A 52-Year-Old Man with a Gustillo-Anderson IIIB Open Tibial Shaft Fracture with Extensive Soft-Tissue Defect Requiring Limb Salvage with Artificial Deformity-Creating Technique

**Patient:** Male, 52-year-old
**Final Diagnosis:** Distal tibial fracture • Gustillo-Anderson IIIB type
**Symptoms:** Bone fractures • extensive soft-tissue defect • pain
**Medication:** —
**Clinical Procedure:** —
**Specialty:** Orthopedics and Traumatology

**Objective:** Unusual setting of medical care
**Background:** In this case report, an alternative way of treating Gustillo-Anderson IIIB type fractures with severe soft-tissue damage is provided for cases where, for various reasons, it is not possible to close a soft-tissue defect with a flap.

**Case Report:** An artificial deformity-creating technique was applied for a patient with a right distal tibial open fracture (Gustillo IIIB type) with complete tibial cartilage and bone loss of 10 cm and severe soft-tissue defect after high-energy trauma. This technique includes damaged limb shortening, translation, angulation, and rotation for closure of soft-tissue defects using orthopedic hexapod and bifocal bone transport without need for plastic surgery. Because of the timely planning and application of the orthopedic hexapod for the artificial deformity correction, the final alignment of the limb was close to the physiological standard and had good functional outcomes. Despite the extremely severe shortening and acute angles, the total treatment time was only 75 weeks. At the 1-year follow-up after treatment completion, the patient had good functional outcomes with the 36-Item Short Form Survey score: general health, 80%; physical functioning, 85%; and social functioning, 100%.

**Conclusions:** In conclusion, we show that the artificial deformity-creating with subsequent orthopedic hexapod application and lengthening of a limb is a robust method that can be applied even for the treatment of severe open fractures with significant soft-tissue damage and bone loss, which can be performed outside high-level trauma hospitals and has good clinical outcomes without significant complications.

**Keywords:** Ilizarov Technique • Open Fracture Reduction • Tibial Fractures

**Full-text PDF:** https://www.amjcaserep.com/abstract/index/idArt/934788
Background

High-energy traumas of lower limbs are usually complicated by a severe soft-tissue defect, which significantly complicates treatment and is associated with poor outcomes [1] and are always challenging and requires highly qualified medical personnel, prolonged treatment time, resources, and a high level of compliance from the patient [1,2]. For lower-limb traumas with severe soft-tissue defects like Gustillo-Anderson IIIB type fractures, the most commonly performed technique is the “fix and flap,” which is currently considered the criterion standard [3,4]. However, in various situations, it is not possible to cover the defect with a flap, for example, in a single-vessel limb, when local muscle tissue damage is present, necrosis of a previous flap, or lack of an experienced plastic surgeon [5]. Additionally, using a flap has better results with internal rather than external fixation of bone fragments, but with large bone loss, internal fixation is usually not the ideal option [3].

In cases where it is not possible to close a soft-tissue defect with a flap, an amputation of a lower limb or a limb-salvaging attempt can be performed by using bifocal or trifocal osteotomy and lengthening of the injured limb with soft-tissue transport [1,6,7]. Alternatively, the artificial deformity-creating (ADC) technique, which includes damaged limb shortening, translation, angulation, and rotation, can be used for closing soft-tissue defects [8]. The advantages of the ADC technique include good adaptation for circular soft-tissue defects, decreased dead space at the defect site, the possibility of end-to-end vascular suture, avoidance of long surgery time in polytrauma patients, and the possibility of covering the residual soft-tissue defect with a small local flap [9]. Importantly, if the ADC technique is selected, a correction of the artificial deformity must be planned and performed later, which can be achieved by several options. However, part of this technique, including acute shortening, is currently used only to treat fractures with soft-tissue defects with small limb shortening (<3 cm) [9]. In this report, we provide treatment details and outcomes of an alternative limb-salvaging method for a patient with an open tibial fracture with severe limb shortening (10 cm) and soft-tissue defect after a high-energy trauma by using severe artificial deformity-creation and concurrent deformity correction using the orthopedic hexapod “Ortho-SUV™” (“Ortho-SUV” Ltd., Saint-Petersburg, Russia) system and bifocal bone transport (BFT).

