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Ankle arthrodesis after combat related injuries

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Combat related injuries of the ankle joint (AJ) are often accompanied by severe changes in the musculoskeletal system, which require arthrodesis of the damaged joints in the final stage of treatment. Objective. To analyze the results of AJ arthrodesis in patients after combat related injuries, to highlight aspects of the use of different fixation methods. Methods. AJ arthrodesis was performed in 21 patients with the consequences of severe combat related injuries of the posterior part of the foot. An intramedullary locked rod (18 patients), screws (2 patients) and an Ilizarov-type external fixation device (EFD) were used for fixation in one patient. The results were assessed no earlier than 6 months after the start of loading using the AOFAS (posterior part), SMFA (short musculoskeletal functional assessment) and EQ-5D-5L (mobility, self-care, usual activity, pain, anxiety, VAS) scales and questionnaires. Results: In the specified terms, the results were traced in 21 patients. A differential approach was used in choosing the method of fixation of the AJ. A significant increase in function was obtained according to the AOFAS, SMFA and EQ-5D-5L scales ($p < 0.001$). Conclusions. AJ arthrodesis in patients with the consequences of severe combat related injuries allows to restore the resistance of the limb and is the final stage of treatment of these patients.

Бойові поранення нижньої кінцівки, в тому числі ділянки надп'ятково-гомілкового суглоба (НГС), є найчастішими на полі бою й зазвичай супроводжуються тяжкими змінами опорно-рухової системи. Ортопедичні реконструктивні втручання є фінальним етапом лікування уражень цієї ділянки і направлені на виконання артродезу через тяжкі внутрішньосуглобові ушкодження НГС, що супроводжуються післятравматичним остеоартрозом із вираженим больовим синдромом. Мета. Проаналізувати результати артродезу НГС у хворих після вогнепальних поранень, висвітлити аспекти застосування різних способів фіксації. Методи. Проведений артродез НГС у 21 пацієнта з наслідками тяжких вогнепальних поранень заднього відділу стопи. Вік постраждалих становив (38,1 ± 10,9) року, жінок було 2, чоловіків — 19. Застосували для фіксації інтрамедулярний блокований стрижень (18 осіб), гвинти (2) та в одного — апарат зовнішньої фіксації (АЗФ) типу Ілізарова. Методика артродезу НГС передбачала виконання двох доступів: латерального та медіального, останній здійснювали за необхідності. Результати оцінювали не раніше 6 міс. після початку навантаження за шкалами та опитувальниками AOFAS (задній відділ), SMFA (short musculoskeletal functional assessment) та EQ-5D-5L (мобільність, самообслуговування, звичайна активність, біль, тривога, VAS). Результати. У зазначені терміни результати оцінювали у 21 пацієнта. Застосовували диференційний підхід у виборі метода фіксації НГС. Незадовільний результат отримано в 1 випадку, відповідно до AOFAS, але згідно з шкалами SMFA та якості життя EQ-5D-5L відмічено суттєве покращення показників самообслуговування пацієнта через 6 міс. Зафіксовано достовірний приріст функції за шкалами AOFAS, SMFA та EQ-5D-5L ($p < 0,001$). Висновки. Артродез НГС у осіб із наслідками тяжких поранень дозволяє відновлювати опороздатність кінцівки та є фінальним етапом лікування цих пацієнтів. Ключові слова. Вогнепальне поранення, надп'ятково-гомілковий суглоб, артродез, опороздатність кінцівки.

Keywords. Combat related injuries, ankle joint, arthrodesis, resistance of the limb

Introduction

Today's combat injury is a severe injury due to the high kinetic energy of projectiles and the use of a wide range of means of destruction. All gunshot wounds can be divided into bullet and mine-explosive (mine-explosive trauma, MET) with high, medium and low energy of impact on the human body, which depends on many factors. In MET, damage occurs both because of direct contact with an explosive device and as a result of injury by elements (fragments, shrapnel, etc.). Severe injury can also occur without direct contact with the projectile (device), i. e. as a result of the action of the blast wave on protective elements and their direct traumatic effect (for example, an explosion in a car without the penetration of fragments into the interior) [1].

