



Unstable Fractures Osteosynthesis of Malleoli and Posterior Edge of the Tibia Using Posterolateral Surgical Approach

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Abstract

Background. The malleoli fractures in combination with the fractures of posterior edge of the tibia are considered unstable injuries and present particular difficulties in surgical treatment. **The aim of the study** was to evaluate short-term and mid-term results of osteosynthesis on account of unstable fractures of malleoli and posterior edge of the tibia using posterolateral surgical approach. **Materials and methods.** The analysis of short-term and mid-term results of the treatment of 29 patients with malleoli fractures types 44-B3 and 44-C1.3, C2.3 and C3.3 (according to the AO classification) with the involvement of the Volkman's posterior tibia fragment was performed in traumatology departments of three hospitals during the period from January 2019 to September 2020. In all 29 cases the fracture of the posterior edge of the tibia was classified as type 1 according to the classification of N. Haraguchi et al. All patients underwent osteosynthesis of the posterior edge of the tibia and the lateral malleolus via posterolateral surgical approach. Combined fracture of the medial malleolus was fixed via classical medial approach. 5 patients (17.2%) with continued instability of the distal tibiofibular syndesmosis underwent fixation with positional screw. Functional results, as well as the range of motions in the ankle joint were evaluated with the use of AOFAS and Neer scales 3, 6 and 12 months after surgery. **Results.** Statistically significant improvement in functional outcomes over time was noted when evaluated on the AOFAS scale ($p < 0.05$) and on the Neer scale ($p < 0.01$). 12 months after the surgery these points were 83.2 ± 13.4 and 87.8 ± 16.8 respectively. Complications were noted in 5 patients (17.24%). Deep periimplant infection was registered just in one case, another patient had marginal necrosis of the operative wound. Three patients had clinically significant post-traumatic deforming arthritis of the ankle joint. **Conclusions.** Posterolateral surgical approach has advantages when performing osteosynthesis in patients of the studied profile and enables anatomical reduction and stable fixation of fragments of the Volkman's posterior edge of the tibia, which provides the possibility of early mobilization of the ankle joint and has positive effect on the results of treatment.

Keywords: malleolar fracture, tibial posterior edge fracture, osteosynthesis of malleolar fractures, posterolateral surgical approach.

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Остеосинтез нестабильных переломов лодыжек и заднего края большеберцовой кости из заднелатерального хирургического доступа

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Реферат

Переломы лодыжек в сочетании с переломами заднего края большеберцовой кости (ББК) являются нестабильными повреждениями и представляют особые сложности в хирургическом лечении. **Цель работы** — оценить ближайшие и среднесрочные результаты остеосинтеза при нестабильных переломах лодыжек и заднего края большеберцовой кости с использованием заднелатерального хирургического доступа. **Материал и методы.** Выполнен анализ ближайших и среднесрочных результатов лечения 29 больных с переломами лодыжек типов 44-B3 и 44-C1.3, C2.3 и C3.3 по классификации АО с вовлечением заднего фрагмента Фолькмана ББК. У всех пациентов перелом заднего края ББК был классифицирован как тип I по классификации N. Naguchi. Всем больным выполнен остеосинтез фрагмента заднего края ББК и латеральной лодыжки из заднелатерального доступа. Сочетанный перелом медиальной лодыжки фиксировали из медиального доступа. У 5 (17,2%) пациентов при сохраняющейся нестабильности дистального межберцового сочленения выполняли его фиксацию позиционным винтом. Функциональные результаты по шкалам AOFAS и Neer, а также амплитуду движений в голеностопном суставе оценивали в сроки 3, 6 и 12 мес. после операций. **Результаты.** Улучшение функциональных исходов с течением времени отмечалось по шкалам AOFAS ($p < 0,05$) и Neer ($p < 0,01$). На сроке 12 мес. эти показатели составили $83,2 \pm 13,4$ и $87,8 \pm 16,8$ баллов соответственно. Осложнения были отмечены у 5 (17,2%) пациентов. Глубокая периимплантная инфекция зарегистрирована в одном случае, еще у одного больного отмечен краевой некроз послеоперационной раны. У трех больных имелся клинически значимый посттравматический деформирующий артроз голеностопного сустава. **Заключение.** Заднелатеральный хирургический доступ имеет преимущества при выполнении остеосинтеза и позволяет добиться анатомичной репозиции и стабильной фиксации отломков заднего края ББК Фолькмана, что обеспечивает возможность ранней разработки движений в голеностопном суставе и положительно сказывается на результатах лечения.

Ключевые слова: переломы лодыжек, переломы заднего края большеберцовой кости, остеосинтез, заднелатеральный хирургический доступ.

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Background

One of the most frequent intraarticular injuries are unstable malleolar fractures [1]. Such injuries are usually associated with subluxations or dislocations of the ankle joint due to the lesion of its stabilizing ligaments, and in 7–40% of cases they are also combined with the fracture of posterior edge of distal tibia with formation of one or more bone fragments in the area of the anatomical Volkmann triangle [2, 3]. This combination of fractures forms a group of severe unstable injuries of the ankle joint, which present certain difficulties in surgical treatment.

