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Treatment outcomes of patients with knee hyaline cartilage damages using osteoperforative methods

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BACKGROUND: The treatment of traumatic and degenerative cartilage damage is one of the largest areas in orthopedic practice, and the therapy success remains limited.

AIM: To analyze the results of surgical treatment of patients with traumatic and degenerative injuries of the knee joint hyaline cartilage using debridement and osteoperforative techniques, taking into account the time from the surgical intervention.

MATERIALS AND METHODS: A statistical analysis was conducted on the treatment outcomes of servicemen with traumatic and degenerative damage in the knee joint articular hyaline cartilage. Patients underwent surgical treatment using osteoperforative techniques (abrasive chondroplasty, tunneling, and microfracturing) at the Clinic of Military Traumatology and Orthopedics of the S.M. Kirov Military Medical Academy from 2009 to 2019. The study relied on the data obtained from questioning the patients using the Knee Injury and Osteoarthritis Outcome Score (KOOS) and LKSS questionnaires.

RESULTS: The result analyses using the KOOS and LKSS scales revealed significantly higher good results in the observed group in the postoperative period from 1 to 4 years than in the groups from 4 to 8 and more than 8 years ($p = 0.004$). No significant differences were determined in the treatment outcomes of the groups with resection and different osteoperforative methods.

CONCLUSIONS: Treatment methods for hyaline cartilage defects, such as resection and osteoperforative, are technically simple with good treatment outcomes in patients with articular cartilage injuries from 1 to 4 years postoperative. Treatment outcome deterioration was noted in 4–8 years postoperative, regardless of the treatment method used, which is more significant in patients in >8 years postoperative.

Keywords: knee joint; hyaline cartilage; cartilage defect; chondropathy; chondroplasty.

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Результаты лечения пациентов с повреждениями гиалинового хряща коленного сустава с применением резекционных и остеоперфоративных методик

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Обоснование. Повреждение хрящевой ткани травматического и дегенеративного генеза встречается наиболее часто в практике ортопеда, при этом успех терапии остается ограниченным.

Цель — проанализировать результаты хирургического лечения пациентов с травматическими и дегенеративными повреждениями гиалинового хряща коленного сустава с применением дебридмента и остеоперфоративных методик и с учетом времени, прошедшего после выполнения оперативного вмешательства.

Материалы и методы. Проведен статистический анализ результатов лечения 223 пациентов с травматическим и дегенеративным повреждением суставного гиалинового хряща коленного сустава, которые получили оперативное лечение с использованием дебридмента зоны повреждения и остеоперфоративных методик (туннелизация, микрофрактурирование) в клинике военной травматологии и ортопедии Военно-медицинской академии им. С.М. Кирова в период с 2009 по 2019 г. В работе опирались на данные, полученные при анкетировании пациентов с помощью опросников KOOS и LKSS.

Результаты. Доля пациентов с хорошими результатами в период наблюдения от 1 года до 4 лет после операции была достоверно больше, чем доля пациентов в период от 4 до 8 и более 8 лет ($p = 0{,}004$). Достоверные различия в результатах лечения между группами с резекционными и разными остеоперфоративными методиками отсутствовали.

Заключение. Резекционные и остеоперфоративные методики лечения дефектов гиалинового хряща являются технически простыми и позволяют получить хорошие результаты у пациентов с повреждениями суставного хряща в период от 1 до 4 лет с момента операции. Ухудшение результатов лечения отмечено в период с 4 до 8 лет вне зависимости от использованной методики и более значимо у пациентов с послеоперационным сроком более 8 лет.

Ключевые слова: коленный сустав; гиалиновый хрящ; дефект хряща; хондропатия; хондропластика.

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BACKGROUND

Cartilage injuries of traumatic and degenerative origin are most common in the practice of an orthopedist, and the complexity of therapy is due to the specificity of the hyaline cartilage histological structure [1].

More than 50% of outpatient orthopedic traumatologist visits are associated with pain in large joints. Result analysis of more than 30,000 arthroscopic surgeries for large joint damage revealed that damage to the articular cartilage was of various degrees in 63% of cases [2, 3].

