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Association of post-traumatic pain and knee joint changes according to magnetic resonance imaging

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Abstract

Background. Chronic post-traumatic pain (CPTP) occurs in 15-50% of patients who have suffered knee joint injury (KJ). Post-traumatic pain is considered as one of the predictors of the development of post-traumatic osteoarthritis (PTOA). Early changes in the knee joint, characteristic of the development of PTOA, can be determined using magnetic resonance imaging (MRI).

Aim – to evaluate the relationship between CPTP and structural changes in the knee joint, which are determined using MRI.

Material and methods. The study group consisted of 98 patients, 48% women and 52% men, aged 39.2 ± 14.7 years, who had suffered a knee joint injury with damage to the anterior cruciate ligament (ACL) and/or meniscus (confirmed by MRI data), and experiencing pain ≥4 points on a numerical rating scale (CRS) of at least one month after the injury. The patients were followed up for 12 months. CPTP was determined with pain persistence for at least 3 months at the level of 4 points on the CRS. Repeated MRI was performed 12 months after inclusion in the study. Changes in the knee joint according to the MRI data were quantified using the WORMS system.

Results. CPTP was detected in 45.9% of patients. According to the initial MRI parameters, the groups of patients with CPTP (n=45) and without CPTP (n=53) significantly differed in cartilage morphology (minimal changes were more often detected in patients without CPTP), the presence of osteophytes, damage to the medial collateral ligament and rupture of the medial meniscus body. Almost all patients in both groups had ligament damage and meniscus rupture (with varying degrees of severity), as well as synovitis; about a third of the examined individuals had signs of bone marrow edema. After 12 months observations between patients with and without CPTP showed a significant difference in MRI parameters such as cartilage morphology, osteophytes of the medial condyle of the femur, damage to the posterior cruciate and medial collateral ligaments, rupture of the body, anterior and posterior horns of the medial meniscus, rupture of the anterior horn of the lateral meniscus, synovitis. Thus, severe cartilage damage (≥2 by WORMS) was noted in 82.1% of patients with CPTP and 43.4% without CPTP ($p < 0.05$), synovitis in 95.6% and 24.5% ($p < 0.05$).

Conclusion. CPTP, which occurs after the knee joint injury, is associated with structural changes in the joint, which can be regarded as an early stage of PTOA.

Keywords: chronic post-traumatic pain, post-traumatic osteoarthritis, magnetic resonance imaging.

Conflict of interest: nothing to disclose.

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Ассоциация посттравматической боли и изменений коленного сустава по данным магнитно-резонансной томографии

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Аннотация

Обоснование. Хроническая посттравматическая боль (ХПТБ) возникает у 15–50% пациентов, перенесших травму коленного сустава (КС). ХПТБ рассматривается как один из предикторов развития посттравматического остеоартрита (ПТОА). Ранние изменения КС, характерные для развития ПТОА, могут определяться с помощью магнитно-резонансной томографии (МРТ).

Цель – оценить взаимосвязь между ХПТБ и структурными изменениями КС, которые определяются с помощью МРТ.

Материал и методы. Исследуемую группу составили 98 пациентов, 48% женщин и 52% мужчин, возраст 39,2 ± 14,7 года, перенесших травму КС с повреждением передней крестообразной связки (ПКС) и/или мениска (подтвержденное данными МРТ) и испытывающих боль ≥4 балов по числовой рейтинговой шкале (ЧРШ) не менее месяца после травмы. Пациенты наблюдались в течение 12 мес. ХПТБ определялась при персистенции боли не менее 3 мес. на уровне ≥4 балов по ЧРШ. Повторная МРТ проводилась через 12 мес. после включения в исследование. Изменения КС по данным МРТ оценивались количественно по системе WORMS.

