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Surgical Treatment of Osteochondral Lesions of the Talar Dome: Review

Ekaterina A. Pashkova, Evgenii P. Sorokin, Viktor A. Fomichev, Nikita S. Konovalchuk, Ksenia A. Demyanova

Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia

Abstract

Background. The relevance of the talar dome osteochondral lesions problem is assosiated with the difficulties of diagnosis, the lack of unified treatment algorythm and the great number of unsatisfactory clinical and functional results. In the last decade, there has been increasing interest in this topic in the literature, which is demonstrated by a great number of publications with series of observations or clinical cases. However, attempts to create the universal algorithm for this group of patients treatment are limited by the low level of existing studies evidence, high frequency of the new data publications, as well as the impossibility of using a number of surgical methods in different countries for legislative or other reasons. ***The aim*** is to determine the current state of the problem of the talar dome osteochondral lesions surgical treatment and to identify types of surgical interventions in patients with the studied pathology. Material and methods. 120 international articles published from 2000 to 2021, as well as 18 domestic publications for the period from 2007 to 2021 were selected for the literature analysis. The search for publications was carried out in the PubMed/MedLine and eLibrary databases. ***Results.*** The most widespread are surgical interventions aimed at stimulation of the bone marrow, and plastic surgery using osteochondral auto - and allografts. Currently, there is no consensus on the indications for different types of surgical methods, and the previously used indications are being questioned. This determines the need to improve diagnostic and treatment concepts. ***Conclusions.*** The studied literature cannot fully answer a number of questions related to the methods of surgical treatment of patients with symptomatic osteochondral lesions of the talar dome and indications for them. A more detailed assessment of the medium- and long-term clinical outcomes of various surgical methods and the development of algorithms for this group of patients treatment, specific for different countries, are needed.

Keywords: osteochondral lesions of the talar dome, mosaic osteochondroplasty, osteochondral defect, talus, ankle arthroscopy.

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Ekaterina A. Pashkova; e-mail: caterinapashkova@yandex.ru

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Хирургические методы лечения остеохондральных повреждений блока таранной кости: обзор литературы

Е.А. Пашкова, Е.П. Сорокин, В.А. Фомичев, Н.С. Коновальчук, К.А. Демьянова

ФГБУ «Национальный медицинский исследовательский центр травматологии и ортопедии им. Р.Р. Вредена» Минздрава России, г. Санкт-Петербург, Россия

Реферат

Введение. Актуальность проблемы остеохондральных повреждений блока таранной кости обусловлена трудностями диагностики, отсутствием единой схемы лечения и большим количеством неудовлетворительных результатов. В последнее десятилетие отмечается повышение интереса к этой теме в литературе, что проявляется большим количеством публикаций, представленных сериями наблюдений или клиническими случаями. Однако попытки создания универсального алгоритма лечения этой группы пациентов ограничены низким уровнем доказательности имеющихся исследований, быстротой появления новых данных, а также невозможностью применения ряда хирургических методов в разных странах по законодательным или иным причинам. ***Цель*** — оценить современное состояние проблемы хирургического лечения остеохондральных повреждений блока таранной кости и выявить спектр оперативных вмешательств у пациентов с изучаемой патологией. ***Материал и методы.*** Для анализа литературы было отобрано 120 иностранных статей, опубликованных с 2000 по 2021 г., а также 18 отечественных публикаций за период с 2007 по 2021 г. Поиск публикаций проводился в базах данных PubMed/MedLine и eLIBRARY. ***Результаты.*** Наибольшее распространение получили вмешательства, направленные на стимуляцию костного мозга, и пластические операции с использованием остеохондральных ауто- и аллотрансплантатов. В настоящее время нет единого мнения о показаниях к разным хирургическим методам, а используемые ранее показания ставятся под сомнение. Это определяет необходимость совершенствования диагностических и лечебных концепций. ***Заключение.*** Изученная литература не может в полной мере ответить на ряд вопросов, связанных со способами оперативного лечения пациентов с симптомными остеохондральными повреждениями блока таранной кости и показаниями к ним. Необходима более детальная оценка среднесрочных и отдаленных клинических исходов различных хирургических методов и разработка алгоритмов лечения этой группы пациентов, специфичных для разных стран.

Ключевые слова: остеохондральные повреждения блока таранной кости, мозаичная остеохондропластика, костно-хрящевой дефект, таранная кость, артроскопия голеностопного сустава.

Источник финансирования: исследование проведено без спонсорской поддержки.