Several treatment methods are available for articular cartilage defects, but the success of therapy remains limited. In surgical treatment, autologous osteochondral grafts are used to replace cartilage defects; however, this technique is not free from shortcomings. The graft sampling site is limited by the area of the donor site, which should correspond to the unloaded articular surface of the cartilage. The donor site is a risk factor for soreness in the postoperative period and the development of a degenerative-dystrophic process of the joint [4].

Techniques using biotechnologies, cell therapy, and tissue engineering methods are actively developed [5]. This approach is associated with the provision of the necessary laboratory conditions and the availability of specialists with the appropriate qualifications for culturing cell material. Additionally, cartilage tissue is not always formed due to treatment, and treatment outcomes using regenerative medicine are comparable to widely used methods of osteoperforation [6–8]. Concurrently, the advantage of the latter consists of the minimum set of necessary surgical instruments, low cost, and ease of performing procedures through a minimally invasive short-term single surgical intervention. However, evidence revealed that the obtained results using osteoperforative techniques deteriorate over time after surgery, which limits their use [9, 10].

The Clinic of Military Traumatology and Orthopedics of the Military Medical Academy has accumulated extensive experience in the use of debridement of damaged articular cartilage areas and osteoperforative techniques such as tunneling and microfracturing.

This study aimed to analyze the results of surgical treatment of patients with traumatic and degenerative injuries of the hyaline cartilage of the knee joint using debridement and osteoperforative techniques, considering the time after surgery.

MATERIALS AND METHODS

This retrospective study included 223 patients who are operated on at the Clinic of Military Traumatology and Orthopedics of the S.M. Kirov Military Medical Academy from 2009 to 2019. Participants were distributed into two groups. Group 1 consisted of 43 patients with chondromalacia of the articular cartilage of the supporting surface of the femoral condyles after a knee joint injury, and group 2 (180 patients) included patients with chondromalacia of similar zones as a result of chronic degenerative damage of the cartilage, as an indication of the initial manifestations of gonarthrosis. The criterion for inclusion of patients in the study was damage to the articular cartilage degrees II (34; 15.2%), III (105; 47.1%), and IV (84; 37.7%) (according to Outerbridge, 1961) with damage to the supporting surface of the articular cartilage of one of the condyles of the femur with a total area of up to 2 cm^2. The study did not include patients with concomitant pathology of the knee joint, except the flap and degenerative injuries of the menisci, for which their partial resection was required. All patients underwent the surgical procedures, namely damaged cartilage zone debridement (50%; 22.4%), mainly in patients with degree II of articular cartilage damage and tunneling (64; 28.7%) and microfracture (99; 44.4%) in patients with degrees III and IV. On day 2 postoperative, the knee joint was punctured. Walking with crutches without any load on the operated leg, as well as physical therapy exercises (contractions of the muscles of the thigh and lower leg) were recommended starting from day 2, and physiotherapy procedures (magnetotherapy, ultrahigh-frequency therapy) were recommended starting from day 7 postoperative. Dosed load in patients with joint debridement was allowed from day 2 and week 4 postoperative in case of osteoperforative techniques. Males significantly predominated with 164 (73.5%) whereas women were 59 (26.5%). The age of patients ranged from 17 to 69 years, with an average of 32.7 ± 12.4 years at the time of surgery in group 1 and 40.3 ± 12.4 years in group 2.

