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Saving of Foot Support Ability in Post-traumatic Defects Using Microsurgical Tissue Autotransplantation

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BACKGROUND Severe open injuries of the lower extremities in most cases are the result of high-energy trauma, because the foot and ankle are damaged as a result of automobile accidents almost in every fourth victim. According to the literature, the percentage of infectious complications after surgical debridement of open injuries of the foot is 43–67.9% and shows no tendency to decrease.

MATERIAL AND METHODS We performed 32 operations with the use of free revascularized grafts in patients aged from 16 to 70 years with extensive post-traumatic defects of the foot between 2010 and 2018.

RESULTS As a result, 30 (93.7%) out of 32 grafts provided foot support ability provided during the post-operative period. When replacing large defects (more than 80 cm2) of soft tissues supporting surface of the foot we used free musculocutaneous flap of the latissimus dorsi, fasciocutaneous flaps were used for defects of the dorsum of the foot (less than 80 cm2). Long-term results were assessed using the Foot and ankle ability Measure (FAAM) questionnaire.

CONCLUSION Primary early replacement of tissue defects on the foot with free revascularized autografts is the method of choice for solving this problem, as it allows you to maintain the supporting function of the foot and is often alternative method to amputation.

Keywords: soft tissue defects, free revascularized flaps, reconstructive microsurgery, open fractures of the foot bones

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CT – computed tomography
USE – ultrasound examination
BMB – the broadest muscle of the back
FAAM – Foot and Ankle Ability Measure, questionnaire of functional capabilities of the foot and ankle joint

RELEVANCE

The problem of treating extensive post-traumatic defects of the soft tissues of the foot has not lost its importance so far. Severe open injuries of the lower extremities are in most cases the result of high-energy trauma; for example, the foot and ankle joint are injured as a result of car accidents in almost every fourth victim [1–4].

The high risk of developing infectious complications in such injuries is due to the peculiarities of the anatomical and physiological characteristics of the foot, which include a small array of soft tissues, many bone and articular formations that are in close contact with each other, mainly reduced regional blood flow, the presence of the most pathogenic infectious agents [5]. According to the literature, the proportion of infectious complications after surgical treatment of open injuries of the foot is 43–67.9% and does not show a tendency to decrease [6–9].

A number of authors associate the development of complications with open fractures of the foot bones with an increase in post-traumatic edema, the occurrence of tense hematomas and the inability to actively drain the infected postoperative wound, which entails ischemia of soft tissues with the subsequent appearance of necrotic changes [7, 10–12].

Post-traumatic complications lead to the formation of extensive wound surfaces in various parts of the foot and ankle joint. Exposure of functional structures on the foot (tendons, bone tissue, neurovascular bundles) requires their closure as early as possible. The need for daily dressings, the inability to wear shoes, dysfunction of the injured lower limb force the victims to change their profession, and sometimes lead to disability – according to some authors, this happens in 67% of cases after severe injuries [13]. The use of traditional methods of treatment (local plastic, cross-plastic, autodermoplasty, etc.) of extensive post-traumatic leg and foot defects does not always allow achieving the desired anatomical, functional and expert labor outcomes. In addition, such reconstructions are often multi-stage and time-consuming. [4, 14–18].

All this determines the urgency of the problem and requires the development of new methods of treating this pathology.

Purpose of work: to evaluate the possibilities of treating patients with extensive post-traumatic defects of the soft tissues of the foot using reconstructive microsurgical operations for the transplantation of blood-supplied tissue complexes (flaps).

MATERIAL AND METHODS

In the Department of Emergency Plastic and Reconstructive Surgery of the N.V. Sklifosovsky Research Institute for Emergency Medicine, for the period from 2010 to 2018, 24 patients with extensive post-traumatic foot defects were treated. The age of the victims varied from 16 to 70 years, of the total number of victims there were 3 women (12.5%), the rest were men (87.5%). There were 23 victims of working age (95%) (mean age 42.4 ± 5.3 years). All patients were admitted to the hospital on the first day after the injury, 7 victims (30%) had a concomitant injuries. The area of integumentary tissue defects averaged 107 cm2 (range from 70 to 118 cm2). In 9 patients (37.5%), open fractures of the bones of various parts of the foot were observed. By localization of defects on the foot: dorsum – 12.5%, plantar surface – 65.6%, combined damage – 21.8%.

According to the influence of external factors in the event of an injury, defects of the soft tissues of the foot in the victims were distributed as follows: a car accident – 65.6%, a fall from a height – 9.3%, a burn or frostbite – 6.2%, other reasons – 18.7%.

