is more reliable on sagittal and mid-coronal sections.

ACL tear is usually connected with medial compartment trauma often seen in skiers and football players. The result of ACL tear is anterolateral instability of the knee joint. Lee *et al.*[37] have reported 78%-89% clinical sensitivity of tests for ligament rupture. With 15-20° of external rotation and neutral extension of the leg, ACL is well seen on a single image or on two adjacent sagittal images in 95% of patients. The following signs are present showing ACL tear: discontinuity of the ligament and fluid filling defect, edematous mass replacing whole or part of the ligament, forward translation of the tibia in relation to the femur, acute angulation or buckling of the posterior cruciate ligament, fragment of ACL with abnormal orientation, focal angulation, tears at femoral or tibial (less frequent) attachments, bone contusion at the lateral compartment, and deepened lateral femoral notch. Mink *et al.*[30] have described 10 false positive and 3 false negative cases in the diagnosis of ACL tears from a total of 242 MR examinations. The sensitivity, specificity and accuracy were 92%, 95% and 95%, respectively. Fischer *et al.*[5] report on a series of 1014 patients in whom MR imaging results were true positive in 173 cases, true negative in 757, false positive in 54, and false negative in 13 cases. The accuracy, specificity and sensitivity were 93% each.

T2 weighted images are significantly more sensitive in detecting ACL tears. If the findings on sagittal images are equivocal, coronal planes are helpful. Also, commonly associated injuries should be searched for (tears of MCL, menisci, lateral compartment bone contusion).

Articular cartilage changes including focal erosions, contour irregularity, and thinning can be seen in patients with traumatic conditions such as osteochondral fractures, chondromalacia patellae, degenerative osteoarthritis, and synovial inflammatory processes. Hyaline cartilage is normally increased in signal intensity relative to meniscal fibrocartilage on T1 and T2 weighted images due to the higher content of type II collagen and hydroxylysine. Chandnani *et al.*[42] have shown in cadavers that a 3-mm chondral defect can be properly seen on T2 weighted sequences in the presence of fluid. Gradient echo sequences are best in giving contrast between the articular cartilage of higher signal and cortical bone of lower signal. The interface between joint fluid and cartilage is best differentiated with the use of moderate flip angle (20-30°). Recent advances in chosen sequences show that depicting chondral defects is best with hybrid sequences with fat saturation. Mori *et al.* analyzed partial and full thickness tears with the magnetization transfer technique and achieved 88%-93% accuracy.

Conclusion

In conclusion, low field MRI is diagnostically useful and equally reliable as compared with diagnostic arthroscopy in evaluating traumatic meniscal lesions, however, we prefer MRI as the method of choice for its noninvasiveness and multiplanar capabilities of pathology visualization. In our series of 40 patients, low field MRI was less reliable in showing ACL tear and chondral lesions, i.e. diagnostic arthroscopy proved superior. Recent software advances and development of new sequences and techniques have further improved the method. We conclude that proton density, T1-weighted sequences are sufficient in traumatic meniscal lesion evaluation, in sagittal and coronal projections, however, we recommend SE T2 and GE sequences to diagnose ACL pathology. We think GE sequences are superior for cartilage evaluation, while T2 weighted sequences in coronal and axial planes are of help.

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Sažetak

MAGNETSKA REZONANCIJA U DIJAGNOSTICI OZLJEDA KOLJENSKOGA ZGLOBA

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Mogućnosti MR dijagnostike patologije koljenskoga zgloba na uređajima 1 i 1.5 T su poznate. U literaturi se navodi osjetljivost od 87%-100% i specifičnost od 64%-100% u dijagnostici patologije meniska na tim uređajima. Cilj rada bio je ustanoviti osjetljivost i specifičnost, odnosno vrijednost MR-e u pregledu meniska i ukriženih ligamenata koljenskoga zgloba MR-om 0.2T, niske jačine magnetskog polja, kao i procijeniti pridružene ozljede MR-om (ozljede hrskavice, kosti, kolateralnih ligamenata). Dobiveni MR nalazi korelirani su s artroskopijom kao zlatnim standardom. MR nalaze provjerilo je dvoje radiologa po načelu među promatračima ("interobserver difference"). Pregledano je ukupno 40 bolesnika, od toga 32 muškarca i 8 žena, u dobi od 17-46 godina, prosječne životne dobi 27±5 godina. Sljedeće sekvence su bile napravljene uvijek u tri projekcije: SE 1500/38; SE 1500/25; SE 1700/40; SE 200/38; SR 550/25; SR 550/38; GE 100/23/45; GE 100/23/60; GE 500/23/40. U zaključku: MR 0.2T je jednako osjetljiva metoda kao dijagnostička artroskopija u procjeni traumatskih ozljeda meniska, no dajemo joj prednost zbog neinvazivnosti. MR niske jačine polja slabije je osjetljiva metoda od artroskopije u procjeni lezije prednjega ukriženog ligamenta te ozljeda hrskavice.