Case report
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Long-Term Treatment Outcome of a Patient with Extensive Circular Soft Tissue Defect of the Distal Third of the Lower Extremity: A Case Report

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Abstract

Background. Open fractures of the lower limb bones associated with extensive soft tissue defects are among the most challenging in trauma surgery.

Aim of the study is to demonstrate the possibilities of modern reconstructive surgery in the treatment of severe polystructural trauma of the lower limb using a unique clinical example.

Case description. An 18-year-old patient sustained a polytrauma which included head and extremities injuries as a result of a fall under a moving train. Due to the signs of uncompensated ischemia of the left lower limb at the first stage of treatment the patient underwent emergency left tibial artery thrombectomy, repeated debridement of the left lower leg wound, remounting of the external fixator, and lumbar sympathectomy. The second stage of surgical treatment included free transplantation of a vascularized anterolateral flap of the right thigh. The third stage included staged necrectomies; replacement of the soft tissue defect of the posteromedial surface of the distal lower leg with a sural fasciocutaneous vascularized flap on the distal vascular pedicle from the contralateral tibia; the fourth stage included cutting off the fasciocutaneous cross flap. At the follow-up, 2 years after the end of the treatment the patient complained of persisting swelling of the foot, which occurred during prolonged standing in the upright position and required elastic compression of the ankle joint. The cause of the swelling was impaired lymphatic outflow due to the damage to all venous collaterals in the injury area. She walks with full load on the injured limb without additional support. There is no pain syndrome, foot sensitivity is fully preserved.

Conclusion. Presented clinical case demonstrates the possibility of successful replacement of an extensive circular defect of the distal lower limb using sequentially free and non-free vascularized tissue complexes.

Keywords: extensive soft tissue defect, free vascularized anterolateral thigh flap, flap necrosis, non-free sural flap, microsurgical transplantation of tissue complexes.

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Клинический случай
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Отдаленный результат лечения пациента с обширным циркулярным дефектом мягких тканей нижней трети голени: клинический случай

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Реферат

Актуальность. Пострадавшие с открытыми переломами костей голени, сопровождающимися обширными дефектами мягких тканей, относятся к одной из самых сложных категорий пациентов в травматологии.

Цель — на уникальном клиническом примере показать возможности современной реконструктивной хирургии при лечении тяжелой полиструктурной травмы нижней конечности.

Описание случая. Пациент 18 лет получил сочетанную травму головы и конечностей в результате падения под движущийся поезд. В связи с наличием признаков некомпенсированной ишемии левой нижней конечности на первом этапе лечения пострадавшему в экстренном порядке были выполнены тромбэктомия из левой большеберцовой артерии, повторная хирургическая обработка раны левой голени, перемонтаж стержневого аппарата, поясничная симпатэктомия. Второй этап хирургического лечения включал свободную пересадку кровоснабжаемого переднелатерального лоскута правого бедра. На третьем этапе – этапные некрэктомии; замещение дефекта мягких тканей заднемедиальной поверхности нижней трети голени несвободным суральным кожно-фасциальным кровоснабжаемым лоскутом на дистальной сосудистой ножке с контралатеральной голени; четвертый этап включал отсечение перекрестного кожно-фасциального лоскута. При контрольном осмотре через 2 года после окончания лечения пациент предъявлял жалобы на сохранение отечности стопы, возникающей при длительном нахождении в вертикальном положении и требующей эластической компрессии голеностопного сустава. Причиной отечности являлось нарушение лимфатического оттока в связи с повреждением в области травмы всех венозных коллатералей. Ходит с полной нагрузкой на травмированную конечность без дополнительных средств опоры. Болевой синдром отсутствует, чувствительность стопы полностью сохранена.

Заключение. Представленное клиническое наблюдение демонстрирует возможность успешного замещения обширного циркулярного дефекта нижней трети голени с использованием последовательно свободного и несвободного кровоснабжаемых комплексов тканей.

Ключевые слова: обширный дефект мягких тканей, свободный кровоснабжаемый переднелатеральный лоскут бедра, некроз лоскута, несвободный суральный лоскут голени, микрохирургическая пересадка комплексов тканей.