Plastic material for closing defects on the foot was selected according to the following parameters: area and depth of the defect, localization of the defect, degree of microbial contamination, age of the victim, presence of concomitant pathology. Patient examination methods included performing radiographs in two projections, computed tomography (CT) and ultrasound (ultrasound) examination of the vessels of the donor and recipient bed, thermal imaging diagnostics (Fig. 1). The task of CT included the final verification of the diagnosis and assessment of the volume of the bone defect in various parts of the foot. The possibility of microsurgical transplantation of tissue complexes was assessed using ultrasonic triplex angioscanning of the arterial and venous vessels of the leg and foot.

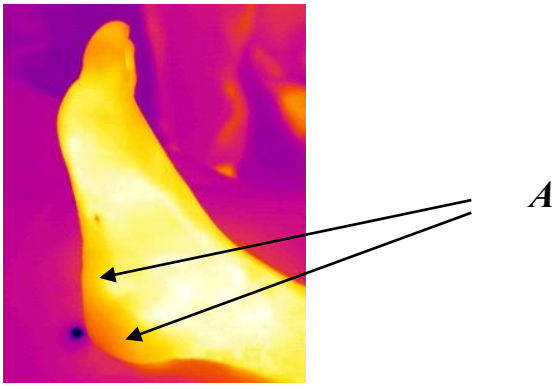


Fig. 1. Thermal imaging for evaluation of plantar blood supply. A. Zone of soft tissue necrosis in the area of the calcaneus

Depending on the localization of defects on the foot, the following types of flaps were used: serratus anterior muscle – 5, fascial skin radial flap - 4, latissimus dorsi muscle flap – 17, fascial skin flap of the scapular region – 4, skin-bone complex with a fragment of the iliac crest – 2.

Musculocutaneous BMB flap was used mainly for extensive and deep defects (more than 80 cm2), mainly on the supporting surface of the foot, with presentation of functional structures in the wound (vessels, tendons, nerves, bones) and, as a rule, with the presence of infectious markers. When filling defects of tissue smaller in size and depth (from 50 to 80 cm2), which were located on the dorsal and non-supporting surfaces of the foot, we used skin-fascial radial and scapular flaps, as well as a flap of the serratus anterior muscle. Для сложной реконструкции, когда в процесс были вовлечены (помимо мышечной и сухожильной) еще и костная ткань, применяли кожно-костный комплекс с фрагментом гребня подвздошной кости.

When choosing flaps, the somatic state of the patient and the local status of the wound defect were taken into account. The general condition of the patient, age, presence of concomitant diseases, professional activity were assessed by somatic criteria. At the initial closure of the soft tissue defect, which was performed within 5 days, the first stage was performed by surgical debridement and one-stage autotransplantation of flaps. With a delayed – within 5-12 days, dressings were performed, the condition of the wound edges, the absence or presence of purulent discharge were taken into account. If tendons were presented in the wound, colloidal dressings (hydrogel, protosan, etc.) were used to maintain it in a humid environment. In order to cleanse the wound and prepare for surgical treatment, staged necrectomies were performed with intraoperative or postoperative application of the VAC system (vacuum therapy). After the appearance of a clear demarcation zone and the formation of granulation tissue (provided that there was no purulent discharge), autologous flap transplantation was performed.

All operations were performed within 3 to 14 days from the moment of admission of the victims to the hospital (in the primary-delayed order). In total, there were 24 inpatients who underwent 32 operations to replace soft tissue defects with free revascularized flaps. Long-term results were assessed using the Foot and Ankle Ability Measure (FAAM) questionnaire – a questionnaire for assessing a wide range of orthopedic diseases of the feet and lower limb function. The questionnaire consists of two separate modules: daily physical activity (21 questions) and a sports module (8 questions). The time interval is 1 week. Each question has 5 options for assessing the parameter and the "no answer" column (the patient cannot answer the question). The total score is calculated by adding the scores, calculating the proportion to the maximum possible total score, taking into account the number of answers in the "no answer" column. The final value of each module ranges from 0 to 100 points, where the maximum score corresponds to the best function.

RESULTS AND DISCUSSION

Complete engraftment was observed in 28 cases (87.5%). Some of the patients underwent 2–3 free flap grafts due to the large defect zone (Table).

Table

Results of free composite foot flaps transplantation

Flap type	Number of grafts	Implant survival rate	Necrosis
Thoracodorsal	17 (53.1%)	15	2
Scapular	4 (12.5%)	3	1
Serratus anterior muscle	5 (15.6%)	4	1
Fasciocutaneous flap Radial flap	4 (12.5%)	4	0
Osteocutaneous complex with a fragment of the iliac crest	2 (6.3%)	2	0
Total	32 (100%)	28 (87.5%)	4 (12.5%)