The surgical treatment results of patients in each examined group were analyzed using the international systems for evaluating the results on two scales. The Knee Injury and Osteoarthritis Outcome Score (KOOS) scale were used to subjectively assess the patient's condition and the impact of the disease on the quality of life, and professional activity. The score was from 100 to 0, while the results were considered unsatisfactory with values from 0 to 49 points, satisfactory with 50–79 points, good results were with 80–99 points, and excellent results with 100 points. This scale consists of five subscales to assess pain and other symptoms, activities of daily living, leg function during sports and recreation, and overall quality of life. The KOOS scale questionnaire reflects only the subjective opinion of patients; therefore, the Lysholm Knee Scoring Scale (LKSS) score was used for the knee joint to avoid distortion of the results due to the individual perception of the above parameters. It objectifies the results of treatment and includes questions regarding lameness, knee joint swelling, blockage episodes, and joint instability,

as well as pain, discomfort, and restrictions when climbing stairs, squatting, and using supportive devices. According to the LKSS scale, <65 points are poor, 65–83 are satisfactory, 84–94 are good, and 95–100 are excellent results. The study was performed using two scales for a comprehensive treatment outcome analysis since they are based on different approaches in assessing patient conditions [11, 12].

Statistical processing of the obtained results was performed using the program StatSoft Statistica 6.1. The relative frequencies within the two groups were compared by testing the hypothesis of equality of the relative frequencies in the two populations; the significance level was taken as $p < 0.05$; at $0.1 \geqslant p \geqslant 0.05$, there was a tendency to difference [13].

RESULTS

The treatment result analysis of patients in group 1 with distribution into subgroups based on the postoperative period duration is presented in Table 1.

Treatment satisfaction in group 1 was assessed according to the KOOS and LKSS scales at different periods after surgery. An interesting pattern was established that the proportion of patients with good and excellent results from 1 to 4 years after surgery was statistically significantly greater than from 4 to 8 years ($p = 0.004$). According to these questionnaires, none of the patients, whose treatment outcome was analyzed over >8 years, rated their condition as "excellent" or "good."

The survey results of group 2 are presented in Table 2.

We registered a presentation similar to the data of group 1 when assessing the satisfaction with the treatment results in group 2 according to the KOOS scale. With increased duration of the postoperative period, the proportion of good and excellent results decreased from 93.2% in the subgroup with a postoperative follow-up period of 1–4 years to 62.7% and 18.2% in 4–8 and 8–10 years, respectively. Concurrently, the proportion of patients who rated their treatment results as satisfactory increased ($p = 0.035$). According to the KOOS scale, even with the maximum follow-up period, no unsatisfactory results were obtained.

A survey of patients in group 2 according to the LKSS scale was conducted, in which good and excellent results during the follow-up of 1–4 years were noted in 93.2% and 51.0% of cases in the 4–8 years. Additionally, in the subgroup of patients with terms of 8–10 years after surgery, no good and excellent treatment results were obtained. The same regularity was revealed using the KOOS scale ($p = 0.014$). Concurrently, 4 years after the intervention, some patients of group 2 regarded the treatment result as poor.

Table 1. Results of treatment of group 1 based on the postoperative period duration according to the KOOS and LKSS scales

The period after surgery, subgroups	Treatment result							
	KOOS scale				LKSS scale			
	poor	satisfactory	good	excellent	poor	satisfactory	good	excellent
1–4 years (1)	0; 0%	0; 0%	24; 92.3%	2; 7.7%	0; 0.0%	2; 7.7%	17; 65.4%	7; 26.9%
4–8 years (2)	0; 0%	10; 71.4%	4; 28.6%	0; 0%	0; 0.0%	10; 71.4%	4; 28.6%	0; 0.0%
8–10 years (3)	0; 0%	3; 100%	0; 0%	0; 0%	1; 33.3%	2; 66.7%	0; 0.0%	0; 0.0%
Significance level, p	–	–	$p_{1-2} < 0.001$ $p_{1-3} < 0.001$	–	–	–	$p_{1-2} = 0.032$ $p_{1-3} = 0.04$	$p_{1-2} = 0.039$ $p_{1-3} = 0.31$

Note: p_{1-2}; p_{1-3}; p_{2-3}: level of significance of differences in the treatment results depending on the postoperative period duration.

