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Treatment of tibial wound consequences: further development of the Ilizarov technology

Alexey V. Lychagin[1], Andrey A. Gritsyuk[1]✉, Vadim S. Korytin[1,2]

[1] I.M. Sechenov First Moscow State Medical University (Sechenov University), Moscow, Russian Federation
[2] 3 Central Military Clinical Hospital named after A.A. Vishnevsky, Moscow region, Krasnogorsk, p. Novy, Russian Federation

Corresponding author: Andrey A. Gritsyuk, drgaamma@gmail.com

Abstract

Introduction Severe open injuries and wounds of the tibia refer to the topical problem of traumatology due to the difficulties in the functional restoration of the segment when there is a bone and soft tissues defect. **Material and method** The treatment of 11 patients with soft tissue and tibial defects was analyzed. At the time of reconstruction, the age of male patients ranged from 20 to 52 years (mean age 34.2 ± 3.2 years). Gunshot wounds of tibia occurred in 7 injured and tibial injury was observed in 4 cases. Segmental defects of the tibia ranged from 6 cm to 18 cm, mean 12.6 ± 4.4 cm, myocutaneous defects ranged from 20 cm^2 to 112 cm^2, mean 74.4 ± 22.4 cm^2. **Results** In seven cases, the wounds healed by primary intention, the signs of infection and marginal necrosis of the soft tissue component of the flap were observed in 4 (36.4 %) cases and were addressed conservatively (dressings and debridement), but in one case, necrosis was excised (on day 21) and autodermoplasty was performed using split skin graft. We had no problems with the transport (distraction) of bone regenerates, since the rib cage of the flaps protected the soft tissues and the vascular pedicle of the flap, despite the early start of distraction (mean period 7.3 ± 2.1 days) and the length of treatment, when averaged, was 163.2 ± 8.7 days. Support function was restored in all patients and the functional results were satisfactory. **Discussion** The combination of Ilizarov distraction osteogenesisand soft tissue reconstruction using free vascularized flap grafting makes it possible to invalidate the short-comings of both, i.e. to lighten up the bone transfer, to avoid damage to the scarred skin of the anterio-medial surface of tibia and to preserve the axial circulation of the graft. The inclusion of a rib fragment provided the required conditions for application the Ilizarov distraction method. The rib, not being a supportive bone tissue, protected the soft tissue component of the flap and its vascular pedicle from deformity and participated in the formation of callus. **Conclusions** Plastic filling in the extensive tibial defects using free vascularized myocutaneous flap with rib fragments and Ilizarov distraction osteogenesis provides favorable conditions for acute surgical intervention allowing to save the limb, restore the support ability and return the patients to work.

Keywords: tibia, wounds and injuries, soft tissues plastics, reconstructive operations

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INTRODUCTION

Severe open injuries and tibial wounds relate to the topical problems of traumatology in several ways. Initially, during treatment, it is often necessary to solve the problem of the limb salvage; later, in significant damage to the soft tissues and the tibia, the issues of damaged structures reconstruction come first in order to restore the segment with fully valuable functions. The greatest difficulties are observed in case of bone and soft tissue defect of tibia [1–5].

Restoration of soft tissue structures using free revascularized autografting techniques have been thoroughly developed to date and the microvascular plasty of complex of tissues of any size and composition has no difficulties if there is a recipient vascular bundle [6]. However, vascularized bone autografts are either not supportive (rib, edge of the scapula or ilium), or have problems with healing or donor area (fibular graft) [7].

G.A. Ilizarov method of distraction osteogenesis is a "golden standard" for limb lengthening and circular bone defect repair. However, its application is difficult if there is soft tissue defect in this area[8, 9], that again raises the question on the usefulness of the limb segment reconstruction [10, 11].

These situations are quite rare in clinical practice [12–14] and we have not found any algorithm in the scientific literature, as well as a consensus on solving this issue. We have developed and patented an effective plasty technique and this work is devoted to the analysis of the long-term (more than 10 years) follow-up of our work [15].

The purpose of the research was to study the immediate and late follow-up of the treatment of severe tibial injuries with soft tissue and bone defects using combination of the Ilizarov techniques of distraction osteogenesis with microsurgical plasty.

