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Study on role of fibular graft in non-union and complex fractures of long bone

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ABSTRACT

Background: Road traffic injuries are the seventh most common cause of long bone fractures. Following high velocity limb trauma, the defects in the long bone are usually associated with appreciable soft-tissue losses. These open long bone injuries always require multidisciplinary managements to reconstruct the composite defects of bone and soft tissue. **Aims and Objectives:** The aim of the study was to find out radiological and clinical outcome, complications, and union time in complex and non-union fractures of long bone managed by fibular graft. **Materials and Methods:** Out of 50 cases, 40 cases were of complex fractures and ten cases were of non-union. We used Fibular strut grafts in reconstruction of bone defects and soft tissue injury. **Results:** Thirty (60.0%) had excellent functional outcome, 10 (20.0%) had good, 6 (12.0%) had satisfactory, and 4 (8.0%) patients had poor outcome. Main complications were non-union 2 cases and 3 cases of superficial wound infection, which subsided by wound dressing and intravenous antibiotic treatment. **Conclusion:** Free fibular grafting has been proven to be an ideal choice in the management of large segmental bone defects as well as in situations of biological failure of bone healing.

Key words: Long bone defect; Fibular graft; Functional evaluation

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INTRODUCTION

Numerous studies and reports by the World Health Organization indicate that injury is a substantial cause of morbidity and mortality in low- and middle-income countries.[1] The 2013 Global Burden of Disease and Injury study shows that road injuries are the seventh most common cause of disability adjusted life years.[2] The Centres for Disease Control and Prevention indicates that fractures feature in the top-20 first-line diagnoses presenting to emergency departments.[3] A fracture is "any loss in the continuity of bone."[4]

The goals of management are first and foremost, appropriate first aid in the field to protect the bone and soft tissues from further trauma. An envelope of intact skin overlying the fracture is a major contributor to a successful outcome.

Case selection for open reduction and internal fixation should be based on an understanding of the mechanical characteristics and biologic environment of the fracture zone. Fibular strut grafts (with cancellous bone grafts and/or bone graft substitutes) provide a reliable means of treating such conditions in developing countries where bone banks are scarce or not available for allograft procurement.[5,6]

Masquelet technique is an interim procedure, which is widely acceptable worldwide for treatment of long bone osteomyelitis and open fractures with bone loss. It induces a periosteal membrane and also promotes release of growth factors which prepares the fracture bed against graft resorption and toward eradication of infection with an antibiotic impregnated polymethyl methacrylate (PMMA) spacer that preserves dead space volume and length of the limb for delayed reconstruction.[7-9]

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Staged treatment for open fractures with debridement, primary stabilization of fracture with an external fixator and PMMA spacers (beads/blocks) followed by definitive fixation and use of ample amount of bone grafts has been labeled as standard protocol for open fractures of distal femur.[10]

Aims and objectives

The aim of the study was to find out radiological and clinical outcome of fibular graft in complex fracture and non-union of long bones, namely, femur, tibia, and humerus and to study the complications and union time associated with this treatment modality.

MATERIALS AND METHODS

The study was a hospital-based prospective study conducted among 50 cases (40- complex; 10-non-union) long bone fractures using consecutive sampling in the Department of Orthopedics, Maharani Laxmi Bai Medical College, Jhansi constituting both sexes belonging to adult age group presenting with fracture long bone treated by fibular bone grafting from March 2020 to August 2021 among those satisfying inclusion criteria, were surgically fit and written informed consent for study.

Out of 40 complex fractures, 21 were of supracondylar femur fracture, ten were of proximal tibia, three were of distal tibia, and six were of distal humerus. Out of ten non-union cases, three cases were of distal femur, three were of proximal tibia, two were of shaft humerus, and two were of distal humerus.

Inclusion criteria

The following criteria were included in the study:

1. Long bone compound comminuted/closed comminuted fractures of long bone femur, tibia, humerus with significant bone loss
2. Non-union of long bones- femur, tibia, humerus
3. Definite treatment of compound fractures of long bone fractures managed initially with damage control orthopedics
4. Age 18 years–75 years
5. Given written informed consent for study.

Exclusion criteria

The following criteria were excluded from the study:

1. Age <18 years and >75 years
2. Patients medically unfit for surgery
3. Patients not given written informed consent for study

Plan of study

All the cases were treated initially with emergency care in emergency room itself and then once the patient was stabilized, investigated preoperatively. The name of the patient, age of the patient, sex, occupation, and detailed history regarding nature of injury, conscious level, any treatment history, signs of shock, and any emergency treatment were recorded on predefined pro forma. In this history, symptoms of pain, swelling, abnormal mobility, deformity, and loss of function were also recorded. All routine investigations were done including X-ray with antero-posterior and lateral view.

