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Research Article

Magnetic Resonance Imaging Diagnostics of Changes in the Articular Cartilage of the Knee Joint in Football Players

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Abstract

The success of targeted surgical and medical treatment leads to an increase in clinical interest in the early diagnosis of degenerative changes in articular cartilage. Magnetic resonance imaging (MRI) is currently the most effective non-invasive method for visualizing and monitoring of damages of the articular cartilage of the knee joint. This article presents the results of a study of the articular cartilage of the knee joint in athletes based on the measurement of T2 relaxation time. Numerous studies have shown positive results in identifying structural changes in articular cartilage..

Keywords: Magnetic Resonance Imaging; T2 Mapping; Articular Cartilage of the Knee Joint; Diagnostics; Athletes

Introduction

A long-term study of the localization and nature of traumatic injuries of the musculoskeletal (MSK) system of athletes revealed that the most vulnerable link is the knee joint, which accounts for about 50% of all MSK system pathology [1]. Athletes of various specializations have the most common injuries of the knee joint (KJ). Anatomical and functional features of the KJ during sports cause very frequent injuries and disorders. Overstrain of the musculoskeletal system leads to sprains, ruptures of the lateral and cruciate ligaments, and damage of the meniscus.

"Sports injuries are the injuries obtained in training or during competition when an athlete performs a set of exercises to maintain or improve its physical condition or aims to achieve a certain athletic result" [2]. More acceptable definition to the sports injury has been given by the European Council, which states that "...any injury resulting from sports activity and having consequences such as a decrease in the volume or level of sports activity; the need for medical advice or treatment" [3]. Consequently, any type of injury involves a violation of the functional integrity of the entire body, which can lead to loss of performance, severe complications and disability.

Research in the field of sports traumatology shows that about a third of sports injuries are the result of ineffective rehabilitation after previously suffered injuries. In athletes who have suffered serious acute or fatigue injuries, the strength of the muscles capability is decreased, the joints flexibility is deteriorated, the muscle balance is disturbed and its stiffness is increased, etc. [4,5].

MRI is used in various fields of sports medicine and in almost all cases provides valuable information. The advantages of the method include high soft-tissue contrast, free choice of the image plane, three-dimensionality of the received information, and the absence of radiation load and artifacts from bone structures and air [6]. Thanks to the possibilities of direct visualization of articular cartilage, accuracy and reproducibility, which increase with the improvement of technology and the creation of new protocols, MRI has become the standard method for assessing cartilage and bone-cartilage injuries, as well as the process of joint surface recovery after injuries and reconstructive plastic surgery over the past 20 years. Despite the fact that various methods of obtaining images of articular cartilage are currently known (sonography, contrast arthrography), MRI is considered the method of choice. In addition, MRI provides information about the state of the subchondral spongy bone [7,8]. Due to the performance of sections in any planes, good visualization of vascular structures and high contrast of soft tissues, MRI is used in diagnostically complex cases. For example, when it is necessary to assess the involvement of vascular structures, in differentiation of benign and malignant formations [9], as well as to assess pathological changes in the articular cartilage, meniscus and ligaments of the knee joint [10].

The aim of the investigation was to study changes in the articular cartilage of the knee joint in football players based on an assessment of the T2 relaxation time on MRI.

Materials and Methods

The research was conducted at the Republican scientific and practical center of sports medicine at the National Olympic Committee of Uzbekistan. 92 football players were divided into 2 groups. Group 1 consisted of 46 patients under the age of 30 years old, group 2 – 46 people over the age of 30 years old.

MRI studies of the knee joint with cartilage mapping were performed on the Philips Ingenia 1.5 Tesla device using standard modes and sT2Cal TSE–coronal. The results were processed using the MR Cartilage Assessment program. The stage of damages of the articular cartilage of the knee joint was evaluated based on the results of mapping the structure of the articular cartilage and the relaxation time T2, which describes the processes in the X-Y plane.

Results and Discussion

Quantitative evaluation of the T2 relaxation time was applied due to the fact that this parameter is a non-invasive marker of articular cartilage degeneration and depends on the degree of tissue hydration and its biochemical composition. The water of the articular cartilage is bound to the surrounding macromolecules, which causes its low intensity of the MR signal in sequences with a long echo time (TE), i.e. on T2-weighted images. T2 relaxation reflects the ability of hydrogen molecules to move and intermolecular energy interaction in the cartilage matrix and directly depends on the microscopic mobility of the system. The method of cartilage mapping included performing a study with subsequent reconstruction and construction of coloured T2 maps.

In vitro studies have demonstrated the dependence of T2 relaxation time on the biochemical structure of articular cartilage. It was found that the intensity of the MR signal in determining the T2 time is affected by chondral dehydration and violation of the collagen structure. Mosher determined the T2 relaxation time of articular cartilage in healthy patients and osteoarthritis patients and revealed a significant increase in T2 values in the group of osteoarthritis patients [11].

Thus, the relaxation time T2 is a parameter that characterizes the hydrophilicity of articular cartilage tissue and the anisotropy of collagen distribution. Its values can vary significantly in healthy patients, depending on the field strength of the tomography and the type of pulse sequence. Therefore, when evaluating areas of altered articular cartilage structure, it is necessary to use intact cartilage sections in the same patient as reference values. The T2 relaxation time increases as degenerative changes are progressing.

