Research Paper Medical Science

Usefullness of Fibular Grafts in Various Orthopaedic Indications

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ABSTRACT

Objectives: To study the results of using fibular autograft & its effects on fracture union in various orthopaedic conditions and to study the clinical, functional and radiological outcomes of using fibular autografts. Methods: Prospective study was of 30 patients fulfilling inclusion and exclusion criterias were included in the study and subjected to a detailed clinical, radiological and functional evaluation, clinical photography and were monitored with periodical xrays postoperatively for 9 months

Results:. By the end of 1 month, 14 cases (46.66%) showed radiological evidences of signs of union, in the form of callus & new bone formation and formation of bony trabeculae and also FG hypertrophy. By the end of the 3 months, 19 cases (63.33%) were either in union or united. 25 cases (83.33%) showed radiographic evidences of bony union by the end of 6 months. By the end of the 9 months, we achieved bony union and good incorporation of FG in 26 patients (86.66%) and 4 (13%) patients went into non-union.

Conclusions Non vascularized fibular graft is a simple procedure that is still useful to bridge bone defects; it takes longer duration to achieve union but if used in selected patients with good vascular bed and soft tissue coverage, can yield comparable results to vascularized fibular Also donor site complications are minimal. The procedure should be avoided when the recipient bed is not ideal.

KEYWORDS : Autograft, fibula, orthopaedic, vascularised

INTRODUCTION

Bone grafting is a surgical procedure that replaces missing bone in order bone fractures, that are extremely complex, pose a significant health risk to the patient, or fail, to heal property. Bone grafts are used to treat various disorders, including delayed union and nonunion of fractures, congenital pseudoarthrosis, osseous defects from trauma, infection, and tumors.[1]

Bone generally has the ability to regenerate completely but requires a very small fracture space or some sort of scaffold to do so. Bone grafts may be autogous, allograft, or synthetic (often made of hydroxyapatite or biocompatible substances) with similar mechanical properties to bone. Most bone grafts are expexted to be reabsorbed and replaced as the natural bone heals over a few month's time.

Bone grafting is possible because bone tissue, unlike most other tissues, has the ability to regenerate completely if provided the space into which to grow. As native bone grows, it will generally replace the graft material completely, resulting in a fully integrated region of new bone. The biologic mechanisms that provide a rationale for bone grafting are osteoconduction, osteoinduction and osteogenesis. Osteogenesis only occurs with autografts.[2-5]

Bone grafts may be used for the following purposes:

1. To fill cavities or defects resulting from cysts, tumors, or other causes
2. To bridge joints and thereby provide arthrodesis
3. To bridge major defects or establish the continuity of a long bone
4. To provide bone blocks to limit joint motion (arthrorisis)
5. To establish union in a pseudarthrosis
6. To promote union or fill defects in delayed union, malunion, fresh fractures, or osteotomies
7. To plastical arthrosis of acetabulum for Congenital Dislocation of the Hip and Perthes disease.

Autogenous bone graft obtained from Iliac crest is the most commonly used bone graft today. The iliac crest is an ideal source of bone graft because it is relatively subcutaneous, has natural curvatures that are useful in fashioning grafts, has ample cancellous bone, and has cortical bone of varying thickness. Removal of the bone carries minimal risk and usually there is no significant residual disability. Posterosuperior iliac spine is the best source of cancellous bone.[6]

But cancellous bone grafts are not useful in situations where bone gap at the fracture is bigger and needs to be "bridged" by using a strong cortical graft along with a rigid fixation. Patient's own fibula is, now a days, widely used as the source of cortical bone graft for this purpose.Fibula is one of the most common bones used as Cortical Bone Graft and as osseous transfers, because,

1) Fibula is a strong cortical bone which allows rigid fixation with plates and screws.
2) About „26" centimeters of the bone can be harvested without causing any harm to the subject.

Fibular Grafts are frequently used for bridging the bone gaps in conditions like,

1. Open fractures with bone loss,
2. Cases of Gap Nonunions and Malunions
3. Bone loss caused due to Resection of Bone Tumours

Vascularised fibular bone graft along with its muscle flap is also widely used in the cases where bony as well as muscular reconstruction is needed, especially in cases of open fractures of upper and lower extrimities. Vascularized fibula based muscle flaps are also commonly used for Mandibular and facial reconstruction surgeries.Also, using smaller fibular strut grafts for cervical / lumbar vertebral body fusion in cases of cervical / lumbar corpectomy, is a common orthopaedic practice.

