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SHORT
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Efficiency of High-Resolution MRI at Different Stages of Subchondral Insufficiency Fracture of the Knee

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Abstract

The history of subchondral insufficiency fracture is closely related to a pre-existing diagnosis of spontaneous osteonecrosis of the knee (SONK). Previously, it was thought that subchondral linear or lunate pathological changes on magnetic resonance imaging (MRI) scans in elderly patients with a history of osteoporosis are the result of spontaneous osteonecrosis, but in the 2000s, studies by T. Yamamoto showed that a small proportion of patients with osteonecrosis of the femoral head initially have a fracture of insufficiency that gets complicated by secondary osteonecrosis. Subsequent studies of SONK also showed that the subchondral insufficiency fracture is precisely the initial process, osteonecrosis is secondary and it is a complication of the fracture. The aim of our study was to evaluate the effectiveness of high-resolution MRI at different stages of this disease.(**International Journal of Biomedicine. 2022;12(1):67-69.**)

Key Words: high-resolution MRI • osteoporosis • knee

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Introduction

Insufficiency fracture is a type of stress fracture that usually occurs in individuals over 50-55 years of age with normal joint stress. The reason for this fracture is the weakening of the trabeculae of the subchondral bone marrow of any condyle of the knee joint, more often the medial one.[1-4] The history of the diagnosis of insufficiency fracture is associated with the fact that in a number of cases, researchers led by T. Yamamoto[5] found a non-classical diagnostic picture when osteonecrosis of the femoral head was suspected, which later turned out to be an insufficiency fracture. And subsequent studies by T. Yamamoto et al.[5-7] showed that in the knee joint, in patients with a presumed diagnosis of spontaneous osteonecrosis, the insufficiency fracture was the initial process resulting from the weakening of trabeculae in the subchondral bone, and osteonecrosis was a secondary and optional process. It should be noted that at the initial stages of insufficiency fracture, the process is not complicated with early treatment of the patient, and osteonecrosis and subchondral collapse (flattening of the articular surface) are secondary and, in fact, they are a complication of the insufficiency fracture itself.[8] The main methods for diagnosing subchondral insufficiency fracture are primary radiography and MRI.[9] X-ray of the knee joint has limited capabilities since it does not allow visualization of the edema and the area of subchondral fracture at the early and advanced stages of the process.[9] In this case, the MRI is the method of choice since it has more possibilities for assessing the state of the bone and soft tissues of the joint.[9]

MRI-semiotics

Diagnostic MRI criteria for subchondral insufficiency fracture include diffuse bone marrow edema of the affected articular condyle[8,10] (Fig.1), hypointense fracture line on T1-WI and fluid-sensitive modes (T2- and PD with fat suppression – FS) (Fig.2), hypointense "thickening" on T1- and PD-FS (T2-FS) in the area of the cortical bone layer (Fig.3). In the presence of complications in the form of secondary osteonecrosis in the area of subchondral fracture, there is a risk of collapse (flattening) of the articular surface of the affected condyle of the joint. The area of secondary osteonecrosis on liquid-sensitive tomograms PD-FS (T2-FS) is visualized as an

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area of increased signal in the area between the fracture line and the subchondral cortical bone layer[10] (Fig.4). Subchondral collapse (flattening) of the affected articular surface is shown in Figure 5.

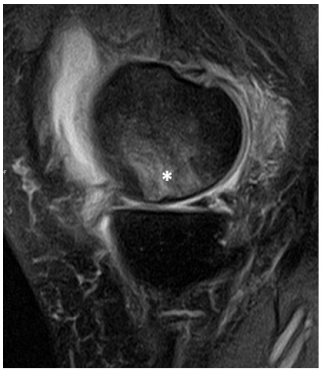

Fig. 1. *MRI (PD-FS). Subchondral edema in the fracture zone (asterisk).*

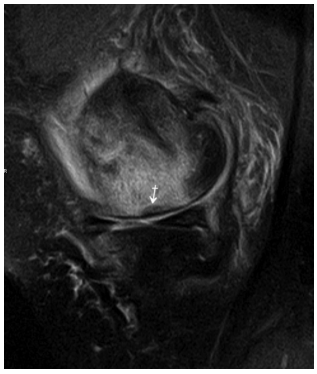

Fig. 2. *MRI (PD-FS). Insufficiency fracture. Fracture line (arrow)*

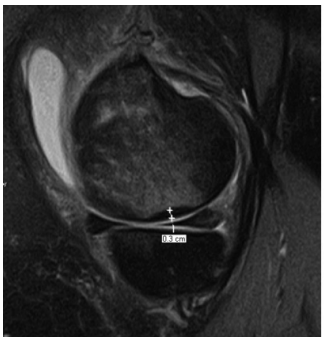

Fig. 3. *MRI (PD-FS). Insufficiency fracture. Hypointense "thickening" (measured).*

