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Magnetic resonance imaging of the shoulder joint: imaging features of normal structures

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Magnetic resonance imaging (MRI) – a modern high-tech medical imaging method characterized, primarily, by absence of radiation exposure. In addition, this method is highly effective for the detection of pathology of soft structures, including structures of the shoulder joint. Tendons, muscles, articular cartilage, articular labrum and other structures of the shoulder joint are best visualized by magnetic resonance imaging. Experience of most radiologists in conducting surveys, at present is rather poor. Usually, a patient address to clinicians, mostly orthopedists, neurologists and rheumatologists, complaining of pain in the shoulder joint. After clinical examination, clinicians appoint additional methods. The priority is to perform radiography of the shoulder joint in a straight projection. Referral of patients for MRI of the shoulder joint on the diagnostic stage is limited due to lack of awareness of the feasibility of this procedure and, possibly, from an economic point of view. Usually, same imaging modalities, such as radiography, computed tomography, can diagnose most bony changes.

After eliminating obvious bone pathology, the next step should be to appoint more informative diagnostic methods, particularly MRI. We believe that MRI is a more advanced method of detecting damaged soft tissue structures of the joint. Confirmed by a large number of works in foreign literature [10, 13, 14, 17, 21, 22]. Most authors argue that MRI is the "gold" standard for non-invasive means of imaging soft tissue structures of the shoulder joint [1, 3, 4, 5, 27]. However, if MRI is performed outside the box by specialists who do not have sufficient experience in executing such a study, not adapted to the equipment, there is a high probability of obtaining false-negative or false-positive results that may lead to inadequate treatment, and impair the health of the patient . To eliminate the possibility of significant errors and interpret such research in other clinics, it is advisable to conduct MRI - study of the shoulder joint according to the standard protocol.

In recent years, modern orthopedics supplemented plenty of arthroscopic treatments pathology of the shoulder joint. Very often doctors during orthopedic surgeries reveal pathology of soft structures, other than those previously diagnosed. Another problem is the difficulty of evaluating the results of research conducted outside the box, using other than conventional pulse sequences. In most diagnostic centers protocols, used in examination of the shoulder joint differ in range of pulse sequences and planning during scanning. If necessary, consult with other specialists such studies - radiologists evaluation results can be misleading, given that the images of structures of the shoulder joint in a non-standard planning and various types of pulse sequences will differ.

Objective – to analyze the anatomical features of the structures of the normal shoulder joint in MRI to a standard local study protocol, in compliance with clinician diagnostic tasks.

Materials and Methods

For 600 patients with complaints of radicular pain in the region of the shoulder joint, extending along the upper limb MRI studies of the shoulder joint and cervical spine during the period 2012-2014 were performed. Among them selected 130 patients who had no revealed pathological changes in MR- shoulder joint. Research was conducted on modern diagnostic equipment (magnetic resonance machine with magnetic field 1,5T - Espree, Siemens), was used pecial surface coil for the shoulder joint. Learning data of a large number of foreign literature [7, 11, 12, 18, 20, 22, 25], we have formed and defined a standard protocol for study of the shoulder joint, which included generally accepted pulse sequence: PD-WI fs (proton density weighted images with fat saturation) and T1-WI in three standard planes (axial, coronal, sagittal).

In order to compare the completeness of information displayed in the structures of the shoulder joint, 90 patients in addition to the standard protocol were performed pulse sequence - T2-tirm cor, T1-vibe cor iso, T2-W1 cor, T2- cor with fs (fat saturation), T2 -sag with fs (fat saturation).

To clarify the changes identified in standard scan, with indirect arthrography intravenous administration of paramagnetic contrast agents in T1-WI fs in three standard planes (axial, coronal, sagittal) was performed 23 patients.

Also, within the additional examination of 17 patients we performed direct arthrography – T1-WI fs in three planes (axial, coronal and sagittal). One of pulse sequences that we used in the standard protocol of the study of the shoulder joint - PD-WI fs (proton density weighted images - with the suppression of signal from fat), conducted in three planes. In PD - WI contrast of the image does not depend on T2- T1- and relaxation, and is fully driven by the concentration of hydrogen protons in the tissue: the higher the concentration, the stronger the signal MR- and brighter image. As you know, most of the hydrogen protons in the liquid, the lowest number in their solid (compact bone layer) and connective tissue (ligaments, joint capsule). So this pulse sequence is used mainly in the study of bones and joints because of the high tissue contrast. Also, performance of standard sequence T1-WI, where the fluid has low MR- signal and fat has high signal, allows the differential diagnosis in detecting pathological changes in fat or yellow bone marrow.