Lower limb injuries are the most common on the battlefield [2–4]. At the same time, gunshot wounds to the lower leg and foot occur in 26 % of cases, with bullet wounds prevailing over explosive trauma [5].

Injuries to the talocrural joint (TCJ) have their own characteristics due to the small volume of soft tissues around the bone and joint, which, for example, in 80 % of cases of gunshot wounds leads to bone fractures with a predominance of intra-articular injuries and trauma to the vascular and neurovascular trunks [6]. A corresponding problem of injuries to the TCJ is the issue of preserving the lower limb or performing primary amputation. We were unable to track the frequency of TCJ injuries separately in the literature [5, 7, 8].

Orthopedic reconstructive interventions are the final stage of treatment of lesions in this area and are aimed at performing arthrodesis due to severe intra-articular injuries of the TCJ, accompanied by post-traumatic osteoarthritis with severe pain syndrome [9]. External fixation devices (EFDs), particularly those using ring supports of the Ilizarov type, are commonly employed for the fixation of the TCJ after gunshot wounds. This method is associated with microbial contamination of the tissues. The possibility of using other fixation methods and the frequency of complications during their use are unclear. The terms of union of the TCJ area when using different fixation methods are observed on average after 8–12 weeks [11], and bone union occurs in 69–77 % of cases [12], which may require repeated surgical interventions.

Purpose: to analyze the results of arthrodesis of the talocrural joint in patients after gunshot wounds, to highlight aspects of the use of different fixation methods.

Material and methods

The results of the treatment of 21 patients with the consequences of severe injuries of the TCJ area, who were hospitalized in the clinic at the State Institution "National Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine", Kyiv from 2014 to 2024, are presented. The study was approved by the Bioethics Commission of the State Institution "ITO of the National Academy of Medical Sciences of Ukraine" (protocol No. 2 dated 07.02.2025). The study was conducted in compliance with the requirements and provisions of the Helsinki Declaration on Human Rights (2000), including the revision of EC-GCP, the Constitution and Fundamentals of Ukrainian Legislation on Health Care (1992), and all ethical standards for conducting clinical trials. All patients signed informed consent.

Most patients (18 subjects, 86%) were injured after the start of the full-scale invasion of the Russian Federation on 24 February 2022. Among them, 2 (9.5 %) were civilians. The age of the patients was (38.1 ± 10.9) years, there were 2 women, and 19 men.

The patients received treatment at the evacuation stages in accordance with the rules for providing medical care to the wounded. At the time of hospitalization, they had no wounds or clinical signs of infection.

The study did not include patients with consequences of minor injuries to the TCJ area and those who required high amputation of the lower limb.

Arthrodesis of the TCJ was performed with screw fixation, intramedullary locking rod, and external fixation device. The function of the lower limb was assessed before and after surgical treatment using the AOFAS scale (TCJ segment and hindfoot (HF)), SMFA (Short musculoskeletal function assessment) and EQ-5D-5L quality of life questionnaire. The data were entered into Excel spreadsheets, and the significance of the difference in means was calculated using a paired two-sample t-test. The results were evaluated no earlier than 6 months after the start of loading the limb after surgery.

Additionally, the type of injury (mine-explosive or bullet), the degree of tissue damage according to the Gustilo-Anderson classification, the time from the moment of injury to reconstructive surgery, the number of previous operations, the presence of an infectious process at the previous stages of treatment or after the performed reconstructive surgery were analyzed.

Results

Severe cases of gunshot wounds of the TCJ are characterized by significant disintegration of the anatomy of this area (Fig. 1), the supporting function in this case is achieved by arthrodesis of the damaged joints.