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Пашкова Екатерина Анатольевна; e-mail: caterinapashkova@yandex.ru

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Background

Surgical treatment of patients with chondral and osteochondral lesions of the talar dome (OLTD) is a difficult task for orthopedic surgeons, since there is no single algorithm to develop indications for various treatment methods, and the contradiction of the data available in the literature complicates the treatment of patients with this pathology [1, 2]. In recent decades, there has been a trend towards a detailed consideration of the etiology and pathogenesis of OLTD and the introduction of modern types of surgery [1]. However, most of the publications are presented by a series of observations or clinical cases with a low level of evidence, and some of the proposed surgical methods of treatment are not applicable in a number of countries for various reasons [3].

The aim of the study was to determine the current state of the problem of surgical treatment of patients with OLTD based on the analysis of foreign and domestic literature and to identify the range of possible surgical options.

Materials and methods

To analyze the literature on this topic, 120 foreign articles published from 2000 to 2021 were selected, as well as 18 domestic publications for the period from 2007 to 2021. Publications were searched in PubMed/MedLine and eLibrary databases. Keywords and phrases were used: osteochondral lesions of the talar dome; Dias's disease; osteochondritis dissecans; mosaic osteochondroplasty; tunneling; microfracturing; osteochondral transplantation; talus; bone-cartilage defect; osteochondral defect; osteochondral lesion; talus; microfracture; osteochondral autogenous transfer; bone marrow aspirate concentrate; cartilage repair.

From the publications reviewed during the analysis, the most relevant sources indicated in the list of references were selected. A number of classifications proposed in 1950-1990 are presented with references to primary sources.

Results

Anatomical background

The participation of the talus bone in the formation of the joints of the posterior foot explains its extensive cartilage coverage (up to 60-73% of the surface) and the features of blood supply [4, 5, 6, 7]. A small number of artery entry points make the talus bone at risk of aseptic necrosis and limit its regenerative potential due to the formation of numerous "watershed lines" of vascular areas [5, 6, 7].

The ankle joint is the most congruent among the large joints of the lower limb and in comparison, has thinner cartilage coating. The average thickness of the cartilage of the talus dome is 1.06-1.63 mm, while the thickness of the cartilage of the knee joint is 1.65-2.65 mm. Due to the high congruence of the ankle joint, even minor post-traumatic disorders of the ratios lead to rapidly progressive injury to the cartilage and subchondral bone [5, 7].

The talus bone is responsible for redistributing the load from the lower limb, acting as "meniscus of the foot", and pronounced axial loads passing through the posterior foot affect the regenerative capabilities of the talus bone, provoking the progression of OLTD and osteoarthritis [7].

Prevalence and etiology

The occurrence of OLTD is not precisely determined due to the difficulties of diagnosis, especially in the early stages. It is believed that they account for 4% of all osteochondritis dissecans and up to 63% of patients with cruzalgia of unknown origin. At the same time, attention is drawn to the high incidence of young people of working age: the predominant age group is from 20 to 40 years, the incidence in men is greater than in women (1.6:1) [5].

The etiology of OLTD remains not fully understood. According to the literature, 76-85% of observations are associated with trauma: fractures of the bones forming the ankle joint; ligaments injury; repeated microtraumatization. The incidence of OLTD in patients with acute ruptures of the lateral ligamentous complex of the ankle joint is 5-13%, and concomitant OLTD are detected in 50-73% of cases of acute injuries of the ankle joint [5, 8]. Lateral OLTD is associated with trauma in 93-98% of cases. Medial injuries are associated with acute trauma less often: from 61 to 70% of cases [5, 9].

Several theories of the development of OLTD of non-traumatic genesis have been proposed, including vascular and synovial injuries, soft tissue impingement by an additional anteroinferior tibiofibular ligament (Bassett ligament), chronic instability of the ankle joint [5]. F. König in his original study suggested that non-traumatic injuries are the result of subchondral vascular occlusion leading to subsequent cystic changes [10].

Clinics and diagnosis of OLTD

The most typical complaint of patients with OLTD is diffuse deep pain in the ankle joint associated with physical loads. Moreover, there may be a discrepancy between the localization of pain syndrome and OLTD [5, 9, 11, 12]. Less common are complaints

of swelling of the ankle joint and limitation of the range of motions. There may be mechanical symptoms, such as clicks, joint blockage and a feeling of instability [13, 14].