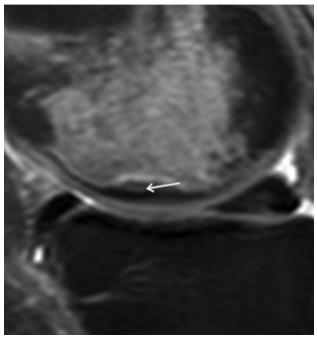

Fig. 4. *MRI (PD-FS). The area of increased signal (zone of secondary osteonecrosis).*

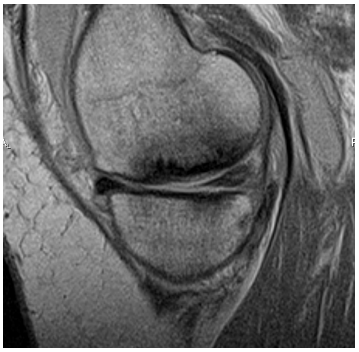

Fig. 5. *MRI (PD-WI). Insufficiency fracture. Subchondral collapse of the weight-bearing aspect femoral condyle.*

Materials and Methods

We studied 150 patients with subchondral insufficiency fracture at different stages of the process. For the purpose of clinical control of the diagnosis, the patients underwent control MRI after 3 months with a second consultation with an orthopedist. MRI was performed on a 1.5T MRI machine (Toshiba) using a 4-channel knee coil. Scanning parameters: PD-, PD-FS, T1-WI, coronal, sagittal, and axial plane, matrix 288x384, FOV 15 cm. An early stage of subchondral fracture was found in 39 patients (up to 3-4 days from the onset of the disease), 82 patients had an advanced stage of the disease, and 29 patients had a stage of complications. The ratio of men to women was almost equal - 48% men and 52% women. The average age of the studied patients was 63.1 (range 51-89 years) years. The standard formulas were used to calculate the sensitivity, specificity, and accuracy of the MRI method at an early stage, an advanced stage, and a stage of complications.

Results

The most common localization of insufficiency fracture in the knee was the medial condyle of the femur (79,3%), the second most frequent was the lateral condyle of the femur - 12%; 8,0% of lesions were localized in the medial parts of the tibial plateau and only 0,6% in the lateral parts of the tibial plateau. Localization of insufficiency fractures was predominantly central (coronary scans) - 76.5%, in the peripheral regions in 23.5% of patients. On sagittal tomograms, the fracture zone was also localized mainly centrally (middle third of the condyle) - 81.4%, in 17.6% of patients in the posterior parts of the condyle, and only 1% in the anterior third of the condyle. Synovitis was also found in 100% of cases in patients with insufficiency fracture and perifocal edema of the surrounding soft tissues in 91% of cases. Quite often, a fracture of insufficiency was combined with a rupture of the meniscus; in our survey, 91.3% of patients had a rupture of the adjacent meniscus, more often the medial one (78.2%). The chondromalacia zone (Noyes) of the adjacent articular surface was found in 96.7% of patients.

The information content of the MRI study consisted of the calculation of the sensitivity, specificity, and accuracy of the method at three stages: early stage, advanced stage, and at the stage of complications. The survey gave the following results (Table 1).

Table 1.

The informativeness of MRI at different stages of subchondral insufficiency fracture

Criteria	Early stage	Advanced stage	Stage of complications
Sensitivity	97.2%	100%	96.0%
Specificity	66.6%	75.0%	75.0%
Accuracy	94.8%	98.7%	93.1%

Thus, at an early stage in the presence of subchondral edema and the formation of a fracture line, there is some risk of an erroneous diagnosis since posttraumatic condyle contusion and transient osteoporosis of the knee condyle have a similar MRI picture; therefore, the sensitivity of MRI at this stage is very high, but the specificity does not show such high numbers.

At the stage of complications, there is a risk of a false-positive result because subchondral collapse of the affected condyle can be the outcome of osteoarthritis or acute impression fracture. Therefore, the specificity of the MRI method at the stage of complications is not so high.

In general, as shown in the table, the informativeness of the MRI method is rather high at different stages of subchondral insufficiency fracture.

In conclusion, subchondral insufficiency fracture of the knee is an urgent medical problem that requires high-quality early diagnosis. The method of choice for subchondral insufficiency fracture is a high-resolution MRI of the knee joint, which demonstrates high sensitivity, specificity, and accuracy.

Competing Interests

The authors declare that they have no competing interests.

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