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Mid-term outcomes of ankle fracture repair with the Ilizarov method

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Abstract

Introduction The aim of the study was to analyze the functional results of surgical treatment in patients with unstable ankle fractures with the Ilizarov method (controlled retrospective cohort monocenter non-randomized study; Level of evidence II). **Materials and methods** Fifty-three patients, 15 males and 38 females, in the mean age of 48 years, with ankle fractures met the inclusion criteria. The patients were divided into three groups according to the principle of dominant lesion location and according to the number of damaged bone structures. The patients underwent surgical interventions comprising closed reduction and external fixation with the Ilizarov apparatus bridging the ankle and subtalar joints. The study period was 34.6 months after surgery. Functional outcomes were evaluated based on the data of the AOFAS questionnaire. **Results** The average AOFAS score for Weber type A fractures was 95.25 ± 6.84 (SD), 93.77 ± 6.85 (SD) for type B, and 93.57 ± 4.03 (SD) for type C. In the patients with isolated fractures of the lateral malleolus it was 93.44 ± 8.38 (SD), in bimalleolar fractures – 94.09 ± 6.41 (SD), and in trimalleolar fractures – 93.71 ± 6.39 (SD). There were no significant differences between the groups of patients with different (Weber) types of ankle fractures. There was tendency to worse outcomes in patients whose surgical treatment was carried out 7 days or more after the injury. **Conclusion** Ankle osteosynthesis with the Ilizarov apparatus in unstable ankle fractures demonstrates excellent mid-term (range, 2 to 4 years) functional outcomes. The number of damaged bone structures of the ankle joint and the location of the dominant injury are not predictors of an unfavorable outcome in unstable ankle fractures in case of definitive fixation with the Ilizarov apparatus. There is a tendency to worse functional outcomes in delayed surgical treatment if the time from injury to surgery is more than seven days.

Keywords: ankle fracture, Ilizarov apparatus, closed transosseous osteosynthesis

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INTRODUCTION

Ankle fractures account for up to 10 % of all fractures with an incidence of about 137/10^5/year [1–4]. They are the second most common lower extremity fractures after femoral neck fractures [5]. The average age of patients is 45 years [2]; postmenopausal women and younger male patients prevail [2, 4].

These are low-energy injuries due to a fall from a height lower than one's own height [2, 3, 4], and in most cases are caused by forced external rotation and supination or pronation and abduction of the foot [6, 10, 11].

There are pathomechanical [6] and anatomical [7, 8, 9] classifications of ankle fractures that describe most of their patterns. Different types of ankle fractures are characterized by various pathomechanics and may have a significant effect on long-term functional results [12, 13]. A separate place is occupied by trimalleolar fractures that comprise a fracture of the posterior edge of the distal metaepiphysis of the tibia, which have separate classifications [14-16]. Some of these injuries (extending up to ½ of the articular surface of the distal tibial epiphysis) are, in essence, anterior pilon fractures involving the malleoli [17], while others are avulsions of a fragment of various sizes from the posterior tubercle due to traction by the posterior tibiofibular ligament [6, 18, 19].

Frontal stability of the ankle joint is provided by the internal and external bone-ligament complexes along with the distal tibiofibular syndesmosis [20]. Most ankle fractures are amenable to closed reduction and are stable after immobilization with a cast. Unstable injuries include injuries accompanied by external subluxation of the foot or a violation of the integrity of two out of three stability complexes (i.e., more than one malleolus or the lateral malleolus and tibiofibular syndesmosis) [21, 22]. Surgical treatment is indicated for unstable injuries or Weber types A with fractures of both malleoli, B with external subluxation of the foot and/or fracture of the medial malleolus, and C, which consists in osteosynthesis of malleolar fractures and elimination of external subluxation of the foot (if any) [23 , 30].

To date, there are methods for internal fixation of ankle fractures, which consist in open reduction and osteosynthesis of the medial and lateral malleolus, the posterior edge of the distal metaepiphysis of the tibia with lag screws, a wire loop, and bone plates [24].