The technique of arthrodesis of the TCJ involved performing two approaches: lateral and medial, the latter was performed if necessary. A feature of the approaches after TCJ injuries is the presence of post-traumatic scars, which can be quite large in area, different in localization, and depends on the nature of the injury, methods of treatment and closure of soft tissue defects. In our study, lateral access to the TCJ was not possible in 2 injured patients (10 % of cases), so the main one was medial, due to significant cicatricial changes of the lateral surface of the TCJ. Resection of the lateral bone was mandatory, which could later be used for plastic surgery of bone defects; in 2 patients it was not performed due to damage to this bone. Next, sparing resection of the articular ends of the TCJ of the tibia and talus was performed in such a plane that it was possible to set the foot at 90° to the axis of the lower leg and in a neutral position of the posterior part of the foot to the supporting surface.

We mostly used intramedullary locking rod (ILR) for fixation (18 out of 21 cases), due to existing bone defects in the wound area, complex disintegration of anatomical structures (not only the TCJ, but also the entire posterior part of the foot) with significant changes in the subtalar joint. In 6 patients (29 % of cases), a significant defect of the tibia or talus in the TCJ area was diagnosed, but bone defect replacement was used in 4 (19 % of cases). In 2 with existing defects, stability of fixation was achieved by using intramedullary rod fixation without bone autoplasty.

In 2 patients, screws were installed for fixation of the TCJ (without fixing the subtalar joint), since the patients had a rapid development of post-traumatic osteoarthritis of the TCJ after injury, but there were no avascular changes in either the talus or degenerative changes in the subtalar joint. In 1 person, a rod EFD on Ilizarov-type ring supports was used for fixation due to the manifestation of clinical signs of infection during hospitalization and preparation for surgical intervention. EFD fixation was in the stabilization version without further correction of fragments, since the plane of resection of the articular surfaces provided for the installation of the foot at an angle of 90° to the tibia with tight contact of the surfaces. In the case of ILR fixation, dosed loading of the limb was started 4–5 weeks after dynamization of the fixator, in the case of screws — after 8 weeks, and in the case of EFD — after 12 weeks, when signs of union were noted. The presence of a defect and bone autoplasty during surgery did not affect the timing of the start of dosed loading with ILR fixation.

Most patients had the consequences of mine-explosive trauma with shrapnel wounds (Table 1), which is a result of modern wars with the use of explosive shells. In our study, there were no consequences of bullet wounds, but this is more of an exception than a rule, since bullet wounds of the talocrural joint usually occur on the battlefield [3].

Severe injuries of the TCJ were observed in METs that occurred in the event of a car explosion without the penetration of fragments, as well as during injury by a “petal” type mine. It should be noted that the latter variant of injury did not lead to amputation of the lower limb if the servicemen used footwear with the appropriate class of protection against such mines.

Fig. 1. Radiographic images and clinical presentation of patient G. exhibiting the sequelae of shrapnel injury to the TCJ and the posterior part of the foot

Among the features of gunshot wounds are injury to soft tissues, tendons, vessels and nerves, primary contamination of wounds with microorganisms, which requires appropriate tactics with staged surgical interventions. In our study, the number of previous operations ranged from 1 to 8, on average (4.7 ± 2.6). All of them were aimed at bone stabilization, infection prevention, staged necrotectomies and secondary closure of the tissue defect. Accordingly, the time from injury to reconstructive intervention took on average (10.8 ± 6.9) months (from 1 to 30 months). During reconstruction, 11 out of 21 patients (52 %) had an equinus foot position, which did not allow full loading of the limb and sufficient assessment of the possibility of its single-bearing loading.

We obtained good anatomical and functional results, taking into account the indicators of the AOFAS scales (segment for TCJ and HF) and SMFA, as well as the data of the EQ-5D-5L quality of life questionnaire (Table 2 and 3), with a significant increase in function 6 months after the start of limb loading after surgery.

Infectious complications in the postoperative period were observed in 2 patients (9.5%). In one case, after drainage of the pathological focus and targeted antibiotic therapy, the infectious process was stopped, the wound healed with secondary tension. In another patient, after 6 months of observation and union at the site of TCJ resection, the metal fixator was removed, and the infectious process was transferred to the remission stage (Fig. 2).