Table 2. Treatment results in group 2 based on the postoperative period duration according to the KOOS and LKSS scales

The period after surgery, subgroups	Treatment result							
	KOOS scale				LKSS scale			
	poor	satisfactory	good	excellent	poor	satisfactory	good	excellent
1–4 years (1)	0; 0%	8; 6.8%	93; 78.8%	17; 14.4%	0; 0.0%	8; 6.8%	19; 16.1%	91; 77.1%
4–8 years (2)	0; 0%	19; 37.3%	32; 62.7%	0; 0%	4; 7.8%	21; 41.2%	15; 29.4%	11; 21.6%
8–10 years (3)	0; 0%	9; 81.8%	2; 18.2%	0; 0%	1; 9.1%	10; 90.9%	0; 0.0%	0; 0.0%
Significance level, p		$p_{1-2} < 0.0001$ $p_{2-3} = 0.008$	$p_{1-2} = 0.031$ $p_{2-3} = 0.009$	$p_{1-2} = 0.005$	$p_{1-2} = 0.002$ $p_{1-3} = 0.002$	$p_{1-2} < 0.0001$ $p_{2-3} = 0.004$	$p_{1-2} = 0.049$ $p_{2-3} = 0.045$	$p_{1-2} < 0.0001$ $p_{2-3} < 0.0001$

Note: p_{1-2}; p_{1-3}; p_{2-3}: level of significance of differences in the treatment results based on the postoperative period duration.

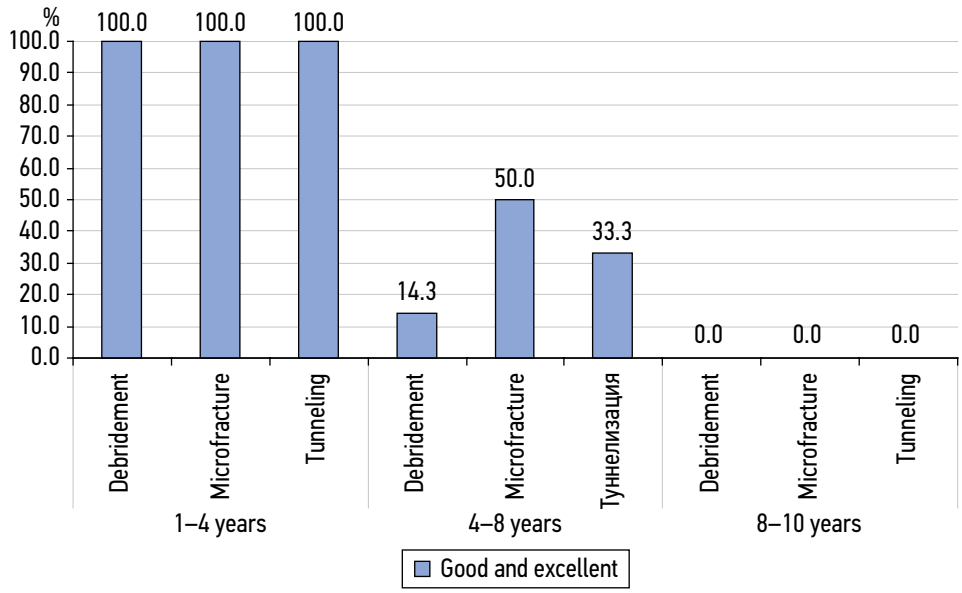

Fig. 1. The total frequency of good and excellent results of treatment of group 1 at different times after surgical interventions based on their type (score on the KOOS scale)

The comparison of data in Tables 1 and 2 showed that the proportion of good and excellent results with an increased follow-up period decreased in both groups. Additionally, among group 2 patients with a postoperative period of 4–8 years, the proportion of patients who assessed their condition as good was statistically significantly higher than group 1 (62.7% and 28.6%, respectively, $p = 0.026$).

Figures 1 and 2 present good and excellent treatment results of patients based on the type of surgery and the postoperative period duration.

No statistically significant differences were found in the treatment results of patients in group 1 between the subgroups with different postoperative periods depending on the type of surgical treatment. In the subgroup with a postoperative period of 4–8 years, the results were significantly better in patients after microfracture.