Результаты. ХПТБ была определена у 45,9% пациентов. По исходным параметрам МРТ группы пациентов с ХПТБ (n=45) и без ХПТБ (n=53) достоверно различались по морфологии хряща (минимальные изменения чаще выявлялись у пациентов без ХПТБ), наличию остеофитов, повреждению медиальной коллатеральной связки и разрыву тела медиального мениска. Практически у всех пациентов в обеих группах отмечались повреждение связок и разрыв мениска (с разной степенью выраженности), а также синовит; около трети обследованных лиц имели признаки отека костного мозга. Через 12 мес. наблюдения между пациентами с ХПТБ и без нее была зафиксирована достоверная разница по таким МРТ-параметрам, как морфология хряща, остеофиты медиального мыщелка бедренной кости, повреждение задней крестообразной и медиальной коллатеральной связок, разрыв тела, переднего и заднего рога медиального мениска, разрыв переднего рога латерального мениска, синовит. Так, выраженное повреждение хряща (≥2 по WORMS) было отмечено у 82,1% пациентов с ХПТБ и у 43,4% без ХПТБ (p <0,05), синовит у 95,6% и 24,5% (p <0,05).

Заключение: ХПТБ, возникающая после травмы КС, ассоциирована со структурными изменениями сустава, которые можно расценивать как раннюю стадию ПТОА.

Ключевые слова: хроническая посттравматическая боль, посттравматический остеоартрит, магнитно-резонансная томография.

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Список сокращений
ПТОА – посттравматический остеоартрит; КС – коленный сустав; ПКС – передняя крестообразная связка; ХПТБ – хроническая посттравматическая боль; МРТ – магнитно-резонансная томография; ОА – остеоартрит; ОКМ – отек костного мозга; ЧРШ – числовая рейтинговая шкала; НПВП – нестероидный противовоспалительный препарат; БК – бедренная кость; ББК – большеберцовая кость.

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INTRODUCTION

Post-traumatic osteoarthritis (PTOA) is a prevalent complication of traumas manifested by chronic pain, persisting inflammation and progressing disorder of articular biomechanics. PTOA is most typically localized in the knee joint [1, 2]. In the event of injury of the anterior cruciate ligament (ACL) and the menisci of the knee joint, PTOA is developing in 20–50% cases 5–15 years after the injury. From the medical and social perspectives, this pathology has a high impact primarily due to the young age of patients: with traumas suffered at the age of 20–30, the characteristic clinical manifestations of PTOA and pronounced structural alterations severely impairing functional capabilities and working capacity occur as early as at the age of 35–45, i.e. at the most active age of members of modern society [3, 4].

Early identification of signs of PTOA prior to the onset of irreversible structural changes of the joint ('pre-radiographic stage') and active preventive therapy are the major vector of improvement of medical aid to patients suffering a trauma of the knee joint. To that end, PTOA predictors are sought and target groups of patients are identified among patients that suffered injuries of the knee joint and underwent orthopedic surgeries for ACL and meniscus ruptures and are in need in close supervision, treatment and rehabilitation [1–4].

The first manifestation of PTOA is the chronic post-traumatic pain (CPTP). It appears due to biomechanical disorders persisting after the trauma and/or respective orthopedic intervention, inflammatory process involving the synovia, subchondral bone, ligaments and entheses, degenerative changes (neoangiogenesis, nerve fiber sprouting), dysfunction of the nociceptive system and psycho-emotional problems. In essence, the same mechanisms underlie the development of PTOA, which opens the possibility of viewing the CPTP not only as a symptom but as a predictor of the disease [5, 6].

The analysis of correlation of painful sensations and structural changes of the joint persisting (or progressing) after the sustained energy are of principal importance for the evaluation of the role of CPTP as the factor indicating the high risk of PTOA development. The major method ensuring quality visualization of pathology of soft tissues of the knee joint is the magnetic resonance imaging (MRI). It is important that MRI allows identification of alterations in the ligaments, menisci, cartilage and subchondral bone long before the development of typical radiographic features of PTOA. Apart from the qualitative assessment of the pathology (presence or absence of changes), MRI allows its quantitative analysis using such systems as WORMS (Whole Organ Magnetic Resonance Imaging Score), MOAKS (MRI Osteoarthritis Knee Score), ICRS (International Cartilage Regeneration and Joint Preservation Society) and others [7, 8].

