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Treatment of a patient with a post-traumatic combined extensive defect in the lower leg tissues (case report)

Mikhail Yu. Korostelev[1], Natalia G. Shikhaleva[2]✉, Konstantin I. Novikov[2]

[1] SM-Clinik, Moscow, Russian Federation
[2] Ilizarov National Medical Research Centre for Traumatology and Orthopedics, Kurgan, Russian Federation

Corresponding author: Natalia G. Shikhaleva, nshihaleva@mail.ru

Abstract

Introduction Treatment of patients with open fractures of long bones with soft tissue defects remains one of the most difficult tasks of current traumatology. **Material and methods** We repor a clinical case of the treatment of a patient with an extensive purulent wound, a defect in the tibia, chronic damage to the anterior neurovascular bundle, tendons and muscles of the anterior and lateral groups of the lower leg, post-traumatic severe lymphedema of the right foot. The complex of the treatment process included debride-ment of the wound, orthoplastic surgery using Ilizarov transosseous osteosynthesis and elements of plastic surgery. The defect of the right tibia was managed using a non-free vascularized peroneal compound flap from the opposite tibia. **Results** The treatment of this patient resulted in the arrest of osteomyelitis, a significant reduction in foot lymphedema, restoration of weight-bearing and functional capacity of the right lower limb. This was achieved by replacing a significant defect in the tibia and soft tissues under conditions of long-term wound and scar processes and compromised main blood flow in the affected lower leg. **Discussion** The main operations for management of complex defects in the tissues of the lower leg are demonstrated. Among them, the main ones are transosseous osteosynthesis according to Ilizarov and microsurgical replacement with a vascularized complex of tissues.

Keywords: bone defect, lower leg, extensive wound of the lower leg, fibula flap, Ilizarov apparatus

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INTRODUCTION

Treatment of patients with open long bone fractures with associated soft tissue defects remains one of the most difficult tasks of contemporary traumatology [1–6].

A special problem is medical rehabilitation of patients with severe extensive damage to all tissues of the limb, complicated by associated osteomyelitis, cicatricial process, post-traumatic lymphedema.

G.A. Ilizarov wrote, "*... that in order to ensure a normal, and, consequently, rapid course of the regenerative process of bone and soft tissues, treatment should provide not only the contacts of adapted and tightly contact-ing surfaces of bone fragments, but also good conditions for the trophism of the latter. Thereby, the treatment process should spare and not disrupt the physiological functions of the affected limb and the body as a whole*" [7, 8]. At present, the method of transosseous osteosynthesis is able to effectively solve various problems of restoring the musculoskeletal system, in particular, delayed consolidation, bone defects, etc. Moreover, the combination of this method with microsurgery allows not only to solve complex problems in a comprehensive way, but also to significantly reduce the time of the treatment process.

The purpose of this work was to demonstrate a clinical case with the application of the method of simulta-neous management of a complex post-traumatic deficiency of the lower leg tissues in the conditions of an old defect and compromise of the main vessels of the affected lower leg with the creation of conditions for the resolution of post-traumatic lymphedema using the method of transosseous osteosynthesis and plastic surgery techniques.

MATERIALS AND METHODS

We present a patient U., 17 years old. He sustained a combined injury of the right lower leg while working at a fish processing plant in October 2017. The upper third of the tibia was swept by a cable, a sliding loop of the cable pulled off the skin with subcutaneous fat, degloving it to the border of the middle and lower thirds, and a loader fell on the same. A severe injury resulted in an open comminuted fracture of the bones of the right lower leg (Gustilo-Anderson type III B [9]) with a total degloving of the skin of the lower leg, a defect in the muscles of the anterior and lateral groups, and a defect in the anterior neurovascular bundle (classification of

open frac-tures AO and E Muller et al. (1990, 1996) – IO-5, MT-4, NV-4). According to J.W. May this fracture belongs to the 4th type: defect of the tibia > 6 cm with an associated injury to the fibula.

