

Optimization of Radiological Diagnostics of Injuries of the Soft Tissue Structures of the Knee Joint and Their Complications

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Abstract Relevance. The main advantages of MRI are the ability to directly visualize and simultaneously assess the state of the synovial membrane, articular cartilage, fibrocartilaginous structures, bones and paraosseous soft tissues, as well as the possibility of morphological identification of tissues and control of tissue contrast based on their different signal characteristics in different modes of study. The aim of the study is to improve the radiological diagnosis of injuries to the soft tissue structures of the knee joint and their complications. Material and methods. The study included 11 patients with partial and complete cruciate ligament injuries. Research results. Ligamentous apparatus injuries were clinically characterized by various manifestations. In the case of cruciate ligament injuries, clinical symptoms were nonspecific and included pain, swelling, and limitation of movement in the joint, and a drawer symptom. Conclusion. Due to the possibility of obtaining a multi-plane spatial image of the ligaments with the help of MRI, a significantly higher quality image of the ACL, including due to the lack of anisotropy effect and the need for forced knee flexion, MRI is a more effective diagnostic method in recognizing injuries of the ligamentous apparatus.

Keywords Knee joint, Damage to intra-articular structures, Diagnostics, Ultrasound, Magnetic resonance imaging, Arthroscopy

1. The Relevance of Research

Considering that only 6% of injuries of the knee joint are related to bone structures, and the rest to damage to soft tissue structures [3,6,7], the role of ultrasound and MRI, highly informative methods for diagnosing menisci and ligaments of the knee joint, becomes obvious. The main advantages of MRI are the possibility of direct visualization and simultaneous assessment of the state of the synovial membrane, articular cartilage, fibrocartilaginous structures, bones and paraosseous soft tissues, as well as the possibility of morphological identification of tissues and control of tissue contrast based on their various signal characteristics in different modes of study [2,4,8]. Therefore, the use of MRI is a highly informative non-invasive (as opposed to arthroscopy) method for diagnosing injuries of the knee joint, but insufficient availability and high cost of examination limit the use of this method at present.

The literature data on the diagnostic value of ultrasound in injuries to the soft tissue structures of the knee joint [1,3,9]

are rather high, but still not informative enough, compared with MRI and arthroscopy, which requires further improvement of the method. The indicators of the effectiveness of ultrasound in relation to damage to each intra-articular element of the knee joint, especially the ligaments, are insufficiently covered, which would allow to optimize the algorithm of clinical and radiation examination [5,7,10].

Thus, the high frequency of injuries and insufficient knowledge of pathological changes in the knee joint determine the urgency of the problem and substantiate the need to improve the issues of radiological diagnosis of pathologies of the soft tissue structures of the knee joint.

2. Aim of the Study

Aim of the study is to improve the radiological diagnosis of injuries to the soft tissue structures of the knee joint and their complications.

3. Research Material

The study included 11 patients with partial and complete cruciate ligament injuries.

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4. Research Results

In 36.4% of cases, the presence of fluid in the volvulus and the joint cavity was determined. Signs of deforming arthrosis were not identified in this group. In 19.3% of patients with ligament injuries, areas of bone marrow edema were identified.

Ligamentous apparatus injuries were clinically characterized by various manifestations. In the case of cruciate ligament injuries, clinical symptoms were nonspecific and included pain, swelling, and limitation of movement in the joint, and a drawer symptom.

X-ray of joints in patients of this group in 80.8% of cases did not reveal any pathological changes, and in 19.2% - signs of subluxation in the joint were determined. Ultrasound signs of cruciate ligament injury were local changes at the site of injury as compared to the contralateral side. In case of complete ruptures, the site of injury was filled with a hematoma, which was detected as an an- or hypoechoic zone with or without hyperechoic inclusions. In case of partial damage to the ligaments at the site of damage, an - or hypoechoic area, thickening and partial interruption of the ligament fibers, concomitant edema of soft tissues was determined.

The damage to the anterior cruciate ligament according to ultrasound was characterized by a decrease in echogenicity (69%) and its thickening (67%) compared to the contralateral side (Fig. 1). The diagnosis was difficult because the anterior access for the ultrasound beam was limited, since the patient could not bend the knee optimally due to pain. When viewed from the posterior approach, in 26% of cases, a delimited accumulation of a hypoechoic fluid along the lateral edge of the intercondylar sulcus was revealed, which corresponded to the appearance of a hematoma.