Open reduction and internal fixation is the dominant method of surgical treatment of unstable ankle fractures, providing good long-term functional results [25, 26]. However, it is accompanied by the

risk of complications, such as superficial and deep infection of the surgical site, implant migration and secondary displacement, post-traumatic deformity, and post-traumatic crusarthrosis [27-31]. At the same time, there are contradictions regarding the fixation of the tibiofibular syndesmosis with a positional screw (diameter, number of screws, insertion of screws through three or four cortical layers, timing of screw removal) or button fasteners. Literature on this topic shows similar effectiveness of various types of osteosynthesis and stabilization of the tibiofibular syndesmosis without any clear advantages of any concept, despite the different biomechanical substantiation of the techniques [32-34]. The need to fix small fragments of the posterior edge of the distal metaepiphysis [35] and restore the anterior tibiofibular [36] and medial collateral ligaments [37] also remains a controversial issue. Moreover, there are contradictions in postoperative protocols regarding external immobilization and the timing/volume of loading on the affected limb [38, 39].

Despite the effectiveness of open reduction and internal fixation for ankle fractures, some problems remain unresolved, such as the questionable stability of osteosynthesis in patients with osteoporosis, the relatively high incidence of complications in elderly patients and those with diabetes [40-44], the lack of full limb weight-bearing, and the need for additional support for a long period of time [38, 39], the need to remove metal structures (the positional screw and plates), since even low-profile plates disturb patients, what affects the results of treatment and reduces the quality of life of the patient [45].

An alternative functional method of surgical treatment of unstable ankle fractures is closed transosseous osteosynthesis. Despite the long history of the method and its effectiveness [46-51], there are practically no recent studies on long-term functional results with a high-quality design and statistically processed results.

Purpose: analysis of functional results after surgical treatment of patients with unstable ankle fractures using closed transosseous osteosynthesis with the Ilizarov apparatus.

Study design: controlled open retrospective cohort monocenter non-randomized study. Level of evidence II.

MATERIALS AND METHODS

Inclusion criteria: patients with an unstable ankle fracture and a complete radiological archive, catamnesis. Exclusion criteria: unavailable patients' follow-ups due to transfer to another institution or death, multiple trauma to the lower extremities, conservative treatment or surgical treatment of a fracture with internal structures.

Seventy-nine patients with ankle fractures were treated during the period from January to August 2019 in department 1 at the Ilizarov NMRC for TO, of which 53 patients met the inclusion criteria (Table 1). Fifteen were men and 38 were women aged 27 to 68 years (average age: 48 years). The average time from injury to surgery was 6.27 days. Patients' sample comprised three groups according to the principle of the dominant injury location: 4 patients with subsyndesmotic fractures of the lateral malleolus, 39 patients with transsyndesmous fractures of the lateral malleolus, and 10 patients with suprasyndesmotic fractures of the distal third of the fibula shaft.

Table 1

Distribution of patients according to Weber fracture type

Weber fracture type	Patients	
	Number	%
A	4	7.55
B	39	73.58
C	10	18.87

The same sample of patients, but with the exception of 4 patients with Weber type A fractures, was divided into three groups according to the number of damaged bone structures: 9 patients with fractures of the lateral malleolus and external subluxation of the foot (Fig. 1), 33 patients with fractures of the medial and lateral malleolus (Fig. 2); 7 patients with fractures of the medial, lateral malleolus and posterior edge of the distal tibial metaepiphysis, which involved more than 25 % of the articular surface and required additional fixation (Fig. 3), (Table 2).

All patients took X-rays of the ankle joint in frontal and lateral projections at admission, intraoperatively, before discharge from the hospital (on average, 7 days after surgery), after dismantling the distal base (calcaneal) support, and after dismantling the Ilizarov apparatus.

The patients underwent surgery of closed transosseous osteosynthesis with the Ilizarov apparatus with fixation of the ankle and subtalar joints. The key surgical technique was closed direct reduction of fragments with reduction olive wires (Fig. 4). Dismantling of the distal base support from the calcaneus was carried out, on average, on the 28th day from the day of surgery. The removal of the Ilizarov apparatus was performed, on average, 78 days after the operation.

Mid-term outcomes were studied in 53 patients out of 79 (89.83 %). The follow-up period averaged 34.6 months. The results were evaluated on the basis of subjective and objective clinical examination data. For a subjective study, patients were asked to fill a test using the AOFAS questionnaire [52]. Statistical data processing was carried out in Microsoft® Excel 16.16.27 (201012) with AtteStat 12.0.5.