Primary surgical treatment of the wound and osteosynthesis of the lower leg with an external fixator were performed at the place of patient's residence. Subsequently, 13 operations followed, including necrectomy, plasty with split skin autografts. Within one year of treatment at the place of residence, bone union and wound healing were not achieved. The patient was admitted to the Clinic for Purulent Orthopedics of the Ilizarov Cen-ter in 2018 with an extensive purulent wound, a defect in the tibia, chronic damage to the anterior and peroneal neurovascular bundles, tendons and muscles of the anterior and lateral groups of the lower leg, post-traumatic severe lymphedema of the right foot. Upon admission, the patient walked with two crutches, without bearing weight on the right lower limb. Locally, there were circular hypotrophic scars around the entire circumference of the lower leg (from the knee joint to the fracture site) with the absence of subcutaneous fat. That area was the site of split skin autografts transplanted onto the superficial fascia (Fig. 1, 2). Distal to the border of the middle third and up to the line of the ankle joint, there was a sluggishly granulating uneven wound over 3/4 of the cir-cumference of the lower leg, sized 13×20 cm, with serous purulent scanty discharge and with a depression in the bone gap area. The size of the soft tissue defect was significantly larger than the size of the gap between the ends of the tibia. The preserved bridge of soft tissues along the posterior surface of the lower leg was "invaginated" into the space between the fragments of the tibia with a rigid skin fold without the possibility of acute unfolding. The test of the biomaterial from the wound upon admission to the clinic detected *Pseudomonas ae-ruginosa*, confluent growth, methicillin-resistant *Staphylococcus aureus* 10^5. The only objective argument in favor for the preservation of the right foot was complete sensitivity of the entire plantar surface and rocking active flexion movements of the toes.

For the purpose of diagnosis, contrast angiography of the vessels of the right lower extremity was performed. After CT with vascular contrast, 3D modeling showed that the anterior tibial artery ends in the middle third, the peroneal and posterior tibial arteries were sharply narrowed at the level of the tibial defect and tortuous (Fig. 3). The consequence of such an injury and the absence of load on the leg for a year was almost complete demineralization of the foot bones, what was also clearly visible on the CT scans. In addition, trauma and the long-term subcircular extensive wound in the fracture zone with the development of rough scars led to an almost complete blockage of the lymphatic outflow from the right foot, which sharply reduced the venous out-flow. In fact, at the time of patient's transfer to the Clinic for Reconstructive Plastic Surgery and Surgery of the Hand, the lymph outflow of the right foot ran from the wound of the lower third of the lower leg into bandages, which also aggravated the situation.

Fig. 1 Photo of the lower limbs at admission to the clinic for purulent orthopaedics

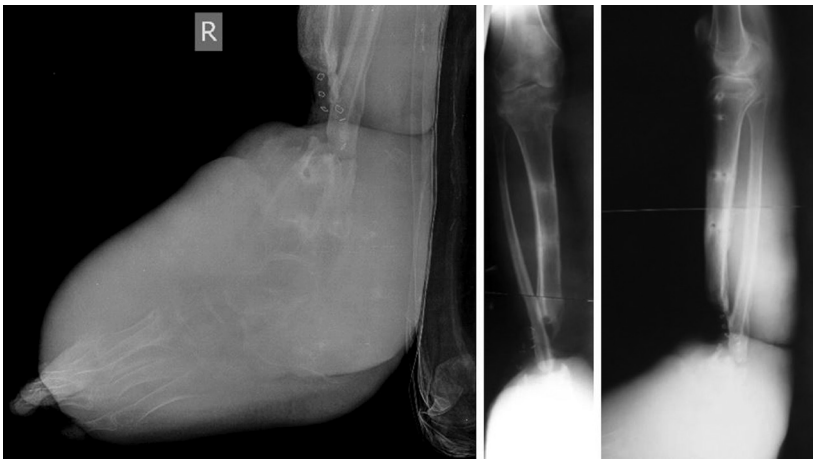

Fig. 2 Radiographs of the right lower limb at admission. There is a post-traumatic defect-diastasis of the tibia and nonunion of the fibula on the background of marked osteoporosis

