

Original Research Article

Management of massive trauma over lower extremity with free flap and Ilizarov method

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Abstract: Twenty-six patients with massive combat injuries to the lower extremities were treated with Ilizarov bone transport and free flap coverage. In all cases, debridement was performed thoroughly and with caution, followed by free flap coverage and external fixator application. The Ilizarov transport method using ring fixators was applied 4-6 weeks later, with distraction osteogenesis beginning 2-3 days later. The segmental bone defects ranged from 5cm to 16cm in the greatest dimension, and the total disability time from initial injury ranged from 14-26 months. However, two patients experienced partial flap necrosis, which was later treated with local transposition flap cover and split skin graft. Despite the late treatment, successful results were obtained in all 26 patients, with the original length of the tibia maintained and timely definitive treatment provided for the massive injuries of the lower extremities. Thus, the Ilizarov transport method used in combination with free flap coverage provides an effective therapy for repairing massive injuries to the lower extremities.

Keywords: Ilizarov bone transport; Free flap coverage; Combat injuries; Lower extremities; Segmental bone defects.

1. Introduction

The lower limbs are highly vulnerable to trauma, including road traffic accidents, and require extensive treatment to repair high-energy wounds of the lower extremity. Early treatment is crucial for successful management of these injuries, which often involve bone defects in addition to soft tissue damage. The reconstruction of both the soft tissue and bone defects is essential, and since the development of free tissue transfer techniques, reconstructive and orthopedic surgeons have been able to overcome the challenges associated with managing these injuries [1].

The tibia is particularly susceptible to injury due to its subcutaneous location and limited soft tissue coverage. Restoring the tibial continuity, original length, and near-original function is the primary goal of salvage therapy for massive trauma to the lower extremity. Traditional methods for achieving this goal, such as shortening the bone and subsequent distraction of the leg, non-vascularized bone grafts, vascularized bone grafts, and bones, may not always provide optimal results [2-4]. However, the Ilizarov bone transport technique, in combination with free tissue coverage, has been shown to provide better outcomes with shorter morbidity [2,5-14].

2. Materials and Method

From January 2017 to November 2022, 26 patients who suffered severe lower extremity wounds resulting from road traffic accidents were included in this study. Of these, 24 patients had grade (3B) injuries and two patients had grade (3C) injuries. The mean age of the patients was 27 years (range: 20-35). Vascular imaging was conducted prior to microsurgical intervention in all cases. Patients with comorbid conditions such as diabetes mellitus, chronic smoking, hypo/hyperthyroidism were excluded from the study.

The treatment protocol followed in all cases involved aggressive, but careful debridement of the wound with external fixators to stabilize the fracture. Early reconstruction of soft tissue was performed using well-vascularized tissue (free flap). After the flap had healed on the wound for about 4-6 weeks, the Ilizarov frame was applied. In almost all cases, weight bearing started 4-5 days after the Ilizarov application. Antibiotic beads were used in all cases to maintain the gap between the edges of the defect to support the free flap. In 21 cases, free latissimus dorsi muscle flaps were used, and in five cases, anterolateral thigh free flaps were used to cover the defect. An Ilizarov frame was used to distract the bone, and care was taken not to cut through the pedicles of the flap. Vascular anastomosis was performed with anterior tibial vessels, posterior tibial vessels, either end-to-end or end-to-side, depending on which was more healthy. Postoperatively, anticoagulation (heparin) and low-molecular-weight dextran were used for 5-7 days.

Bone distraction was initiated between day 5 and day 9 after corticotomy. The following Ilizarov methodology was used:

1. Compression osteosynthesis - 9 cases
2. Bone transport without shortening - 15 cases
3. Acute shortening followed by gradual lengthening - none
4. Gradual shortening with gradual lengthening - 1 case
5. Trifocal osteosynthesis - 1 case

Overall, the treatment protocol involved a combination of aggressive but careful debridement of the wound, early reconstruction of soft tissue with well-vascularized tissue, and the application of an Ilizarov frame for bone distraction.

2.1. Case 1



(a) Before debridement



(b) After debridement and ext fix applied

Figure 1. Massive crush injury due to RTA



Figure 2. Defect covered with free flap(lattissimus dorsi muscle and ssg)

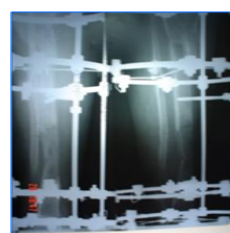
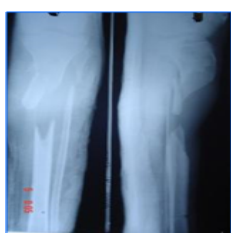


Figure 3. Bone distraction of 1mm/day and was kept mobile with full weight bearing



