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Original Research Paper

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PROSPECTIVE OBSERVATIONAL STUDY OF LIMB RECONSTRUCTION IN TREATMENT OF OPEN TIBIAL DIAPHYSEAL FRACTURES.

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ABSTRACT

Background: There is still dispute over how to manage open tibial diaphyseal fractures with bone loss. External fixators, nailing, ring fixators, and grafting with or without plastic reconstruction are all alternatives for treatment. Each treatment has its own set of consequences, such as acute docking difficulties, shortening, trouble with soft tissue management, chronic infection, greater morbidity, repeated surgeries, longer hospital stay, malunion, nonunion, and increased patient disappointment. We assessed the effectiveness of the limb reconstruction system (LRS) in treating open tibial diaphysis fractures with bone loss as a definitive way of care to accomplish union and limb lengthening at the same time. **Materials And Methods:** 44 open tibial diaphysis fractures with bone loss of at least 4 cm or more and a mean age of 35.3 years were treated with the LRS following debridement. To maintain limb length, distraction osteogenesis was performed at an average rate of 1 mm per day away from the fracture site. After approximating the fracture ends, the dynamized LRS was left for another 15-20 weeks before the patient was mobilized with weight bearing to accomplish union. The functional assessment was performed using the Association for the Study and Application of Illizarov Methods (ASAMI) standards. **Results:** The average followup was 12 months. The average bone loss was 4.9 cm (range: 3–8 cm). The average duration of bone transport was 16 weeks (range 9-32 weeks), while the average period for LRS in situ was 42 weeks (range 25-48 weeks). The mean implant index was 54.8 days per centimeter. The average union time was 46 weeks (range 42 to 48 weeks), with a mean union index of 71.7 days/cm. Bony results according to the ASAMI rating were excellent 78% (34/44), good 12% (6/44) and fair 5% (2/44) with union in all but two patients, who had poor results (5%) with three patients having a leg length disparity of more than 2.2 cm. Functional outcomes were excellent in 86% (37/44), good in 9% (3/44), and fair in 5% (3/44). Three occurrences of pin tract infection were observed, with all being superficial and healing with dressings and medicines. **Conclusion:** The limb reconstruction system is effective for treating open fractures of the tibia with bone loss, achieving union and lengthening simultaneously. Its advantages include early union and limb lengthening, a simple surgical technique, and minimal invasive procedures. Patient compliance, ease of wound treatment, reduced hospitalization, and lower risk of problems such as infection, deformity, or shortening.

KEYWORDS : LRS (Limb Reconstruction system),Bone Loss,Non union

INTRODUCTION

Trauma surgeons face challenges with open fractures of the tibia due to its subcutaneous location, resulting in significant soft tissue injury and bone loss. There are various treatment options for these fractures, including external fixators, ring fixators, nailing, plating, tibial synostosis, free or vascularized bone grafting, and allografts or bone substitutes, each with its own complications.(1-4) Although ring fixators are effective for fractures, they can be difficult for both patients and surgeons to use and need technical expertise. The limb reconstruction system (LRS) consists of clamps that slide on a rigid rail and link via compression-distraction units for bone transfer. This prospective study assessed the effectiveness of LRS in treating open tibial diaphysis fractures with bone loss, aiming for both union and limb lengthening(5-7).

MATERIALS AND METHODS

The study included 44 patients of open tibial diaphysis fractures with bone loss treated with LRS to achieve union and lengthening in 2024-2025. Inclusion criteria included patients aged 22-53, Gustilo Anderson type III A or III B, injury severity score of at least 5, and bone loss of 4 cm or greater. The study excluded closed fractures, infected gap nonunions, osteoporotic fractures, fractures with less than a year of follow-up, and metaphyseal fractures. The institutional ethical committee provided clearance.

Initially, a primary survey was conducted to identify associated injuries and avert potentially fatal consequences. Following advanced trauma resuscitation, the wound was thoroughly irrigated and splinted with crammer wire. antibiotics were administered.

Pre-operative workup included X-rays of the afflicted leg, including the knee and ankle, in both anteroposterior (AP) and lateral perspectives

Operative Procedure

All patients were taken for immediate surgical debridement, which included the removal of all dead necrotic tissues as well as the removal of free loose bone pieces, followed by fracture stabilization using the LRS system while under spinal anesthesia with a tourniquet and image intensifier in the supine position. The tourniquet was only inflated when the debridement was complete and before the osteotomy.