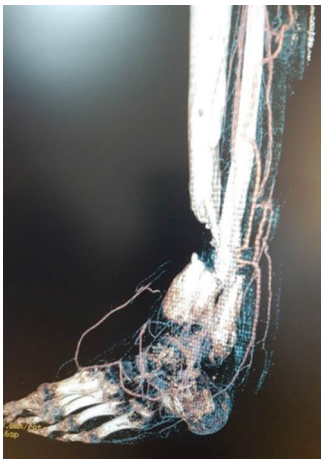

Fig. 3 CT with vessel contrast in 3D modeling of the right tibia and foot

At the first stage, osteosynthesis was performed with the Ilizarov apparatus of the right leg and foot. In the postoperative period, a dosed distraction was performed between the tibial fragments. The result of this stage was the elimination of the interposition of the lower leg soft tissues, what clinically resulted in a decrease in the severity of foot lymphedema (Fig. 4, 5). Computed tomography performed at this phase showed an increase in the lumen of the preserved main arteries of the leg and a decrease in their curvature.

A meeting was held to discuss options for surgical treatment. Diagnosis: acquired recurvation deformity of the lower third of the right tibia, pseudoarthrosis, defect-diastasis of 7 cm of the lower third of the right tibia, malunion of the fibula. Extensive deep flaccid granulating wound in the lower third of the leg. Chronic osteo-myelitis of the right lower leg and foot (remission). Chronic damage to the anterior tibial artery, peroneal nerve, extensor tendons of the foot and toes. Osteoporosis of the bones of the foot. Post-traumatic lymphedema of the right foot. Circular hypotrophic scars in the right lower leg.

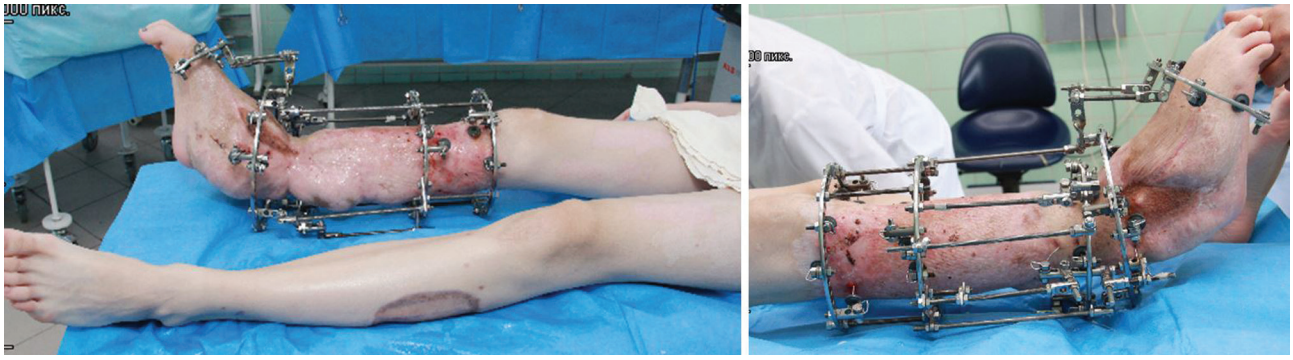

Fig. 4 Photos of the lower limbs at the stage of soft tissue interposition elimination in the right tibia

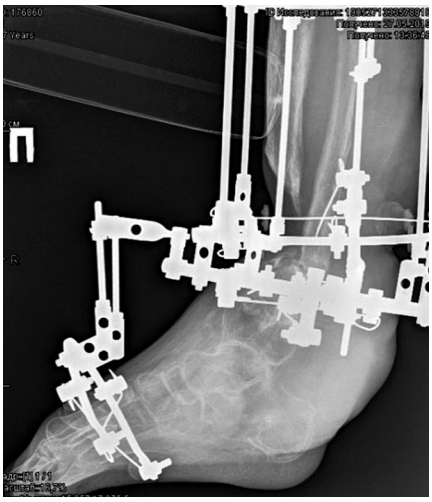

Fig. 5 Radiograph of the right foot and lower third of the tibia (lateral view) at the stage of soft-tissue interposition elimination