Table 1

Distribution of patients by nature of injury, type of TCJ injury according to the Gustilo-Anderson classification, number of previous surgical interventions, and history of clinical infection

No.	Type of injury	G-A	Time to arthrodesis of the TCJ, months	Number of previous interventions	History of clinical infection
1	MET (fragments)	II	9	6	—
2	MET (fragments)	II	10	3	—
3	MET (fragments)	III-A	9	5	—
4	MET (fragments)	II	13	1	—
5	MET (mine)	III-A	30	1	—
6	MET (fragments)	II	4	7	—
7	MET (fragments)	II	8	3	—
8	MET (fragments)	II	10	5	—
9	MET (fragments)	II	5	4	—
10	MET (fragments)	III-A	9	8	yes
11	MET (fragments)	II	11	8	—
12	MET (mine)	III-A	2	7	—
13	MET (mine)	—	1	4	—
14	MET (fragments)	II	12	5	—
15	MET (fragments)	III-A	24	7	—
16	MET (car bomb)	—	10	1	—
17	MET (fragments)	III-A	8	8	yes
18	MET (fragments)	III-A	10	7	—
19	MET (car bomb)	II	21	1	—
20	MET (fragments)	II	11	6	—
21	MET (fragments)	III-A	8	5	yes

Table 2

Average lower limb function scores according to the AOFAS and SMFA scales before and after surgical treatment with comparison of the difference in means

Scale	Before intervention (n = 21)	After intervention (n = 21)	p (at α = 0,05)
AOFAS	24.6 ± 16.3	79.8 ± 10.5	$p < 0.001$
SMFA	126.5 ± 19.4	46.7 ± 14.5	$p < 0.001$

Clinical example

A 36-year-old patient G., military serviceman. In the anti-terroristic operation zone (2015) as a result of an MET (stepped on an anti-personnel mine with his left foot), the left foot was amputated and open comminuted fractures of the right TCJ (Gustilo-Anderson IIIA) bones and toes of the foot occurred. Staged treatment, final amputation of the left lower limb at the level of the proximal third of the tibia, successful prosthetic repair. Open injuries of the right lower limb were healed, the fusion of the right TCJ fracture did not occur, due to the use of the leg, a varus deformity was formed, and deforming arthrosis significantly progressed. Full loading of the limb is impossible. He was hospitalized and examined in the clinic of the State Institution "National Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine". Resection arthrodesis of the TCJ with intramedullary fixation with a blocked retrograde tibial rod in a dynamic blocking variant was performed. The postoperative period was uneventful, after 1.5 months the patient began to bear weight in the "Chobit" orthosis, after another month — without restrictions. Examination after 6 months: walks without additional support, full weight-bearing on the right lower limb (Fig. 3).

Discussion

Intra-articular gunshot fractures of the TCJ are characterized by pronounced post-traumatic changes, which are accompanied by the development of osteoarthritis and require reconstructive interventions aimed at immobilizing the joint with the foot in a functionally advantageous position [9, 13]. This improves the function of the limb, despite the lack of complete recovery.

In our study, an unsatisfactory result was obtained in 1 case, according to AOFAS, but according to the SMFA and EQ-5D-5L quality of life scales, asignificant increase in patient self-care indicators was noted 6 months after the start of loading the limb, while the patient's function recovery is still ongoing. Therefore, we also used patient-oriented scales in the assessment of results. If we consider only the AOFAS scale, then the number of good, positive and negative results in our study coincides with the observations of recent years by foreign specialists [9, 13].