According to experts, the results of surgical treatment of such fractures, unfortunately, are worse in comparison with the injuries without the fracture of posterior tibial fragment and are far from desirable [4]. In particular, a large percent of complications and unsatisfactory outcomes remains, primarily associated with mistakes in the restoration of the ankle anatomy, especially the articular surface of the tibia. At the same time, according to some authors, the percent of post-traumatic arthrosis in patients with malleolar fractures, including fractures of posterior edge of the tibia can reach 40% [5]. And, as it became clear analyzing the pre- and postoperative results of computer tomography (CT), this often happens due to neglect of osteosynthesis or incorrect reduction and fixation of fragments of posterior edge of the tibia.

After studying the publications, we came to the conclusion that in the absolute majority of cases, the best surgical treatment tactics for unstable malleolar fractures associated with fractures of posterior edge of the tibia is anatomical reduction and fixation of all components of such fractures [6]. For these purposes, the use of posterolateral surgical approach seems to be very promising, so that it is considered convenient to perform an open direct reduction and fixation of the posterior Volkmann fragment, and it is also possible to perform osteosynthesis of the lateral malleolus. Some foreign publications also indicate that the posterolateral approach is ideal for one of the most frequent variants of discussed injuries: the lateral malleolus fracture in (with) the presence of large fragment of the posterior edge of the tibia, but it is used in clinical practice quite rarely [7]. This is due to the lack of knowledge regarding the details of the surgical

technique, possibilities for osteosynthesis, fears of damaging important anatomical structures or disrupting the blood supply of the skin, but most importantly – the lack of information about the outcomes of osteosynthesis performed via posterolateral approach. All the factors mentioned above determined the aim of our study.

The aim of the study was to evaluate the short-term and mid-term results of osteosynthesis of unstable malleolar fractures and posterior edge of the tibia using posterolateral surgical approach.

Materials and methods

Design of the study

A retrospective cohort observational multicenter clinical study is based on the analysis of the results of surgical treatment of malleolar fractures types 44-B3 and 44-C1.3, C2.3 and C3.3 according to the AO classification involving the posterior fragment of Volkman in the orthopedic departments of three hospitals of the Leningrad region (Tosnenskaya, Gatchinskaya and Vsevolozhskaya Clinical Hospitals) from January 2019 to September 2020. A total of 302 patients with fractures of segment 44 according to the AO classification underwent surgery during this period.

Patients who met the following criteria were included in the study group:

- isolated closed injury with fractures of types 44-B3 and 44-C1.3, C2.3 and C3.3 according to the AO classification;
- age of patients older than 18 years;
- absence of chronic diseases in the stage of sub- and decompensation, oncological pathology and chronic usage of glucocorticoids;
- the time from the injury is no longer than 30 days.;
- treatment of fractures of posterior edge of the tibia and lateral malleolus using posterolateral surgical approach.

A total of 29 patients (6 men and 23 women) were included in the study, whose average age ranged from 31 to 86 years (on average 52±15 years).

According to the AO classification, in 25 (86.2%) cases fracture type was 44-B3 (transyndesmototic fracture of the lateral malleolus in combination with fractures of the medial malleolus or rupture of the medial ligament complex

and with the fracture of the posterior edge of the tibia), in 1 (3.4%) case – type 44–C1.3 (simple suprasyndesmotoc fracture of the fibula with the fracture of the posterior edge of the tibia and medial malleolus), in 1 (3.4%) case – type 44–C2.3 (comminuted suprasyndesmotoc fracture of the fibula with the fractures of posterior edge of the tibia and medial malleolus) and in 2 (6.8%) cases – type 44–C3.3 (high fracture of the fibula in combination with the fracture of posterior edge of the tibia and medial malleolus).

The size of posterior edge of the tibia fragment was measured on radiographs in the lateral view relative to the sagittal size of the articular surface of the tibia. In 8 (28%) patients, this size was less than 0.3, but was sufficient for fixation; in 3 patients it was close to 0.5 (10%), and in 18 patients it was 0.3–0.4 of the length of the articular surface of the tibia in the lateral view (projection) (62%). Taking into account the results of measurements on radiographs in all patients, the fracture of posterior edge of the tibia was classified as type I according to the classification of N. Haraguchi et al. [8].

In the majority of patients (26 or 89.7%) the mechanism of the injury was a low-energy trauma and usually involved ankle joint rotation when falling from their own height. One patient (3.4%) in the study group was injured when falling down the stairs, and two more (6.9%) received a direct blow to the ankle joint.

Primary trauma care in most cases (17 patients – 56%) consisted of closed manual reduction of bone fragments using local anesthesia and subsequent plaster immobilization. However, in 11 (37.9%) patients the result of the primary closed reduction was unsatisfactory with the presence of a significant displacement of bone fragments. In this situation skeletal traction was applied. In one case (3.4%) an external fixation device with ankle joint immobilization was applied as the first stage of the surgical treatment.