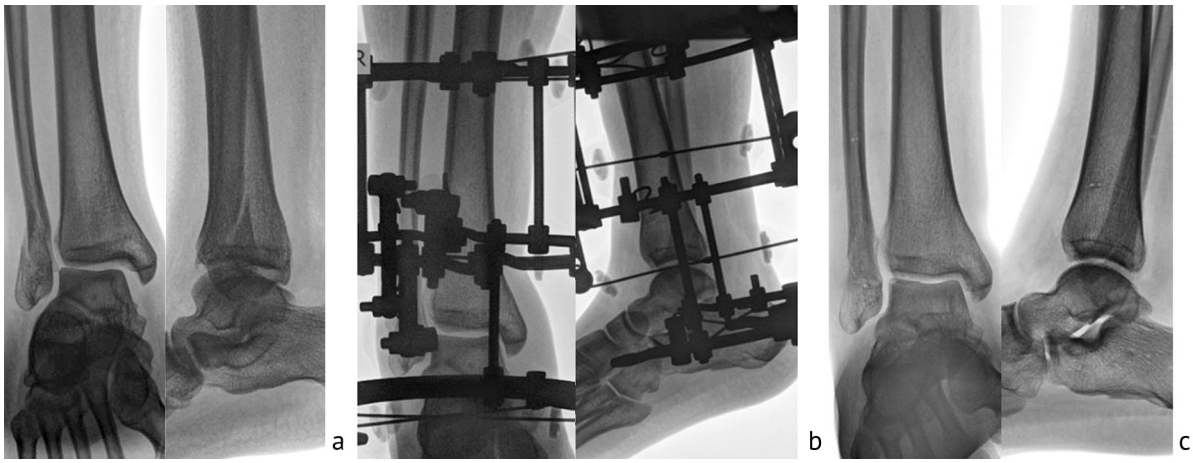

Fig. 1 Patient, 36 years old, ♂, with transsyndesmosis fracture of the lateral malleolus, lateral subluxation of the foot. Radiographs at admission (a), after surgery on the 5th day after the injury (b), after dismantling the Ilizarov apparatus 68 days after surgery (c)

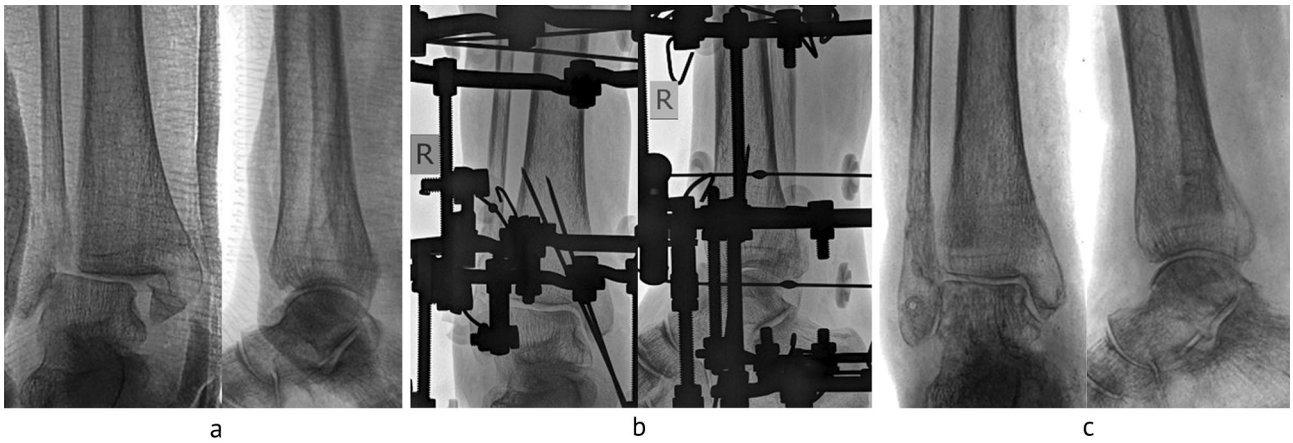

Fig. 2 Patient, 69 years old, ♀, with a transsyndesmotic fracture of the lateral malleolus, a fracture of the medial malleolus, and lateral subluxation of the foot. Radiographs at admission (a), after surgery on the 5th day after the injury (b), after dismantling the Ilizarov apparatus 72 days after surgery (c)