The characteristic features identified on the MRI of the knee joint in the post-trauma period are ruptures (with subsequent degenerative changes) of the ACL and menisci, as well as general inflammatory changes in the

articular tissue in the form of synovitis and bone marrow edema (BME) as a manifestation of the bone 'contusion' [9, 10]. There are series of clinical studies and respective meta-analyses confirming the correlation between this MRI-identified pathology and the manifestation of CPTP. Thus, the availability of correlation between the alterations identified in the MRI and the osteoarthritic (OA) pain was the subject of the work of P. Dainese *et al*. [11] who performed a meta-analysis of 37 studies in 17 of which the correlation of the clinical manifestations with the status of synovitis or bone marrow edema was evaluated. Six papers showed that contrast-enhanced MRI identified moderate positive correlation between the visualized features of inflammation and pain status. The systematic review of A. Ghouri *et al*. [12] evaluated the correlation between the MRI features of meniscal rupture and severity of pain. According to the data of 11 studies, in single-timepoint analyses pain and meniscal injury were interrelated.

It is to be noted that the combination of MRI-identifiable alterations of the knee joint and the chronic pain are assessed by some experts as criteria of the early stage of OA. Specifically, the evaluation of these features were listed in the early version of criteria of F. Luyten *et al*. (as of 2012) [13].

To date, no domestic studies have investigated the correlation between chronic post-traumatic bone changes and knee joint alterations using MRI.

AIM

To evaluate the relationship between CPTP and structural changes in the knee joint, which are determined using MRI.

MATERIAL AND METHODS

The study group comprised 98 patients meting the following *inclusion criteria:* age 18 to 50 years; traumatic injury of the knee joint due to which the patient had to seek medical aid; trauma of soft tissue elements of the knee joint confirmed by MRI findings; moderate or severe pain in the knee joint area (>4 points on the numerical rating scale, NRS 0–10, where 0 = no pain, 10 = worst imaginable pain) for ≥ 1 months after the injury; availability of the patient's informed consent.

Exclusion criteria were confirmed fracture of bone structures in the knee joint area (confirmed clinically and radiologically), availability of credible signs of a rheumatic disease (including previously diagnosed OA and fibromyalgia), severe disorders of the musculoskeletal system and comorbid pathologies precluding regular visits required by the study protocol.

The study group mainly consisted of young persons with approximately equal number of male and female patients with injuries of the ACL, menisci or a combination thereof, with moderate or severe pain in the knee joint; almost half of patients required orthopedic intervention (**Table 1**).

All study participants were advised to use knee braces, perform regular physical exercise and administer systemic and/or local non-steroid anti-inflammatory drugs (NSAIDs) as ointment or gels upon pain onset in compliance with 2024 clinical recommendations on injury of knee joint ligaments and the Order of the Ministry of Health of the Russian Federation dated 29.06.2023 No. 331n "On Approval of the Medical Care Standard for Adults with Knee Joint Meniscus Injury (Diagnosis and Treatment)".

The analysis of clinical manifestations was performed during the first visit, and 3, 6 and 12 months later. CPTP was identified during the second visit, 3 months after the follow-up started. The CPTP criteria was moderate or severe pain in the knee joint on activity or at rest (>4 on the numeric rating scale (NRS), where 0 = no pain, 10 = worst imaginable pain), that persisted for the majority of days in the 3 months before the evaluation.