The individual architectonics of fractures were evaluated on the basis of radiograms of the ankle joint and lower leg in three standard views – anteroposterior, lateral and anteroposterior with internal rotation of the foot by 15–20°. In 15 cases (51.7%) CT of the ankle joint was performed in the preoperative period, which allowed to study in details the features of the fracture, to assess the degree of involvement of posterior Volkman

fragment and articular surface of the distal tibia. The decision on the requirement of posterolateral surgical approach and open fixation of posterior edge of the tibia was made based on the classification of N. Haraguchi [8]. The chosen method of osteosynthesis was used in the case of the patients with the fracture of posterior fragment of the tibia type I according to N. Haraguchi – posterolateral fragment with an oblique plane of the fracture [8]. We included these patients in the study. In most cases (86.2%) operations were performed under spinal anesthesia. The rest were performed under endotracheal anesthesia.

Surgical technique

Posterolateral surgical approach was performed with the patients in prone or lateral decubitus position. A linear longitudinal incision of the skin was performed in the middle of the distance between the posterior edge of the fibula and the lateral edge of the Achilles tendon from the tip of the lateral malleolus proximally. The length of the approach was determined by the localization and the type of fracture of the fibula and usually did not exceed 10–12 cm.

It should be noted that the sural nerve, which is located in the subcutaneous fat in the zone of incision, is at risk to be damaged using this approach. To prevent its damaging, it was identified in the wound and was retracted to the side and protected by plate retractor. The crural fascia was dissected along the cutaneous incision line, the peroneus muscle tendons were also displaced medially or laterally, depending on the approach being formed to the posterolateral surface of the lateral malleolus or to the posterior edge of the tibia. To expose and visualize the tibia, the deep fascia was also dissected and the tendon of the flexor hallucis longus, which protects the posterior tibial neurovascular bundle, was retracted medially. In case of combined injury of the lateral malleolus and posterior edge of the tibia, the Volkman fragment was initially reduced and fixed, which made it possible to restore distal syndesmosis partially and facilitated subsequent osteosynthesis of the lateral malleolus. We tried to achieve the "tooth to tooth" reduction of the tip of the Volkman fragment and the corresponding place on the distal metaepiphysis of the tibia. To create an interfragmental compression pointed bone clamp was applied temporarily, then 4.0 mm cancellous

screws with a short thread were applied perpendicular to the fracture plane and parallel to the plane of the articular surface, trying to position it in the subchondral layer of the tibia. Notably in 9 (31.0%) patients with sufficiently large fragment of posterior edge of the tibia, which does not tend to displace proximally, its fixation was performed only with screws (Fig. 1).

1/3-tubular, reconstructive, small T-shaped plates were used for the fixation of comminuted fractures of the posterior Volkman fragment.

This method of fixation was chosen in 20 (68.9%) patients (Fig. 2). In some cases, the method of sequential tightening of the plate to the main fragment with 3.5 mm cortical screws from top to bottom was used, thereby achieving some displacement of posterior edge of the tibia downwards and anti-glide effect. In all cases intraoperative X-ray control in lateral and AP views was used to assess the reduction of posterior fragment of the tibia and to control the position of the implants.



Fig. 1. Malleolar fracture type 44-B3 and the osteosynthesis result in patient 46 y.o.: a, b – primary X-rays in AP and lateral views; c, d – postoperative X-rays – the posterior edge of the tibia fragment is fixed with two 4.0 mm cancellous screws