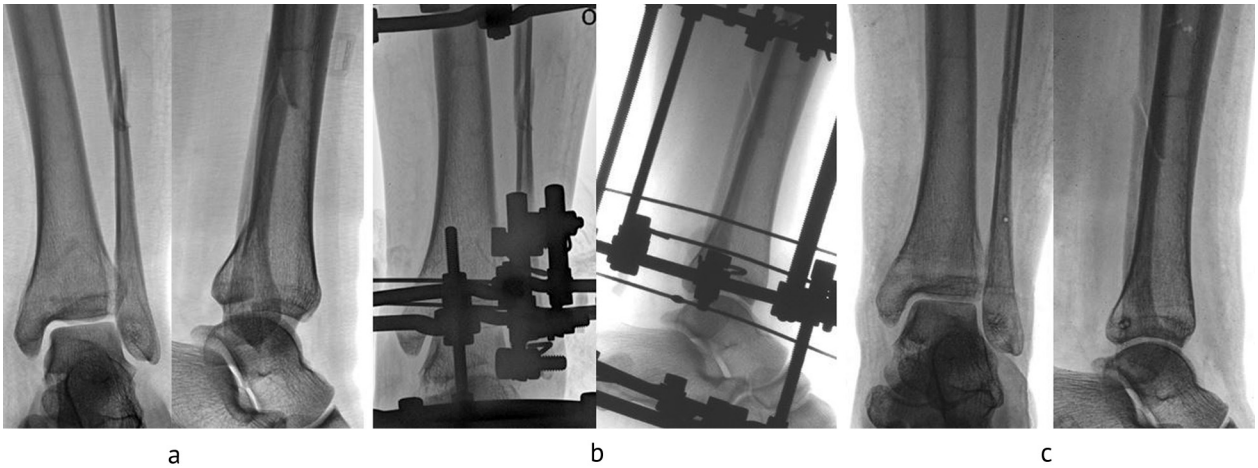

Fig. 3 A 34-year-old patient, ♀, with a suprasyndesmotic fracture of the fibula, a fracture of the posterior edge of the distal tibial metaepiphysis, and posterior subluxation of the foot. Radiographs at admission (a), after surgery on the day of injury (b), after dismantling the Ilizarov apparatus 79 days after surgery (c)

Table 2

Distribution of patients according the number of fragments

Pott's fracture type	Patients	
	Number	%
Lat.	9	18.37
Lat. + Med.	33	67.35
Lat. + Med. + Post.	7	14.28