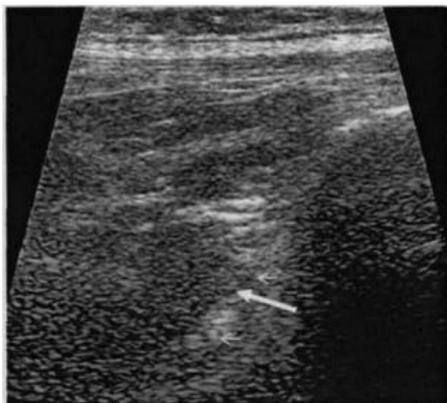


Figure 1. Echogram of the knee joint. Partial damage to the anterior cruciate ligament

Ultrasound criteria for posterior cruciate ligament rupture were reduced echogenicity (98%) and thickening (92%) compared to the contralateral side (Fig. 2). Compared to the anterior cruciate ligament, there are no serious imaging limitations in diagnosing posterior cruciate ligament injuries due to the more superficial location and the lack of the need for maximum knee flexion.



Figure 2. Echogram of the knee joint. Partial injury to the posterior cruciate ligament

MPT signs of traumatic damage to the ligaments were mainly confined to the appearance of an area of increased MP signal intensity in the ligament substance. In case of rupture of the anterior cruciate ligament, both direct and indirect signs of damage were considered. Direct signs of ACL damage on MRI scans were discontinuity in the low-intensity band of the ligament (92%), an increase in the intensity of the MP signal on T2-WI (90%), partial or complete absence of an image (84%), a change in the ligament axis, concavity or undulation of the contour (75%) (Fig. 3). Acute injuries were always accompanied by edema and hemorrhage of varying severity. Therefore, often with a rupture on MP-tomograms, the complete absence of an image of the ligament was determined with the presence of a zone of edema or hemorrhage in its projection. In such a situation, indirect (secondary) symptoms of rupture provided significant assistance in making the diagnosis. These included: concussions or depressed subchondral fractures of the lateral condyle of the CD and articular surfaces of the TBC (19.3%), anterior tibial displacement (6.4%), a marginal fracture of the outer part of the proximal tibial epiphysis (5.2%).

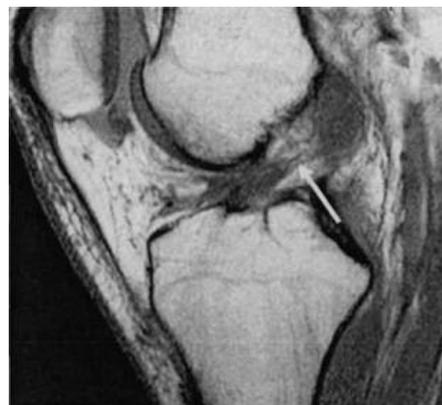


Figure 3. MRI of the knee joint. Sagittal projection. Partial damage to the anterior cruciate ligament

MPT signs of posterior cruciate ligament rupture included the presence of areas of increased intensity in the ligament substance (100%), disorder of the internal structure (98%),

changes in the diameter and wave-like contours of the ligament (91%), as well as the absence of an image of part of the ligament (86%) (Fig. 4).

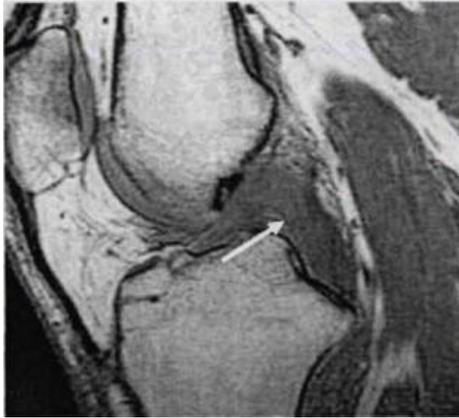


Figure 4. MRI of the knee joint. Sagittal projection. Partial injury to the posterior cruciate ligament

Arthroscopic intervention for injuries of the cruciate ligaments of the knee joint was performed in all patients (Fig. 5).