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BACKGROUND

Patients with open fractures of the lower leg bones associated with extensive soft tissue defects rightfully belong to one of the most difficult categories of patients in traumatology and reconstructive surgery of the limbs [1]. The most frequent cause of such injuries are high-energy traumas that occur in everyday life as a result of road and railway accidents, and in wartime as a consequence of mine blast and gunshots. Extensive damage to tissues, significant contamination of wounds, vascular and nerve damage are high-risk factors for delayed fracture healing and development of infectious complications [2]. To save the limb, it is necessary to evacuate the patient as soon as possible to a specialized medical care center, to cooperate the work of specialists in the field of traumatology and orthopedics, vascular, plastic, septic and neurosurgery. At the same time, the problems of surgical wound treatment and its stages, preparation of the wound surface for plastic closure, choice of tissue complexes are priorities in the struggle for limb salvage. It should be noted that knowledge of the entire arsenal of reconstructive surgery methods, including the use of microsurgical techniques, allows to successfully restore the integrity of damaged tissues even in conditions of wound infection [3].

This clinical case illustrates the result of a complex treatment of a patient with severe trauma of the lower third of the leg resulting from a collision with a wagon wheel bogie.

Aim of the study is to demonstrate the possibilities of modern reconstructive surgery in the treatment of a patient with severe polystructural trauma of the lower limb.

CLINICAL CASE DESCRIPTION

An 18-year-old patient sustained a polytrauma of head and limbs as a result of falling under a moving train. He was taken to a district hospital, where he was diagnosed with craniocerebral injury, concussion, closed fracture of the body of the left clavicle without displacement of fragments, severe mechanical trauma to the left lower limb with open dislocation of the left foot, comminuted fracture of the left medial malleolus, extensive degloving wound of the anteromedial surface of the left tibia, circular skin detachment of the lower third of the leg (4% of the body area), damage to the anterior and posterior tibial arteries, tibial and peroneal nerves, uncompensated ischemia of the left leg (Fig. 1).

After physical examination the patient underwent wound debridement of the left lower limb. External fixation was performed on the day of admission.

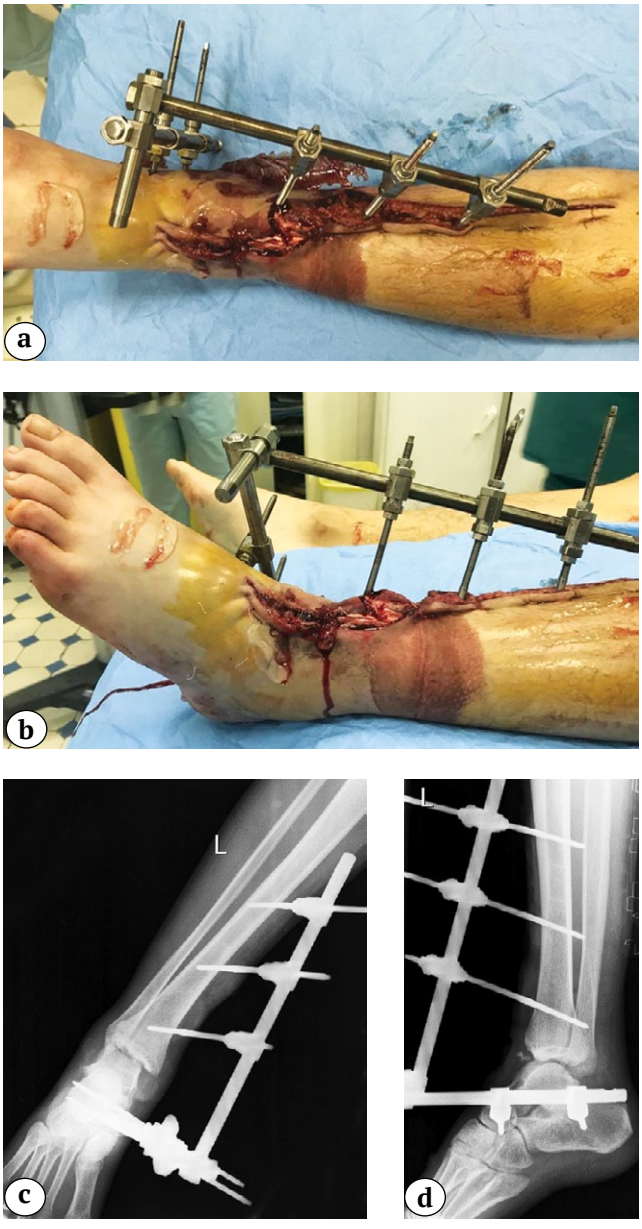

Fig. 1. Patient's left lower limb fixed with an external fixator:
a, b — general view;
c, d — X-ray images of the left lower limb and foot in two views