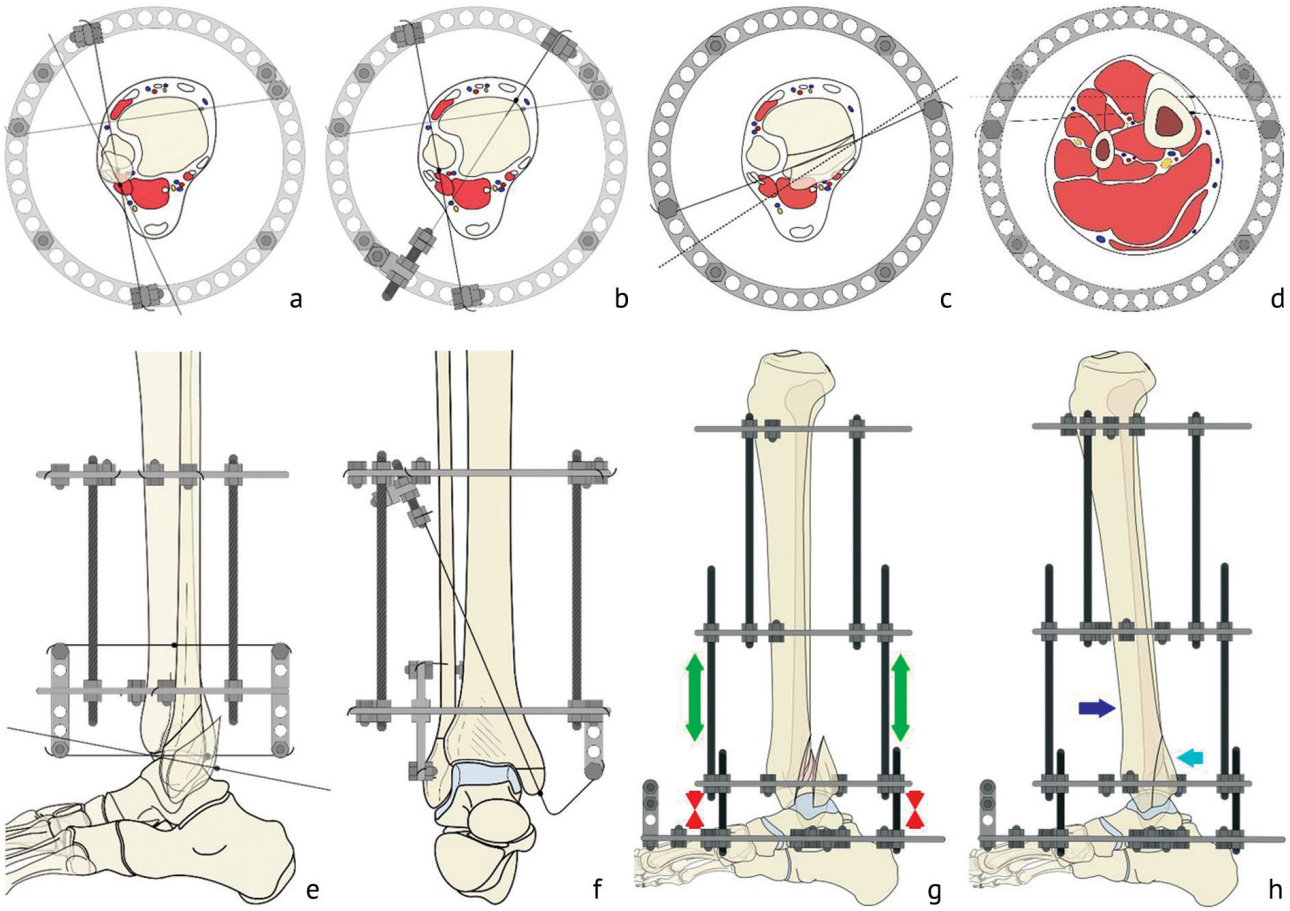

Fig. 4 Closed direct reduction of ankle fragments under conditions of fixation with the Ilizarov fixator: *a, e* lateral malleolus; *b, f* medial malleolus; *c, d, g, h* posterior edge of the distal metaepiphysis of the tibia

RESULTS

Short-term results

Short-term results (up to 1 year) were monitored at the outpatient stage after the device had been removed and studied in all patients. At the follow-up examination after the dismantling of the Ilizarov apparatus (on average, 78 days after the operation), an X-ray of the ankle joint was taken in two projections in order to control consolidation and exclude secondary displacement of fragments. Clinical tests were also conducted to detect frontal and/or sagittal instability of the ankle joint. One patient (1.88 %) had residual frontal instability of the ankle joint. Fifteen patients (28.30 %) had no complaints at the time of examination, 18 patients (33.96 %) had swelling of the ankle joint area, 24 patients (45.28 %) noted pain and fatigue after a long walk, 16 patients were disturbed by the sensation of stiffness in the morning. Radiographically, union of the lateral malleolus and the posterior edge of the distal tibial metaepiphysis was observed in all patients, nonunion of the medial malleolus was observed in 4 cases (7.54 %) (out of 40 patients with fractures of the medial malleolus in Weber types B and C), without affecting functional results; in transsyndesmotic fractures, moderate osteoporosis of the distal metaepiphysis of the tibia, lateral malleolus, and foot bones was observed in 17 patients (32.07 %); in suprasyndesmotic fractures (10 patients), paraossal callus was observed which density corresponded to the density of the surrounding bone or exceeding it.

Mid-term results

In the group of patients with ankle fractures of Weber type A, the average AOFAS score was 95.25 ± 6.84 (SD), in Weber type B it was 93.77 ± 6.85 (SD), in Weber type C – 93.57 ± 4.03 (SD). In patients with ankle fractures of Weber types B and C, the average AOFAS scores were: 93.44 ± 8.38 (SD)in isolated fractures of the lateral malleolus, 94.09 ± 6, 41 (SD) in fractures of the medial and lateral malleoli, 93.71 ± 6.39 (SD) in fractures of the medial, lateral malleolus and posterior edge of the distal metaepiphysis of the tibia (Table 3). There were no significant differences between groups of patients with different types of Weber ankle fractures (Fig. 5).