We excluded from the analysis patients requiring high lower limb amputation (HLA) based on the sum of the signs and the absence of prospects for reconstructive and restorative treatment. Despite the possible reluctance of the patient and doctors to perform HLA, the results of reconstructive interventions in

Table 3

Average values of EQ-5D-5L before and after surgical treatment with comparison of the difference in means

EQ-5D-5L	Before intervention (n = 21)	After intervention (n = 21)	p (at α = 0,05)
Mobility	3.9 ± 0.8	2.1 ± 0.5	p < 0.001
Self-care	2.9 ± 1.1	1.5 ± 0.6	p < 0.001
Routine activity	3.8 ± 0.9	2.2 ± 0.6	p < 0.001
Pain	3.8 ± 0.9	2.1 ± 0.6	p < 0.001
Anxiety/depression	2.6 ± 0.9	1.4 ± 0.5	p < 0.001
VAS	53.4 ± 14.8	81 ± 6.0	p < 0.001

Fig. 2. Radiographic images and clinical presentation of patient G. exhibiting the condition after reconstructive and restorative treatment and removal of the metal fixator

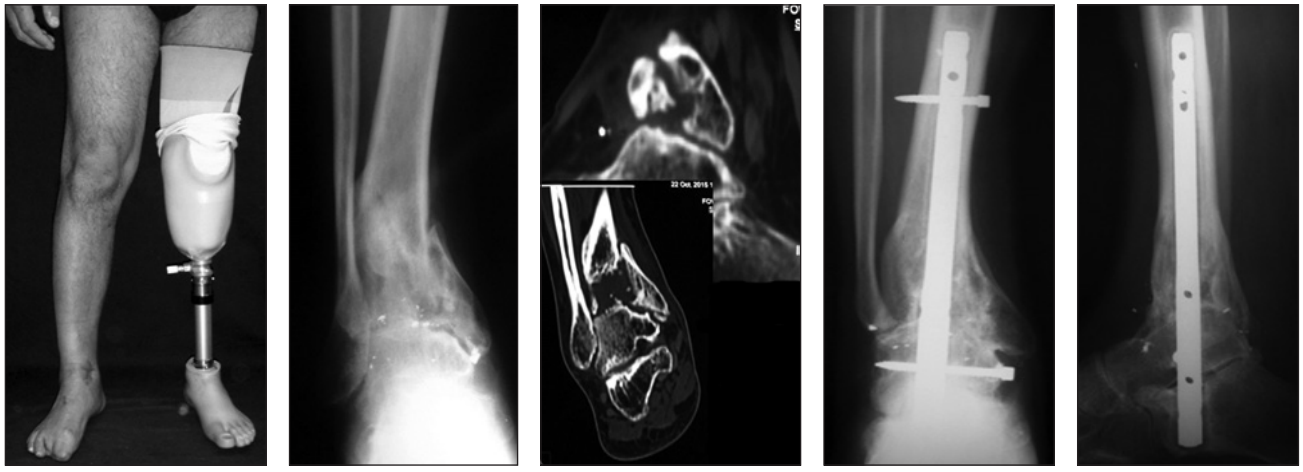

Fig. 3. Radiographic images, computer scans and clinical presentation of patient G. before and after reconstructive and restorative treatment on the right lower limb

such cases, even in the case of achieving wound healing and bone consolidation, do not provide a significant increase in limb function, which is confirmed by relevant studies [10, 14, 15].

Depending on the type of TCJ injury, the main ones are mine-explosive (fragmentation, direct contact with mines and in the case of a car explosion) and bullet wounds. The former are more common in the case of combat operations in open and rural areas [3], which may explain the absence of consequences of bullet wounds in our study.

An additional problem in patients is the development of equinus foot posture, which makes it impossible to load the entire surface after injury. Prevention of the development of such posture at the stages of treatment in several cases allows avoiding orthopedic surgical interventions, since the destruction of cartilage from injury can spontaneously lead to ankylosing of the joint. If the limb is fixed after removal of the EFD in an orthosis or plaster cast, the desired angle of 90° can be obtained to achieve resistance of the limb and avoid further surgical interventions.

During the treatment of patients with the consequences of gunshot wounds to the area of the TCJ, we applied a differential approach to choosing a fixation method, which was aimed at achieving resistance with maximum preservation of limb function. This approach is similar to the approach to treating the consequences of traumatic injuries to the TCJ [11].