The next day the patient was transferred to the Clinic of Military Traumatology and Orthopedics for further treatment. The general condition on admission was assessed as severe and corresponded to 24 points according to the MS-COA scale, 9 points — MS-D (MT), 4 — AIS, 8 — MESS [4, 5, 6]. The diagnosis was made: polytrauma of the head, limbs (02.03.2020). Craniocerebral trauma; cerebral concussion; severe mechanical trauma of the left lower limb — open dislocation of the left foot, comminuted fracture of the left medial malleolus, fixed with a KST external fixator. Extensive wound of the anteromedial surface of the left tibia, circular skin detachment of the lower third of the leg (4% of the body area). Interruption of the anterior tibial artery with a 10 cm defect. Thrombosis of the posterior tibial artery. Rupture of the deep branch of the peroneal nerve throughout. Contusion of the tibial nerve. Mosaic necrosis of the anterior and posterior muscle groups of the left leg. Uncompensated ischemia of the left lower limb. Moderate acute blood loss.

Due to the signs of uncompensated ischemia of the left lower limb, the patient underwent emergency thrombectomy of the left tibial artery; repeated debridement of the leg wound, remount of external fixator, and lumbar sympathectomy (Fig. 2).

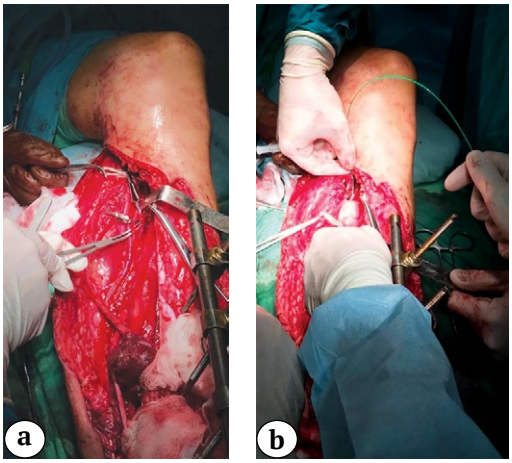

Fig. 2. Stages of posterior tibial artery thrombectomy:
a — isolation of the posterior tibial artery;
b — insertion of the Fogarty catheter into the posterior tibial artery

A stable blood flow was achieved in the left tibial artery system with restoration of blood supply to the distal parts of the left lower limb. In the following 2 weeks, the patient received complex therapy aimed at restoring homeostasis and preventing infectious complications. Local treatment included changing aseptic dressings, necrectomy with subsequent negative pressure wound therapy (NPWT). Later, the 400 cm^2 soft tissue defect of the lower third of the leg with exposure of the underlying tendon and neurovascular structures developed. In this regard, a free transplantation of a vascularized anterolateral flap of the right thigh was planned (Fig. 3). In the preoperative period, the patient underwent ultrasound Doppler examination of the anterolateral surface of the right thigh to clarify the localization of the perforating vessels, which are branches of the descending branch of the lateral femoral circumflex artery (*a. circumflexa femoris lateralis*).