At the meeting, based on clinical and radiological data, it was decided that classical Ilizarov bifocal distrac-tion-compression osteosynthesis of the leg bones would be ineffective in the conditions of a large wound. Compression between the ends of the tibia would have increased the folding of the tissues of the isthmus with compression of the great vessels, which would first entail an increase in lymphedema, and then trophic disorders in the tissues of the foot. Insertion of wires through scar tissue would also provoke purulent complications. On the other hand, microsurgical technique for managing a complex tissue defect in the lower third of the leg with a precision suture of donor and recipient vessels would be also very risky due to the presence of compromised arteries located under the scar tissue. It was practically impossible to find a vein worthy of a vascular suture due to circular scars. However, a decision was made to reconstruct the young patient's right limb.

We have proposed, in our opinion, the most optimal and least risky method of treating that patient, which included the following:

• replacement of the tibial defect with a non-free vascularized peroneal composite flap from the opposite tib-ia;

• installation of fixators on both legs with a single module for the optimal position of the pedicle of the non-free fibular flap.

The operation involved two surgical teams. The first team performed harvesting of a non-free fibular flap on a healthy lower limb with the preparation of the longest vascular pedicle of 18 cm.

The second team rearranged the Ilizarov apparatus on the right leg and foot, allowing the left leg to be positioned over the right one. The same team prepared the tibia for plasty. Hypergranulations were removed from the wound, bone endplates from the ends of the tibial fragments. Osteotomy was performed through the area of the fibula nonunion. A bed was formed for a fragment of a non-free vascularized flap with a fibula. To immobilize the right tibia relative to the left tibia, the pre-assembled Ilizarov apparatuses were interconnected using hinged assemblies. A non-free vascularized flap with the fibula from the left side was placed into the defect of the right tibia (Fig. 7, 8). The bone graft was fixed with an intramedullary wire. The pedicle of the flap was wrapped with a full-thickness skin graft. Soft tissues were adapted to each other. All wounds were sutured. Drains and aseptic bandages were applied.

In the postoperative period, no trophic disorders were found in the transferred flap. All wounds healed by primary intention. After a 7-week fixation period for both lower extremities, the pedicle of the flap was transected, and the apparatus was dismantled from the left lower extremity. The patient began an active lifestyle.

The patient was verticalized four days after the last operation, he began to walk with the help of two crutches. Gradually, over the course of three months, the patient reached full weightr-bearing on the right lower limb.

Fig. 6 Photo of the lower limbs showing preoperative mark for cuts in the left limb