Table 3

AOFAS scores

Fracture type	AOFAS mean score	Standard deviation (SD)	Number of patients
Weber A	95.25	6.84	4
Weber B	93.77	6.85	39
Weber C	93.57	4.03	10
Lat.	93.44	8.38	9
Lat. + Med.	94.09	6.41	33
Lat. + Med. + Post.	93.71	6.39	7

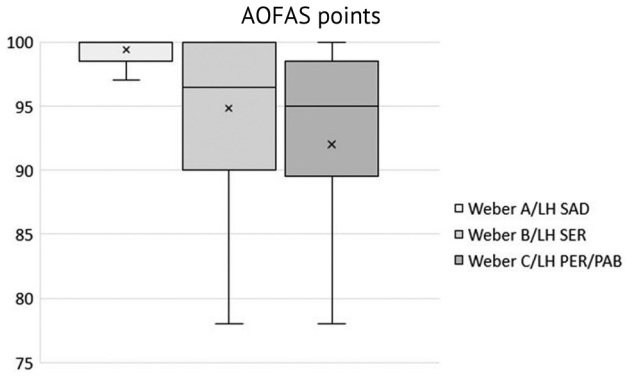

Fig. 5 Results of the AOFAS questionnaire depending on the type of Weber type ankle fracture

Between groups of patients with fractures of Weber types B and C, Mann-Whitney U-test = 0.52. Between groups of patients with isolated fractures of the lateral malleolus and patients with fractures of both malleoli, Mann-Whitney U-test = 0.94. Between groups of patients with fractures of both ankles and patients with fractures of both ankles and the posterior edge of the distal metaepiphysis of the tibia, Mann-Whitney U-test = 0.59 (Fig. 6). There were no significant differences in the functional results after surgical treatment carried out at different terms (up to 14 days). However, there was a tendency towards worse treatment outcomes in patients who underwent surgical treatment 7 days or more after the injury compared with patients that underwent surgery earlier, Mann-Whitney U-test = 0.14 (Fig. 7).

The average duration of surgery for a fracture of the lateral malleolus was 64.0 minutes, for a fracture of both ankles – 71.25 minutes, for a fracture of both ankles and the posterior edge of the distal tibial metaepiphysis – 98.83 minutes.

Secondary displacement of fragments of the lateral malleolus developed in one case (1.88 %) due to cutting and penetration of the olive bead platform. Symptoms and radiological signs of post-traumatic crusarthrosis were noted in the observed periods in 4 patients (7.54 %) (1 – Weber type A and 3 – Weber type C). Six patients (11.32 %) had superficial inflammation of the skin of grade I according to the Saw classification [59] in the area of the wire tracts (in 2 patients, more than one area), developed most frequently at the level of the distal base support. Infectious complications that affected the final result of treatment were not observed.

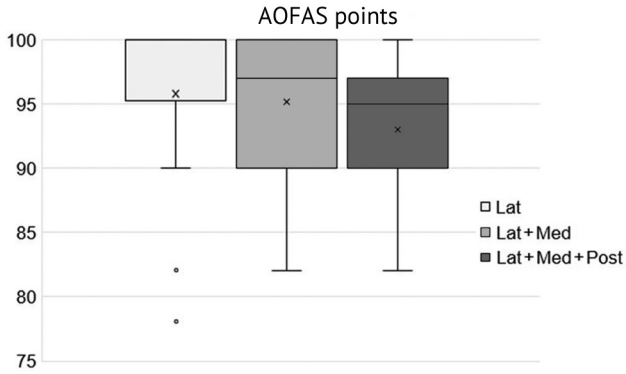

Fig. 6 AOFAS results in regard to the number of damaged bone structures of the ankle joint

