International Journal of Innovative Research in Medical Science (IJIRMS)
Volume 07, Issue 11, November 2022,
https://doi.org/10.23958/ijirms/vol07-i11/1559

Original article

Bone Defects Following Trauma, Managed by Non-Vascularized Fibular Strut Graft: A Single Centre Study

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Received 30 October 2022; Accepted 16 November 2022; Published 18 November 2022

Abstract

Objective: Treatment of segmental bone loss is a challenge in orthopaedic practice. The purpose of our study is to evaluate results of non-vascularized fibula strut graft in patients treated for bone loss in femur and tibia bone defects. ***Methods:*** We prospectively evaluated 20 patients who have underwent non-vascularized fibular grafting as definitive treatment of post-traumatic bone defects of femur or tibia from January 2019 to October 2021. The pre-operative information including clinical and radiological examination to assess the condition of bone and to estimate the length of defect were collected and fibula graft of appropriate length was placed in the defect. Follow up results of the ranges of motion and limb length discrepancy were measured, and radiological outcome was assessed. All patients were followed up at 6 weeks, 3, 6 and 12 months. ***Results:*** Out of twenty patients only a single report of nonunion was noted. Union was achieved in 95% of our patients. Sixteen of our patients had good range of movement of knee and four patients had problem of knee stiffness. Six patients had shortening of 2cm. Two of our patients had superficial infection and one had deep infectivity an another had developed ankle stiffness and another one developed flap necrosis. ***Conclusion:*** Union rate of 95% and a near functional range of motion was seen in majority of our patients. Thus, we recommend use of non-vascularized fibula graft for open fracture with bone defect as it is simple, effective, inexpensive, technically less demanding with less donor site morbidity.

Keywords: ***Fractures, bone; Tibial fractures; Bone plates; Bone screws; External fixators; Bone transplantation.***

Introduction

Segmental bone defect due to trauma, post infection or post tumor excision, atrophic nonunion, leads a big challenge in orthopaedic practice. Allogenic bone grafts and bone graft substitutes, Vascularized bone transfer, Bone transport with Illizarov fixator, and various other treatment options have been explained in literature [1]. If neglected, severe limb length discrepancy can be observed and may render the extremity inept for use, with amputation of the limb being the last resort for the patient and the surgeon. Owing to its tubular shape and excellent strength, fibula can easily be used as autogenous bone graft for filling in gaps of bony continuity. No other autogenous bone graft is rendered as strong as fibula [2-4]. "When used with internal fixation methods, fibular grafting stabilizes the fracture and hastens union [5]". Another benefit of this procedure is that limb reconstruction is completed as single stage procedure rather than a cumbersome bone transport procedure with the help of Ilizarov ring fixator.

Procedures such as vascularized fibular grafts, Illizarov are other described options for the reconstruction of such defects; however, such procedures are cumbersome and time taking and have several noted complications [6,7].

When compared to other grafts, fibula graft is easily revascularized, is non-immunogenic and constitutes all desirable attributes of a good graft, risk of cross transmission of infection is minimized. The major shortcoming of cancellous grafting is limited availability of harvest site. Donor site morbidity and high failure rate is another problem [8]. On other hand, Allografts have no issue of donor site morbidity yet can transmit infection, require a tissue bank which is not accessible in developing countries and have lower graft acceptability rates compared to autografts [9].

A vascularized fibular graft could be a better option to conventional bone graft but is surgically demanding with microsurgical techniques making it difficult to be practiced routinely in most centers [10-12].

The aim of our study is to evaluate results of non-vascularized fibular strut graft combined with cancellous bone graft used to re-establish bone continuity in patients treated for bone loss in femur and tibia.

Material and Methods

After Scientific and Ethical clearance, this prospective study was conducted between January 2019 to October 2021 in NDMC Medical college and Hindu Rao Hospital, India. All the patients with post traumatic defects of tibia and femur were considered for the study. We excluded patients with infection on the operative site, with Mangled extremity score > 7 in lower limbs and any pathology of fibula. All the patients were adults and no minors, with epiphysis still not fused were included in the study. A total of 20 patients were admitted with post-traumatic bone defects of femur and tibia. All patients were operated by same senior surgeon. The minimal follow-up period was set at 12 months. A total of 20 patients (male=13, female=7) with the mean age of 40 years were evaluated.

Operative Technique

Written and informed consent was taken, and all possible complications were explained to the patient and attendants. Identical surgical technique was applied in all the cases by same surgeon. Surgery was done under general or spinal anesthesia in supine position with tourniquet in all patients. Now, the defect in femur or tibia was opened and visualized utilizing the lateral approach for femur and antero-lateral approach for tibia (**Figure 1**). Fracture margins were freshened, sclerotic bone ends were resected and medullary canal opened. Next, the Fibula graft was harvested (3cm larger than the measured bone defect) using Henry approach involving dissection between peroneus longs and soleus muscles (**Figure 2**). From Iliac crest, cortico-calcaneus graft was harvested using standard approach.