There are no specific symptoms of the disease, untimely and incorrect diagnosis of OLTD in the group of patients with chronic pain in the ankle joint reaches 81% [15]. The results of physical examination of patients are often uninformative, osteochondral injuries may be asymptomatic and be a random finding. The diagnosis of OLTD can be made immediately after the injury, but it is often associated with prolonged cruzalgia, which gives grounds for dividing osteochondral defects into acute and chronic without specifying the dates in the literature.

The first-line diagnostic method for OLTD is anteroposterior and lateral radiographs of the ankle joint, as well as radiographs in the mortise projection under load [5, 12]. The absence of an identifiable lesion on radiographs does not exclude the diagnosis of OLTD. According to S. Hepple et al, 43% of OLTD visualized on MRI were not initially detected on radiographs [16]. Computed tomography (CT) provides a more detailed visualization of the lesion and reflects the true size of the detached fragment. It is especially useful for determining the state of the surrounding bone tissue and the volume of cysts associated with OLTD, which can be used for preoperative planning [5]. Magnetic resonance imaging (MRI) is useful for identifying bone marrow edema in the early stages of OLTD and correlates fairly well with the results of arthroscopy. But it should be taken into account that MRI can exaggerate the severity of damage due to the variability of signal changes [5, 12, 17].

Scintigraphy is not used in all medical institutions due to the high cost, however, there are indications of 99% sensitivity when using scintigraphy with technetium 99m in the diagnosis of OLTD. The addition of the method of SPECT-CT (single-photon emission computed tomography) can help in the detection of asymptomatic lesions by assessing the actual metabolic changes in the bone [5].

Pathophysiology of pain syndrome

Various assumptions are made about the cause of pain syndrome in OLTD: increased intra-articular pressure, increased intraosseous pressure, synovial pain, etc. [9, 18]. The pathogenetic theory proposed by S.N. van Dijk has become the most widespread. He associates the appearance of pain syndrome directly with the anatomy of the talus dome. The fluid content in the interstitial matrix of cartilage, the subchondrally located cortical bone plate and the underlying richly innervated spongy bone are of great importance [18].

When a cartilage defect occurs that passes through the subchondral bone plate, a connection occurs between the articular space and the subarticular spongy bone. The local fluid pressure in the spongy bone is a powerful stimulus for the nerve endings located in it. Cartilage is a viscoelastic material, interstitial fluid is released from the cartilage matrix as it is compressed. In a congruent joint, when compressed, the fluid remains in the cartilage and does not penetrate into the articular space. In case of congruence violation, the fluid tends both into the joint cavity and into the underlying tissues, and when the subchondral bone plate is injuried, it penetrates into the subcortical spongy bone, provoking the development of pain syndrome. During exercise, there is a recurring local fluid pressure that leads to osteolysis and is a powerful bone resorptive stimulus. Bone resorption leads to the formation of subchondral cystic changes surrounded by a newly formed calcified zone [18].

As the subchondral bone continues to be damaged, its ability to retain the cartilage coating decreases, which leads to a more extensive detachment of articular cartilage [9, 18]. The resulting local OLTD changes the biomechanics of the entire joint, predisposing to the development of osteoarthritis [11, 12].

Classifications

In 2001, I. Elias et al, and later in 2006, S.M. Raikin et al. proposed systems for clarifying the localization of OLTD, providing for the division of the talus dome into 9 zones [19]. The systematic review by P.R. van Diepen et al. reviewed studies that included 2,087 observations of OLTD. According to the results of their analysis, the overwhelming majority of OLTD were localized in the posteromedial (28%) and central medial (31%) zones. At the same time, a correlation was revealed between the size of the defect and its localization: the damage was greatest in the central-central zone [20].

Currently, a large number of OLTD classifications have been proposed, which are used in individual studies. All of them reflect the stages of the ongoing processes, but none of them determines the prognosis and a single treatment tactic. Historically, the first is the radiographic classification of A. Berndt and M. Harty (1959): stage I - subchondral impression (impression fracture); stage II - partial detachment of the osteochondral fragment; stage III - completely detached fragment

without displacement from the detachment zone; stage IV - dislocated fragment [21].

Some of the new classification schemes modify the system of A. Berndt and M. Harty, adding a subtype that takes into account the presence of subchondral cystic changes, for example, the classification of P.E. Scranton et al. in 2001 [22].

The classification of S. Hepple, based on the results of MRI, has become widespread, which makes it possible to distinguish chondral lesions into a separate stage [16]. Also relevant is the classification of R.D. Ferkel and N.A. Sgalione based on CT, recommended for use in preoperative planning [23]. In addition, it is possible to classify OLTD intraoperatively based on arthroscopic data, the most widely used classification system is R.D. Ferkel and M.S. Cheng [24].