On arrival of the patient in the emergency room, initial emergency management was carried out by maintaining airway, breathing, and circulation. Thorough assessment of the patient was done to rule out head, chest, spinal, or pelvic injury. Musculoskeletal examination was done to look for associated fractures. Then, the fractured extremity was immobilized in splint and sent for radiological examination. For open fractures thorough irrigation and lavage, debridement, intravenous antibiotics and delayed wound closure were done. Proper skeletal fracture and splintage were given according to site of bone and fracture of bone. After obtaining X-ray fracture was classified according to the Muller Association of Osteosynthesis (AO) classification with the help of radiographs.

Pre-operative planning was done to assess the size of plate and screws to be used. Fracture and non-infected non-union cases were evaluated preoperatively by means of complete hemogram, total count, differential count, erythrocyte sedimentation rate, and radiography of the appropriate part. Patient with infected non-union was excluded from the study. The other investigations to assess the general condition of the patients regarding fitness of the surgery were also done. All patients were given intravenous antibiotics before surgery. Posterior approach for humerus and lateral approach for tibia, femur was used.

Radiological union was defined as presence of bridging callus across the cortices. The radiological unions were confirmed by computed tomography scan of all the cases. The clinical union was assessed by absence of deep tenderness and absence of abnormal movement at fracture site. Functional outcome for femur and tibia cases was assessed using Karlstrom-Olerud criteria and humerus cases were assessed using Constant and Murley score.

The study was approved by Institutional Ethics Committee, Maharani Laxmi Bai Medical College, Jhansi. Informed written consent was taken from each patient. The nature and consequence of study was explained to them. Strict privacy and confidentiality were assured.

The data obtained were entered into MS Excel. Descriptive analysis was done using frequency, percentages.

RESULTS

Complex fractures were 80% (40/50) whereas non-infected non-union accounted for 20% (10/50) of study patients. Approximately half patients had femur fractures (48%) (Table 1).

Maximum cases belong to C3 (40%) as per Muller's AO classification whereas A3 cases were lowest (8%) (Table 2).

The defect length in three–fifth of cases was 6–8 cm (60%) (Table 3).

Out of 50 cases, majority of cases 45 (90%) had no complications, 3 (6%) case having infection, and only 2 (5%) were found non-union (Table 4).

Out of 50 cases, maximum case 46 (92%) had no shortening, 1 cm shortening found in 3 (6%) cases, and only 1 (2%) case had 2 cm shortening (Table 5).

For lower limb, the union time was 12–24 weeks in 22 (55%) patients whereas it was 8–12 weeks in 16 (40%) patients. Two patients (5%) showed non-unions. For upper limb, the union time was 12–24 weeks in 6 (60%) patients whereas it was 8–12 weeks in 4 (40%) patients (Table 6).

Functional outcome was excellent in three–fifth (60%) of both upper and lower limb fractures (Table 7).

Table 1: Distribution of cases

Long bone	Complex	Non-union	Total no. of cases	Percentage
Femur	21	3	24	48.0
Humerus	6	4	10	20.0
Tibia	13	3	16	32.0
Total	40	10	50	100

Table 2: Distribution of cases according to Muller's AO classification

Classification	No. of cases	Percentage
A2	14	28.0
A3	4	8.0
C2	12	24.0
C3	20	40.0
Total	50	100

Table 3: Distribution of cases according to defect length

Defect length (cm)	No. of cases	Percentage
6–8	30	60.0
9–11	10	20.0
12–14	10	20.0
Total	50	100

Out of 50 cases, 30 cases (60%) had excellent outcome followed by ten cases (20%) with good outcome and six cases (12%) with satisfactory outcome. Only four cases (8%) had poor outcome (Table 8).

DISCUSSION

In our study, 22 patients (55.0%) had >100° of knee flexion and 18 patients (45.0%) had <100°. The minimum flexion

Table 4: Distribution of cases according to complications

Complications	No. of cases	Percentage
Infection	3	6.0
Non union	1	2.0
None	46	90.0
Total	50	100

Table 5: Distribution of cases according to shortening

Shortening	No. of cases	Percentage
Nil	46	92.0
1 cm	3	6.0
2 cm	1	2.0
Total	50	100

Table 6: Distribution of patients according to radiological union time

Weeks	Lower limb		Upper limb	
	No. of cases	Percentage	No. of cases	Percentage
8–12	16	40	4	40
12–24	22	55	6	60
Total	38	100	10	100

Table 7: Functional outcome of patients

Functional outcome	Lower limb		Upper limb	
	No. of cases	Percentage	No. of cases	Percentage
Excellent (86–100)	24	60.0	6	60.0
Good (71–85)	8	20.0	2	20.0
Satisfactory (56–70)	5	12.5	1	10.0
Poor (<70)	3	7.5	1	10.0
Total	40	100	10	100