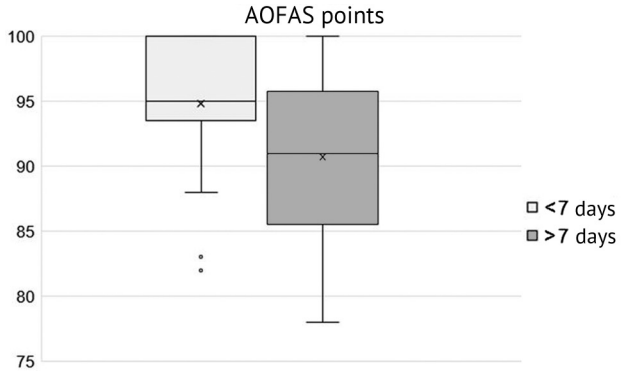

Fig. 7 AOFAS results in regard to duration of the preoperative period

DISCUSSION

In acute cases of unstable ankle fractures, surgical treatment with the use of closed transosseous osteosynthesis of the lower leg bones with fixation of the ankle joint demonstrates excellent mid-term functional results due to early limb weight-bearing and stable fixation, which stability is controllable at any stage of fixation. Fractures of both malleoli [53], the posterior edge of the distal metaepiphysis of the tibia [54], and suprasyndesmotic fractures of the fibula are predictors of lower functional results in osteosynthesis of ankle fractures with implant structures; moreover, there are significant differences in the duration of surgical

intervention. The absence of differences between the groups of patients with various types of ankle fractures treated with closed transosseous osteosynthesis can be explained by the possibility of customized constructs of the Ilizarov apparatus based on the pathomechanics of the fracture and the direction of reduction forces, the possibility of directed, supported and dosed interfragmentary compression.

The results of surgical treatment of unstable ankle fractures using closed transosseous osteosynthesis are comparable with the results of open reduction and internal fixation [55-58], but the number of complications affecting the treatment outcome is lower. The incidence of infectious complications after closed transosseous osteosynthesis is lower than after open reposition and internal fixation [27, 28, 33]; in the majority of cases they are wire-tract infection, which is associated with inflammation of the soft tissues in the zones of the wire insertion. This is a curable condition at almost any stage, and with the correct regimen of outpatient monitoring and dressings, it does not affect the outcome of treatment [60].

To date, most patients with unstable ankle fractures and signs of damage to the internal collateral ligaments undergo immobilization of the ankle and subtalar joints for three weeks after surgery, after which the distal base support is dismantled. An early consequence of fixation of the ankle and subtalar joints is a combined post-immobilization and transfixation contracture, which, however, can be rehabilitated and levels out, on average, after 6-8 weeks from surgery. In the case of intact medial collateral ligaments, such as a fracture of the medial malleolus, there is no final need for fixation of the ankle joint upon stable osteosynthesis. It is possible to connect the fixation-reduction and distal base supports by means of hinges installed along the axis of the ankle joint, and this approach has been introduced into the clinical practice of the department and is more promising in terms of accelerating the rehabilitation of patients. However, at the time of the study, fixation and decompression of the ankle and subtalar joints in the position of mild arthrodistraction for a period of 3 weeks was an empirically verified treatment strategy. Moreover, plaster immobilization is used both for stable ankle fractures as the main method of treatment and as an additional method after internal osteosynthesis of unstable fractures and does not significantly affect long-term results [61, 62].

Closed transosseous osteosynthesis for ankle fractures is possible at any time after the injury and in any condition of the soft tissues, without disturbing the blood supply to the fragments and creating the most favorable conditions for fracture consolidation. Along with controlled reductin and fixation of fragments, the Ilizarov method allows decompression of the ankle joint by controlled arthroditraction, which has a beneficial effect on the state of the damaged cartilage. Limb weight-bearing is possible one day after the operation. If hinges are installed, active movements in the ankle joint are also possible. The Ilizarov method in the treatment of unstable ankle fractures is devoid of the disadvantages of open reposition and internal fixation, and the possibilities and advantages mentioned above are currently unattainable in osteosynthesis with implanted structures.

Thus, osteosynthesis with the Ilizarov method for unstable ankle fractures is a highly effective method of surgical treatment, demonstrating excellent functional results, corresponding to modern methods of internal fixation but with fewer complications, their severity and curability.

CONCLUSIONS

1. Osteosynthesis of the lower leg bones with the Ilizarov apparatus bridging the ankle joint in unstable ankle fractures demonstrates excellent mid-term (2 to 4 years) functional results of treatment.

2. The number of damaged bone structures of the ankle joint and the location of the dominant injury are not predictors of poor outcomes in the management of unstable ankle fractures in the conditions of osteosynthesis with the Ilizarov apparatus.

3. There is a tendency to deterioration of the functional results of surgical treatment if the time from injury to surgery is more than 7 days.

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