The statistical analysis of the treatment results in group 2 according to the KOOS scale also revealed no significant differences between the subgroups based on the postoperative period, considering the surgical technique. In the subgroup with a postoperative period of 4–8 years, a tendency toward a difference was found between the treatment outcomes with the highest number of positive results in patients using debridement ($p = 0.08$).

The comparison of treatment results in patients of groups 1 and 2 with a postoperative period of 4–8 years revealed

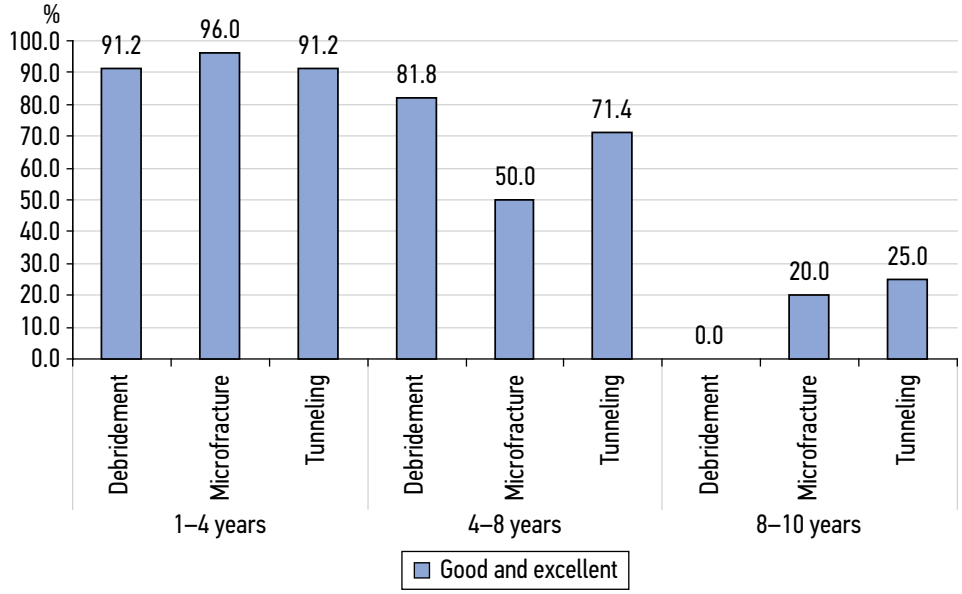

Fig. 2. The total frequency of good and excellent treatment results of group 2 at different times after surgery, based on their type (score on the KOOS scale)

a significant decrease in the assessment of treatment results by debridement of the cartilage damage zone in patients with traumatic damage to the articular cartilage ($p = 0.02$). No other statistically significant differences were found in the treatment outcomes between the groups.

DISCUSSION

The surgical treatment results of articular cartilage defects were analyzed using the most commonly used and technically simple and accessible methods. Debridement, as a resection method, is aimed at local smoothing of the damaged cartilage surface and removal of detached cartilage. This technique aims to restore joint movement and improve the congruence of the articular surfaces but does not provide stimulation of histogenesis in the resulting defect. The integrity of the subchondral bone is disrupted to create channels between the defect in the cartilage and the underlying bone marrow in using osteoperforative techniques to repair cartilage damage [14]. The recruited multipotent bone marrow stromal cells penetrate the created articular cartilage defect through these channels, facilitating the subsequent formation of new tissue similar to the articular cartilage (remodeling).

Our study revealed no statistically significant differences between the groups using the osteoperforative treatment methods. Similar data are also presented by the international authors [15]. However, the result analyses of debridement and osteoperforative techniques revealed a greater of patients in group 2 with a postoperative follow-up period of 4–8 years who assessed their condition as good than among the patients of group 1. Debridement proved to be a less effective treatment method for patients with traumatic cartilage damage. The rapid progression of the destructive process in the injured articular cartilage, leading to the early formation of degenerative-dystrophic changes in the joint, is presumably associated with the natural phenomena of secondary alteration in the defect zone, aggravated by the debridement procedure, and the anatomical and physiological aspects of the cartilage tissue itself, which determine its inability to spontaneous regeneration.