All patients underwent MRI at the moment of inclusion and 12 months after the start of the study with a semi-quantitative analysis of structural changes as per WORMS system. The following was assessed: signal intensity and cartilage morphology in the center of the medial tibiofemoral joint and lateral tibiofemoral joint in coronary projection; proximal part of the patellofemoral joint in lateral projection (0 = norm, 1 = thinning of cartilage, without defects, 2 = one individual non full-thickness defect, 3 = several partial defects, 4 = full-thickness defect <50% of cartilage length, 5 = full-thickness defect >50%); OCD in the medial and lateral femoral condyles (FC), medial and lateral tibial condyles (TC), and central tibial plateau (0 = none, 1 = < 25% or the region area, 2 = 25–50%, 3 > 50%); subchondral cysts in the medial and lateral FC, medial and lateral TC (0 = none, 1 = < 25% of the region area, 2 = 25–50%, 3 = > 50%); subchondral edema in the medial and lateral FC, medial and lateral TC (0 = none, 1 = mild, 2 = severe); osteophytes of the medial and lateral FC, medial and lateral TC (0 = none, 1 = small, 2 = medium, 3 = large); damage of the anterior cruciate ligament, posterior cruciate ligament, medial collateral ligament, lateral collateral ligament (0 = intact, 1 = damaged); tear of the

Parameter	Value
Sex (F/M, %)	47 (48,0) /51 (52,0)
Age, years; M±σ	39,2 ± 14,7
Body mass index, kg/m2; M±σ	27,1 ± 6,3
Injury of knee joint tissues as per MRI data, %	ACL 42.0, meniscus 56,0, combined injury of ACL + meniscus 15.0, ACL + other injury (tendinitis, cysts, strained ligaments, etc.) 28.0
Surgical intervention (ACL reconstruction, meniscal repair, meniscal resection, combined surgery), %	39,0
Pain on activity; Me [25th; 75th percentiles]	5,0 [3,5; 6,5]
Pain at rest; Me [25th; 75th percentiles]	2,0 [1,0; 4,0]
Pain at nighttime; Me [25th; 75th percentiles]	2,0 [0,5; 3,5]
Functional disorder; Me [25th; 75th percentiles]	5,0 [2,0; 5,5]
KOOS total; M±σ	48,6 ± 19,1
KOOS symptoms; M±σ	58,7 ± 22,3
KOOS pain; M±σ	57,4 ± 18,1
KOOS activity; M±σ	65,6 ± 20,4
KOOS sports; M±σ	30,5 ± 21,7
KOOS quality of life; M±σ	39,1 ± 19,8

Table 1. *Clinical characteristics of patients at inclusion in the study (n=98)*

Таблица 1. *Клиническая характеристика пациентов на момент включения в исследование (n=98)*

MRI-symptom >1, n (%)		CPTP+ (n=45)	CPTP- (n=53)	p-value
Cartilage morphology		26,7	66,7	**0,012**
Bone marrow edema	Medial TC	26,7	30,2	0,61
	Lateral TC	20,0	20,8	0,401
	Medial FC	22,2	13,2	0,508
	Lateral FC	20,0	13,2	0,803
	Central part of femur	20,0	20,8	0,597
SC	Medial TC	11,1	5,7	0,521
	Lateral TC	4,4	10,0	0,078
	Medial FC	6,0	9,4	0,703
	Lateral FC	6,0	4,9	0,814
	Central part of femur	4,4	4,9	0,612
SO	Medial TC	15,6	7,1	0,332
	Lateral TC	2,2	1,9	0,891
	Medial FC	22,2	9,4	0,081
	Lateral FC	4,4	3,8	0,901
Osteophytes	Medial TC	44,4	20,8	**0,042**
	Lateral TC	31,1	15,1	0,064
	Medial FC	37,8	20,8	0,061
	Lateral FC	35,6	13,2	**0,041**
Ligament damage	Anterior cruciate	82,2	86,8	0,533
	Posterior cruciate	37,8	24,5	0,469
	Medial collateral	24,4	9,4	**0,048**
	Lateral collateral	8,9	1,8	0,112
Meniscus tear (>2)	Body of medial meniscus	75,6	49,1	**0,008**
	Anterior horn of medial meniscus	48,9	37,8	0,549
	Posterior horn of medial meniscus	75,6	56,7	0,063
	Body of lateral meniscus	44,4	32,0	0,382
	Anterior horn of lateral meniscus	44,4	28,3	0,204
	Posterior horn of lateral meniscus	44,4	28,3	0,311
Synovitis		97,8	88,7	0,204
Osteonecrosis		4,4	1,8	0,611