MATERIALS AND METHODS

We performed retrospective study approved by the ethical committee. All patients signed an informed consent. 11 patients with combined bone and skin-soft tissue defects of tibia underwent operation according to the offered technique [16]. At the time of reconstruction, male patients' age ranged from 20 to 52 years (mean age 34.2 ± 3.2 years), the mean follow-up (at the time of paper writing) was 14.5 ± 5.5 years. Gunshot wounds of tibia occurred in

7 cases and tibial injuries were observed in 4 cases. The length of the tibial bone defects (circular) ranged from 6 cm to 18 cm, mean 12.6 ± 4.4 cm, myocutaneous wounds (soft tissue defects) were projected in the area of the bone defect and their area ranged from 20 cm^2 to 112 cm^2, mean 74.4 ± 22.4 cm^2. It should be noted that all patients have already underwent treatment within 3 to 24 months (mean 6.3 ± 3.3 months) and from 3 to 12 surgical interventions.

A portion of the latissimus dorsi muscle was used as the myocunateous component of the flap in 7 (63.6 %) patients and a portion of the serratus anterior muscle was used in 4 (36.4 %) cases. The bone graft fragment consisted of fragment from the VII (18.2 %), VIII (90.9 %) or IX (45.5 %) rib and in 6 (54.5 %) cases the fragments of two ribs were used. In 9 (81.8 %) cases, the osteomyocutaneous flap was applied and in 2 (18.2 %) cases it was musculoskeletal with autodermoplasty by split graft. Distraction osteogenesis was performed using proximal monofocal corticotomy in 5 (45.5 %) patients, distal monofocal corticotomy was in 3 (27.3 %) patients and bifocal corticotomy was performed in 3 (27.3 %) patients.

Statistical analysis was performed using the Wilcoxon test for non-parametric data (p value < 0.05 was considered to be statistically significant).

Technique of surgical intervention

The surgical intervention included two stages: the first one was acute, when the soft tissue defect was filled in and the tibial osteotomy was performed (Fig. 1a–e); the second one was dynamic and involved distraction osteogenesis of the tibia (Fig. 1, f, g).

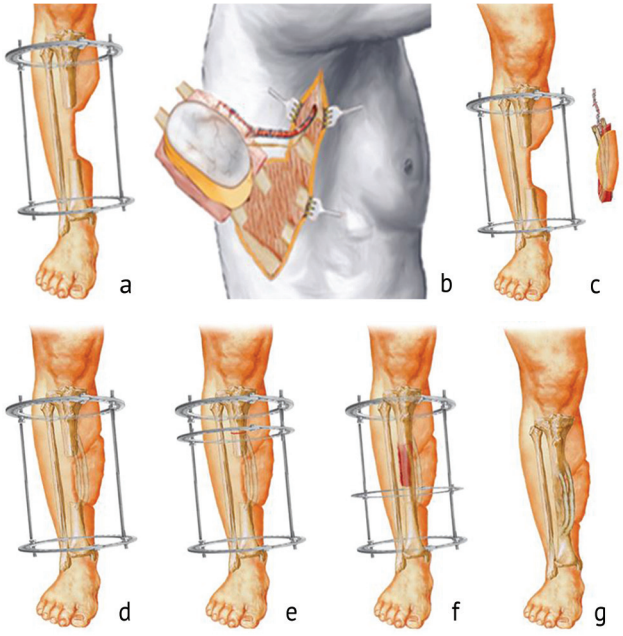

Fig. 1 Scheme of the first stage of the operation: a – tibia with combined bone and soft tissue defect was fixed with a frame; b – formation of osteomyocutaneous anterior serrated flap; c – microsurgical transfer of the flap into the recipient area. The second stage of the operation: d, e – proximal monofocal corticotomy; f – distraction osteogenesis – transport of the tibial fragment; g – removal of the external fixator after healing of rib fragments and tibia regenerate

As a clinical example, we present a wounded soldier S., 24 years old, who sustained severe combined mine-explosive wound, fragment wound to the head, chest, abdomen and limbs, gunshot fragment blunt penetrating wound of the skull and brain, fragment blunt wound of the soft tissues of the chest and abdomen, gunshot comminuted fracture of both bones of the left tibia in the mid-shaft with displacement of fragments, avulsion of the right lower limb in the lower third of the right femur and traumatic shock of 3 grade. Multi-stage treatment, primary surgical treatment of the wounds and the application of the Ilizarov fixator in the left tibia were performed (Fig. 2, a). The wound process was aggravated with osteomyelitis and after numerous repeated and secondary surgical debridement of the wounds 18 cm tibial resection in the middle third was performed (Fig. 2, b), resulting in the possibility to suture the soft tissue defect and to arrest the infection.