Then defect in femur/tibia was filled with fibular graft and iliac crest graft and internal fixation done with plating while maintaining limb length. Patient was given Intravenous antibiotics in the post-operative period till post-operative day5 and then discharged on oral antibiotics and analgesics. Suture removal was done on day 15. Weight bearing started was started when radiographic evidence of callus formation was seen on x-ray. Clinical union was seen when the fracture site was stable and when there was absence of abnormal mobility and pain. Radiographic union was considered when plain radiographs showed bone trabeculae bridging the Graft bone-host bone interface.

Radiological outcome was assessed with the help of X-ray appearance of the lower limb on 6th week, 3rd month, 6th month and 1st year. Clinical outcome was assessed on the basis of range of motion at knee, ankle and foot, limb length disparity, deformity and complication on 6th week, 3rd, 6th and 12thmonth. Functional ability of patients was assessed on walking ability and was graded as, Good: able to walk independently, Fair: walk with assistance, Poor: unable to walk. Data were stated as mean and standard deviation with Categorical data compared using two-tailed Student t-test. For all analysis p value < 0.05 was considered significant. SPSS version 22 software was used to analyze the data.

Results

We prospectively evaluated 20 patients who have undergone non-vascularized fibular grafting for treatment of bone defects of femur or tibia due to trauma and were followed up postoperatively at 6 weeks, 3, 6 and 12 months and further till bony union was achieved.

In our study the mean age of patients with posttraumatic bone defects was 40 ± 10.71 years (24-63yrs). Out of 20 patients participating, 13 were male and 7 females. 19 patients (95%) sustained injury due to a Road traffic accident (RTA), whereas in 1 patient (5%) it was due to fall. In 20 patients, 10(50%) had their femur involved and 10 had a defect in tibia. All 20 patients had compound fractures which were classified on the basis of Gustilo and Anderson classification, 2 patients were type II compound, 10 were type IIIA, and 8 were type IIIB (**Table 1**).

Union was achieved in 19 of our patients (**Figure 3**). One patient developed non-union which was managed with Illizarov fixator application. 16 of our patients had good range of movement of knee with 4 having 0-100 ROM and 9 having 0-90. Knee stiffness was encountered in 4 of the patients. Range of motion of knee 6 weeks post-operatively was 35±13.95 degrees, at 6 months was 59.5±18.77 degrees and at 12 months was 81±21 degrees signifying that with passage of time and physiotherapy knee ROM improved in all the cases (**Table 2**).

11 patients had dorsiflexion of ankle in range of 10-20 degrees and rest 9 between 0-10 degrees. One patient had 0-10 degrees plantar flexion, 5 had 0-20 degrees, 10 had 0-30 degrees and rest 4 had 0-40 degrees. Foot inversion was found to be 0 degrees in 1 patient, 0-10 degrees in 10, 0-15 degrees in 1 and 0-20 degrees in 8 patients. Lastly, with respect to degrees of eversion of foot, 0 degrees was seen in 1 patient, 0-10 degrees in 18 and 0-15 degrees in one patient.

The mean length of bone defect was 6.50±1.52 cm (4.5-10 cm). Mean length for tibial defect was 5.70±0.86 cm (4.5-7.5cm) and for femur 7.30±1.65 cm (5-10cm) (**Table 2**). In our study 13(65 %) of patient had good functional outcome and walked independently and 6 had fair functional outcome due to problem either with stiffness of knee or ankle or required assisted ambulation. One patient had poor functional outcome due to nonunion and required bone transport using Ilizarov ring fixator application and protracted duration of treatment (**Table 1**).

Shortening was the most common complication of our study in which 6 patients (30%) had shortening of 2cm which was compensated with shoe raise. 3(15%) patients developed infection, out of which 2 developed superficial infection which was managed with antibiotics and debridement. Four (20%) patients had knee stiffness. One (5%) patient developed ankle stiffness and another patient (5%) developed flap necrosis requiring revision flap surgery.

Figure 1: Lateral approach in femoral bone defects.

Figure 2: Harvested fibular graft using Henry approach.