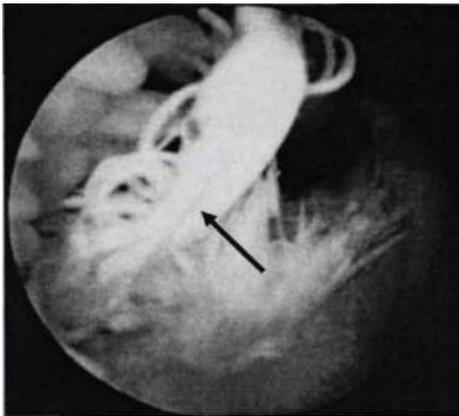


Figure 5. Arthroscopy. Anterior cruciate ligament rupture

Thus, the analysis of clinical observations showed that ultrasound and MRI were effective in recognizing injuries of the ligamentous apparatus, and the complex application of these methods in controversial cases helps the final diagnosis.

With the help of ultrasound, 11 cases of ligament injuries were diagnosed. There were 2 false negative cases in total and 1 case was false positive.

Knee ultrasound made it possible to reveal signs of ligament ruptures with a sensitivity of 71.7%, a specificity of 95.8%, and an accuracy of 85.8%.

Ultrasound revealed a false-positive result in 1 case, which were mistaken for breaks and 2 false-negative results, which were confirmed as breaks during verification. False positive results were associated with the presence of anisotropic effect, when an apparent decrease in the echogenicity of the ligaments occurs. All false-negative results were due to poor visualization of the cruciate ligament due to the lack of maximum flexion of the knee

joint for optimal access to the ligament, as well as due to pronounced muscle and subcutaneous fat layer in large and obese patients.

MRI also diagnosed 11 cases of ligament injury. A total of 1 case were false-negative, no false-positive results were found.

The sensitivity of MRI in diagnosing ligament ruptures was 98.6%, specificity - 100%, accuracy - 99.4%.

No false-positive results were found on MRI, but 1 false-negative result was present when ACL rupture was detected on arthroscopy.

Arthroscopy also diagnosed 11 cases of ligament injury. There were no false-negative and false-positive results in total.

Arthroscopy showed no false positive or false negative results, i.e. the sensitivity, specificity and accuracy of arthroscopy in diagnosing ligament ruptures was 100%.

5. Conclusions

Thus, when diagnosing ruptures of the ligamentous apparatus of the knee joint, ultrasound, MRI and arthroscopy demonstrate high diagnostic capabilities in comparison with radiography, since these methods can reveal direct signs of damage to the ligaments that are not visible on radiographs. Indicators of the diagnostic significance of MRI in detecting ligament ruptures are higher than with ultrasound. The X-ray method is low-informative in relation to data on pathological changes in the ligamentous apparatus, but this method must be used as a technology designed to exclude other pathological processes.

Analysis of the results of the study of patients in this group allowed us to clarify the ultrasound and MP symptoms of ligament injuries. The main ultrasound criteria for detecting damage to the ligamentous apparatus were a thickening and a decrease in echogenicity, violation of the integrity of the fibers, their anatomical continuity. Intra- and periarticular edema was an additional sign. Although these ultrasound signs for the knee ligaments were identical, there were also differences in diagnosis. Edema of soft tissues was absent with damage to the LCS, due to its extracapsular location, which made ultrasound diagnostics much more difficult. There were also differences in the diagnosis of injuries of the lateral ligaments and the patella's own ligament from the cruciate ligaments and were associated with the following points. First, the depth of the cruciate ligaments, especially the ACL, is greater than the others, which directly leads to a decrease in the quality of ultrasound imaging. Secondly, the possibility of maximum flexion of the knee joint for optimal visualization of the ACL is often limited by pain, which practically excludes an adequate diagnosis of its damage. And, thirdly, this is the effect of anisotropy, which worsens the diagnosis of the cruciate ligaments to a much greater extent than the lateral ligaments, and even more so, the patellar ligament itself. MPT signs of traumatic damage to the ligaments were reduced to the appearance of an area of

increased intensity of the MP signal on T2-WI in the ligament substance, discontinuity of a low-intensity ligament strip, partial or complete absence of its image, change in the ligament axis, the presence of a localized zone of edema or fluid accumulation around the ligament. Due to the possibility of obtaining a multiplanar spatial image of the ligaments with the help of MRI, a significantly higher quality image of the ACL, including due to the lack of anisotropy effect and the need for forced knee flexion, MRI is a more effective diagnostic method in recognizing injuries of the ligamentous apparatus. presence of a localized area of edema or fluid accumulation around the ligament. Due to the possibility of obtaining a multi-plane spatial image of the ligaments with the help of MRI, a significantly higher quality image of the ACL, including due to the lack of anisotropy effect and the need for forced knee flexion, MRI is a more effective diagnostic method in recognizing injuries of the ligamentous apparatus.

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