There is a tendency to create classifications based on several research methods and classification schemes that have a confirmed correlation with arthroscopic data, for example, the MRI classification of D.N. Mintz et al [25].

Treatment of patients with OLTD

Treatment of patients with OLTD is a difficult task due to the limited regenerative potential of the articular surface of the talus and significant loads transmitted through the ankle joint. The preferred method of treatment for symptomatic OLTD remains surgical.

The existing surgical methods of treatment are based on one of the following principles–

- surgical debridement of lesion and stimulation of the bone marrow (microfracturing, tunneling);
- fixing of the detached bone-cartilaginous fragment on the talar dome (fixation);
- stimulation of hyaline cartilage development (osteochondroplasty using auto- and allografts, implantation of autologous and juvenile chondrocytes) [18].

In some literature sources, surgical methods of treating patients with OLTD are divided into primary restorative (fixation), lavage and debridement (palliative treatment), restorative (reparative techniques) and plastic (restorative techniques). The restorative methods include surgery aimed at stimulating the bone marrow: abrasive arthroplasty, microfracturing, tunneling. Plastic methods include implantation of autologous chondrocytes (ACI — autologous chondrocyte implantation), ACI using membranes/matrices (MACI — matrix/membrane autologous chondrocyte implantation), the use of osteochondral allografts and autografts (OATS and mosaic transplantation), transplantation of juvenile chondrocytes, the use of cartilage implants and scaffolds saturated with stem cells, etc. [15].

There are a number of conditions that must be taken into account when choosing tactics: the severity of symptoms, the size and depth of the defect, the displacement of the fragment, the presence of cystic changes in the subchondral bone, patient factors, etc.

Most often, the largest diameter of the OLTD with a boundary value of 15 mm is used to differentiate the indications for restorative techniques (reparative techniques) and plastic surgery of the talus (restorative techniques) [12, 15, 17, 26]. According to the international consensus on the restoration of ankle cartilage (2017), the lack of clinical studies comparing the long-term results of these groups of surgery makes such a differentiation of indications (15 mm) "historically conditioned". Currently, there is no consensus on the reliability of this principle [26].

Lavage, debridement, curettage

The ankle lavage, debridement and curettage described in early sources are non-radical in nature and are not able to fully restore the cartilaginous surface, so they are currently used as an adjunct to the main intervention. Isolated use of these techniques is acceptable for incomplete chondral injuries of the talus dome, acute OLTD, accidental findings during arthroscopy and cartilage damage caused by other diseases (gouty arthritis, pigmented villesonodular synovitis, etc.) [4, 26].

Surgical debridement, bone marrow stimulation

The main goal of surgical treatment of the defect is to stabilize the bone and articular cartilage within the boundaries of the lesion and create an environment that will promote the formation of fibrous cartilage tissue [18, 19]. Bone marrow stimulation (BMS) involves the removal of unstable fragments of the cartilaginous coating, followed by tunneling or microfracturing of the subchondral bone, the result of which is the induction of blood supply in the area of OLTD. In addition to mechanical stimulation of regenerative processes, a fibrin clot forms inside the treated defect, initiating an inflammatory reaction and the subsequent release of cytokines and growth factors to stimulate the healing process. Pluripotent mesenchymal stem cells migrate from the bone marrow to the clot, begin to differentiate and proliferate, forming a fibrous-cartilaginous type of tissue, subsequently coarse-fibrous cartilage forms at the site of injury [26, 27].

Disputes about indications for BMS continue: 94% of participants in the consensus on the restoration of ankle cartilage (2017) agreed that the "ideal" OLTD for BMS are injuries with a diameter of <10 mm, an area of <100 mm^2 and a depth of <5 mm. The probability of a good outcome after BMS in lesions with a diameter of 15 mm or more is considered doubtful [26].

This is confirmed by recent data that injuries with a diameter of >10 mm after BMS have a greater risk of progression, which is presumably due to mechanical inferiority of coarse-fibrous cartilage [28].

L. Ramponi et al. in a systematic review define the area of OLTD as one of the predictors of the outcome of BMS: according to their data, the optimal area of OLTD for BMS is less than 107.4 mm^2 [17]. J.I. Choi et al. found a deterioration in OAFAS indicators in the groups of increased lesion size: groups 100-149 mm^2, 150-199 mm^2 and >200 mm^2 were associated with an increased probability of clinical inefficiency of BMS compared with lesions <100 mm2 [29]. The ambiguity of the data suggests that the indications for BMS, determined by the size of the damage, should be revised.