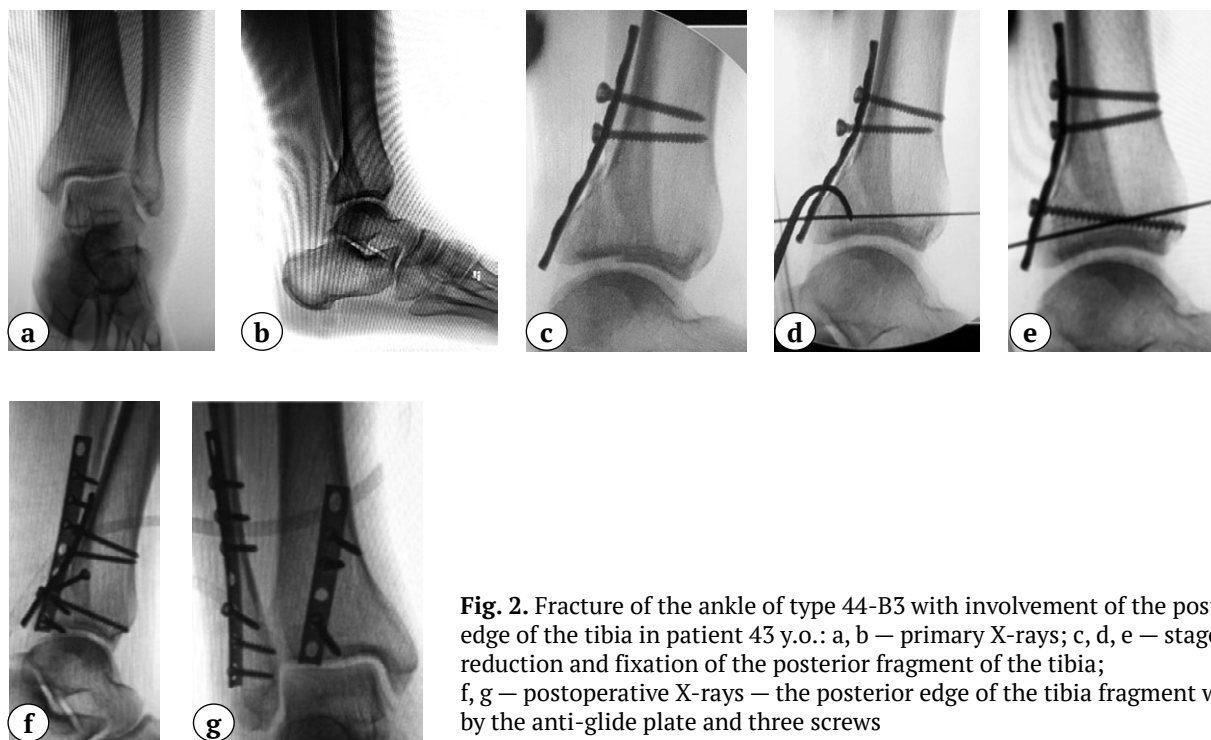


Fig. 2. Fracture of the ankle of type 44-B3 with involvement of the posterior edge of the tibia in patient 43 y.o.: a, b – primary X-rays; c, d, e – stages of reduction and fixation of the posterior fragment of the tibia; f, g – postoperative X-rays – the posterior edge of the tibia fragment was fixed by the anti-glide plate and three screws

An open reduction of the lateral malleolus was performed via the same approach. Depending on the type of fracture of the fibula, anatomical reduction and interfragmental lag screw through the plate were used for oblique fractures and restoration of the fibula length and splinting – for comminuted fractures. 1/3-tubular plate was traditionally oriented along the posterolateral or lateral surface of the fibula.

In 5 (17.2%) patients the persistent instability of the distal syndesmosis, diagnosed by intraoperative hook test and valgus stress test [9], was fixed with a positional screw according to generally accepted technique. It should be noted that the advantage of this posterolateral approach is the possibility to apply the positional screw from the outside to the inside and from back to front without technical difficulties.

Associated fractures of the medial malleolus were fixed via separate classical medial approach. In most clinical cases – in 17 patients (58.6%) – osteosynthesis of the medial malleolus was performed with two 4.0 mm cancellous screws with a short thread. Fixation with one 4.0 mm screw and two K-wires and a tension band was performed in 7 (24.0%) patients. In 2 (6.8%) cases a large fragment of the medial malleolus was fixed with a plate. 5 (17.2%) patients had no fracture of the medial malleolus, and 1 of these patients had the lateral subluxation of the talus after osteosynthesis of the lateral malleolus and posterior edge of the tibia, which required revision of the medial ligament complex. During the revision, the interposition of the damaged deltoid ligament between the articular surfaces was revealed, which was eliminated intraoperatively by the subsequent deltoid ligament suture. In 4 remaining cases no intervention on the medial ligamentous complex of the ankle joint was performed.

All surgeries were completed with control radiographs using intraoperative X-ray in three standard projections (anteroposterior, anteroposterior with internal rotation and lateral). The congruence of articular surfaces of the tibia and talus, as well as the position of the screws and implants were evaluated. The results of the reduction of posterior fragment of the tibia were evaluated in three gradations, depending on the presence of a residual displacement of the articu-

lar surface in the form of a "step" and/or widening of the fracture gap on the lateral radiograph. At the same time, the reduction was considered "excellent" (anatomical) in case of the absence of the "step", absence of widening of the fracture gap and absence of subluxation of the talus, visible on AP and lateral views with total congruence of the articular surfaces (the same distance between the articular surfaces of the talus, tibia and fibula). A satisfactory reduction assumed the presence of the step of the articular surface and/or widening of the fracture gap of no more than 2 mm, and an unsatisfactory one was characterized by the step of articular surface and/or widening of the fracture gap of more than 2 mm and/or subluxation of the talus.

Wound closure and drainage were performed according to the generally accepted technique, avoiding tension in the wound edges. Since the second day after the surgery, active movements in the ankle joint were recommended. Axial load was limited in average for 2.5–3 months after the surgery until the signs of consolidation of fractures appeared. Control radiographs were performed the day after the surgery and in 1.5, 3, 6 and 12 months. The positional screw (if used) was removed 8–10 weeks after the surgery.

Evaluation of results

The assessment of fracture consolidation was performed on the basis of control radiographs at the time indicated above. Consolidation of the fracture was confirmed in the case of the presence of callus or absence of the fracture line in the AP and lateral views. Special attention was paid to the signs of subluxation of the talus, increase of deformation, secondary displacement and migration of implants. The functional outcome of the treatment was evaluated in 3, 6 and 12 months after surgery using the AOFAS and Neer scales. In 3 months, the functional outcome was assessed in 24 (82.8%) patients, in 6 months – in 21 patients (72.4%), and in 12 months – in 17 (58.6%) patients.

The range of motion of the ankle joint was measured in 3, 6 and 12 months after surgery. The following guidelines and estimated characteristics of movement restriction were used. The range of motions is normal: extension – 70–75°, flexion – 135–140° (the measurement is performed from the angle of 90° – functionally

advantageous position of the foot); moderate restriction: extension – 80–85°, flexion – 110–130°; significant restriction: extension – 90–95°, flexion – 90–105°; pronounced: extension and flexion within 10°. The range of motion of the ankle joint was calculated summing of deviations from the zero position of the foot (90° relative to the axis of the lower leg) with its plantar and dorsal flexion. The data obtained were used for calculating values on the AOFAS and Neer scales, and the range of motion of the ankle joint was also evaluated (estimated).