METHODS The present study was of 30 patients who were compatible with the inclusion criteria. Patients fulfilling inclusion and exclusion criterias were included in the study and subjected to a detailed

clinical, radiological and functional evaluation, clinical photography and were monitored with periodical X rays postoperatively.

a. **Design**: Prospective
b. **Place Of Study**: LTMGH and LTMMC, Sion, Mumbai
c. **Proposed Duration Of Study:** 9 (nine) months
d. **Sample Size:** Minimum of 30 (Thirty) patients
e. **Inclusion Criteria :**
   - Ø Subjects in age group 3 years to 60 years.
   - Ø Male and female subjects are included.
   - Ø Subjects with documented Radiological and clinical fea turs suggesctive of fracture of bone, nonunion / malunion of bone fracture and bone gaps and bony deformities, who have been treated with use of Fibular Grafts.

f. **Exclusion Criteria**
   - Ø Subjects having HIV / HBsAg.
   - Ø Subjects < 3 years and > 60 years of age
   - Ø Subjects who are known case of Psychiatric disorder.

g. **Sampling Method**

Patients who were operated in LTMMC and LTMGH, Sion, Mumbai and patients who were operated elsewhere and then referred to LTMMC and LTMGH, Sion, Mumbai and who fulfilled all the Inclusion and Exclusion criterias were included in the study, after obtaining their valid informed consent.

h. METHODOLOGY:

Subjects with documented Radiological and clinical features suggestive of fracture of bone, nonunion / malunion of bone and bone defects and bony deformities, who have been treated with the use of Autologous Fibular Grafts are selected & followed up. Their timely x-rays have been obtained and studied. Radiological features like, fracture union & its rate, time required for union in various indications and evidence of any infection are observed and studied. Clinical features like healing of the operated area and healing of the bone graft donor area are observed and studied. Functional assessment like range of motion, active and passive movements in operated and donor limbs and their functional outcomes are observed. Donor site comlpications are also observed.

Table 1: Indications for vascularized fibula grafting

Segmental bone defects Greater than 6 – 8 cm	Traumatic bone loss
	Tumor resection
	Osteomyelitis
	Infected nonunion
Biological failure of bony healing	Persistent nonunion
	Osteonecrosis
	Congenital pseudarthrosis

Table 2:- Gustilo Anderson Grading for open fractures[6]

Type I	Wound less than 1cm. Minimal soft tissue injury. Wound clean.
Type II	Wound greater than 1cm. Moderate soft tissue injury. No large flaps/avulsions.
Type III	High energy injury. Exenstive dagamge to or loss of soft tissues.
Subtype IIIa	Type III with adequate coverage of bone despite extensive soft tissue injury.
Subtype IIIb	Type III with bony exposures, soft tissue loss and periosteal stiping.
Subtype III C	Type III associated with arterial injury requring repair.

Table : 3 Results At 1,3,6 and 9 Months

Union		At 1 month	At 3 month	At 6 month	At 9 month
No Signs Of Union	Count	16	11	5	4
	Percent(%)	53.33	36.67	16.67	13.33
Signs Of Union	Count	14	5	6	1
	Percent (%)	46.67	16.67	20.00	3.33
United	Count	0	14	19	25
	Percent (%)	0.00	46.67	63.33	83.33
Total	Count	30	30	30	30
	Percent(%)	100.00	100.00	100.00	100.00

Table 4 : Complications seen in this study

	Complications	No. Of Cases	Percentage (%)
Recipient Site	Infection	3	10
	Nonunion	4	13.33
	Stress Fracture	0	0
Donor Site	Long Term Pain	0	0
	Infection	1	3.33
	Nerve injury	0	0
	Muscle weakness	0	0

STATISTICS

Data Recording :All the information obtained on the preoperative evaluation and at each and every follo-up was recorded in a pre-designed case record form.