Table 8: Final outcome of patients

Final outcome	No. of cases	Percentage
Excellent	30	60.0
Good	10	20.0
Satisfactory	6	12.0
Poor	4	8.0
Total	50	100

obtained was 60° and maximum being 140°. Similar results were found by Sabarisree et al., who used fibular bone grafting with plating for comminuted supracondylar fracture femur with 14 patients (58.3%) had >100° of knee flexion and ten patients (41.7%) had <100°. The minimum flexion obtained was 70° and maximum being 120°.[11] Our results were superior on comparison to other studies like Yeap and Deepak who used locking compression plate (LCP) fixation for distal femoral (DF) fractures without fibula graft and found mean extension was 1° (range 0–5°), with mean flexion 107.7° (range 40–140°). Mean range of motion was from 1° to 107.7°.[12] Zimmermann used LCP fixation in supracondylar fractures of femur in adults without fibula graft with average knee flexion ranging from neutral to 104° with more than 60% patients having knee range of motion from neutral to 110°.[13]

In our study, six patients (60.0%) had >100° of elbow flexion and four patients (40.0%) had <100°. The minimum flexion obtained was 45° and maximum being 150°. Similar results were observed by Boddu et al., 2020, who conducted a study on functional outcome evaluation of distal humerus fracture fixation locking plate with screws without fibula graft. About 77% patients had flexion of >100°, while 23% patients had <100° of flexion.[14]

In our study, out of 50 cases two cases (one case of distal femur fracture and one case of proximal tibia fracture) went into non-union and three cases developed superficial wound infection in our study which subsided by wound dressing and intravenous antibiotic treatment, no case required further surgery. The study by Yeap and Deepak who used LCP fixation for DF fractures without fibula graft found complication in 11 cases which included one implant fracture which required revision to another DF-LCP surgery. There was one mal-alignment of the lower limb. One plate was cutting out due to poor fixation. There were no non- unions, deep infections, or removal of implants due to ilia-tibial tract pain.[12] In Zimmermann study of 20 adults who used LCP fixation in supracondylar fractures of femur with no fibula graft, they found two patients had signs of early postoperative infection which settled with re debridement and intravenous antibiotics. However, there were two cases with failure of fixation, which occurred early in their series. Both were loosening of the proximal fixation of less-invasive stabilization system.[13]

In our study of 50 patients, none of the patients developed the complication of implant failure. In Jhatoth study of 52 patients with distal femur fractures treated surgically by LCP with no fibula graft, two cases had implant failure of screw breakage, same patients had plate back out also.[15]

In our study, four patients had shortening among them 3 had 1 cm shortening and one patient had 2 cm shortening. A study of LCP fixation in supracondylar fractures of femur in 20 adults by Zimmermann nine patients had shortening; eight patients with shortening of 2 cm and one patient with shortening of 3 cm. Patient with 3 cm shortening was managed with heel raise.[13]

In our study, out of 50 patients, 40 patients had femur or tibia fracture out of these 40 cases 16 patients (40%) showed union within 3 months (average=11 weeks) and were allowed weight bearing following union. 22 cases showed radiological union within 6 months (average=18 weeks) following which they were allowed weight bearing. In Jhatoth study of 32 patients with distal femur fractures treated surgically with locking competition plate, with no fibula graft 28 patients (87.5%) showed radiological union within 20 weeks, the average time for radiological union and the mean time for allowance for weight bearing was 16 weeks.[15]

In our study, ten patients had humerus fracture, four cases (40%) showed union within 2–3 months (average: 11 weeks). Following evidence of union, the patients were allowed to perform full daily living activities. In six cases (60%), the union was evident within 3–6 months (average 20 weeks) following which the patients were allowed to perform full daily living activities. In Mahajan et al., study 38 out of total 42 patients with distal humerous fractures treated surgically with LCP with no fibula graft, 17 cases (40%) showed union at 1–3 months which corresponded to performing their daily routine activities while 25 patients (60%) showed union at 3–6 months which corresponded to performing their daily routine activities.[16]

In our study, 30 (60.0%) had excellent functional outcome, 10 (20.0%) had good functional outcome, 6 (12.0%) had satisfactory functional outcome, and 4 patients (8.0%) had poor outcome. Our results were better on comparing the study conducted by Sabarisree et al., who uses fibular bone grafting with plating for comminuted supracondylar fracture femur showed 14 patients with excellent, five patients with good, three patients with fair, and two patients with poor outcome by assessment of Neer's score.[11]

Limitations of the study

The study had few limitations-

1. Heterogeneity of study sample with respect to age, site of fracture, and initial presentation
2. Absence of control group to make definitive conclusion
3. Long-term follow-up required.