LRS Schanz pins were placed by a longitudinal stab incision, followed by blunt dissection on the anteriomedial surface of the tibia to separate soft tissue from bone, reducing the risk of neurological, vascular, and tendon damage. To reduce the potential of heat necrosis and pin loosening, the proximal most Schanz screw was predrilling with an appropriate-size bit before being manually inserted with the T handle. The proximal pin was inserted at least 15 mm from the joint to prevent penetration of the capsule and avoid the pes and patellar tendon. The distal Schanz screw is inserted in the same manner. The rod and assembly were connected over the proximal and distal pins to maintain leg length. The definitive fixator was used as a guide to pass the rest of the pins, ensuring that the rail is parallel to the long axis of the bone and all remaining screws are on the bone, perpendicular to the long axis of the tibia, parallel to the knee and ankle joints, and aligning the tibial tuberosity with the second metatarsal. The foot and ankle were adjusted to prevent musculotendinous tethering.

The pin retaining nuts (clamps) were tightened once the pins and fixator were secured to the limb. The compression-distraction unit was attached to the proximal and middle clamps using the available holes. A low energy osteotomy was performed between the proximal and intermediate clamps using a gigli wire or a thin osteotomy that connected predrilled holes. The pin holding onto nuts (clamps) were tightened once the pins and fixator were secured to the limb. The compression-distraction unit was attached to the proximal and middle clamps using the available holes. A low energy osteotomy was performed between the proximal and intermediate clamps using a gigli wire or a thin osteotomy that connected predrilled holes. After one week, the osteotomy was distracted at a pace of one-fourth turn four times per day, resulting in a total bone transfer of 1 mm/day or 7 mm/week. The rate of distraction in certain patients altered during the distraction phase, depending on the patient's cooperation and the kind of treatment. Patients were urged to achieve knee and ankle range of motion (ROM) following the administration of LRS, depending on their pain tolerance. Bone transfer continued until the fracture was nearing completion. After approximating the bone ends, the distraction was discontinued and the LRS system was dynamized. The patient was then allowed to mobilize to their comfort level. The dynamized LRS system was left in place for 17-22 weeks to allow for the regeneration and fracture union to occur. After the union and consolidation phase, the LRS system was removed and a patellar tendon bearing cast was put to allow complete weight bearing for another 8-12 weeks. The LRS was present for 26-51 weeks, resulting in well-consolidated regenerates. . The Association for the Study and Application of the Methods of Illizarov (ASAMI) criteria were used to assess bone and function. Criteria included union, infection, limb length discrepancy, and deformity at the docking site, as well as patient activity, limping, stiffness, reflex sympathetic dystrophy, and pain.

RESULTS

The results are based on 44 patients. Six patients were lost to follow-up and excluded from the research. The average age of the patients was 34.8 years (range: 22-53 years). Eighty-eight percent (n = 38) of the patients were male, with road traffic accidents (94%) being the leading cause of injury. The remaining six patients were injured owing to falls from height. 94% (n = 41) of the fractures occurred in the middle or lower part of the tibia. The average follow-up duration was 10 months (range 9-12 months).

In 26 cases, the wound healed completely with distraction and histogensis, likely due to increased vascularity at the fracture site. In 10 cases, additional skin grafting was performed, and in 8 cases, fasciocutaneous flap rotation was done within one week as the wound condition improved. The average bone loss was 4.90 cm (range: 3-8 cm). The average bone transport time from LRS application to bone approximation following distraction was 16 weeks (9-32 weeks). The average time for LRS in situ was 42 weeks (range 25-48 weeks), including a 1-week waiting period, distraction or bone transport to fill a 3-8cm gap, and 16-22 weeks for fracture consolidation. The average implant index was 54.8 days/cm. After identifying three cortical unions on AP and lateral views, the LRS was removed and a patella tendon bearing (PTB) cast was applied for 8-12 weeks to cement the union and repair the pin tracts. The average period from application of LRS to removal of PTB cast was 46 weeks (range 42-48 weeks), with a mean union index of 71.7 days/cm. Bony outcomes based on ASAMI score were excellent in 78% (34/44), acceptable in 12% (n = 6/44), fair in 5% (n = 2/44), and bad in 5% (n = 2/44). Functional outcomes were outstanding in 86% (36/44), good in 9% (n = 5/44), and fair in 5% (n = 3/44). None of our patients experienced poor outcomes or failed. Only one (2%) patient experienced nonunion at the docking site, resulting in unsatisfactory outcomes and the need for further bone grafting and plating to establish union with dynamized LRS and PTB casts. In one patient, the LRS was removed owing to infection. In another, the LRS was utilized for a long time but did not demonstrate three cortical unions, necessitating grafting and plating. At the end follow-up, only 3 (9%) patients had a leg length disparity of more than 2.2 cm, whereas 41 (91%) had a gap of less than 2.5 cm and were able to walk without shoe increase. At the final follow-up, 84% (n = 35) of patients had knee ROM more than 125°, whereas 95% (n = 42) had ankle ROM greater than 25°.