Case Report

A 52-year-old man was admitted to the Emergency Department at Riga East Clinical University Hospital “Gaiļezers” clinics, 1 h 30 min after a motorcycle accident (09/2018). The patient had a right distal tibia open fracture with severe soft-tissue defect. The blood supply and innervation of the extremity was preserved. On admission to the Emergency Department, the patient was fully conscious, oriented, and hemodynamically stable. He had no preexisting conditions or co-morbidities and denied any allergies. To exclude polytrauma, a whole-body computed tomography (CT) scan with contrast was performed, which confirmed isolated lower-limb trauma and identified complete tibial cartilage and bone loss of 10 cm (Gustillo IIIB type) (Figure 1A, 1B).

After the diagnostic workup, the patient was immediately transferred to the emergency operating room (3 h 10 min after the accident) for wound revision and debridement (Figure 1C). The soft-tissue defect was 9×18 cm, and the a. tibialis anterior was damaged. The monolateral external fixation apparatus (ExFix) was placed to stabilize the fracture, and a vacuum-assisted closure system was used to cover the wound, with a pressure of 15 mmHg (Figure 1D). The patient was administered 1 g cefazolin 4 times a day for 3 days. On the third day, the patient underwent second-look debridement and wound closure by artificially creating a deformity of the damaged limb by performing shortening, translation, angulation, and rotation (Figure 2A, 2B). During the operation, blood flow in the lower extremity was monitored using duplex ultrasound. At this step, the 6-component and 3-plane deformity was created with 9-cm limb shortening, 32° varus, 45° apex posterior angulation, inner rotation of 15°, and 3-cm posterior and 1-cm medial translation. The patient felt well after surgery, and there were no signs of infection. Also, in the first 2 weeks after the ADC technique was used, blood flow in the lower limb was checked several times using duplex ultrasound.

On day 15, an auto-deploplasty was performed by using the skin graft from the right thigh (Figure 2C). At that time there was no infection of the Shanz screws from the ExFix system.

On day 28, the ExFix system was replaced with a circular Ilizarov frame for long-term immobilization and further correction. The used Ilizarov frame formula was according to the method for the unified designation of external fixation (MUDEF). On the next day, mounting of the orthopedic hexapod Ortho-SUV™ frame was performed (Figure 3A). As the next step, X-rays were taken to perform the deformity correction calculations using the hexapod software. The correction began on the same day, and adjustments of the hexapod system were made 4 times per day with intervals of 6 h.

After 36 days, the deformity correction was completed (Figure 3B), and the hexapod frame was removed. On the next day, talocrural arthrodesis (docking) was performed with fixation using the Ilizarov frame with bone fragment autotransplantation from the crista iliaca dextra (Figure 3C). The post-surgery
period was uneventful. The patient felt well, and the wound was healing primarily, with no signs of pin tract infection.

On the 80th day, the patient was discharged from the hospital with corrected axes and total limb shortening of 9.6 cm and had no pain in the damaged extremity. The patient was walking with crutches with partial weight-bearing (Figure 3D). The patient’s leg difference was 9.6 cm as measured on X-ray with linear calibration.

After 3 months, once the arthrodesis consolidated, the patient was readmitted to the same hospital for the limb lengthening, where the double-level osteotomy was performed on the day of readmission (Figure 4A). The Ilizarov frame formula was according to MUDEF. After 7 days, the distraction was initiated by transporting both bone fragments with a mean speed

Figure 1. (A) Computed tomography scan (preoperative) of the 52-year-old man showing Gustilo-Anderson III B open distal third tibial fracture. (B) Clinical photograph (preoperative) presenting the damaged limb with severe soft-tissue defect. (C) Clinical photograph showing extensive soft-tissue and bone defect after wound revision and debridement. (D) Clinical photograph (postoperative) presenting the fracture stabilization using monolateral external fixation apparatus and the vacuum-assisted closure system for wound coverage.
Figure 2. (A) Clinical photograph showing the wound closure of the damaged limb by artificial deformity-creating including shortening, translation, angulation, and rotation. (B) X-ray (anteroposterior and lateral) showing the damaged limb after artificial deformity-creation was performed. (C) Clinical photograph presenting the residual skin defect closure using auto-dermoplasty.
of 0.75 mm per day [6,7]. Regeneration quality was assessed during radiological control. The lengthening was stopped several times due to the patient’s report of pain in the lengthening extremity.

At 89 days after the double-level osteotomy, the Ilizarov frame correction was performed with the foot ring removal and reinsertion of 2 Shanz screws due to the superficial site infection. At 100 days after readmission, a secondary deformity was identified. Therefore, 2 hexapods were applied at the same time to correct the secondary deformity, similar to that performed during the ADC correction described above (Figure 4B). On the 111th day after readmission, the lengthening and secondary deformity correction were completed, with full restoration of leg length and anatomical alignment (Figure 4C).