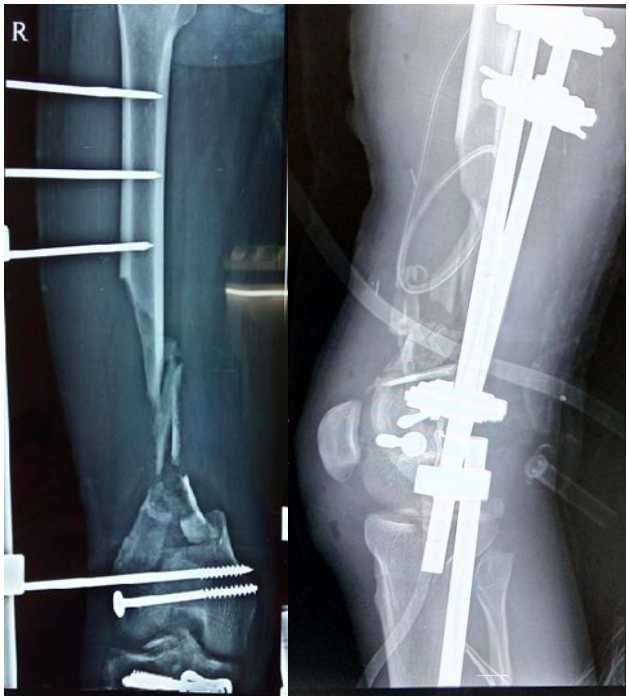

Figure 3 (a): This 39/M with Grade IIIA fracture of the femur with 7 cm of bone loss. Debridement with external fixator was applied and planned for free non-vascularised fibular graft harvested from same side after 1 week.

Figure 3 (b): Bridging was done with a non-vascularized fibular graft, fixed in the medullary cavity with locking pre contoured plate.

Figure 3 (c): Radiographs after 3 months showing fibular graft consolidation.

Figure 3 (d): X-ray post 12 month follow up showing complete union at both ends of the fibular graft.

Figure 3 (e): Range of motion of knee at 12 month follow up visit.

Table 1: Table comparing Gustilo-Anderson grading at the time of presentation and final outcome

Outcome	Bone Involved						
	2		3A		3B		Total
	Tibia	Femur	Tibia	Femur	Tibia	Femur	
POOR	0	0	1(5%)	0	0	0	1(5%)
FAIR	0	1(5%)	3(15%)	0	1(5%)	1(5%)	6(30%)
GOOD	1(5%)	0	1(5%)	5(25%)	3(15%)	3(15%)	13(65%)
TOTAL	1(5%)	1(5%)	5(25%)	5(25)	4(20%)	4(20%)	20(100%)

Table 2: Results of our study in terms of mean and standard deviation

	Tibia(N=20)	Femur(N=20)	Total(N=40)
Age (Years)	36.1±10.03	43.9±10.39	40±10.71
Preop Defect (cm)	5.7±0.86	7.3±1.65	6.5±1.52
Range of motion knee at 6 weeks	40±13.33	30±13.33	35±13.95
Range of motion knee at 6 months	63±13.37	56±23.19	59.5±18.77
Range of motion knee at 12 months	87±14.18	75±25.50	81±21
Number of surgeries	2.9±0.99	2.2±0.63	2.55±0.89
Duration of treatment (Months)	12.2±2.82	9.8±1.93	11±2.66

Discussion

Bone gap is a difficult issue and procedures for its management including allografts, autografts and bone lengthening procedures. Likewise, various fixation techniques for stabilizing such fractures are described such as Illizarov ring fixator, Osteosynthesis, interlocking nailing. Cancellous bone grafting, Masquelet technique, Free vascularized fibula grafting are other options for management of these defects [13,14].

Fractures with segmental loss of more than 2-3 cm or half of the circumference of the bone are less likely to unite if only skeletal stabilization done [13]. There is no definitive evidence to decide regarding the different management of bone loss post trauma. A cancellous graft is a viable option, but due to its shortcomings such as donor site morbidity and limited availability, it is not appropriate for bone loss greater than 4 cm [14].

The Masquelet technique is a two-stage technique that uses induced biological membranes with delayed placement of the bone graft to manage large bone defects of 20 cm or even longer [15]. Longer recovery time and it being a technically demanding procedure being its major limitations [16]. Vascularized fibular graft can deal with defects larger than 5-6 cm or with poor vascularity of the surrounding soft tissues. Extensive planning, skillful microvascular techniques, and vigilant follow-up are necessary to lower complications and improve the result [17,18]. Bone transport with Ilizarov ring fixator on the other hand is another option for the limb lengthening and soft tissue defects but has a difficult and lengthy procedure and have many known complications [19,20].

This study was performed to give more insight into the outcomes of free non-vascularized fibular graft in treatment bone defects in Tibia and Femur post trauma. Clinical assessment includes weight bearing status, movements at knee, ankle and foot, limb length discrepancy, deformity and complication. Radiological assessment was done on the basis of X-ray appearance. In our study of 20 patients of non-vascularized bone grafting the success rate was 95% with mean age of 40 years (24-63years) constituting 13 males and 7 females. Similar age distribution was in study of Lin et al. [14] with success rate of 100% [14]. But, El-Sayed et al. [17] with mean age, 25 and union rate, 92% and Mahdi et al. [18] with mean age, 25.4yrs and union rate 89.5% had young distribution of patients. Union rate was comparable in all the studies.