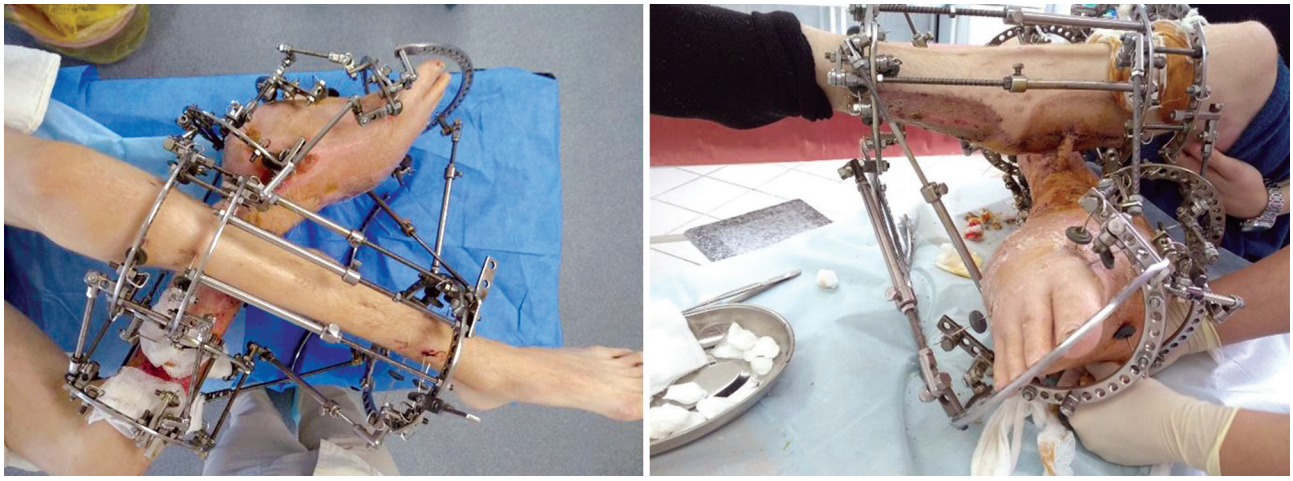

Fig. 7 Photos of the lower limbs showing fixation of both tibiae following the plasty with a non-free fibular flap

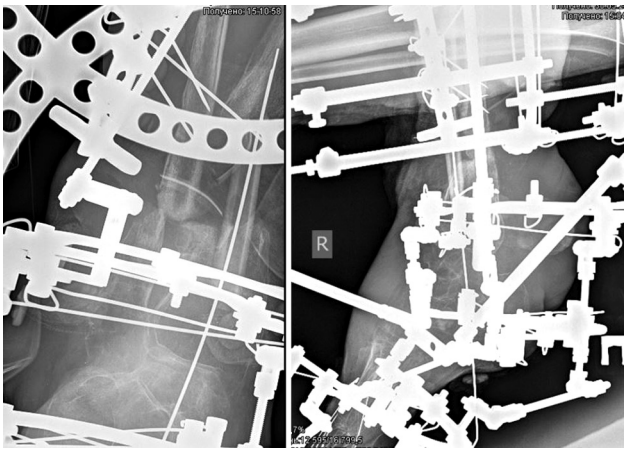

Fig. 8 Radiographs of the lower limbs showing fixation of both tibiae following the plasty with a non-free fibular flap

X-ray control showed not only the processes of consolidation of tibial bone fragments, but also a gradual de-crease in the phenomena of local osteoporosis of the bones of the right foot. Throughout the period of fixation of the right leg, we noted a gradual decrease in foot lymphedema.

The apparatus was dismantled after 6 months of fixation. Then the patient underwent a course of rehabilita-tion at the place of residence.

One year after the removal of the apparatus, the right femur was lengthened by 5 cm to restore the length of the right lower limb,. At present, the patient walks independently, without additional support, limping slightly.

RESULTS

The treatment of this patient resulted (Fig. 9, 10) in arrest of osteomyelitis, a significant decrease in foot lymphedema, restoration of weight-bearing and function of the right lower limb, which was achieved by filling a significant defect in the tibia and soft tissues in conditions of long-term wound and scars and compromised main blood flow of the affected lower leg.

The proposed set of measures, including elements of reconstructive plastic surgery, traumatology and ortho-pedics, allowed us to avoid amputation of the foot, which would have entailed a constant problem of choosing prostheses and, possibly, of phantom pains. The patient wears wide shoes, is engaged in amateur boxing, drives a car, works, and got married.

Fig 9 Radiographs of the lower limbs at a 3-year follow-up

Fig. 10 Photo of the lower limbs at a 3-year follow-up

DISCUSSION

There is a known method of replacing the tissues of the lower limb using an Italian flap with a loose type of blood supply from the opposite leg. This method involves the flap, which includes the skin and subcutaneous fat, is cut out according to the size of the existing defect on the posterior and/or lateral surfaces of the lower leg. After the flap is harvested, it is fixed on a feeding pedicle on the recipient wound. After 30-40 days, the flap is cut off [10, 11].