Data Analysis :Data was analysed using SPSS (Version-15) software. Quantitave data is presented with the help of Mean, Standard Deviation, Median and IQR.Correlation among study groups is assesed with Pearson's correlation coefficient**.Qualitative data is presented with the help of Frequency and Percentage table, association among study group is assesed with the help of Chi-Square test.P- value less than 0.05 is taken as significant level.

OBSERVATIONS AND RESULTS

OBSERVATIONS IN POSTOPERATIVE EVALUATION

Postoperative evaluation was done on post-op day 1. All patient went through the same protocol i. e. radiological, clinical, and functional evaluation. Postoperative clinical-functional evaluations showed no difference as compared to preoperative evaluations. Active and passive ROM exercises were started in the ward itself, only when was comfortable to attempt them. All the patients were taught these exercises and were advised to do them regularly at home, after discharge.

POSTOPERATIVE ASSESSMENT OF FG DONOR SITE

On post-op day 1, every patient was evaluated for four important complications related to FG donor site, such as :i. Peroneal Injury, ii. Weakness Of Peroneus Longus,iii. Knee instability, iv. Ankle Instability.

In 24 cases, FG was harvested by using Minimally Invasive technique and in other 6 cases by using Open Method. In all patients, FG was harvested from middle one third to two thirds of its length, sparing the proximal and distal ends of fibula. This avoided knee and ankle instability. So, there were no postoperative evidences of knee or ankle instability in any patient.

FOLLW-UP AT 1 MONTH : At the very first follow-up, i.e. at 1 month postop., out of 30 patients, 14 patients (46.66%) showed signs of bony union (i.e. formation of bony trabeculae and callus, hypertrophy of FG) over their radiographs. Fibular graft was found to be at its place with definite hypertrophy in all the 14 cases at 1st follow-up. There were no donor site related complications. All the 14 patients in union showed improvement in functional outcomes in the form of increase in range of motion. Many of other 16 patients with no signs of bony union over radiographs also showed increase in range of motion, owing to their daily passive mobilization excercises. There was no any evidence of infection at graft donor or recipient site at 1 month follow-up.

AT 3 MONTHS :Another 5 cases showed signs of bony union over the radiographs and also previous 14 cases showed radiographic evidence of solid union. Thus, total 19 (63.33%) cases were either united or were in union by the end of 3 months. Previous 14 cases showed well incorporation of fibular graft at graft recipient site. There were no donor site related complications, except one patient showed evidence of infection at donor site and was immediately treated accordingly. Except the cases with chronic osteomyelitis, other patients showed significant amount of increase in their range of motion at operative as well as donor

At 6 Months: Another 6 cases showed signs of bony union and also previous 19 cases (63.33%) showed radiographic evidence of solid union by the end of 6 months. This means total 25 cases (83.33%) were either united (19) or in union (6) by the end of 6 months. 3 cases showed evidences of infection at operative / graft recipient site at this follow-up. They were taken care of accordingly. Except the cases with chronic osteomyelitis, other patients showed significant amount of increase in their range of motion at operative as well as donor limb.

At 9 months : showed not much of a difference in the results of bony union as only 1 case showed signs of union over radiographs. Thus total 26 (86.66%) cases were either already united (25) or in union (1) by the end of 9 months. All the patients showed good clinical and functional outcomes, except those with osteomyelitis and preoperative joint stiffness due to chronic trauma. Thus, by the end of this study (in a period of 9 months), we achieved bony union and FG incorporation with its definite hypertrophy at recipient site in 26 cases (86.66%) out of 30 and 4 cases (13.33%) were still in nonunion with no signs of union over their radiographs. Out of the 4 cases with nonunion, 3 cases showed evidences of infection at operative / graft recipient site and other case showed nonunion but no signs of infection.