Figure 4. Bony union and range of movements

2.2. Case 2



Figure 5. Massive crush injury leg and covered with free flap



Figure 6. Healed flap and ilizarov frame applied



Figure 7. Before and after distraction

2.3. Case 3



(a) Crush injury of right leg

(b) After debridement

Figure 8



(a) Covered with free LD FLAP



(b) Healed flap with ilizarov fixators

Figure 9

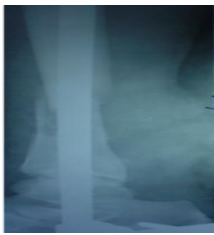


Figure 10. Pre op x rays



Figure 11. Mobilization of patient



Figure 12. Post op picture and x-ray

2.4. Case 4



(a) Crush injury right leg



(b) Covered with free ALT FLAP

Figure 13



Figure 14. Healed flap with ilizarov fixator

2.5. Case 5



(a) Crush injury injury foot

(b) covered with free LD flap

Figure 15



(a) Healed flap

(b) Ilizarov fixator application

Figure 16



(a) Xray of patient

(b) Mobilization of patient

Figure 17

3. Results

In this study, all 26 patients with severe lower extremity wounds resulting from road traffic accidents underwent aggressive but careful debridement of the wound with stabilization of the fracture with external fixators. Early reconstruction of the soft tissue with well vascularized tissue (free flap) was performed, followed by application of an ilizarov frame about 4-6 weeks later. The average time of bony union after docking was 3-4 months, and weight bearing in almost all cases started 4-5 days after the ilizarov application.

The bone distraction was started between day 5 and day 9 after corticotomy, using one of several ilizarov methodologies including compression osteosynthesis, bone transport without shortening, gradual shortening with gradual lengthening, or trifocal osteosynthesis.

All of the flaps were successful, although partial flap necrosis was observed in two patients, which were later covered with a local transposition flap and split skin graft. Two patients exhibited depressions during the distraction, which resulted in bone exposure and were treated with a local transposition flap cover and split skin graft. All wounds eventually healed. The bony defects ranged from 8-16.5 cm, and the fixation period ranged from 16 to 25.5 months. No cases of osteomyelitis or absence of bony union were observed.

Out of the 26 patients, one patient had partial flap necrosis, 10 experienced pain due to distraction, and 12 had pin tract infection. Six patients had union with mild deformity, while two patients experienced non-union at the docking site. Two patients had an inequality of the limbs less than 2 inches, and there were no cases of inequality greater than 2 inches or refracture observed.

4. Our concerns about the procedure

The study found that immediate distraction osteogenesis performed beneath the free flap did not pose a risk to the vascularized tissues in the series. It was observed that excessive distraction performed acutely could potentially harm the microvascular anastomosis. Therefore, the transport procedure was executed gradually at a rate of approximately 1 mm per day to achieve 80% gap filling. During the transport process, patients were encouraged to maintain mobility with full weight-bearing.

5. Discussion

The encouraging results in this series demonstrate that the use of the Ilizarov method in combination with free flap coverage offers an effective strategy for repairing grade 3B and grade 3C defects of the lower extremity, despite the long treatment period required. The ultimate goal is to achieve an optimal outcome, which means "replace like with like."

The rationale for using free flaps is that distracted bone should be in a well-nourished and safe bed, covered with revitalized tissue. The achievement of good, complication-free outcomes justifies the lengthy treatment period required for the Ilizarov method. In this series, an important concern was that bone exposure might occur due to muscle depression or soft tissue deficiency. In one patient, the exposed bone was covered with a local transposition flap. This problem arises when soft tissue coverage is done over a wound that lacks bone support. Antibiotic beads seem to offer the best solution to this problem. This method aims to create a gap between the flap and the base. The antibiotic beads are removed as the distraction progresses. This method has been successfully performed and well described. Other well-known options are available, but they have considerable drawbacks [15].

Shortening and closing the bone, closing the wound primarily, and later performing distraction is feasible for smaller bone defects not suitable for massive injuries with long bone defects. Autogenous non-vascularized bone grafts are one option but are suitable for defects less than 3 cm. However, they are not suitable for larger defects that require multiple bone grafting procedures and are associated with a considerable infection rate. Autogenous vascularized bone grafts (fibula, iliac bone crest) work well. But, protected weight-bearing for approximately 12-18 months is necessary to permit graft hypertrophy [8]. The use of allografts is not suitable in this series because their remodeling is very high. The incorporation of the fibula or iliac crest may be limited by donor site morbidity. Incorporating the ipsilateral fibula leads to impairment in muscle strength and joint motion changes [3]. This method requires a longer time to achieve full weight-bearing. The creation of hernia following the harvest of the iliac crest cannot be ruled out.