This method in our case could not solve the problem of bone tissue defect, and therefore, in the future, the patient would need additional surgery.

В середине XX века выдающимся отечествен-ным травматологом-ортопедом Г.А. Илизаровым пред-ложен метод билокального комбинированного компрессионно-дистракционного остеосинтеза для за-мещения дефектов диафиза костей (рис. 11), заклю-чающийся в формировании дистракционного реге-нерата при перемещении остеотомированного фрагмен-та одного из отломков через зону дефекта [12–20].

In the middle of the 20th century, the outstanding domestic orthopedic surgeon G.A. Ilizarov proposed a method of bilocal combined compression-distraction

osteosynthesis for defects in the bone diaphysis (Fig. 11), which consists in the formation of a distraction regenerate when an osteotomized fragment of one of the frag-ments is moved through the defect zone [12–20].

In 2006, a doctoral dissertation entitled "Method of transosseous osteosynthesis in the system of complex treatment of patients with severe open injuries of the lower extremities" was defended by its author I.I. Martel at the Russian Ilizarov Research Center for Restorative Traumatology and Orthopedics. He presented the methods for the managing associated soft tissue defects on the thigh and lower leg [19].

If a patient has an open fracture of the tibia or femur, accompanied by a wound predominantly located trans-versely relative to the axis of the segment, with a semicircular deficit of soft tissues, it is possible to perform transosseous osteosynthesis of the damaged segment with the creation of an angular deformity of the limb segment in order to reduce the edges of the wound. Upon wound healing, gradual elimination of the deformity is performed until the segment axis is normalized.

In cases where a temporary change in the length, axis, and shape of the segment failed to eliminate the wound defect, the method of dosed soft tissue elongation was used (Fig. 12).

The application of such an approach in our clinical case was highly questionable. The size of the soft tissue defect was significantly larger than the diastasis between the ends of the tibia. Performing compression would exacerbate the severity of the lymphedema. On the other hand, if the patient had circular scars on the lower leg with no subcutaneous fat, these scars would be cut through with pins in the course of distraction and inflamma-tion of the soft tissues would develop.

A more effective method of treating the patient is the following method. There is a well-known and widely used method of one-stage replacement of a complex defect in the tissues of the lower leg with a free peroneal flap from the opposite lower leg [22–24]. The method includes harvesting a free peroneal flap on a healthy limb and using microsurgical techniques for suturing donor and recipient vessels on the affected limb.

Our patient had a severe injury to the anterior tibial, compromised posterior tibial and peroneal vascular bundles of the leg. Microsurgical vascular sutures are possible only with the use of plasty of arteries and veins, which is risky. It is also risky to connect donor vessels to the preserved vascular bundle. Thus in case of failure, necrosis of not only the transplanted tissue complex may develop, but also trophic disorders on the foot.