Early and delayed complications of osteosynthesis were analyzed separately, such as deep and superficial infectious complications, migration of implants, delayed consolidation of fractures, secondary displacement of bone fragments, post-traumatic arthrosis.

Statistical analysis

Statistical analysis of the obtained quantitative data was carried out using the programs "Data Analysis" and "Chart Wizard" of the Excel spreadsheet editor, as well as the Basic Statistics/Tables modules of the Statistica for Windows statistical data processing software package. The mean values and their standard deviations, median, quartiles, maximum and minimum values were calculated using the programs mentioned above. Since the type of distribution of the results obtained does not correspond to normal, nonparametric criteria were used in the statistical analysis of changes in values.

The statistical significance of the differences in the range of motion of the ankle joint and the scores reflecting the functional results of treatment according to the AOFAS and Neer scales was assessed using non-parametric tests.

Differences in values were considered statistically significant at $p < 0.05$. The frequency of complications and clinical signs characterizing the result of surgical treatment were also analyzed.

Results

The duration of preoperative preparation ranged from 3 to 25 days (mean value 10.3 ± 5.8 days), which confirms the severity of the injury studied and significant soft tissue damage in this unstable injury of the ankle joint. It should also be noted that in 20 (68.9%) cases a significant deformation of the ankle joint remained, as was not eliminated

during the primary closed reduction of fractures or was caused by secondary displacement of bone fragments after regression of soft tissue swelling. In our opinion this fact confirms once again the importance of surgical treatment of patients with discussed injuries.

Open reduction and internal fixation of the posterior edge of the tibia via posterolateral surgical approach made it possible to achieve proper restoration of anatomy of the articular surface and congruence of the articular surfaces of the ankle joint in most patients. Based on the established signs, in 23 (79.3%) patients, as a result of open reduction of the posterior Volkman fragment and osteosynthesis of the lateral and in some cases medial malleolus, a complete anatomical reduction of articular surfaces of the ankle joint was achieved, and in 4 patients (13.8%), the reduction was satisfactory. However, 3 (10.3%) patients had the step up to 2 mm between the anterior part of the articular surface of the tibia and its posterior edge, and in 1 (3.4%) case a widening of the fracture gap up to 2 mm remained visible on the radiograph in the lateral view. Another 2 (6.9%) patients had unsatisfactory results of reduction due to the preserved valgus position of the foot and a small wedge-shaped articular gap of the ankle joint revealed on the control radiograph in AP view. In our opinion, the existing subluxation of the talus, revealed on the radiograph in the AP view, was most likely due to the malreduction of the lateral malleolus and its incorrectly restored length, since the position of the Volkman fragment in the lateral projection was correct.

There was no significant residual displacement of the articular surface of more than 2 mm and significant widening of the fracture gap in patients, that indicates the effectiveness of osteosynthesis of posterior edge of the tibia via posterolateral surgical approach, which in most cases gives the ability to achieve more precise reduction of bone fragments under direct visual control. We also took into account the results of intraoperative X-rays, which are considered an essential part of the discussed method of osteosynthesis. The average time of the X-ray exposure was 33.8 ± 18.7 seconds.

Follow-up (control) examinations of patients were performed (carried out) in 3, 6 and 12 months after surgery., In 3 months radiological signs of fracture consolidation were noted in most cases.

The control radiographs in the AP and lateral views showed no signs of fracture gap in the case of simple fractures of the posterior edge of the tibia, medial and lateral malleolus in 19 out of 24 patients (79.2%) examined within 3 months. However, the callus was clearly visible in case of comminuted fractures of the lateral malleolus. No cases of fracture non-union of posterior edge of the tibia and lateral malleolus were observed in 6 months after osteosynthesis. However, one patient had aseptic necrosis of the fragment of the medial malleolus with partial migration of the implants.

The range of motion of the ankle joint in most patients increased in dynamics ($p < 0.01$). The mean values of these measures are shown in Table 1. 6 months after the osteosynthesis, 5 (23.8%) patients had moderate restriction of movements in the ankle joint; 1 (4.7%) patient had significant restrictions, but no pronounced restriction was noted. 12 months after the surgery moderate restriction of movements in the ankle joint was noted only in 3 (17.6%) patients, and there were no significant or pronounced restrictions in 17 patients examined at this period.

The functional result was evaluated at the same time as the range of motion of the ankle joint, and the corresponding data are presented in Table 1. In most patients there was a clear progress in functional results according to both evaluation scales used, and the final values obtained 12 months after the osteosynthesis show excellent functional results in 14 (82.4%) out of 17 examined patients.

The case of patient with a type 44-B3 fracture having excellent result of surgical treatment using the described method is shown in Figure 3.

According to the data obtained, there was a statistically significant increase of the score according to the AOFAS scale ($p < 0.01$). A statistically significant improvement in functional outcomes over time was also noted according to the Neer scale ($p < 0.01$). Patients reported the absence of pain syndrome, even after physical activity, no limping, sufficient range of motion of the ankle joint, comparable to that before the injury and to the range of motion of joint of uninjured leg, as well as the ability to play sports and return to professional activity.