Table 2. *Comparison of structural changes in the knee joint in patients with and without CPTP (MRI data at the beginning of the study)*

Таблица 2. *Сравнение структурных изменений коленного сустава у пациентов с хронической посттравматической болью и без нее (данные МРТ в начале исследования)*

medial meniscus body, anterior horn of the medial meniscus, posterior horn of the medial meniscus, body of the lateral meniscus, anterior horn of the lateral meniscus, posterior horn of the lateral meniscus (0 = intact, 1 = minor radial or parrot-beak tear, 2 = non-displaced tear, 3 = displaced tear or partial resection, 4 = total destruction); synovitis (0 = absent, 1 = present); osteonecrosis (0 = absent, 1 = present).

Frequency and severity of MRI changes (baseline and after 12 months) was performed between groups of patients with and without CPTP.

The statistical analysis of obtained data was performed in the IBM SPSS Statistics 23 software suite. Quantitative variables were tested to meet the normal distribution law. Quantitative variables were described as median values with respective standard deviation (M±σ), in the event of absence of normal distribution in groups, as medians with the interquartile interval Me [25th; 75th percentiles] and verified using the Shapiro-Wilk test. Qualitative variables were presented as absolute values and their respective rates (%). The following statistical analysis methods were used to assess the obtained results: χ^2 Pearson's test (contingency table analysis), unpaired Student's t-test, paired comparisons of quantitative values, Wilcoxon signed-rank test (χ^2) was used. Differences were considered statistically significant at $p<0.05$.

The study was conducted in accordance with the principles of the Declaration of Helsinki. All patients provided written informed consent to participate. The protocol was approved by the Local Ethics Committee of the V.A. Nasonova Research Institute (protocol No. 23, dated 23.11.2022).