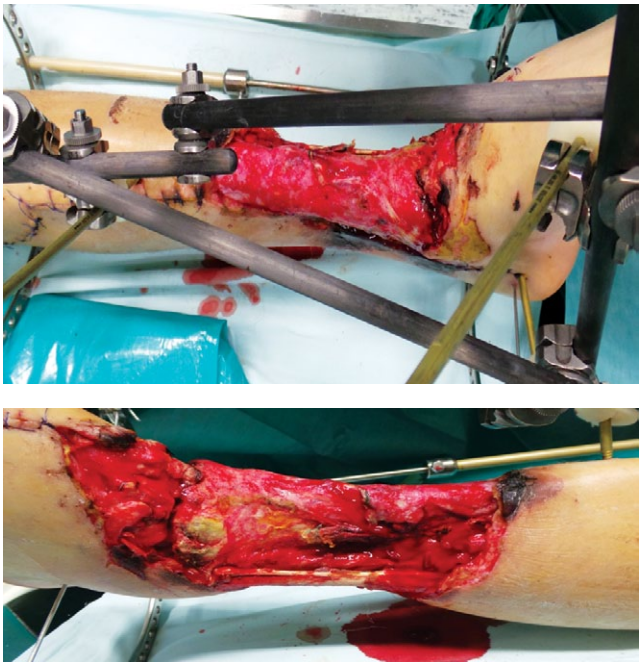

Fig. 3. The wound after staged necrectomies

Initially, after excision of the scar wound edges, the anterior tibial artery and the great saphenous vein were isolated in order to anastomose with the flap vessels, then a free vascularized anterolateral femoral flap was formed on the

right thigh and transplanted to the defect area (Fig. 4). The end-to-end suture of the flap vessels with the pre-selected vessels of the tibia was performed. The total anoxia time of the flap was 95 min. Osteosynthesis of the lower leg bones was performed with hybrid external fixator bridging the ankle joint. In the postoperative period, vasoactive and antibacterial therapy, a course of hyperbaric oxygenation were administered.

However, within 18 days after the surgery, partial (40%) flap necrosis gradually developed due to the venous insufficiency (Fig. 5). As a result of stage debridement, the necrotized part of the flap was excised, and the inner and posterior surfaces of the ankle joint were deprived of skin cover.

Due to the exposure of the posterior tibial artery and tibial nerve, as well as the tendons of the inner and posterior surfaces of the ankle joint, it was decided to replace the soft tissue defect of the posterior medial surface of the lower third of the leg with a non-free sural skin-fascia vascularized flap on the distal vascular pedicle from the contralateral leg.

The flap was started to be formed in the upper third of the lower leg from the separation of the axial vessels along the calf nerve. The flap width at this level was the maximum and made 12 cm. Following subfascially in the distal direction, the graft separation was continued up to the place of the exit of the vessels supplying the tissue complex from the intercostal membrane — 6 cm above the medial malleolus. The length of the flap was 22 cm. The formed sural skin-fascia flap was able to replace up to 80% of the soft tissue defect. The rest of the wound with a granulating base as well as the donor area were closed with a split skin autograft from the outer surface of the left thigh. The lower limbs were externally fixed using the KSVP external fixator, which also protects the transplanted flap from external compression (Fig. 6).

In the postoperative period, uncomplicated complete engraftment of the transplanted flap and split skin autograft was achieved. Three weeks later, the flap pedicle was cut off under local anesthesia, the Ex-Fix was removed, and the legs were separated (Fig. 7).

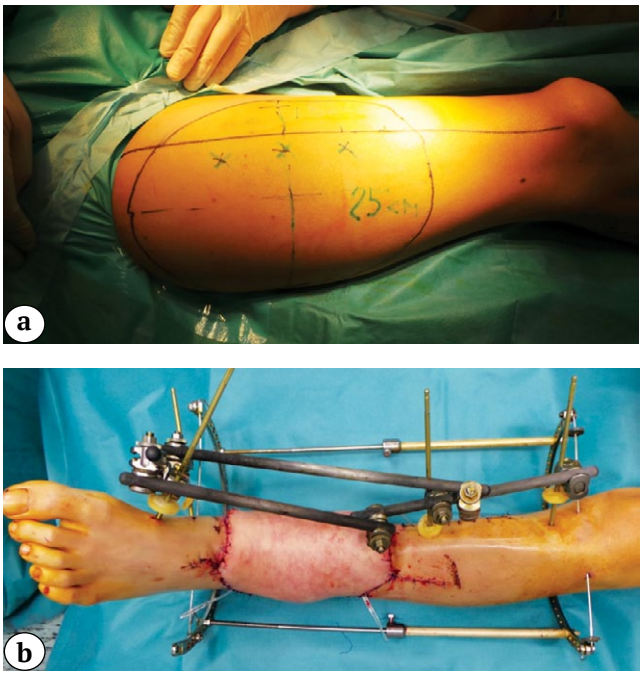

Fig. 4. Marking of the anterolateral flap on the right thigh (a); view of the left lower limb on the 1st day after the transplantation of the vascularized tissue complex in the device (b)