Therefore, future studies that address these limitations are warranted to give more detailed picture on role of fibular graft in non-union and complex fractures of long bone.

CONCLUSION

In our study with fibular grafting in these complex cases, we achieved good union earlier and allowed weight bearing earlier comparative to those studies treated by only plate fixation without fibular grafting. In this study we conducted, we could achieve a success rate of 80%, giving good encouraging results to most of our patients. Hence, fibula grafting provides an attractive reconstructive option for orthopedic surgery. Fibular grafting has been proven to be an ideal choice in the management of large segmental bone defects as well as in situations of biological failure of bone healing.

REFERENCES

1. Haagsma JA, Graetz N, Bolliger I, Naghavi M, Higashi H, Mullany EC, et al. The global hurden of injury: Incidence, mortality, disability-adjusted life years and time trend from the gloal burden of disease study 2013. Inj Prev. 2016;22(1):3-18.
   https://doi.org/10.1136/injuryprev-2015-041616
2. Conway DJ, Coughlin R, Caldwell A and Shearer D. The institute for global orthopedics and traumatology: A model for academic collaboration in orthopedic surgery. Front Public Health. 2017;5:146.
   https://doi.org/10.3389/fpubh.2017.00146
3. Frouzan A, Masoumi K, Delirroyfard A, Mazdaie B and Bagherzadegan E. Diagnostic accuracy of ultrasound in upper and lower extremely long bone fractures of emergency department trauma patients. Electron Physician. 2017;9(8):5092-5097.
   https://doi.org/10.19082/5092
4. Luqmani R, Joseph B, Robb J and Porter D. Textbook of Orthopaedic Trauma and Rheumatology. Vol. 2. Amsterdam: Elsevier Health Sciences; 2013. p. 181-189.
5. Lawal YZ, Garba ES, Ogirima MO, Dahiru IL, Maitama MI, Abubakar K, et al. Use of non-vascularized autologous fibula strut graft in the treatment of segmental bone loss. Ann Afr Med. 2011;10(1):25-28.
   https://doi.org/10.4103/1596-3519.76571
6. El-Sayed M, El-Hadidi M and El-Adl W. Free non-vascularized fibular graft for treatment of post-traumatic bone defects. Acta Orthop Belg. 2007;73(1):70-76.
7. Masquelet AC and Begue T. The concept of induced membrane for reconstruction of long bone defects. Orthop Clin North Am. 2010;41(1):27-37.
   https://doi.org/10.1016/j.ocl.2009.07.011
8. Masquelet AC, Fitoussi F, Begue T and Muller GP. Reconstruction of the long bones by the induced membrane and spongy autograft. Ann Chir Plast Esthet. 2000;45(3):346-353.
9. Masquelet AC. Muscle reconstruction in reconstructive surgery: Soft tissue repair and long bone reconstruction. Langenbecks Arch Surg. 2003;388(5):344-346.
   https://doi.org/10.1007/s00423-003-0379-1
10. Thakkar CV and Dwivedi MS. Open distal femur fractures: Treatment principles. Int J Orthop Sci. 2018;4(4):732-736.
    https://doi.org/10.22271/ortho.2018.v4.i4i.89
11. Sabarisree M, Jyotiprasanth M, Babu S and Sunku N. Study of functional outcome of comminuted supracondylar fracture femur treated by planting with fibular bone grafting. J Bone Res Rep. 2017;3(5):1-15.
    https://doi.org/10.4172/2469-6684.100038
12. Yeap EJ and Deepak AS. Distal femoral locking compression plate fixation in distal femoral fractures: Early results. Malays Orthop J. 2007;1(1):12-17.
    https://doi.org/10.5704/MOJ.0705.004
13. Zimmermann AJ. Intra-articular fractures of distal femur. Orthop Clin North Am. 1979;10(1):75-80.
14. Boddu S, Avulapati SK, Chowdary SK and Koneru S. A rare case: Exostosis of right foot. Int J Res Orthop. 2020;6(4):863-864.
    https://doi.org/10.18203/issn.2455-4510.IntJResOrthop20202700
15. Jhatoth DS. Evaluation and surgical management of bimalleolar fractures of ankle joint. Int J Orthop Sci. 2017;3(3):620-623.
    https://doi.org/10.22271/ortho.2017.v3.i3i.98
16. Mahajan R, Agrawal R, Sharma V and Nangia V. Factors affecting quality of management education in India: An interpretive structural modelling approach. Int J Educ Manag. 2014;28(4):379-399.
    https://doi.org/10.1108/IJEM-10-2012-0115

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