When the soft tissue defect of the foot was closed with a BMB flap, engraftment was observed in 15 out of 17 cases, which amounted to 76.4%. Of 4 scapular flaps, complete engraftment was noted in 3 patients (75%). The serratus anterior muscle was used for closing the defect in 5 cases, of which successful engraftment was observed in 4 patients (80%). When using a skin-fascial radial flap in 4 cases and a skin-bone complex with a fragment of the iliac crest in 2 cases, complete engraftment of the flaps was obtained. In 16 patients (66.6%) out of 24 excellent indicators were noted (complete wound healing through primary tension), in 5 (20.8%) – good indicators (marginal necrosis of the dermis up to 0.5 cm) followed by wound healing through secondary tension , in 3 (12.5%) – satisfactory: there was partial necrosis of the flap (up to 25% of the surface) without disturbance of axial blood flow, which was subsequently closed with the appearance of granulation tissue using autodermoplasty. Out of 24 patients who underwent free grafting of flaps, 5 (20.8%) were reoperated: on the 1st day – 2 patients (8.3%), on the 2nd – 2 (8.3%) patients and on 3rd day – one patient (4.2%). The reasons for repeated urgent surgical interventions were: in 3 cases (12.5%) circulatory decompensation in the flap due to arterial

thrombosis, in the remaining two cases (8.3%) – venous thrombosis. In the 1st case, the hematoma was removed, in the 2nd – vein reanastomosis due to their thrombosis. In 2 cases out of 32 (6.3%), there was total flap necrosis due to arterial (3.15%) and venous (3.15%) thrombosis. In the postoperative period, all patients were prescribed strict bed rest for 5 days, the obligatory elevated position of the lower limbs on the Beler splint or by the installation of an external fixation device. In order to prevent microanastomoses thrombosis, all patients, starting from the intraoperative period, were prescribed rheopolyglucin in a dose of 400 ml intravenously, as well as trental 10 ml per 200 ml of saline once a day. In the postoperative period, simultaneously with the intravenous administration of rheopolyglucin and antiplatelet agents, which lasted for 5-6 days, oral administration of trental 400 (1 tablet 3 times a day), curantil (1 tablet 3 times a day) and aspirin at a dose of 250–300 mg once a day was also prescribed.

The average length of hospital stay was 23 ± 2 bed-days.

As a result, 30 out of 32 transplanted flaps (93.7%) provided support for the foot in the postoperative period.

Clinical observation № 1

Patient D., 17 years old, was admitted to the Department of Traumatology of the Institute named after N.V. Sklifosovsky after a motorcycle injury with a diagnosis of "Extensive bruised-scalped wound of the right calcaneal region." Upon admission, the patient underwent primary surgical debridement of the right foot wound (Fig. 2).

A B

Fig. 2. A 17-year-old male patient D. with a diagnosis: Extensive contused degloving wound of the right calcaneal region (A). Day 7 after the primary surgical treatment of the wound of the right calcaneal region (B)

On the 7th day, the patient developed necrosis of the plantar and heel region of the right foot with exposure of the underlying functional structures (Fig. 2A). After necrectomy, the area of the soft tissue defect along the plantar surface was 10.0x7.0 cm (Fig. 2B). On an urgent-delayed basis, an operation was performed to replace the defect with a free revascularized musculocutaneous BMB graft (Fig. 3).

A B C

Fig. 3. A 17-year-old male patient D. with a diagnosis: Extensive contused degloving wound of the right calcaneal region. Intraoperative images (A) and after surgery (B, C). Day 1 after replacement of the soft tissue defect in the right calcaneal region with free revascularized flap of the latissimus dorsi muscle.

Smooth postoperative period. The wounds healed by primary intention. The revascularized BMB autograft on the right foot is completely valid. The patient was discharged from the hospital on the 30th day after admission. Subsequently, the patient was followed up for the last 5 years. Satisfactory long-term results were obtained. The patient was socially and physically adapted according to the FAAM questionnaire scale, the mean score was 76.7. The support ability of the right foot is fully restored (Fig. 4).

A

B

Fig. 4. A 17-year-old male patient D. after replacement of the soft tissue defect in the right calcaneal region with a free revascularized flap of the latissimus dorsi muscle. Long-term results 5 years after surgery

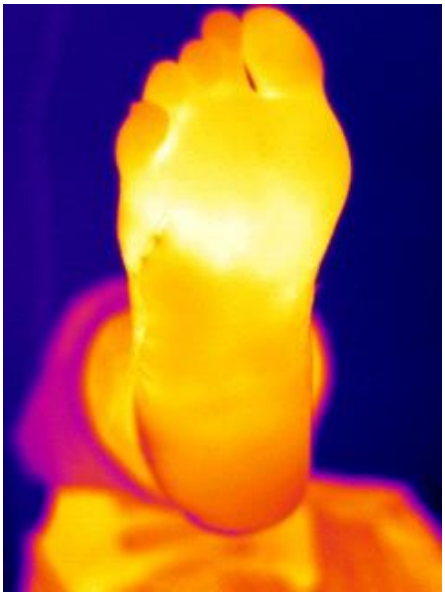
Thus, this observation shows that the early replacement of the soft tissue defect on the foot with free revascularized flaps allows you to preserve the main function of the foot — supportability and movement in space without additional means of support