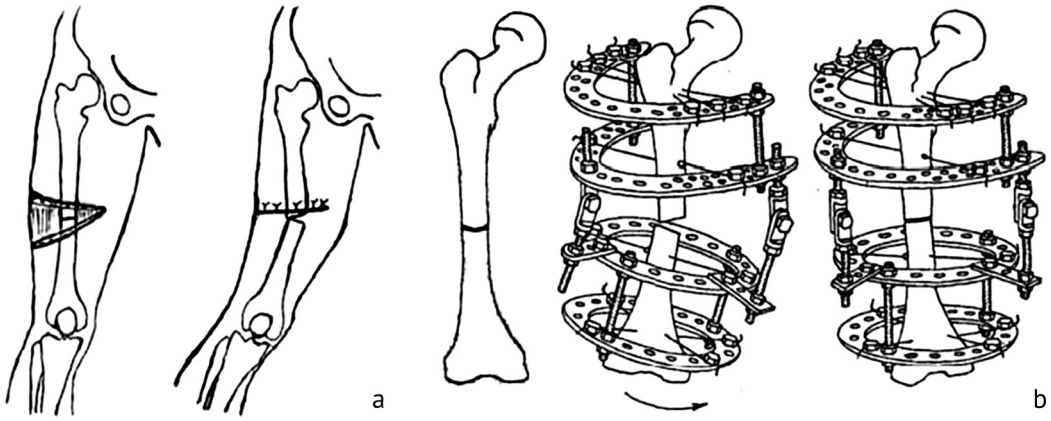

Fig. 11 Sequence of the transosseous osteosynthesis option: *a* view of the segment before and after the creation of its deformity; *b* assemblies after the creation of the angular deformity and after the completion of axis correction

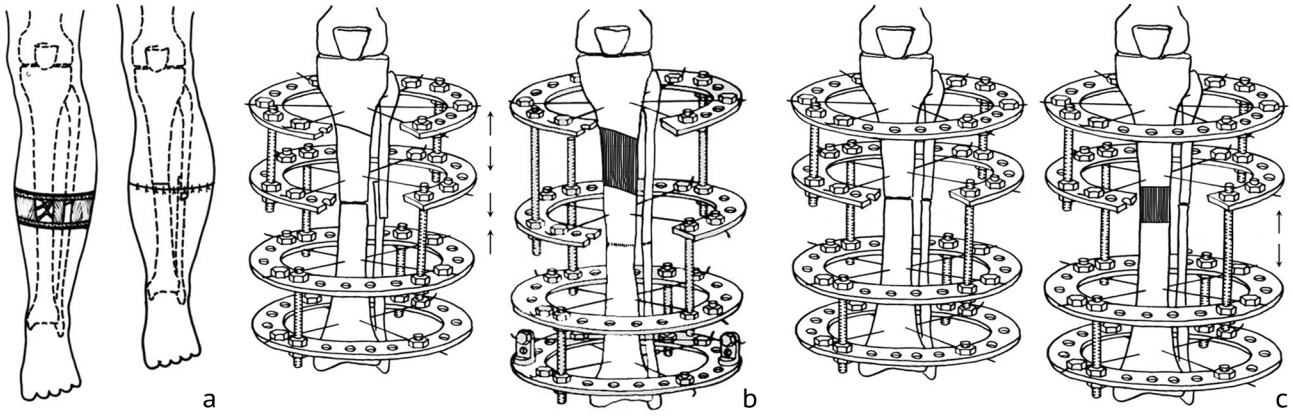

Fig. 12 Diagram of performing successive stages of transosseous osteosynthesis in case of circular injuries of soft tissues: *a* view of the lower leg before and after surgical debridement of an open fracture; *b, c* apparatus design after compression at the junction of tibial fragments and after completion of tibial lengthening

CONCLUSION

This clinical case shows the use of a non-free fibula flap with an included fibula fragment from the opposite tibia. Fixation of both legs in the postoperative period was performed using the Ilizarov apparatus, which performed the function of stabilizing not only the bone fragments of the right leg, but also provided optimal condi-tions for the preservation of the pedicle of the non-free flap. Under the conditions of fixation with the Ilizarov apparatus, there was no tension, compression or torsion of the leg. The apparatus enabled to perform visual con-trol of soft tissues, and it was also possible to conduct instrumental studies of blood flow in transplanted tissues.

Microsurgical suture of recipient vessels with donor vessels was not required in this clinical case. It significantly reduced the risks associated with necrosis of donor tissues and trophic disorders on the foot of the affected lower limb.

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Information about the authors:

1. Mikhail Yu. Korostelev – M.D., 2351724@mail.ru, https://orcid.org/0000-0002-4963-5467;
2. Natalia G. Shikhaleva – Doctor of Medical Sciences, nshihaleva@mail.ru, https://orcid.org/0000-0003-4889-9783;
3. Konstantin I. Novikov – Doctor of Medical Sciences, kinovikov@mail.ru.

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