After 8 months after completion of leg-lengthening, 1 week before the planned final checkout, the patient successfully completed 2 dynamization tests. At the planned final checkout, 525 days (75 weeks) after the trauma and 354 days (50.5 weeks) after readmission, the Ilizarov frame was removed, and the patient was discharged from the hospital with a CAM boot orthosis.

X-rays taken after 3.5 months showed good ossification of the regeneration (Figure 5A). The patient was fully weight-bearing at that time and reported having no concerns or pain (Figure 5B).

At the 1-year follow-up, the patient had good functional outcomes, with a Lower Extremity Functional Scale (LEFS) score of 57/100, American Orthopedic Foot and Ankle Society (AOFAS) score of 50/80, and 36-Item Short Form Survey (SF-36) score of 80% for general health, 85% for physical functioning, and 100% for social functioning, and the patient was satisfied with the results.
Figure 4. (A) Clinical photograph showing the limb lengthening by the double-level osteotomy using Ilizarov frame. (B) X-rays (anteroposterior and lateral) presenting 2 hexapods applied for the secondary deformity correction. (C) Clinical photograph showing the leg length and anatomical alignment were fully restored.
Figure 5. (A) X-rays (lateral and anteroposterior) showing anatomical axis after length restoration and good ossification of the regenerate. (B) Clinical photograph presenting final results with the patient fully weight-bearing with no concerns.

Discussion

In this report, we provided detailed information regarding an unusual alternative treatment strategy for a patient with an open tibial fracture with a severe soft-tissue defect and extreme limb shortening after high-energy trauma. Usually, treatment of such traumas is complicated, and currently there are no evidence-based guidelines or algorithms available [2]. This report proves that the application of the ADC method with deformity correction using the orthopedic hexapod and subsequent limb lengthening with bifocal osteotomy can be successfully performed even in severe cases, with the creation of acute angles resulting in good clinical and radiological outcomes.

The most often performed technique for lower-limb traumas with severe soft-tissue defects, Gustillo-Anderson IIIB type fractures, is the "fix and flap" technique, which includes internal or external fracture fixation with different flap types to cover the soft-tissue defect [3,10]. While with this method the reported complete flap survival is high (~91%) [10], and the primary fracture union can be achieved in 81-84.5% cases [10], this method is associated with a high complication rate, which is reported in 59%-60% of patients and includes partial or complete flap necrosis (17.1% and 18.6%), infections, delayed healing, donor-site complications, and unresolved osteomyelitis [10]. Additionally, this method cannot be performed for all cases (eg, not possible to cover a defect with a flap) and requires the involvement of an experienced plastic surgeon, so this approach is usually possible only in high-level trauma centers. Therefore, the aforementioned reasons limit its application to all patients with such trauma, with no good alternative options being available. However, a combination of acute shortening and the vessel loop shoelace technique may be used as an alternative method to cover soft-tissue defects [11].

ADC recently emerged as a good alternative for cases with Gustillo-Anderson IIIB type fractures or similar fractures where use of a flap is not possible [8]. Because ADC is a combination of shortening, translation, angulation, and rotation, it can be applied to different types of traumas, even to cases with severe limb shortening, as shown in this report. Moreover, because this approach does not require a flap, it could even reduce the complication rate. However, there are currently no large-scale studies available. There is now only 1 study including 19 patients treated with a similar technique. The results were 94% union rate with good bony and functional outcomes and all patients achieved limb salvation [8]. One of the possible complications, caused by extensive angulation in a single-vessel limb, may be this vessel occlusion, which can predispose to acute ischemia. However, in the present case, we did not encounter complications except for the superficial Shanz screw infection, which did not have any severe effects on the treatment or outcomes. Additionally, despite the extremely severe shortening and acute angles, the total treatment time of our case was 75 weeks. Moreover, because of the timely planning and application of the orthopedic hexapod for the artificial deformity correction, the final alignment of
the limb was close to the physiological standard and had good functional outcomes. The use of an orthopedic hexapod (Ortho-SUV™) enables performing high-precision multiaxial deformity correction without strut change or frame re-assembling.

Conclusions

In conclusion, we show that the ADC with subsequent orthopedic hexapod application and lengthening of a limb may be a robust method that can be applied even for the treatment of severe open fractures with significant soft-tissue damage and bone loss, which could be performed outside the high-level trauma hospitals and have good clinical outcomes without significant complications.

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Acknowledgements

We thank the patient for consenting to the publication of this case report. We are grateful for the help with the manuscript preparation and critical comments to Dmitrijs Rots and Proof-Reading-Service.com for English language editing and corrections.

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