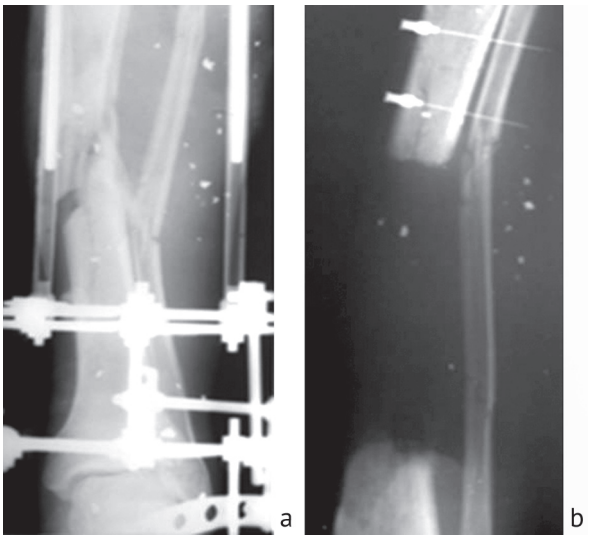

Fig. 2 The X-rays of tibia: Patient S.: a – gunshot multi-comminuted fracture of both tibial bones in the middle third, complicated by osteomyelitis; b – 18 cm defect of the tibia after resection

The patient flatly refused to undergo proposed amputation of the left tibia or its shortening, despite the absence of the opposite limb, and insisted on reconstructive treatment. In order to restore the tissues of tibia, we reassembled unstable fixator in the left tibia and produced osteotomy of the distal fragment to apply distraction osteogenesis of the tibia according to Ilizarov with distraction rate of 1 mm per day. The postoperative course was complicated by skin necrosis in the butt area of the lengthening bone, resulting in the interruption of the distraction for several times (Fig. 3), however, the scars and deficiency of soft tissues of the anterior surface of tibia made it impossible to fill in the tibial defect.

Therefore, free vascularized plasty was performed using anterior serrated flap with the VIII rib fragment in the shape of a bridge flap; the stages of the operation

are shown in Figure 4. Later, after healing of the tibial wounds (Fig. 5, a, b), distraction osteogenesis of the tibia was continued, the bone fragments were reduced by a closed way, and the fracture was healed (Fig. 5, c, d).