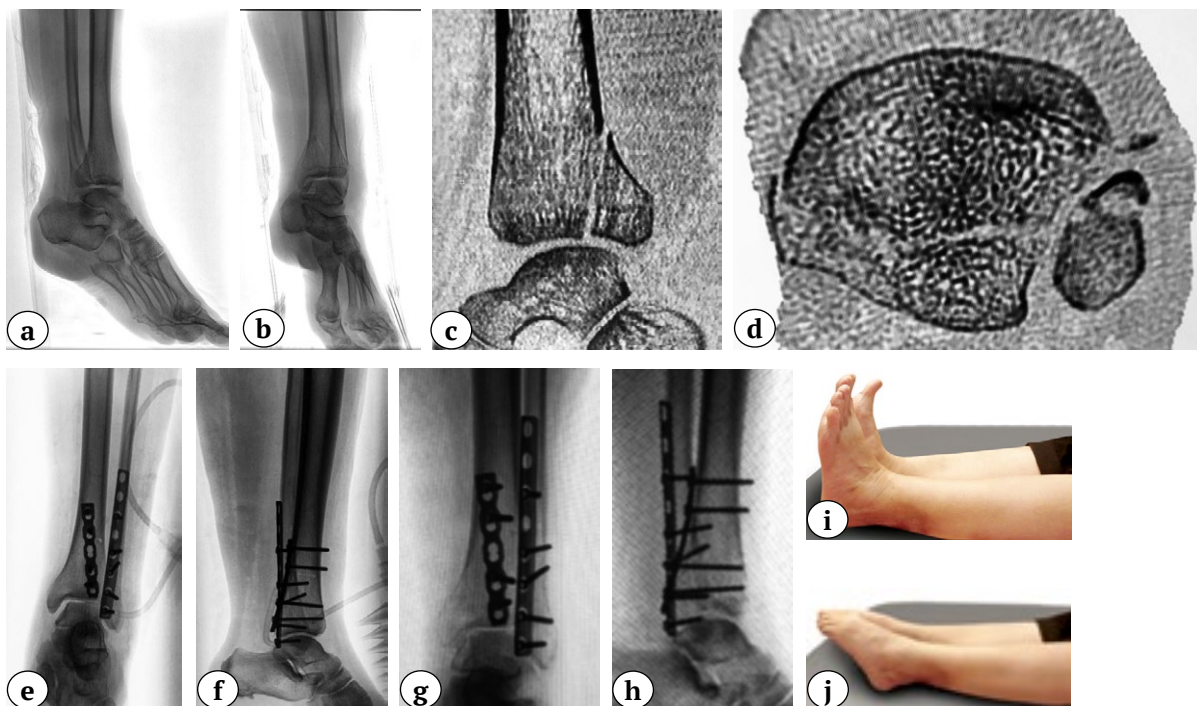


Fig. 3. Excellent result of surgical treatment of patient 58 y. o. with a 44-B3 fracture after osteosynthesis: a, b – primary X-rays in AP and lateral views; c, d – CT scans show the size of the posterior edge of the tibia; e, f – postoperative X-rays in AP and lateral views – anatomical reduction of the ankle joint; g, h – X-rays 3 months after injury – consolidation of fractures; i, j – functional result within 12 months after injury

Table 1

Dynamic of functional results of osteosynthesis

Parameter	Follow-up period								
	3 months			6 months			12 months		
	M±SD	Me/Q1/Q3	Min/Max	M±SD	Me/Q1/Q3	Min/Max	M±SD	Me/Q1/Q3	Min/Max
The range of motions of the ankle joint, degree.	47,2±13,9	50/37,5/60	20/65	56,4±9,7	50/37,5/60	20/65	62,2±5,1	60/51,25/65	35/65
Functional result according the AOFAS scale, points	71,6±10,1	74/66,5/80	46/84	72,6±11,4	74/66,5/80	46/84	83,2±13,4	80,5/75,75/84	56/90
Functional result according the Neer scale, points	67,4±15,0	72/67,5/74	14/76	84,6±13,0	72/67,5/74	14/76	87,8±16,8	89/80/94	50/96

M±SD – mean value±standard deviation; Me – median; Q1 – first quartile; Q3 – third quartile; Min – minimum value; Max – maximum value.

Complications

Complications were noted in 5 (17.24%) patients. An early complication, deep infection of the surgical area was recorded in one (3.4%) patient. The preoperative period was complicated by the development of acute alcoholic psychosis and lasted up to 25 days, which led to the loss of primary reduction of bone fragments and to prolonged skeletal traction. On the 8th day after the surgery, the patient had a purulent wound exudate, which required revision surgery, early removal of implants and led to poor functional result, evaluated 3 months after the surgery.

Another patient on the third day after the surgery had marginal necrosis of the skin in the area of the posterolateral surgical approach without purulent exudate and manifestations of acute inflammation. On the 20th day after the surgery, a necrectomy was performed without exposing the implants. The wound healed per secondary intention with application of ointment dressings and without subsequent complications. The patient was followed up to 12 months after osteosynthesis – fractures consolidated, and there were no signs of early post-traumatic arthrosis on the control radiographs. The range of motion of the ankle joint was satisfactory with minor limitations, and

the functional results were 78 points according to the AOFAS scale and 86 points according to the Neer scale.