Out of 20 patients in our study, 10 patients had femur defects and 10 had tibia bone defects, 19 patients (95%) sustained injury due to Motor vehicle accident, and 1 patient (5%) due to fall. All of our patients had compound fractures which were classified on basis of Gustilo and Anderson classification, two were type II, ten were IIIa and eight were III b. Similarly, in study by Lin et al. [14] all 10 patients had compound fractures, 8 had tibial defect and 2 had femur defect, 9 patients sustained injury due to Motor vehicle accident and 1 patient had history of fall, three were type II, five were IIIa and two IIIb according to Gustilo Anderson.

Classification. Similar distribution was present in study of El-Sayed et al. [17] the injuries were caused by road traffic accident in 8 cases, industrial accident in 3 cases and fall from a height in 1 case of which 8 cases had tibia defect. Injuries with femur or tibia bone defects are common in motor vehicle accidents.

The bone defect length in our study ranged from 4.5 cm to 10cm with mean length defect of 6.50 cm. Mean length for tibia defect was 5.70 cm and femur was 7.30 cm. Similar length of bone defect was reported by El-Sayed et al. [17] with mean bone defect length being 7 cm ranging from 6 to10 cm, similarly in the study of Lin et al. [14] length of bone defect being 7 cm ranging from 4 to 8 cm. Mahdi et al. [18] defect ranged from 4 to 10 cm and in Lawal et al. [9] the mean length was 6.5 cm. External fixator was used as primary fixation method in three patients and plating was used as method of fixation definitively. Our cases included patients with diaphyseal and intra-articular fractures around knee and ankle joints. Similarly, El-Sayed et al. [17] used external fixator as method of fixation in 8 cases of tibia bone defect and plate fixation for 4 cases of upper limb bone defect Lin et al. [14] used plating as method of fixation. In our study there was no functional disability involving the donor leg at 12 months follow up, though some discomfort with exertion were noted post operatively. 16 patients (80%) returned to their pre-injured status. Also 16 patients (80%) walked independently after 12 months and rest needed assistance to walk. Similarly, in study by Lin et al. [14] 80% of the cases returned to their pre-injured status and 80% were able to walk independently and rest needed to walk with a single stick after 12 months. Similarly, in study of El-Sayed et al. [17] after a mean follow up of 2 years, 75% returned to pre-injury status.

In our study patients had an average of 2.55 surgeries (1-5 surgeries), eight of our patients required plastic surgery for wound coverage, six required flap and 2 required split skin grafting. 13 of our patients (65%) had good outcome and walked independently, 6 \had fair outcome (35%) and 1 (5%) had poor outcome and had non-union managed with Illizarov fixation.

Shortening was the most common but acceptable complication of our study 6(30%) patients had shortening of 2cm. Mahdi et al. [18] reported shortening in 3 (15.8%) cases. Lawal et al. [9] reported shortening of 6cm in 1(10%). Lin et al. [14] had no case of limb length discrepancy. The high incidence of shortening in our study might be due to a greater number of cases included in our study as compared to others and our study included patients with diaphyseal and juxta-articular fractures whereas Lin et al. [14] study comprised of 10 patients and mainly of juxta-articular fractures. The shortening was managed with help of shoe raise in our patients.

Rest complications like infection, knee and ankle stiffness were more or less comparable with study of Lin et al. [14] and Mahdi et al. [18] reporting 10% and 15.8% simultaneously. The strength of our study is that patients included in our study had lower limb bone defects of tibia or femur and results were calculated on tibia and femur separately and patients were operated upon by a single surgeon at a single center with consistency in surgical technique and implant used. The major drawback of this study is the small sample size and short-term follow up so results may be differed in a large size sample and a longer follow-up.

Conclusion

In the study we achieved 95% union rate and most of our patient were ambulatory and had satisfactory functional outcome. Thus, non-vascularized fibular strut graft is an effective, inexpensive,

technically less demanding simple procedure to bridge bone defects with almost nil to minimal morbidity at the donor site.

Ethics approval and consent to participate

The study was approved by the ethic committee of NDMC Medical College and Hindu Rao Hospital. All methods were performed only after consent was taken from the patient to participate in the study.

List of abbreviations

GA: Gustilo Anderson Classification
RTA: Road Traffic Accident

Data Availability

The corresponding author can be contacted if there is any request for the data.

Conflict of interests

The authors have no conflict of interests to declare.

Funding Statement

None

Authors' contributions

Study concept and design: Dr. Sumedh Kumar, Dr. Tushar Sachdev
Drafting of manuscript: Dr. Ankush Ratanpal, Dr. Aman Thakur
Date analysis: Dr. Bhanu Pratap Singh, Dr. Anuj Kumar Ekka

Acknowledgments

We would like to offer our deepest gratitude to our seniors in the department who guided us in this research.

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