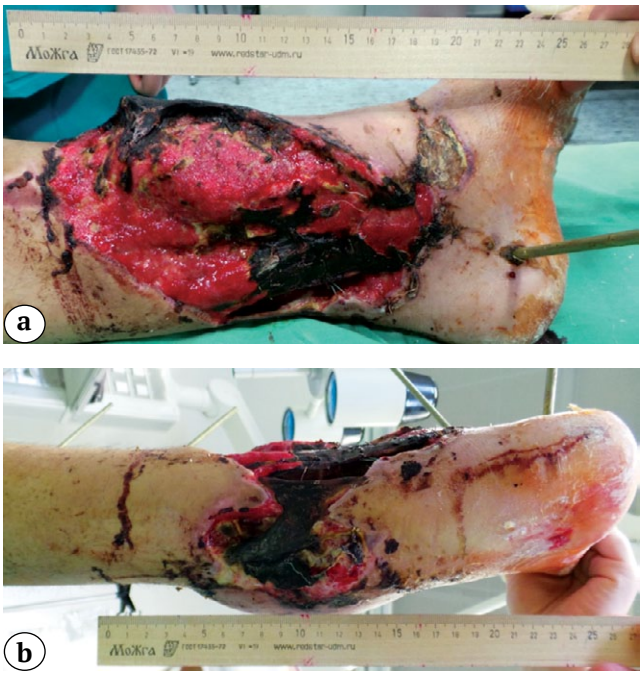

Fig. 5. Left lower limb from the inside (a) and from the back (b) of the left tibia (b) with a partially necrotized transplanted anterolateral flap

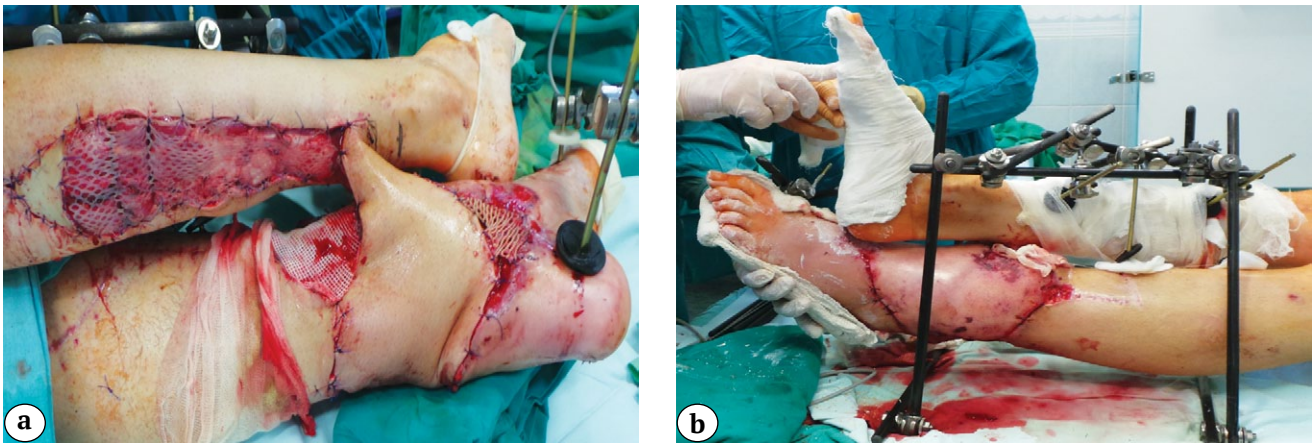

Fig. 6. Lower limb view after transposition of a vascularized sural flap from a healthy limb (a); fixation of both lower limbs in a frame-type external fixator in suspension (b)