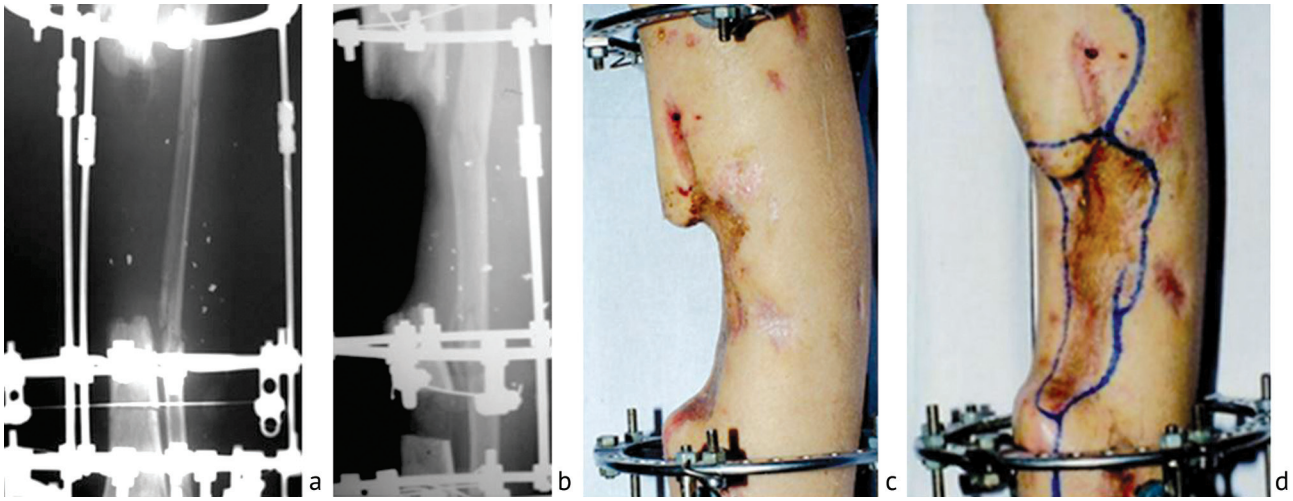

Fig. 3 Patient S.: a, b – X-rays of tibia, osteotomy and distraction of the distal fragment of the tibia were performed; c, d – view of tibia during distraction of the distal fragment of the tibial bone, skin perforation

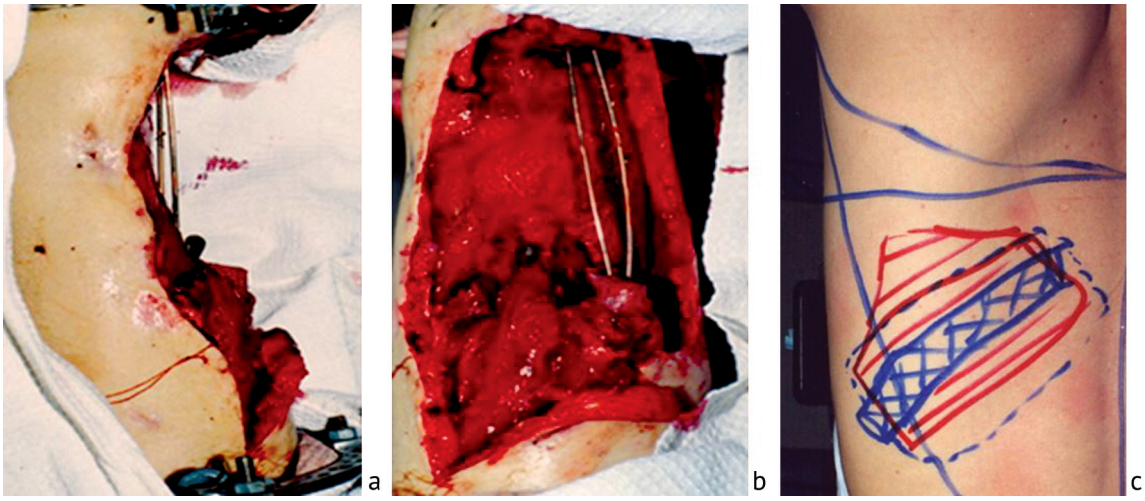

Fig. 4 Patient S. Intraoperative picture: a, b – excision of the anterior tibial scars; c – planning of the anterior serrated flap with the VIII rib fragment