The results of the research revealed degenerative changes in the articular cartilage of the KJ in 54% of cases, and damage in 4% of cases, depending on age. The regularity of increasing the time of T2 relaxation of KJ with increasing of the age of football players was revealed.

Most athletes were most often diagnosed with meniscal injuries (most often the body and posterior horn of the medial meniscus), edema of the condyle bone marrow and cartilage damage, and

damage of the anterior cruciate ligament. Degenerative changes in articular cartilage were detected in 54% of cases. Cruciform ligament damage was detected in 49.7% of cases, with the ratio of anterior and posterior cruciform ligaments 11.6:1. Patellar damage was detected in 36.6% of cases. Effusion of the knee joint cavity and suprapatellar bursae was detected in 83.4% of cases. The average values of T2 relaxation time in the group of up to 30 years the right and left KJ were 41.5 and 44.9 milliseconds, respectively, while in the group of above 30 years of age 49.3 and 45.1, respectively. Defects of up to 50% of the thickness of cartilage without boundary flaps and with small boundary flaps, defects of up to 75% of the thickness of cartilage without boundary flaps and defects more than 75% with "exposure" of bone structure (Figure 1-5).

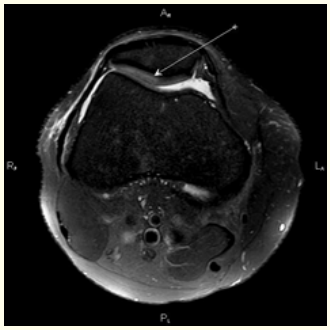

Figure 1: Horizontal valve, without cartilage defect.

Figure 2: Defect of up to 50% of the cartilage thickness without edge flaps.

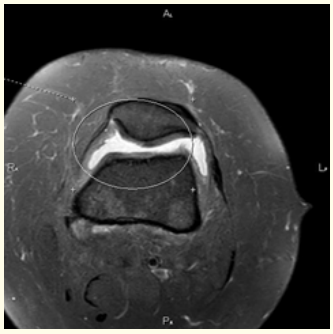

Figure 3: Defect of up to 50% of the cartilage thickness, with a small marginal flap.

Figure 4: Defect of up to 75% of the cartilage thickness without edge flaps.

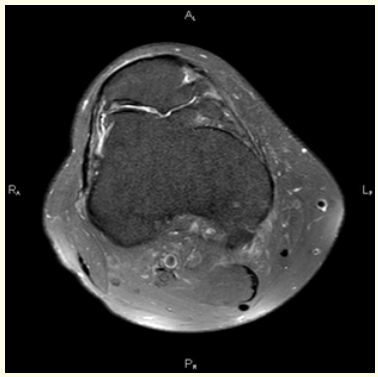

Figure 5: Defect of more than 75%, with "exposure" of the bone structure.

Quantitative methods for assessing articular cartilage (measuring the thickness and volume of articular cartilage, T2) significantly increased the effectiveness of MRI in the diagnosis of degenerative injuries. Each of the methods is characterized by its own physical principle and target in the composition of cartilage tissue, which together allows of detecting minimal manifestations of the disease. According to the results of the investigations, degenerative changes in joint cartilage on the basis of T2 mapping were distributed in 4 degrees compared to the reference value at the level of 32.0-34.0 ms: I degree - 34.1-41.0 ms, II degree - 41.1-65.0 ms, III degree - 65.1-100.0 ms, and IV degree - 100.1 and higher ms.

Thus, the relaxation time T2 is a parameter that characterizes the hydrophilicity of articular cartilage tissue. T2-mapping of articular cartilage can be easily performed in clinical practice, does not require the introduction of a contrast agent, and increases the total time of joint examination by no more than 6-8 minutes. T2-mapping of articular cartilage also allows to perform non-invasive dynamic monitoring of the state of cartilage tissue during treatment. The correlation between the degree of mechanical compression of the cartilage tissue and the T2 relaxation time requires further study: changing the T2 time during physical exertion may allow the formation of more rational training regimes for athletes to prevent the appearance and progression of degenerative changes in the knee cartilage tissue in football players. It should be noted that the key point of MRI diagnostics in athletes with degenerative changes in knee cartilage remains the detection of the disease at the initial biochemical stage before the formation of gross morphological changes that significantly complicate the treatment process. Further developments in this area are needed to improve and standardize quantitative methods, to determine clinical indications with the subsequent implementation them into algorithms for diagnosing knee cartilage damage.

Conclusions

- The method of MRI with T2-mapping of cartilage is effective in diagnosing the early stages of degeneration of the cartilage tissue of the knee joint of football players.
- Quantitative relaxation time T2 is a non-invasive marker of cartilage degeneration.
- T2 is sensitive to the biochemical composition and degree of tissue hydration.
- Immobilization water protons of synovial fluid in the cartilage tissue preserves a high signal of T2.
- Loss of collagen and proteoglycans during cartilage degeneration increases the mobility of water molecules, thereby increasing the signal intensity in T2-weighted images.
- The use of T2 mapping of the KJ cartilage structure can be recommended for early diagnosis, treatment and prevention of complications of knee joint diseases in football players.

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