Clinical observation № 2

Patient S., 45 years old, was admitted to the N.V. Sklifosovsky Research Institute for Emergency Medicine on the 12th day after falling from a height of 2 meters to the area of the right foot. In the hospital at the place of residence, the patient underwent primary surgical debridement of the wound of the right foot and was diagnosed with "Extensive lacerated and contused wound of the right foot with detachment of soft tissues. Soft tissue necrosis of the plantar surface". However, the postoperative period was complicated by the formation of necrosis along the plantar surface of the right foot measuring 15.0x7.0 cm (Fig. 5).

A

B



C

Fig. 5. A 45-year-old male patient C. Diagnosis: Extensive tear-contused wound of the right foot with soft tissues detachment. Plantar soft tissue necrosis. Pictures of the right foot upon admission (A), (B). Thermal imaging of the right foot in the evaluation of plantar blood supply. Zone of soft tissue necrosis of the plantar surface (C)

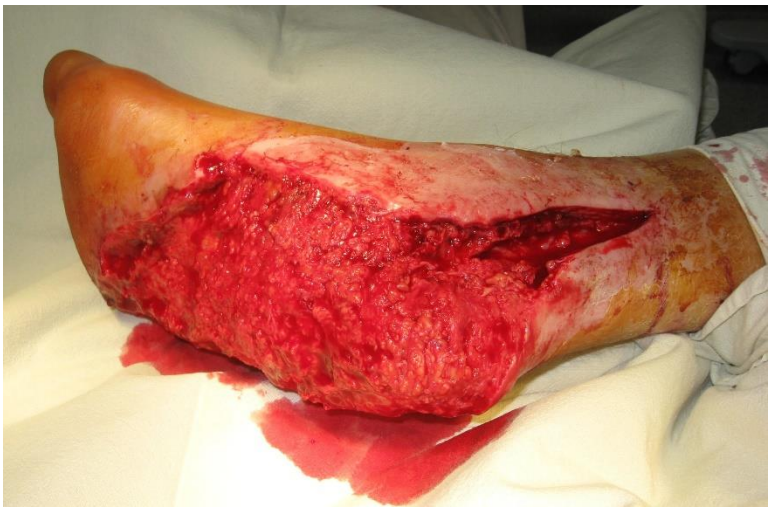


Fig. 6. A 45-year-old male patient C. Diagnosis: Extensive tear-contused wound of the right foot with soft tissues detachment. Plantar soft tissue necrosis. View of the wound after excision of the necrotic areas of the plantar soft tissues of the right foot

On a delayed basis, the patient underwent necrectomy, closure of the soft tissue defect on the right foot with a free revascularized scapular autograft, dermatomal autodermaplasty of the non-supporting surface of the right foot from the right thigh (Fig. 7).

A B

Fig. 7. A 45-year-old male patient C. Diagnosis: Extensive tear-contused wound of the right foot with plantar soft tissues detachment (A). View of the wound on day 6 after the closure of the soft tissue defect of the plantar surface of the right foot with a free revascularized fascial and scapular autograft. View of the right foot in the evaluation of plantar blood supply on day 6 after the operation (B)

The postoperative period was uneventful. All wounds healed by primary intention. Wound healing on the right thigh without inflammation. The fascial skin graft on the right foot is fully functional. The patient was discharged from the hospital on the 14th day after admission. Subsequently, the patient was followed up for the last 2 years. Good long-term results have been obtained. The patient is socially and physically adjusted according to the FAAM questionnaire scale, the mean score is 71.3. The support ability of the right foot is sufficiently restored.

CONCLUSION

Primary early replacement of soft tissue defects on the foot with free revascularized autografts is the method of choice for solving this problem, since it allows preserving the support function of the foot and is often an alternative to amputation. Replacement of defects on the foot in the early stages prevents the development of purulent complications, thereby ensuring the minimum treatment time and successful functional rehabilitation of the patient. With extensive and deep defects, mainly on the supporting surface of the foot (more than 80 cm2), with presentation of functional structures in the wound, the closure of the latter with a musculocutaneous flap of the latissimus dorsi is shown. When replenishing defects on the dorsal and non-supporting surfaces of the foot, smaller in size and depth (from 50 to 80 cm2), the use of a skin-fascial radial and scapular flap, as well as a flap of the serratus anterior muscle is shown. For complex reconstruction (with the involvement of bone in addition to the muscle and tendon areas), it is possible to use a skin-bone complex with a fragment of the iliac crest. Primary plastic surgery using microsurgical tissue autotransplantation methods in the early stages allows for the most reliable, fast and complete recovery of the foot after severe injuries.

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