Microfracturing is carried out using an awl with a given bending angle, which is used to process the bone with the formation of multiple microfractures in the area of lesion. Tunneling of the OLTD zone is performed with a drill or a k-wire before the appearance of blood dew from the subchondral layer of bone [29]. Antegrade and retrograde tunneling are distinguished. Retrograde tunneling under C-arm intraoperative control can be used in isolated subchondral injuries with intact proper articular cartilage [30]. Previously popular antegrade transmalleolar tunneling is currently not recommended for use due to damage to the articular cartilage of the tibia/fibula. The most used is antegrade tunneling of the lesion area using arthroscopic technique. However, with posteromedial lesions, the use of standard arthroscopic approaches is impossible, in this situation, classical transmalleolar open approach can be used [26].

For tunneling, it is recommended to use k-wires or drills with a diameter of 1-2 mm. The holes and bone channels during tunneling should be located approximately 5 mm apart and 3-4 mm deep. J.I. Choi et al. found that a greater depth (up to 6 mm) leads to better results even when using thinner means for tunneling than processing to a smaller depth (2 mm) [29].

A number of studies demonstrate up to 85% of good and excellent results in the group of patients who underwent OLTD tunneling. In particular, the study of B. Chuckpaiwong et al. described the results in 105 patients: OLTD with a size of less than 15 mm (73 observations) after microfracturing were characterized by a successful result. At the same time, only 1 out of 32 OLTD larger than 15 mm met the criteria for successful treatment, and none of the 24 OLTD larger than 20 mm was successful [31].

Fixation of the detached bone-cartilage fragment (fixation on the talar dome)

One of the available options for surgical treatment of patients with primary OLTD is internal fixation of a detached bone-cartilage fragment. The theoretical advantage of fixation is that it facilitates the healing of bone tissue, restores the natural congruence of the subchondral bone plate and preserves the hyaline cartilage of the talar dome [32, 33]. In the long term, this leads to less formation of coarse-fibrous cartilage tissue, which was described in the publication of M.L. Reilingh et al [32]. Studies of the clinical effectiveness of fixation methods (series of observations) demonstrate good and excellent functional results in the range from 78 to 100% [33, 34, 35].

The analysis of the results of fixation with OLTD is difficult due to the variability of the described surgical methods and the wide variety of fixing devices available on the market. Fixation can be performed openly or using arthroscopic techniques and applied with different types of OLTD, while there is no consensus on the optimal surgical technique, method of fixation or defect characteristics that are prognostically favorable.

Fixation can be used in the presence of an intact osteochondral fragment with a diameter of more than 10 mm with a thickness of the bone part of at least 3 mm. Fixation of symptomatic displaced and non-displaced fragments should be performed as soon as possible to increase the healing potential and reduce intra-articular injuries. Most authors recommend debridement and BMS before fixation. The separated fragment due to "swelling" may not correspond to the donor defect on the talar dome and exceed its size, in this situation its modeling is permissible [32, 33].

It is recommended to use at least one bioresorbable compression screw for fixation. To prevent rotation, it is possible to use additional bioresorbable screws or pins, while the size of the fixator should not violate the structural integrity of the fragment, therefore, the maximum recommended diameter of biodegradable fixators is 3.0 mm, steel screws or bone pins (bone peg) — 2.0 or 2.7 mm [32, 33].

Given that most current studies report short-term results of OLTD fixation, future prospective studies should focus on long-term results of clinical efficacy in comparison with BMS.

Stimulation of hyaline cartilage development

Osteochondroplasty using autografts is widely used for the treatment of patients with OLTD. It is indicated in the presence of large symptomatic cystic lesions, as well as when revision interventions are necessary, for example, in case of failure of BMS [17, 36]. The obvious advantage of the technique is the possibility of replacing the OLTD with a graft containing a bone base and hyaline cartilage belonging to the patient [36, 37].

Clinical studies demonstrate the effectiveness of using autologous osteochondral transplantation (AOT): for example, in the review of medium-term clinical outcomes Y. Shimozono et al., good and excellent outcomes were obtained in 87% of patients [38].

Currently, there is no consensus or comparative studies that allow us to formulate reliable indications for AOT and determine the optimal donor site for grafting. The most commonly used area is the lateral condyle of the femur, which is due to the ease of approach, anatomical features and curvature of the articular surface, close to the bend of the talar dome. This area makes it possible to take at least three bone-cartilage grafts without compromising the patellofemoral articulation [36].