For the treatment of post-traumatic changes in the joints that developed because of gunshot wounds, many authors consider it advisable to use only EFD of various modifications [6, 9, 10, 13]. Despite the contamination of tissues with microorganisms during the wound, the use of internal fixation is possible, it does not cause more complications, compared to other methods [16, 17]. The use of ILR in cases of existing bone defects in these patients provides reliable fixation and allows for early rehabilitation and loading of the limb. This is especially important considering the time from the moment of injury to the performance of TCJ arthrodesis (Table 1), since the prolonged absence of loading of the limb negatively affects the restoration of its functionality. Postoperative complications with internal fixation in our study were in 2 cases, while removal of the fixator was performed in one wounded patient, which did not affect the overall result, since bone union was achieved.

Such complications and their number do not go beyond the known data during the treatment of patients with consequences of open fractures using various fixation methods [12], therefore, we believe that ILR is not contraindicated and can be used in patients with consequences of gunshot wounds with fixation of the TCJ. Bek et al. [9], who used EFD for fixation of the TCJ, indicate the presence of previous operations in patients with consequences of gunshot wounds of the hindfoot, which preceded the arthrodesis of the TCJ. These interventions were aimed at arthrodesis of the joints adjacent to the TCJ, damaged during the injury. In our study, the use of ILR allowed us to solve the issue of simultaneous stabilization of the TCJ and the subtalar joint in cases where there was damage to both the talus and calcaneus, which was 2/3 of the cases of gunshot wound consequences, which makes the use of ILR even more appropriate in patients with the consequences of gunshot wounds of the TCJ.

In cases without avascular changes in the talus or severe degenerative changes in the subtalar joint, it is absolutely reasonable to block only the TCJ (fixation with screws or a combination of screws and a plate). It is important to maintain maximum mobility of the posterior part of the foot, and the mobility of the subtalar and transverse metatarsal joints provide 30 % of the amplitude of movements of the ankle joint, allowing to preserve a significant share of human motor activity.

In the presence of clinical signs of infection, we used the TCJ area for fixation of the EFD on Ilizarov-type ring supports. Undoubtedly, EFD is an acceptable option in case of existing infectious processes in the surgical area.

At the same time, the possible choice of types of EFD is quite wide and allows to perform a number of tasks during the treatment of patients with similar issues. In our observation, we waited for the signs of bone union before starting the load in this patient due to pronounced osteoporotic changes in the bones of the foot and fears of the development of osteolysis around the rods, but the use of EFD gives an opportunity to start early load on the operated limb [18], which is relevant during the treatment of this category of patients, as mentioned above.

Conclusions

The final stage of treatment of the consequences of severe gunshot wounds of the TCJ area with the prospect of restoring the function of the limb is the arthrodesis of this joint. Severe disintegration of its anatomy, as well as the subtalar joint, in combination with existing bone defects, makes the option of fixation using ILR a priority during surgical intervention. Rapid rehabilitation of these patients is very important, since the treatment period after injury is extended in time and negatively affects the restoration of the function of the injured limb. At the same time, a differential approach should be applied to fix the TCJ in such patients to achieve the maximum possible functional result.

Conflict of interest. The authors declare the absence of a conflict of interest.

Prospects for further research. In-depth study of the long-term consequences of injuries and the results of treatment of these patients.

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Authors' contribution. Lyabakh A. P. — idea and concept of the study, evaluation of the study results, formulation of conclusions; Pyatkovsky V. M. — structure and drafting, formulation of research methods; Turchyn O. A. — summary of the study results, statistical processing of the results; Omelchenko T. M. — evaluation of the results and discussion of the study results; Evlantyeva T. A. — literature search, preparation of literary sources; Kharchyk V. S. — patient selection, medical documentation processing, data summarization in Excel table.

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ANKLE ARTHRODESIS AFTER COMBAT RELATED INJURIES

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