One 80-year-old patient had signs of aseptic necrosis of the medial malleolus with migration of the K-wires and wire tension band 3 months after surgery, that were noted on control radiographs, which significantly worsened the functional and radiological outcomes of the treatment. The patient refused revision surgery and had to use an additional external immobilization of the ankle joint with an orthosis.

Posttraumatic arthrosis developed in 3 (10.3%) cases 12 months after osteosynthesis. One of these patients, 80 years old, is described above. Two more patients, due to inaccurate intraoperative reduction of bone fragments in the form of a residual step up to 2 mm, early developed post-traumatic arthrosis, visible on control X-rays, which manifested by decrease of the articular gap and sclerosis of the subchondral bone. They also had a relative decrease in functional results: 60 and 68 – according to the AOFAS scale and 66 and 70 points – according to the Neer scale, as well as moderate restrictions of the range of motion of the ankle joint: the amplitude was 35° and 45°.

Discussion

Traditionally, it was considered that the indication for osteosynthesis of fractures of posterior edge of the tibia is the presence of a fragment of posterior edge containing 1/3 or more of the articular surface [6, 10]. This approach led to the non-observance of basic principles of treatment of intraarticular fractures, which consist of complete restoration of anatomy of the articular surface in combination with stable fixation of bone fragments with subsequent early active movements in the damaged joint. One of the factors hindering the development of surgical technologies was insufficient knowledge of methods of accurate diagnosis of architectonics and technique of surgical treatment of fractures of posterior edge of the tibia. That is why some authors use closed reduction with wire fixation or external fixation devices as a method of definitive treatment of such fractures till nowadays [11, 12].

However, in the recent years modern traumatology shows tendency to revise approaches to the surgical treatment of many intraarticular fractures, including unstable fractures of malleoli and the posterior edge of the tibia, regardless of the size of bone fragments containing the articular surface [13]. This is primarily due to the routine use of spiral computer tomography in many trauma hospitals to analyze individual fracture architectonics, to plan surgical treatment and to evaluate its results.

The desire to improve the quality of bone fragments reduction and fixation in such fractures led to development and clinical testing of new surgical approaches that provide better visualization and wide range of manipulations with bone fragments, including fragments of articular surfaces. One of these relatively new approaches, which has not yet become widespread in our country, is the posterolateral approach, which we used for osteosynthesis of combined fractures of posterior edge of the tibia and lateral malleolus [14]. Therefore, the study of potential, advantages and disadvantages of this approach, as well as assessment of the short-term and mid-term results of osteosynthesis performed while using it for unstable fractures of posterior edge of the tibia and malleoli, were chosen as the aim of our study.

One year follow-up of 29 patients with unstable fractures of malleoli and posterior edge of the tibia included in the study allowed us to establish a number of facts. In particular, it was shown

that in 23 (79.3%) patients open reduction and internal fixation of posterior Volkman fragment and osteosynthesis of the lateral malleolus via the posterolateral surgical approach, and in some cases also the medial malleolus via the standard medial approach, give opportunities to achieve proper anatomical reduction of articular surfaces of the ankle joint. In 4 (13.8%) cases the position of bone fragments was considered satisfactory, since the residual step of the articular surface and/or the widening of the fracture gap did not exceed 2 mm. It should also be noted that in 2 (6.9%) patients with preserved subluxation of the talus the position of posterior edge of the tibia after osteosynthesis was also correct.

In our opinion, these results are explained by the fact that open reduction of posterior fragment of the tibia from the posterolateral surgical approach first of all the gives surgeon the possibility of both direct visual control and intraoperative fluoroscopic control of its position. At the same time, he is able to use a wide range of reduction techniques: bone clamps, traction and rotation control using special pointed hooks. In addition, lag screw technique and sequential "squeezing" of the bone fragment with a plate significantly facilitate the reduction of even relatively small and comminuted bone fragments. This way of reduction of posterior fragment of the tibia enables to avoid significant residual displacement of the articular surface of the bone and/or significant widening of the fracture gap. In addition, fixation with two cancellous lag screws or a plate makes it possible to achieve sufficient vertical and rotational stability, which, along with anatomical reduction, is necessary for early active movements in the ankle joint. All these advantages provided by posterolateral approach have positive effects not only on the quality of reduction and fixation of posterior fragment of the tibia, but also increase stability of the syndesmosis, which affects the final functional outcome of treatment positively [14, 15].

In our study, in 9 (31%) cases qualitative fixation of posterior fragment of the tibia was performed with screws only, and in the rest 20 (69%) cases fixation was achieved with various plates. The choice of fixators was determined by the pattern of fracture of posterior edge of the tibia, and the size of the bone fragment, so that the way of fixation could be changed intraoperatively. In

8 (27.6%) patients this size was less than 30% of length of articular surface of the tibia. It should be noted that in such cases, according to the traditional concept, there is no need to reduce and fix the Volkman posterior fragment. However, we fixed such fragments via posterolateral approach and obtained good restoration of congruence of articular surface of the tibia, as well as partial stabilization of posterior ligamentous complex, and consequently, the entire ankle joint.