DISCUSSION

Trauma surgeons often encounter open tibia fractures with bone loss. Conventional treatment methods, such as nailing or fixators with acute docking, have high rates of complications, including bone loss, soft tissue healing issues, multiple surgeries, and a higher chance of malunions and nonunions.(8-11) Secondary nailing after main external fixator or delayed first nailing leads to a much greater infection risk.

LRS is generally used for limb lengthening, nonunions, and deformity repair. It consists of two or three clamps that slide on a rigid rail and connect to compression and distraction units. LRS is generally used for limb lengthening, nonunions, and deformity repair. It consists of two or three clamps that slide on a rigid rail and connect to compression and distraction units. (12-17)

LRS employs osseous callus distraction for bone lengthening in several treatments, including bone transfer, compression and distraction at multiple locations, monofocal lengthening, bifocal lengthening, and correction of deformities by shortening(18-20). We evaluated the functional outcome of LRS in 25 cases of open tibial diaphysis fractures with a mean bone loss of 5.5 cm (range 4-9 cm), a mean age of 32.5 years (range 20-48 years), and an average follow-up of 15 months (range 12-19 months). LRS was used as a definitive treatment for both union and lengthening. Illizarov developed corticotomy to preserve intramedullary and endosteal circulation. Research indicates that conserving periosteum, rather than medullary circulation, and low energy osteotomy are crucial for producing high-quality regenerates. We followed these guidelines by performing a two-incision gigli saw osteotomy. At the final follow-up, all patients had union, except for one (2%) who had unsatisfactory outcomes due to nonunion at the docking site, requiring further plating and bone-grafting. There were no deformities, and only two individuals exhibited leg length discrepancies of greater than 2.5 cm. Our study found excellent to good results in 86% of cases, comparable to other studies that treated bone loss using different methods (e.g. McKee et al(21)., Robert et al.(22), Sen et al.(23), Mekhail et al(24)., Donnan et al.(25)). These studies also reported excellent to good results in 80-90% of cases. Our analysis found a mean bone transfer of 4.9 cm, comparable to previous studies by Robert et al. (22)(6 cm), Sen et al.(23) (5 cm), Mekhail et al.(24) (5.7 cm), Donnan et al.(25) (6.4 cm), and Bubasirevic et al.(26) (6.9 cm). In our series, union with limb length was accomplished in all instances except two, using LRS alone for an average of 42 weeks and a union index time of 71.7 days/cm. Our series had a mean implant index of 54.8 days/cm, similar to previous studies by Robert et al. (22)(54 days/cm), Sen et al. (23)(1.4 months/cm), Mekhail et al. (24)(2.42 months/cm), and Atef and El-Tantawy (27)(45 days/cm). While Illizarov's fixator is still considered the gold standard for fractures with bone loss, our study demonstrates the effectiveness of LRS in achieving union and limb length simultaneously by average orthopedic surgeons who are not trained to use it.

LRS is a simple surgical technique with a short learning curve. Its lightweight, monolateral design allows for early mobilization and easy access to soft tissue and wound management. It is also minimally invasive, resulting in less morbidity, shorter hospitalization, and reduced economic burden.

CONCLUSION

LRS is a successful treatment option for open fractures of the tibia with bone loss due to its simple surgical technique, minimal invasive nature, high patient compliance, ease of wound management, and low rate of complications. However, further multicentric studies and RCTs are needed to confirm its effectiveness in treating open fractures of the tibia with bone loss.

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