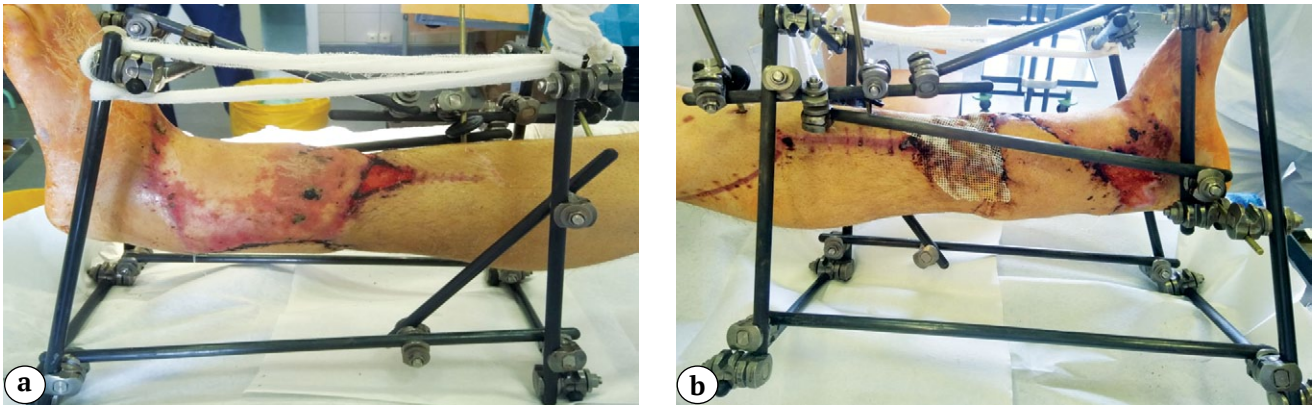

Fig. 7. View of the lower limb and foot after cutting off the pedicle of the sural flap:
a — external surface; b — internal surface

After immobilization was discontinued, the patient started walking on crutches with partial weight bearing on the operated limb. Within 4 weeks, the patient started full weight bearing, which allowed him to completely stop using additional means of support.

At the follow-up examination 2 years after the end of the treatment, the patient complained of persisting swelling of the foot, which occurs when standing upright for a long time and requires elastic compression of the ankle joint. The swelling was caused by impaired lymphatic outflow due to the damage to all venous collaterals in the area of the injury. He walks with full weight bearing on the injured limb without *any* additional means of support (Fig. 8). Pain syndrome is absent, sensitivity of the foot is fully preserved.

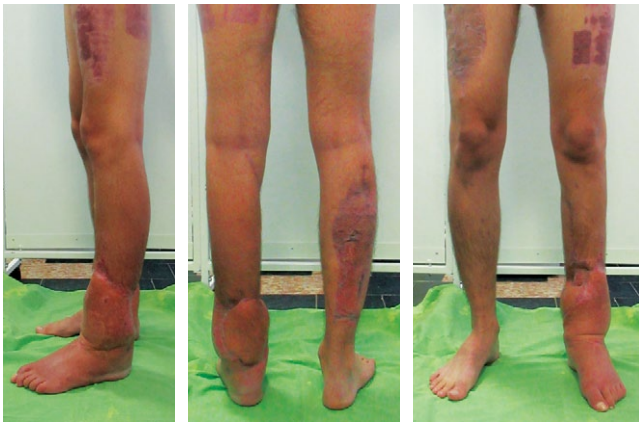

Fig. 8. View of the operated lower limbs 2 years after the surgery

DISCUSSION

Traumatic injuries of the lower limb with extensive soft tissue defects are the result of a high-energy external impact. Due to contamination of the wound surface, as well as the damage to the main vessels, septic inflammation and decompensation of blood supply to the distal parts of the limb become the main causes leading to limb amputation [7, 8, 9]. Before the Industrial Revolution, lower limb injuries were predominantly sustained on the battlefield [10, 11]. The high mortality rate due to infection made primary amputation the standard of care in the management of such injuries [11, 12].

Invention and introduction of penicillin into clinical practice in the 1940s allowed to successfully control wound infection. These developments opened a new era and demonstrated the prospect of the possibility of limb salvage [12]. As a result, amputation was no longer mandatory, shifting the surgical goal to limb preservation. Development of plastic tissue replacement techniques during the 20th century, and in particular, introduction of microsurgical transplants of tissue complexes made limb saving a realistic and pragmatic option for the most complex cases. It should be noted, however, that lower limb defect replacement surgeries, especially on the lower leg bones, despite the progress made in the more than a 50-year history of microsurgery, are still technically the most challenging ones [13].