In the study with intravenous contrast injection of contrast agent or its medication directly into the joint, generally adopted is to perform T1-WI fs sequence, which allows us to suppress MR- signal from fat (including yellow bone marrow).

With contrast enhancement we get a clear picture of the effect of accumulation contrast agent in the affected structures, while MR signal from fat is low, which helps to differentiate pathological foci (inflammation, proliferation process).

With the introduction of contrast agents directly into the joint, we get a clearer reflection of structures, by increasing the amount of fluid in the joint and the high signal from the administered substance containing gadolinium compounds, with the joint structure with low MR signal.

Results

When properly designed studies, depending on the scanning plane and pulse sequence, display of anatomical structures of the shoulder joint is different, and has a different degree of informative value.

First of all, to identify possible pathological changes, it is necessary to be aware of the features of the displayed structures of the normal shoulder joint. After analyzing all our studies of the shoulder joint, we determined that certain structures of the shoulder joint normally have different information content for visual display on MRI scans, depending on the scanning plane, slice thickness, and the type of pulse sequence of the scan. As a result, of the processed data, to form a standard protocol studies of the shoulder joint, it is sufficient to use two pulse sequences PD-WI fs and T1-WI in three standard planes (axial, coronal, sagittal). Visually, T2- WI with fs is virtually similar to PD-WI fs and if necessary, it can be replaced, but on T2-WI with fs we get relatively bright signal of free fluid and lower bound water (in cartilage, capsule and muscles). This sequence also uses additional pulses, providing suppression of the fat signal, which allows to clearly define the bone marrow edema.

For objective evaluation, all examinations were reviewed separately by different doctors. Results processed in Microsoft Excel 2010 SP2 with additional statistical module of XLSTAT 2014. All results for completeness display of certain structures of the shoulder joint is divided into three indicators: 1 – visualization reliable 2 – satisfactory, 3 - unreliable. In the table 1 we result indicators of the completeness display of the structures of the normal shoulder joint.

Table 2 shows the results MR- arthrography (direct) with intra-articular injection of contrast agent to improve the level of display structures of the shoulder joint in comparison with their visualization with standard study, where 1 - a clear improvement, 2 - moderate, 3 - no effect.

The results, that are shown in Table 2 demonstrate improvement and reflect more clearly differentiation of these structures: tendon rotator cuff, glenoid labrum, joint capsule.

Conducting MRI - procedures with intravenous contrast enhancement advisable in case of the clarification of the inflammatory changes in the joint - you can more accurately assess changes in the joint capsule, articular cartilage, articular labrum, ligament apparatus. Such studies are advised to perform if it is necessary to assess the degree of inflammation in rheumatoid arthritis, because of the ability of contrast agent to accumulate in the capsule of the joint. You can also assess the degree of damage, detect the presence subchondral erosions.

Studies with the intra-articular injection of contrast agent allow us to better assess changes in articular labrum, the degree of damage of ligaments and other joint structures. Typically, contrast agent has a significant degree of dilution of 1: 200 solution is introduced into the joint with a syringe in an amount of 20 ml with frontal access at coracohumeral liga-

Table 1.
Visualization of the anatomical structures depending on the scanning plane and pulse sequence.

Anatomical structure	PD-WI fs			T1-WI		
	Ax	Cor	Sag	Ax	Cor	Sag
The head of the humerus	1	1	1	1	1	1
Glenoid	1	2	1	1	2	1
Subacromial space	3	1	2	3	1	2
Articular labrum	1	1	2	1	2	3
Supraspinatus ligament	2	1	2	2	1	2
Infraspinatus ligament	2	1	1	2	2	2
Subscapular ligament	1	1	2	1	2	2
LBT, horizontal part	3	2	3	3	3	3
LBT, vertical part	1	1	1	1	2	2
Glenohumeral ligaments (SGHL, VGHL, IGHL)	2	3	3	3	3	3
Coracohumeral ligament (CHL)	2	3	2	3	3	2
Joint capsule (normal)	3	2	3	3	3	3

Table 2.
Visualization of anatomical structures in intraarticular contrast enhancement, depending on the scanning plane.