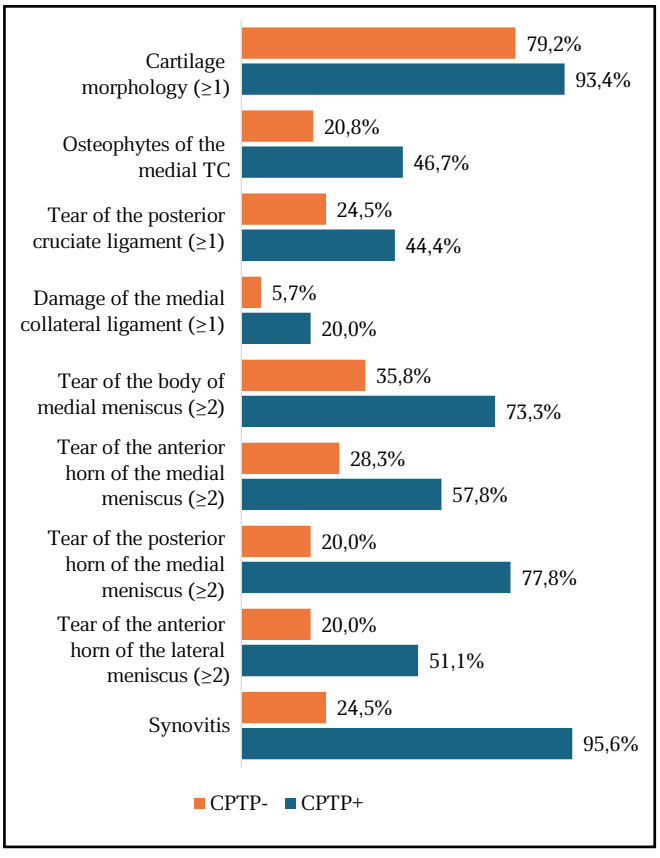
RESULTS

Chronic post-traumatic pain, or persistent sensation of pain ≥4 NRS for 3 months of follow-up, was diagnosed in 45 or 98 patients (45.9%). By the third month of the follow-up, CPTP+ patients, as compared to non-CPTP patients, demonstrated credibly higher pain intensity during movement, at rest and at nighttime, and functional disorders (NRS scale): 5.138 ± 1.512 and 1.771 ± 0.901 ($p<0.000$); 2.27 ± 0.691 and 0.803 ± 0.453 ($p<0.001$); 2.00 ± 1.766 and 0.405 ± 0.342 ($p<0.000$); 4.208 ± 1.356 and 1.898 ± 1.627 ($p<0.0302$). Similarly, in the third month of the follow-up, statistically significant difference between CPTP+ and CPTP- patient groups in all scores of the KOOS scale: the average value of the KOOS total was 58.4 ± 22.1 and 75.7 ± 23.4 ($p=0.012$); KOOS symptoms 58.1 ± 25.5 and 78.3 ± 29.2 ($p<0.018$); KOOS pain 54.6 ± 19.7 and 78.5 ± 28.4 ($p<0.02$); KOOS activity 57.8 ± 18.6 and 80.3 ± 30.3 ($p<0.004$), KOOS sports 51.9 ± 23.2 and 77.8 ± 20.4 ($p<0.009$), KOOS quality of life 46.3 ± 16.8 and 67.2 ± 21.1 ($p<0.025$).

In the baseline MRI parameters, the CPTP+ patient group (n=45) and CPTP- group (n=53) had statistically significant differences in the cartilage morphology (minimal alterations were more frequently identified in the CPTP- group), status of osteophytes of the medial tibial condyle and the lateral femoral condyle, damage of the medial collateral ligament and tear of the medial meniscus body. Practically all of patients in both groups showed injury of the ligaments of the knee joint (most frequently, the ACL) and tear of some meniscus or other (with varying severity), as well as synovitis; about a third of studies patients showed signs of OCD (**Table 2**).

After 12 months of follow-up, the differences in the MRI findings between the CPTP+ and CPTP- groups became more noticeable. Statistically significant difference was registered in such parameters as cartilage morphology, osteophytes of the medial TC, damage of the posterior cruciate and medial collateral ligaments, tear of the body, anterior and posterior horn of the medial meniscus, tear of the anterior horn of the lateral meniscus, positive synovitis status (**Fig. 1**).

It is to be mentioned that while the initial changes in the cartilage structure were more pronounced in the non-CPTP group (due to minimal changes, grade1), by the 12th month the situation changed: the cartilage deterioration was seen



Note. Numbers in brackets designate change gradation as per WORMS; for all indicated parameters, p <0.05..

Figure 1. *Significant difference in some of structural changes in the knee joint in patients with and without CPTP (MRI data after 12 months).*

Рисунок 1. *Достоверное отличие ряда структурных изменений коленного сустава у пациентов с хронической посттравматической болью и без нее (данные МРТ через 12 мес.).*

more frequently and in more severe forms in the CPTP+ group (**Fig. 2**).

DISCUSSION

According to the obtained data, initially, the CPTP+ patients, as compared to CPTP- patients, had statistically significant difference just in several MRI features reflecting the post-traumatic changes of the knee joint. In CPTP+ patients, the more frequently identified features were the osteophytes of the medial TC and lateral FC, and damage of the medial collateral ligament and tear of the body of the medial meniscus. Meanwhile, the cartilage alterations (minimally pronounced) were more pronounced in patients without history of CPTP.

Twelve months later, the MRI findings changed significantly. The number of patients with changes in the ligaments and, specifically, menisci of the knee joint among CPTP+ patients considerably exceeded the number of individual with the same pathology in the CPTP- patient group. A particularly significant difference was observed in both synovitis detection frequency and the dynamic changes of articular cartilage. Initially, cartilage damage was registered in CPTP+ patients only in 26.7%, but after 12 months in 93.4%, and in the majority of them (82.1%), the damage was substantial (≥2 WORMS). In CPTP- patients, such changes were registered only in 43.4%.