There are no unambiguous recommendations regarding the optimal size of the OLTD for the use of AOT, and most studies have a low level of evidence or represent expert opinions [3]. According to the literature sources of recent years, AOT is indicated for primary cystic OLTD more than 1 cm in diameter, as well as for revision interventions after unsuccessful primary treatment with a lesion size of more than 1 cm in diameter. In the review of L. Ramponi et al. considered outcomes after BMS, and the size of OLTD greater than 107 mm^2 was associated with worse results, which can be interpreted as an indication for AOT [17].

An important aspect is the congruence of the implanted graft(s); positioning is recommended, in which the articular surface of the graft will be located as close as possible to the native cartilage of the talus bone. In a cadaveric study, L.D. Latt et al. used 10 cadaveric samples with varying degrees of graft standing over the articular surface of the talar dome to assess their condition under load [39]. It was found that full graft compliance restores the normal mechanics of the ankle joint, and towering grafts are subject to a significant increase in peak contact pressure: standing by 1 mm increases contact pressure by 675% in lateral OLTD and 255% in medial [39]. According to A.M. Fansa et al., graft implantation in the most congruent position restores strength, average pressure and peak pressure on the medial region of the talus bone to levels characteristic of intact cartilage [40].

The recommended depth of treatment of OLTD and the length of the graft during sampling is 12-15 mm. A cadaveric study conducted by N.B. Kock et al. demonstrated that the treatment of OLTD with a depth of 12-16 mm and the introduction of the corresponding graft to the level of articular cartilage have greater stability than grafts of shorter length (8 mm) [41].

In situations where the size of the defect exceeds the size of one graft, but does not correspond to two, it is permissible to expand the implantation zone and install two similar bone-cartilage columns or use overlapping grafts in the shape of a crescent, which will help to reduce the "dead zones". A comparison of the use of one and two autografts did not reveal significant differences in clinical outcomes, but the use of three or more had worse results due to an increase in the proportion of patients complaining of soreness of the donor zone [36, 38]. Currently, it is believed that only 1% of patients after osteochondral autotransplantation have graft failure and progression of OLTD with an unsatisfactory clinical outcome [36].

Postoperative cystic changes of the talar dome are quite common, but the degree of their influence is not clear. Thus, in the study of I. Savage-Elliott et al., an analysis of MRI results was carried out in 37 patients after AOT, subchondral cysts were found in 65% with an average follow-up period of 15 months after surgery. In the short term, there were no symptoms and no effect on the clinical outcome [42].

The incidence of soreness in the donor area is less than 10%, but its probability should be discussed with the patient in the preoperative period, especially with high body mass index values and extensive OLTD [43, 44]. In a multicenter series of observations of 354 patients who underwent mosaic plastic surgery, with an average follow-up period of 9.6 years, the incidence of soreness of the donor zone was 5% [43].

Filling in donor defects is rarely used and does not affect the clinical outcome. In a series of observations assessing the soreness of the donor zone in 40 patients with filling of graft collection sites with bone substitutes, E.J. Fraser et al. reported a 5% occurrence with an average follow-up period of 42 months, which correlates with the literature data

on the frequency of this complication in patients without filling donor zones [45].

The choice of approach to the talar bone depends on the localization and size of the OLTD. Medial OLTD more often have central-medial and posteromedial localization, in this case, transmalleolar access with tibial osteotomy can be used. Lateral OLTD are more often observed in the anterior third of the talar dome, approach to it is possible with the help of arthrotomy, in rarer cases — osteotomy of the lateral malleolus [36]. Complications associated with osteotomy are rare, but it is important to ensure reliable fixation.

Osteochondroplasty using allografts involves the replacement of the OLTD with a cylindrical or volumetric cadaveric graft. It can be used when it is necessary to fill in large defects for which other methods of surgical treatment are not applicable due to size or localization [46]. The advantages of allotransplantation include the absence of the need for tissue collecting from the patient's intact joints [46, 47].

Despite the favorable outcomes when used in complex and revision cases, the decision to perform osteochondral allotransplantation requires consideration of numerous factors that remain the subject of discussion. It is necessary to take into account the characteristics of the OLTD, the preferred type of allograft and its storage parameters, the method of intraoperative measurement of size compliance and potential methods of graft fixation.