Anatomical structure	T1-WI fs with contrast		
	Ax	Cor	Sag
The head of the humerus	3	3	3
Glenoid	2	1	2
Subacromial space	3	1	1
Articular labrum	1	1	1
Supraspinatus ligament	2	1	1
Infraspinatus ligament	2	1	1
Subscapular ligament	1	1	1
LBT, horizontal part	2	1	1
LBT, vertical part	1	1	1
Glenohumeral ligaments (SGHL, VGHL, IGHL)	2	2	1
Coracohumeral ligament (CHL)	2	2	1
Joint capsule (normal)	2	1	2

ment. Followed by a standard study in three planes using T1-WI fs sequence. Performing the standard study protocol is optimal for informative and temporal characteristics. Additional sequences significantly extend the research time and do not bring additional information to improve the study.

After surgery, MRI is appropriate to conduct within 2 months. This is due to the fact that after surgery in the joint structures for a long time persist changes that could lead to misinterpretation of research results. After surgery in the joint assessment of changes made in review of previous MRI - study. In addition one should describe the available postoperative changes implants, clamps and more.

Conclusions: Analysis of survey results using a standard protocol study and examination with the introduction of contrast agents show us the difference in display of the certain structures of the shoulder joint at different levels and with different pulse sequences. However, this does not mean that in the study we should be limited to a particular type of examination because, in most cases, they are of com-

plementary value. Understanding where we can get a clearer display of certain pathological changes, for the doctor-radiologist is more important.

Conducting MRI of the shoulder joint, using standard protocols research has a high degree of the informative value, allows us to obtain objective results, that in most cases were confirmed during surgery, and allows the patient to get adequate assistance in the early stages of treatment.

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MAGNETIC RESONANCE IMAGING OF THE SHOULDER JOINT: IMAGING FEATURES OF NORMAL STRUCTURES

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Conducting MRI of the shoulder joint is of great importance in the diagnosis of traumatic injury of soft tissue structures. To prevent significant errors when reading tomograms, and their interpretation by specialists from other clinics, it is advisable to conduct such research in accord with the standards that have been developed taking into account the physical and functional characteristics of this method of research, followed by the development of unified protocols of the diagnostic procedures. The use of standardized study protocols allows optimally detect abnormalities in structures of the shoulder joint, which in most cases are confirmed during surgical interventions and thereby provide quality patient care in the early stages of treatment.

Keywords: shoulder joint, magnetic resonance imaging, the study protocol.

МАГНІТНО-РЕЗОНАНСНА ТОМОГРАФІЯ ПЛЕЧОВОГО СУГЛОБУ: ОСОБЛИВОСТІ ВІЗУАЛІЗАЦІЇ СТРУКТУР В НОРМІ

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Проведення магнітно-резонансної томографії плечового суглобу має велике значення в діагностиці травматичних ушкоджень м'якотканних структур. Для запобігання значних помилок при читанні томограм, можливості інтерпретації подібного дослідження спеціалістами інших клінік доцільним є проведення дослідження у відповідності до стандартів, які розроблені з урахуванням фізичних та функціональних особливостей даного методу дослідження із подальшим формуванням уніфікованих протоколів діагностичних процедур.

МАГНИТНО-РЕЗОНАНСНАЯ ТОМОГРАФИЯ ПЛЕЧЕВОГО СУСТАВА: ОСОБЕННОСТИ ВИЗУАЛИЗАЦИИ СТРУКТУР В НОРМЕ

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Проведение магнитно-резонансной томографии плечового сустава имеет большое значение в диагностике травматических повреждение мягкотканных структур. Для предотвращения существенных ошибок при чтении томограмм, возможности интерпритации такого исследования специалистами других клиник, целесообразно проведение такого исследования в соответствии со стандартами, которые разработаны с учётом физических и функциональных особенностей данного метода исследования, с последующим формированием унифицированных протоколов диагностических процедур. Применение унифицированных протоколов исследования позволяет в оптимальном режиме выявить патологию структур плечевого сустава, которые в большинстве случаев имеют подтверждение при проведении оперативных вмешательств и тем самым обеспечивают квалифицированную помощь пациенту на ранних этапах лечения.

Ключевые слова: плечевой сустав, магнитно-резонансная томография, протокол исследования.