The obtained results show a clear correlation between the CPTP and the structural alterations in the knee joint. Our data align with the results obtained by foreign colleagues. K. van Oudenaarde *et al.* [14] compared the clinical manifestations and the MRI findings in 174 patients with an injury of the knee joint (follow-up period up to 6 months). Alterations identified by the MRI are predominantly trauma of ACL and menisci were found in 39%. There was credible correlation between changes in the MRI, severity and duration of symptoms persistence. The correlation between post-traumatic alterations found in the MRI and clinical manifestations of the knee joint injury was demonstrated in the works of O. Babalola *et al.* [15] and J.Wasser *et al.* [16].

Correlation of the MRI findings and OA symptoms was shown in a series of clinical studies. According to D. Felson *et al.* [17], who evaluated progression of OA in 110 patients, the pain in the knee joint was credibly more frequently observed in cases when bone marrow edema was identified by MRI: for grades ≥2 WORMS the odds ratio (OR) was

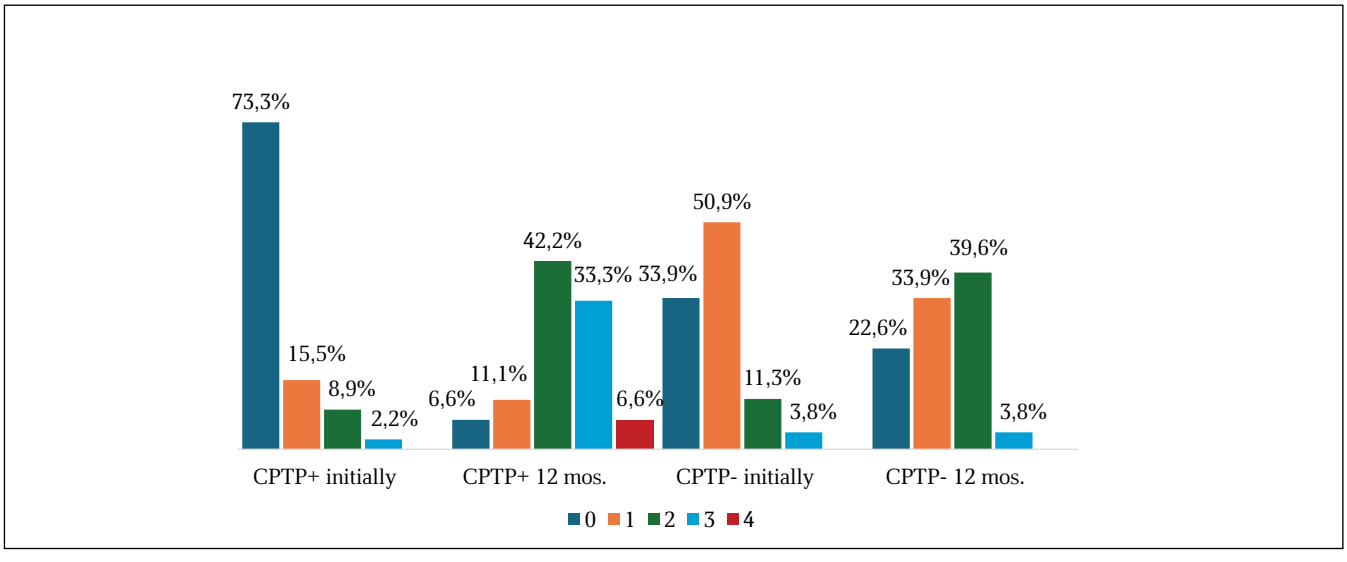


Figure 2. *Dynamics of changes in articular cartilage in the CPTP+ and CPTP- groups (MRI data after 12 months).*

Рисунок 2. *Динамика изменений суставного хряща в группах ХПТБ+ и ХПТБ- (данные МРТ через 12 мес.).*