Several series of observations have been published demonstrating the clinical outcomes of the use of osteochondral allografts [46, 47, 48]. Survival and success vary depending on the duration of follow-up. For example, C.E. Gross et al. published a study with one of the longest observation periods for the use of osteochondral allotransplantation in OLTD with a size of more than 1 cm: 9 patients with stage IV OLTD according to the classification of A. Berndt and M. Harty were observed for 12 years after surgery. Three patients required further fusion of the ankle joint. The remaining 6 patients demonstrated a functional range of motion, only one of the 6 patients described mild pain, the remaining five patients reported no pain symptoms [47].

Osteochondral allotransplantation helps to reduce pain and improve the function of the ankle joint, but there is also evidence of pain retention after surgery. In particular, R. Haene et al. published the results of treatment of 16 patients with an average follow-up period of 4.1 years. The authors noted an improvement in indicators on the AOS (Ankle Osteoarthritis Scale) and AAOS (American Academy of Orthopedic Surgeons) scales, in their series of observations 62.5% of patients had a good or excellent result [48].

In certain situations, the use of cylindrical osteochondral allografts is preferable to autologous ones, in particular with OLTD more than 1.5 cm in diameter, osteoarthritis of the knee joint, a history of knee joint infection and in patients who are negatively inclined towards the risk of complications of autotransplantation (soreness of the donor site). In their study, J. Ahmad and K. Jones compared the results of using autografts (n = 20) and cylindrical allografts (n = 20) and did not reveal a statistically significant difference in clinical outcomes [49]. According to the consensus on the restoration of ankle cartilage (2017), osteochondral allotransplantation can be recommended in situations where the size of the OLTD does not allow it to be restored with two cylindrical autografts [44].

The use of cadaveric talus bone grafts is recommended, taking into account the size and side of the injury for the greatest compliance with cartilage thickness, morphology and congruence. C.R. Henak et al. published a study of biomechanical differences between bone-cartilage grafts from the femur and talus bones. The authors found that the femoral cartilage is about twice as thick as the talus, which leads to a mismatch in the height of the cartilage during the implantation of femoral grafts. In addition, the femoral cartilage is softer than the cartilage of the talus bone near the articular surface, and the minimum shear modulus for femoral cartilage is 4 times lower than for the talus. The authors concluded that the femoral cartilage is less resistant to stress. This can lead to an increase in tension in the native tissue surrounding the graft [50].

The allograft can be modeled according to specific size requirements. There are several types of transplants that differ in the ways they are stored and harvested: previously used frozen and freshly frozen allografts are characterized by low viability of chondrocytes (20-30%). Currently, fresh unfrozen grafts are used for plastic surgery of the OLTD, which after harvesting are placed in Ringer's solution or in a nutrient medium. This type of grafts is characterized by greater viability of chondrocytes (up to 67% within 30 days) and is recommended for implantation within 7 days (in some sources — 28 days) [44, 51, 52].

During preoperative planning, in order to select an allograft suitable in size, it is necessary to measure the patient's talus bone according to CT results (length, width and height). A bone-cartilage allo-

graft should contain at least 10 mm of bone tissue [44, 51].

A tight fit of the allograft using fixators is recommended. A systematic review by P. Johnson and D.K. Lee analyzed 15 publications reporting the results of osteochondral allotransplantation of the ankle joint with various fixation methods. Metal screws were used in 59.7%, bioabsorbable fixation was used in 16.2%, and combined fixation was used in 24.1% of cases. The authors concluded that none of the fixation methods had clinical advantages over the others [46].

There are conflicting data on the prevalence of graft collapse. In a series of observations by S.B. Adams et al., no signs of destruction were found, and in a systematic review by G.F. Pereira et al., the overall survival of transplants was 86.6% [53, 54]. This contradicts the conclusions of C.E. Gross et al. and S.M. Raikin et al., who report graft resorption or collapse in 56% and 67% of cases, respectively [47, 52].

Despite the described good results of using allografts, this method cannot be considered an ideal solution. In the study of R. Haene et al, with an average follow-up period of 48 months, 16 patients showed an improvement on the AOFAS scale from an average value of 45 before surgery to 81 points after surgery (the average lesion size was 2.67 cm^2). All patients were able to return to their previous motor activity within a year after surgery and reported satisfaction with the results. However, control radiographs revealed the presence of osteophytes in all but one patient and moderate progression of osteoarthritis in two patients [44, 48].

The use of allografts helps to restore function, relieves pain and allows patients to return to their previous motor activity, but does not stop the development of degenerative changes in the ankle joint.