Massive injuries to the lower extremities are usually more extensive than can be estimated with the naked eye, and the wounds are more contaminated than anticipated. The most important step in the procedure is debridement and finding a suitable donor vessel.

The good results for these patients show that grade 3B and 3C defects are no longer a problem. Although the repair requires good skills and experience from both plastic and orthopedic surgeons, these two procedures are no longer technically difficult and can be managed with careful planning. However, possible complications should be taken into account while performing these two methods.

The encouraging results in the series demonstrate that the use of the Ilizarov method in combination with free flap coverage offers an effective strategy for repairing grade 3B and 3C defects of the lower extremity, although the treatment period is long. The ultimate goal now is to achieve optimal outcomes, which means replacing like with like.

The rationale for using a free flap is that the distracted bone should lie in a well-nourished, safe bed and should be covered with vascularized tissue. Achieving good, complication-free results that justify the lengthy treatment period for the Ilizarov method is crucial. In the current series, one of the important concerns was the exposure of bone due to muscle depression or soft tissue deficiency. In two patients, the exposed bones were covered with local transposition flap cover. This problem occurs when soft tissue coverage is done over a wound that lacks bone support. Antibiotic beads seem to offer a solution to this problem. This method aims to create a gap between the flap and the base. The antibiotic beads are removed as the distraction progresses. This method has been successfully described. Other well-known options are available but have considerable drawbacks. The bone can be shortened and closed, closing the wound primarily, but later distraction is feasible for smaller defects not suitable for massive injuries with larger bone defects. Autologous non-vascularized bone grafts are one option but are only suitable for defects less than 3cm. However, they are not suitable for larger defects requiring multiple bone grafting procedures and associated with considerable infection rates. Autogenous vascularized bone grafts, such as fibula or iliac crest, work well, but protected weight-bearing for approximately 12-18 months is necessary to allow the graft to hypertrophy [8]. The use of allografts is not suitable in this series because their remodeling is very slow, and the chance of extrusion is very high. Incorporating the fibula or iliac crest may be limited by donor site morbidity. Incorporating the ipsilateral fibula leads to impairment in muscle strength and joint motion changes. This method requires longer time to achieve full weight-bearing, and hernia creation following the harvest of the fibula cannot be ruled out. The rationale for the use of free flap is that distracted bone should lie in well nourished, safe bed and should be covered with revascularized tissue. The achievement of results in a good ,complication free outcome that well justify the lengthy treatment period for the ilizarov method .in the current series one of important concern was that the exposure of bone may occur either due to muscle depression or soft tissue deficiency .one of patients the exposed bones was covered with local transposition flap cover .this problem is encountered when the soft tissue coverage done over a wound that lacks bone support .the antibiotic beads seems to offer the best solution to this problem .this method aims at the creating a gap between the flap and base. The antibiotic beads are removed as the distraction progresses. this method has been performed successfully and well described other well-known options are available but have considerable drawbacks. The bone can be shortened and closed, closing the wound primarily and later distraction that is feasible for smaller bone defects not suitable for massive injuries with long bone defects .autogenous non vassalized bone grafts is one of the option but suitable for the defects less than 3 cm .how ever it is not suitable for the larger defects which require multiple bone grafting procedures and associated with considerable infection rate. Autogenous vassalized bone grafts (fibula, iliac bone crest) work well. But protected weight bearing for approximately 12-18 months necessary to permit the graft hypertrophy. The use allografts are not suitable in this series because their remodeling is very high. the incorporation of fibula or iliac crest may be limited by the donor site morbidity. Incorporating the ipsilateral fibula leads to impairment in muscle strength and joint motion changes. this method requires longer time to achieve full weight bearing. creation of hernia following the harvest of iliac crest cannot be ruled out. Massive injuries of the lower extremity usually are more extensive than can be estimated with necked eye. The wounds are contaminated than estimated. the most important step in the procedure is debridement and finding the suitable donor vessel.

The good results of these patients show that grade (3B) and grade (3C) defects are no more a problem .although the repair needs no more a problem although the repair needs a good skill ,experience the repair needs a good skill , experience for the both plastic and orthopedic surgeons .at present these two procedures are no more difficult technically and can be managed with careful planning .hoe ever the possible complications should be taken in to account while performing these two methods

6. Conclusion

In conclusion, managing massive lower extremity injuries that involve both bone and soft tissue defects can be a difficult task. However, with proper planning and execution following debridement, favorable

outcomes can be achieved. Based on our series, we recommend the use of the ilizarov bone transport technique along with free flap coverage as a viable option for such cases. This approach has demonstrated encouraging results and can be adapted easily. Overall, careful consideration of available options and patient-specific factors is crucial in achieving optimal outcomes in the management of these complex injuries.

Conflicts of Interest: The authors declare no conflict of interest.

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