In addition, it should be noted that the primary reduction and fixation of the posterior Volkman fragment using the posterolateral approach facilitates the reduction and fixation of the injured lateral malleolus in the future significantly. We did not encounter such difficulties during all 29 surgeries we had performed, although the architectonics of fractures of the lateral malleolus were different. This fact, in our opinion, underlines once again the advantages of posterolateral approach for osteosynthesis in patients of the discussed profile.

Osteosynthesis of posterior edge of the tibia only was insufficient to stabilize the ankle joint in 5 (17.2%) patients, the majority of them with fractures type 44-C3.3. These patients retained lateral instability of the ankle joint detected intraoperatively. In these cases, additional fixation of distal syndesmosis was performed with a positional screw. It should be noted that, according to many authors, high-quality fixation of posterior Volkman fragment reduces the need of separate fixation of the syndesmosis and, consequently, the need of positional screws removal, which affects the possibilities of early movements in the ankle joint and restoring its function positively [16, 17].

Functional results of the treatment of patients of our study are comparable with similar data of other authors and confirm clinical effectiveness of the surgical treatment option we studied. So, L.W. Mason et al., who studied functional outcomes a year after open reduction and internal fixation of posterior edge of the tibia via posterolateral or posteromedial approach in 50 patients aged 21 to 87 years, reported 74.1 points out of 100 maximum possible according to the Olerud-Molander Ankle Score scale when using posterolateral approach, and the mean value in the group of posterolateral approach was 75.0 points. These authors also support the tactics of open reduction and internal fixation of posterior

edge of the tibia in all types of fractures affecting the articular surface [18].

The percent of complications obtained in our study was 17.6% and is quite significant. However, it should be kept in mind that the types of fractures of the ankle joint area studied are severe complex intraarticular injuries, and the final result of the surgery depends not only on reduction of the posterior edge of the tibia, but also other components of the joint, but on the quality of bone and condition of soft tissues.

To decrease soft tissues complications, vessels and nerves damaging located in the area of posterolateral surgical approach, it is recommended to protect the sural nerve by identifying it in the surgical wound and retracting it with a plate retractor, as well as to treat carefully the lateral calcaneal artery that supplies the skin in surgical area. It is also possible to mark out low level of soft tissue traumatization of the discussed approach. This, in particular, is evidenced by the low frequency of infectious complications. Thus, only one patient (3.4%) had a deep postoperative infection, one more patient (3.4%) had problems with the healing of the postoperative wound. Large neurovascular bundles damage was not noted, since they were not located dangerously close to the surgical wound. The relatively low percent of post-traumatic arthrosis (10.3%) identified in our study also proves the effectiveness of the proposed treatment method. It is possibly associated with a relatively short follow-up period of patients (12 months). We are planning to get more accurate data on the development of post-traumatic arthrosis during our further research.

It is necessary to mention that the data obtained during current research correspond with the results of work of other surgeons, who used posterolateral approach for fixation of posterior edge of the tibia. C. Von Rüden et al. reported that 2 (18%) out of 18 patients, who underwent open reduction and internal fixation of posterior edge of the tibia, had problems with wound healing. However, the authors noticed more precise restoration of congruency of the ankle joint in these patients and higher functional results comparing with 12 patients, who underwent front to back lag screw fixation of posterior edge of the tibia via small skin incisions [19]. J. Forberger et al. used posterolateral approach to fix the fracture of posterior edge of the tibia, and the authors reported

11% of soft tissue complications. Final functional outcome score 15 to 43 months of follow-up after osteosynthesis was 93 points according to the AAOS foot and ankle scale [20]. Thus, the literature data correspond to our results and confirm high clinical efficiency and perspectivity of using the studied posterolateral surgical approach in patients of discussed profile.

Limitations and prospects of the study

The study was performed on a limited number of patients (29 patients). There are no data on the treatment of patients with similar pathologies for whom the fragment of the posterior edge of the tibia was not fixed, was fixed using less invasive methods or was fixed using alternative surgical approaches. These data will be presented in our future publications. The authors hope that their further research will help to determine the role and place of posterolateral surgical approach in the treatment of patients with unstable fractures of the malleoli and the posterior edge of the tibia more accurately.

Conclusions

Based on the data obtained it can be claimed that the posterolateral surgical approach has significant advantages when performing osteosynthesis in patients with unstable fractures of malleoli and posterior edge of the tibia. It gives an opportunity to achieve anatomical reduction and stable fixation of fragments of posterior edge of the tibia, which enables of early range of motion in the ankle joint and might have positive effects on long-term treatment results by reducing the number of patients with developed post-traumatic arthrosis. Preliminary fixation of posterior edge fragment of the distal tibia via the posterolateral approach allows partially stabilize the damaged distal syndesmosis and creates certain convenience for subsequent reduction and fixation of the fracture of lateral malleolus. The undoubted advantages of the discussed approach can also be attributed to the absence of large neurovascular bundles in the area of its implementation, which practically excludes the possibility of their intraoperative damage.

Informed consent

The patients gave written informed consent to participation in the study and publication of its results.

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Authors' contribution:

All authors have read and approved the final version of the manuscript of the article.

All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

Conflict of interest:

The authors declare that there is no conflict of interest.