Implantation of autologous chondrocytes

The reparative tissue after surgery aimed at stimulating the bone marrow does not fully correspond to the normal articular cartilage of the talar dome. It has a fibrous-cartilaginous nature and differs from hyaline cartilage in the content of collagen. Osteochondral grafts carry intact cartilage with preserved architecture, but achieving anatomical congruence, graft incorporation and complete healing may be difficult. The principle underlying cell repair methods is the ability of transplanted chondrocytes to generate hyaline-like reparative tissue with biochemical and biomechanical properties closer to the native articular cartilage of the talar dome [5, 55].

Implantation of autologous chondrocytes (ACI - autologous chondrocyte implantation) is a two-stage procedure in which chondrocytes are collected with their in vitro cultivation and subsequent implantation into the defect area [55]. The collection of chondrocytes can be carried out from the knee joint, ankle joint or from a detached bone-cartilage fragment. During implantation, several options for covering implanted cells can be used. In the original description of M. Brittberg et al. used periosteal flap for the coating, however, due to problems with graft hypertrophy, a collagen membrane I/III was developed [56]. In a study comparing two types of coating, C. Gooding et al. found similar clinical and arthroscopic results with fewer complications in the group using membranes [57].

Studies demonstrate positive results of implantation of autologous chondrocytes: with an average follow-up period of 26 months in 8 patients, S. Giannini et al. reported no complications in the postoperative period and an improvement on the AOFAS scale from 32.1 points before surgery to 80.6 points after 6 months, 90 points after 12 months and 91 points after 24 months (the average size of the OLTD was 3.3 cm^2). Moreover, histological analysis revealed positive staining for type II collagen and proteoglycan in the extracellular matrix of all samples [58]. M Battaglia et al. reported a similar improvement in average AOFAS scores in 20 patients with a longer follow—up period of 5±1 year (average lesion size 2.7±1 cm^2) [59].

Implantation of autologous chondrocytes using matrices (MACI — matrix/membrane autologous chondrocyte implantation) involves the cultivation of chondrocytes on collagen or hyaluronic acid-based matrices before implantation. The advantages of this method include a more uniform distribution of chondrocytes on the implant, the exclusion of chondrocyte differentiation disorders and the absence of the need for a cover layer [55, 60]. Clinical studies show promising results after MACI with OLTD: B. Magnan et al. reported the results of 30 OLTD with an average lesion size of 2.36 cm^2 after MACI using a collagen matrix. Good and excellent results were obtained in 28 out of 30 patients, and postoperative MRI results showed improved integration [61]. Common indications for MACI are age from 15 to 55 years, single, delimited OLTD, relapse after previous surgery, small lesions with extensive subchondral cystic changes [55, 60].

In the Russian Federation, the use of MACI is limited by the absence of matrices/membranes registered for use in the ankle joint.

Conclusions

The data obtained as a result of a review and analysis of the literature are very heterogeneous. The studied literature could not fully answer a number of questions related to the methods of surgical treatment of patients with symptomatic OLTD and indications for them.

The lack of unambiguous indications for different groups of surgical interventions and the large variability of treatment results emphasize the urgency of the problem and the need for further improvement of diagnostic and therapeutic concepts. It is obvious that a more detailed assessment of the medium- and long-term clinical outcomes of the use of various surgical methods and the development of algorithms for the treatment of this group of patients, specific to different countries, is needed.

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AUTHORS' INFORMATION:

Ekaterina A. Pashkova — Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia
caterinapashkova@yandex.ru
https://orcid.org/0000-0003-3198-9985

Evgenii P. Sorokin — Cand. Sci. (Med.), Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia
sorokinortoped@gmail.com
https://orcid.org/0000-0002-9948-9015

Viktor A. Fomichev — Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia
fomichef@mail.ru
https://orcid.org/0000-0002-0864-0171

Nikita S. Konovalchuk — Cand. Sci. (Med.), Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia
konovalchuk91@gmail.com
https://orcid.org/0000-0002-2762-816X

Ksenia A. Demyanova — Vreden National Medical Research Center of Traumatology and Orthopedics, St. Petersburg, Russia
ksunyablack@yandex.ru
https://orcid.org/0000-0002-2239-2792

Authors' contribution:

Pashkova E.A. — idea, search for scientific literature on the topic, generalization and analysis.

Sorokin E.P. — idea, search for scientific literature on the topic, generalization and analysis.

Fomichev V.A. — search for scientific literature on the topic.

Konovalchuk N.S. — search for scientific literature on the topic.

Demyanova K.A. — search for scientific literature on the topic.

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Conflict of interest:

The authors declare that there is no conflict of interest.