3.2 (95% CI 1.5–6.8, p<0.002). The study of C. Hill *et al.* [18], which involved 270 patients with OA, showed a correlation between severity of MRI-identified signs of synovitis and pain: r = 0.21, p<0.0003. According to the MOST study, lateral osteophytes of the patellofemoral joint, synovitis of the knee joint and infrapatellar synovitis correlated with pain in the anterior part of the knee joint: OR 5.0 (95% CI 1.7-14.6]); 4.7 (95% CI 1.3-16.2), 2.8 (95% CI 1.0-7.8) [19]. Moreover, the follow-up of 1185 patients in the MOST study showed that MRI findings of the cartilage damage (≥2) and of osteophytes (≥2), with signs of bone marrow edema or synovitis (≥1) have higher sensitivity and specificity (over 90%) for the identification of both symptomatic and radiologic progression of OA [20]. According to the study program "Osteoarthritis Initiative", MRI features of meniscus damage in patients with OA correlate with presence of pain in the joint (OR = 2.82, 95% CI 1.79-4.43) [21]. In the study of Z. Zhao *et al.* [22], who used the method of computer-assisted analysis (a total of 421 affected knee joints), correlation was shown between the pain and such MRI findings as bone marrow edema and destruction of the joint cartilage.

The correlation between symptoms and structural alterations of the knee joint confirms significance of CPTP as a predictor of PTOA development. It is evident that the persistence and progression of MRI-identified alterations in the CPTP+ patient group may be regarded as a manifestation of the early stage of the disease. Especially important is the increase in the alterations of the joint cartilage. This MRI-identified feature seems important for the development of early OA even with the absence of manifested pain in the joint. Cartilage deterioration has even greater predictive value if symptoms indicating damage of the knee joint persist and progress [23].

It is to be noted that persistence of symptoms assessed with a standard KOOS questionnaire is one of the major classification criteria of early OA as defined by the research group of F. Luyten *et al.* (updated in 2018: assessment using two scales KOOS ≤ 85 and presence of pain, functional disorder or crepitation of the knee joint) [24]. Recently, two papers were published that assess the outcome of the ACL trauma in which changes after 1 and 3 years were analyzed in accordance with the updated criteria of Luyten. In the study of A. Cronström *et al.* [25], 106 patients were involved after an injury of the knee joint and surgical reconstruction of the ligament. After 1 year and 3 years, the number of persons meeting the Luyten criteria for early OA was 82% and 78%. The study of M. Harkey *et al.* [26] assessed the condition of 82 patients (aged from 13 to 35) after the trauma and subsequent reconstruction of the ACL. Their meeting the Luyten criteria for early OA in the follow-up visits after 6 and 12 months was registered in 22% patients.

CONCLUSION

Development of CPTP after knee joint injury is related to higher rate of progression of structural changes of the affected joint. Persistence of mild or severe pain in the knee joint for over three months after the trauma may be seen as an important predictor of development of early stages of post-traumatic osteoarthritis.

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Ethical review. This work was carried out in compliance with human rights defined by the Helsinki Accords. All patients gave informed consent to participate in the study. The study was approved by the Ethics Committee of the V.A. Nasonova Research Institute of Rheumatology (Protocol No. 8 dated 10/25/2022).	***Этическая экспертиза.*** Настоящая работа проводилась с соблюдением прав человека, определенных Хельсинкским соглашением. Все пациенты дали информированное согласие на участие в исследовании. Исследование было одобрено этическим комитетом ФГБНУ «НИИ ревматологии имени В.А. Насоновой» (протокол № 8 от 25.10.2022).
Study funding. The work was carried out using budgetary funding for the implementation of the state assignment on topic FURS-2022-0009 (state assignment number 1021062512064-0).	***Источник финансирования.*** Работа выполнена за счет средств бюджетного финансирования на выполнение государственного задания по теме FURS-2022-0009 (номер государственного задания 1021062512064-0).
Conflict of interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	***Конфликт интересов.*** Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Contribution of individual authors. Byalik A.A.: collection of database, writing of the text of article. Makarov S.A.: patient selection. Karateev A.E.: idea of the study, editing of the article. Nesterenko V.A., Kudinsky D.M.: statistical processing of results. The authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	***Участие авторов.*** А.А. Бялик – сбор базы данных, написание текста статьи. С.А. Макаров – отбор пациентов. А.Е. Каратеев – идея исследования, редактирование статьи. В.А. Нестеренко, Д.М. Кудинский – статистическая обработка результатов. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.

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