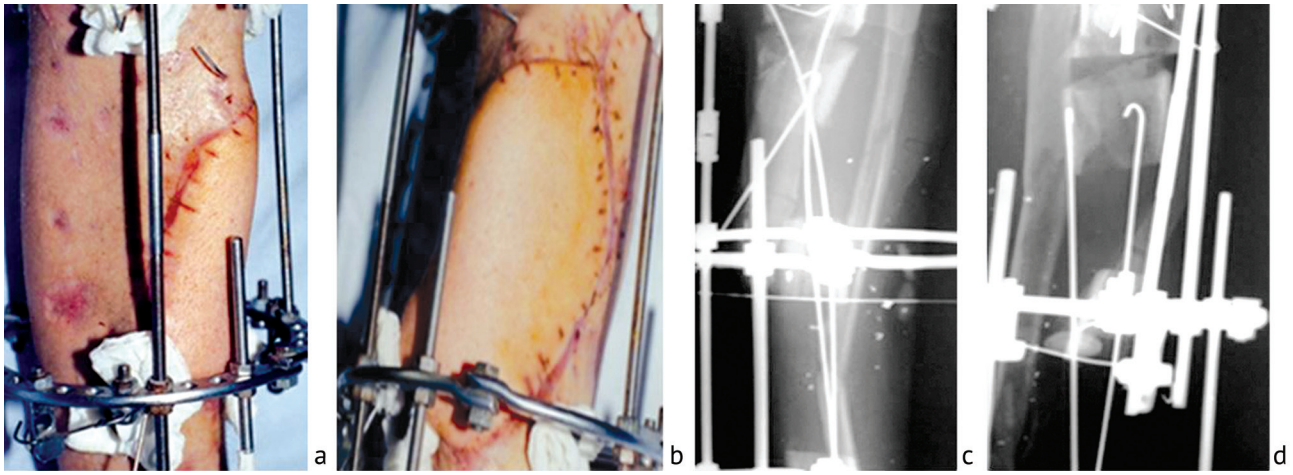

Fig. 5 Patient S.: a, b – view of tibia after reconstruction of soft tissues using anterior serrated flap with the VIII rib fragment; c, d – X-rays of the left tibia after bifocal osteotomy of the tibial bone, the rib plays "bridge" function with tibial fragments transported after osteotomy

The reconstruction of the soft tissues and the tibia was completed and the fibular fracture was healed (Fig. 6). After the course of rehabilitation therapy and fabrication of exoprosthesis for the right lower limb the wounded man was discharged to the military unit and remained on noncombatant military duty.

The patient has been followed up for 10 years (Fig. 7) when the ankle contracture developed, and he periodically undergoes courses of rehabilitation treatment, but no repeated surgical interventions were required.

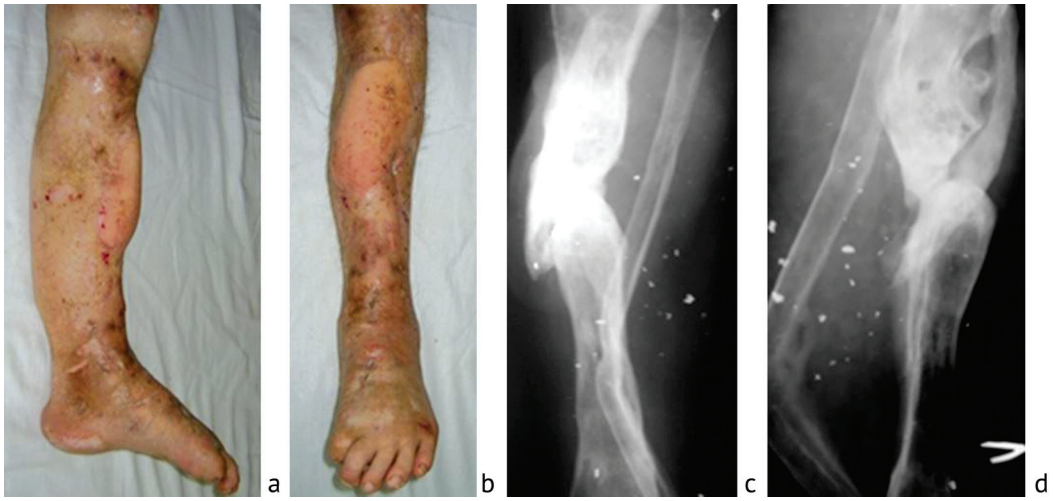

Fig. 6 Patient S. Treatment outcome in 6 month after external fixator removal: a, b – view of the limb, c, d – рентгенограммы левой голени

Fig. 7 Patient S. Functional result in 10 years

RESULTS

In seven cases the wounds healed by primary intention, signs of infection and marginal necrosis of the soft tissue component of the flap were observed in 4 (36.4 %) cases, in three of them conservative treatment was used (dressings, debridement) and in one case with 17 cm^2 area of necrosis that was debrided (on the 21st day) autodermoplasty with a split skin graft was performed.

We had no problems with transport (distraction) of the bone regenerates, since the rib cage of the flaps protected the soft tissues and the vascular pedicle of the flap, despite the early onset of distraction (the mean onset of distraction was 7.3 ± 2.1 days). Since the distraction sometimes had to be stopped and resumed again, mechanical irritation was used to strengthen the regenerate and we took into account the timing of the external fixatior disassembly, that was removed in mean 163.2 ± 8.7 days, but the length of fixation directly depended on the length of the tibial defect. In minimal size (6 cm) this index was 98 days and in maximal size (18 cm) it was more than 3 times higher (376 days).