According to the literature, the probability of uncomplicated engraftment of transplanted free tissue complexes remains lower than in other defect localizations [14]. Thus, according to different authors, reconstructive operations on the lower leg had a favorable outcome in only 80% of patients, while after free flap transplantation in other defect localizations the success was achieved in more than 95% of patients [15, 16]. It is noteworthy that patients with polytrauma are in a state of hypercoagulability, which also worsens the conditions for successful microsurgical reconstruction. Partial or complete necrosis of the transplanted tissue complex, in turn, may lead to the need for limb amputation [17, 18]. Such treatment outcome leads, on the one hand, to a decrease in the patient's quality of life and, on the other hand, to significant health care costs for further treatment, including the need for limb prosthetics [19]. Thus, partial or complete necrosis of the transplanted flap requires the search for alternative reconstructive approaches. However, there are still few publications on the treatment strategy after failed limb reconstruction [20, 21].

The list of surgical strategies to solve this problem includes the use of the second free flap as well as less complex solutions such as local flaps, NPWT, dermatome grafts or amputation. According to G.G. Hallock, reuse of a vascularized tissue complex ends up developing necrosis 8-10% more often than after the primary surgery, with venous thrombosis being the most common cause of failure [22].

Partial necrosis of the free flap we transplanted was most likely also the result of venous outflow insufficiency from the graft. Accordingly, repeated transplantation of the tissue complex with anastomoses to the posterior tibial vessels was associated with an increased risk of the steal syndrome or thrombosis of the recipient vascular bundle. In both cases, this could cause decompensation of the blood supply to the foot and its necrosis. In case of partial flap loss, some authors suggest considering the use of a split skin graft as an option with a high overall probability of success [23]. In our clinical case, the presence of exposed vessels, nerve and tendons excluded the possibility of using both dermatome graft and NPWT.

Several authors consider skin grafting with local tissues to be a reliable alternative to free flap. One of the most frequently used non-free tissue complexes for replacing defects of the distal parts of the lower limb is a sural skin-fascia flap on the distal pedicle, first described by P. Donski and I. Fogdestam in 1983 [24]. Later, in 1992, A. Masquelet et al. performed a topographic and anatomical justification of the use of the sural flap on the distal vascular pedicle [25]. The generally recognized advantages of this tissue complex are the technical simplicity of its isolation, a long pedicle, a wide rotation arch, minimal damage to the donor area, preservation of the main arteries, and the possibility of

including a large part of the posterior surface of the lower leg in the skin-fascia flap. The combination of these features makes it the flap of choice for replacing extensive defects of the lower leg or foot when transplantation of free tissue complexes is impossible [26]. However, in our case, the presence of a primary circular defect of the lower third of the leg excluded its formation on the same limb. At the same time, there was an option of a non-free flap transplantation from the contralateral healthy limb. The first mention about the use of a cross flap dates to 1854, when the American surgeon F.H. Hamilton used it for the first time to treat a persisting wound of the lower leg [27]. Later this method of reconstructive surgery was successfully applied to replace defects of the distal parts of the lower limbs, especially in the treatment of the injured during World War II. In 1952, R.B. Stark summarized previously obtained treatment results and reported the advantages of this type of plastic surgery in lower limb reconstruction [28]. The implementation of microsurgery in the 1970s significantly narrowed the indications for a cross-dermal grafting. In most cases, they are caused either by general factors (age, diabetes, long history of heavy tobacco smoking, etc.) or local factors (obstructive disease or damage to the main vessels, radiation therapy of the limb, etc.) [29].

In our case report, the use of a cross-sural skin-fascia flap on the distal pedicle with a damage to a part of the main great vessels and an extensive soft tissue defect allowed to restore the skin and preserve the limb of a young patient.

CONCLUSIONS

This clinical case demonstrates the possibility of successful replacement of an extensive circular defect of the lower third of the leg using sequentially free and non-free vascularized tissue complexes. The use of a cross non-free sural skin-fascia flap to close the defect that appeared after partial necrosis of the previously transplanted vascularized anterolateral thigh flap allowed to completely restore the skin of the lower third of the leg. The main advantages of this variant of grafting are the relative technical simplicity of the surgical intervention, short time of the operation. The main disadvantage is the necessity to observe strict bed rest with forced position of the legs during 3 weeks before the flap cutting. Thus, the main indication for its application is the failure of previously performed reconstructive surgeries on the distal parts of the lower limb.

DISCLAIMERS

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Ethics approval. Not applicable.

Consent for publication. Written consent was obtained from the patient for publication of relevant medical information and all of accompanying images within the manuscript.

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