Such approaches of articular cartilage restoration are effective only for small defects, with an area of up to 2 cm^2 [16]. A literature review revealed the undoubted superiority of mosaic chondroplasty over osteoperforative techniques in the long term in patients with local cartilage tissue damage with an area of 4–6 cm^2 [17]. Additionally, several authors note that osteoperforative techniques, as well as debridement of the articular surface, provide a relatively short-term functional improvement [18], since, in defiance of all expectations, defects are mainly filled with fibrous rather than hyaline cartilage. This effect was also noted in our study, where excellent results were recorded in subgroups with short follow-up after surgery; however, they were absent in subgroups with a follow-up period of 8–10 years, although it should be noted that the number of patients in them was small (3 patients in group 1 and 11 patients in group 2) (Tables 1, 2). As the postoperative period duration increased, patients more often assessed negatively the results of surgical treatment for degenerative-dystrophic joint diseases. Thus, several authors are doubtful about the choice of surgical techniques for the treatment of patients with osteoarthritis, believing that the number of bone marrow stem cells entering the joint cavity after osteoperforation of sclerotic subchondral bone is insufficient for a regenerative effect [19, 20]. Our study results revealed that the treatment efficiency using resection techniques significantly depended on the causes of articular cartilage damage, thus debridement gave more good results in the group with a degenerative nature of the disease than in the group with traumatic cartilage damage, in subgroups with a postoperative period of 4–8 years.

Generally, the obtained data using the two scales were similar, and the estimates of treatment outcomes worsened with an increased postoperative period duration. Concurrently, using the LKSS scale, which objectively evaluates the treatment results, poor indicators were revealed in the long-term after surgery, which, in our opinion, makes it more informative in comparison with the KOOS scale [11, 12].

Currently, orthopedists are improving methods of osteoperforative treatment of cartilage damage and suggest combining these methods with corrective osteotomy, the use of various matrices to close defects, the introduction of cartilage growth factors, and autologous stem cells [4]. The tissue engineering methods are particularly promising methods for articular cartilage restoration, as they are aimed to create tissue engineering products in the laboratory and use for intra-articular treatment with high regenerative capabilities that can potentiate the formation of remodeled hyaline cartilage in the damaged area [20–22].

Our study has certain limitations associated with the presence of unconsidered factors that could affect the study results, including the age of patients at the time of surgery, body mass index, level of physical activity, and size of the hyaline cartilage defect.

CONCLUSION

Osteoperforative methods of cartilage tissue restoration and debridement, being technically simple methods of treatment, provide good results in patients with local damage to the articular cartilage up to 2 cm during the first 4 years after surgery. In the future, an increased pain syndrome is

noted in patients with both degenerative-dystrophic joint diseases and traumatic injuries of cartilage tissue. In 4–8 years follow-up, the results of debridement in patients with post-traumatic injuries are worse than with the osteoperforative techniques. After 8 years, patient satisfaction with the results of treatment continues to decline, without differences based on the methods used.

ADDITIONAL INFORMATION

Funding. The study had no external funding.

Conflict of interest. The authors declare no conflict of interest.

Ethical considerations. The study on the problem of surgical treatment of articular cartilage defects was approved by an independent ethics committee at the S.M. Kirov Military Medical Academy (protocol No. 175 of 2016). Patients gave informed consent to the non-personalized use of the examination data when publishing the study results.

Author contributions. *S.V. Chebotarev* collected the data and conducted a survey of the patients, prepared illustrations, and wrote the initial draft of the article; *V.V. Khominets* undertook methodological support and editing of the final version of the article; *D.A. Zemlyanoy* performed statistical processing, analysis, and interpretation of primary data, editing of the final version of the article; *L.I. Kalyuzhnaya* searched for literature on the chosen subject, developed the concept and design of the study; *A.S. Grankin, R.A. Fedorov* selected the clinical material, drew up research methodology, edited the final version of the article.

All authors made a significant contribution to the study and preparation of the article, as well as read and approved the final version before its publication.

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