The terms "delayed consolidation" or "nonunion" in the docking site are not entirely appropriate for observation data (considering their timing). This situation was observed in two cases. In one case, tibial external fixation was continued and healing occurred in 175 days after the operation (approximately 3 months

later than planned). In the second case, open docking and microperforation of the fragments contact area and free bone autoplasty (with iliac crest fragment) were required in 70 days after docking, and after another 175 days the fracture was healed and the fixator was removed (totally 345 days after the operation).

Among the "major" complications there was one case of total flap necrosis, that required cross-plasty with a sural flap. "Small" complications, such as pin-tract infection and pin osteomyelitis were observed in three patients (27.3 %) that required their removal.

According to the analysis of the late (more than 5 years) follow-up 5 injured remained in their previous profession, 5 wounded had a disability (1 – the first group, 3 – the second group and 1 – the third group) and one person was involved in study.

DISCUSSION

Clinical practice has shown high efficiency in the treatment of long (more than 5 cm) segmental defects of tibia using the technique of distraction osteogenesis according to G.A. Ilizarov, but the only short-coming or, more correctly, the condition for its application is the preservation of the skin and its vascularity [17]. However, our experience has shown that there are clinical cases when these conditions are absent dictating the need for a double stage approach. At the first stage, the soft tissue defect was restored and after that the tibial defect was filled in, taking much longer time and efforts, and often the patients refused to continue the multi-stage treatment.

Free vascularized bone grafting was an alternative tactics, including acute one. The fibular flap and the iliac crest flap do not allow to obtain the required amount of bone mass corresponding to the size of the tibial defect or the soft tissue defect exceeded the capabilities of these flaps. Again, it makes us either perform sequential treatment of the soft tissue defect first, and then the bone, or combine bone and soft tissue transfer with other bone plastic surgeries [18–20].

We believe that single stage combination of Ilizarov distraction osteogenesis and soft tissue reconstruction using free vascularized flap transfer is possible, and it is confirmed by the works of other authors [21–23]. Few attempts to introduce this tactics had great difficulties in the process of bone transfer since the soft tissue flap was deformed, and axial blood circulation was disturbed that threatened with total necrosis of the graft soft tissues [24, 25]. The inclusion of rib fragment, that we placed over the bone defect in the shape of "bridge", provided the required conditions for applying the Ilizarov distraction technique. The rib, being not supportive bone tissue, protected the soft tissue component of the flap and its vascular pedicle from deformity and participated in the formation of callus, a kind of "consolidate" at the site of bone defect [26–28].

This study including the tactics and technique to fill in combined tibial defects using a free vascularized flap with rib fragment and Ilizarov distraction osteogenesis that was developed and introduced into clinical practice showed their effectiveness, safety and advantages [16, 17].

In this group of patients with complex defects of tibia we managed to save the limb from amputation, arrest infection, restore supportability and return the injured to professional activities in 100 % of cases. Pain scores decreased to a level that was clinically significant by self-assessment but numerically not statistically significant. All patients were satisfied with the choice of restorative treatment instead of amputation.

Our results should be considered in the context of the selection bias commonly found in every retrospective study of small samples. It is important to keep the needs of each patient in mind as they have to be individualized in order to manage complex tibial defects. Finally, we recognize this method as one of many allowing to achieve successful limb salvage in large tibial defects, that is verified by the studies of Zierenberg G.C. et al. (2016) and Masquelet A.C. et al. (2019) [19, 29], but we hope that the discussion of our experience will provide an opportunity to evaluate the proposed technique in the general pursuance of ideal method for recovery of these patients.

CONCLUSIONS

Plastic filling in the extensive tibial defects using free vascularized myocutaneous flap with rib fragment and Ilizarov distraction osteogenesis creates favorable conditions for acute surgical intervention allowing limb salvage, the supportability restoration and to return the injured to work.

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Information about the authors:

1. Alexey V. Lychagin – Doctor of Medical Sciences, Professor, dr.lychagin@mail.ru;
2. Andrey A. Gritsyuk – Doctor of Medical Sciences, Professor;
3. Vadim Sergeevich Korytin – M.D., msk.dr.vadimsergeevich@gmail.com.