DISCUSSION

Defects in long bones pose a great challenge to the orthopaedic surgeon. These can arise in long bones due high energy trauma, osteomyelitis or malignancy.[7,8] Sometimes, bone defects are created by surgeons to relieve nerve compressions, as in spinal surgeries while doing corpectomy. If untreated, such bone defects can lead to unacceptable shortening and may render extremity unfit for use.[9-12]

In 1877 Albert first proposed the use of the fibula as a substitute for the tibia. He obtained fusion between the fibula and the femur in a patient with congenital absence of the proximal tibia[13]. Since then, the fibula has been used as a substitute for a missing segment of tibia or to reinforce a weakened section.[14,15]

Several surgical methods are available for bridging bone defects : bone grafting, free vascularized & non-vascularized fibular grafts, or bone transport with an external ring fixator.[16-20] Non-vascularized cortical autografts have been used for reconstruction of skeletal defects of long bones since long.[21,22,23] The grafts are usually removed from fibula, iliac crest or tibia.Fibular graft is a good surgical option among other available options. Fibula is the strongest autogenous bone graft available when compared to other cortical autograft donor sites such as iliac crest and anterior tibial shaft. When used with internal fixation methods, fibular grafting stabilizes the fracture and hastens union. Less donor site morbidity associated with removal of fibular graft has popularized its use. Although free vascularized bone grafts have been advocated recently , the older methods of bridging these gaps with autogenous non-vascularised bone grafts are still successful . Traumatic diaphyseal bone defects of the forearm larger than 6 cm can best be managed with a fibular graft with excellent functional and cosmetic results.

In our study, we covered 6 various indications and 8 different operative sites with bony defects, where fibular grafts were used to cover the bone defects or to support and stabilize the fracture, which hastened its union.„Bony defects after trauma‟ was the one of the 6 indications contributing to maximum number of the cases (11 out of 30) and „Tibial Shaft‟ contributed maximum number amongst the operative / graft recipient sites (12 out of 30) included in this study. All the patients underwent a series of radiological and clinico-functional evaluation preoperatively, intraoperatively and postoperatively & at each follow-up at 1 month, 3 months, 6 months and 9 months.

By the end of 1 month, 14 cases (46.66%) showed radiological evidences of signs of union, in the form of callus & new bone formation and formation of bony trabeculae and also FG hypertrophy. By the end of the 3 months, 19 cases (63.33%) were either in union or united. 25 cases (83.33%) showed radiographic evidences of bony union by the end of 6 months. By the end of the 9 months, we achieved bony union and good incorporation of FG in 26 patients (86.66%) and 4 (13%) patients went into non-union. All the united 26 cases showed excellent functional outcomes with drastic increase in their movements and range of motions in the operated as well as FG donor limb.

There was no evidence of Graft Donor Site complications like long term pain, muscle weakness and Peroneal Nerve Injury in any case. Infection at the operative / graft recipient site was the reason behind the non-united cases. Only one case showed evidence of infection at Graft Donor Site.[24]

Bone gap / bone defect is a challenging problem and the different methods available to treat it include use of are autografts, allografts and bone lengthening procedures. Allografts are expensive and require specialized set up. Also there is risk of Complications associated with allografts namely – disease transmission and immunogenic reactions. Moreover, allografts are poorly taken up as compared to autografts.

Auto grafts result in good uptake of graft. There is no risk of disease transmission or immune reaction which are associated with allograft. They can be augmented with routine fixation methods thus requiring no special surgical skills. Fibula is the most suitable bone to transfer for a large defect in a tubular bone because of its established length, geometrical shape and strength and low donor site morbidity. In addition to its strength both fibulas can be used when required. Proximal fibula can also be used for reconstruction of defects in distal radius as an osteochondral graft. It provides considerable amounts of wrist motion and forearm rotation when compared with graft from ilium, tibia or wrist prosthesis.[25]

Several studies have shown that vascularized grafts are significantly stronger than conventional non-vascularized grafts, but it is technically difficult and occasionally impossible. Economy of time and equipment to microsurgical techniques, which still remains important consideration for many orthopedic surgeons can't be overlooked. While a high incidence of stress fractures has been reported with non-vascularized grafts, they have also been shown to occur with free vascularized grafts.

In our study, there was no instance of fracture of the graft. Stable fixation & proper positioning of FG were the probable reasons behind this. Our results confirm what had been found by Falder et al, who noted that long term behavior of the Non-vascularised FG, which responds physiologically to biomechanical loading, resulted in complete "tibialisation" of the fibula and also in cases of bone defects of humerus shaft, the fibular graft used there transformed into humerus shaft itself.

There is a linear correlation between length of the bone defect (length of FG used) and time required for bony union, FG incorporation and its definite hypertrophy. Infection is the most frequently occurring and most serious postoperative complication, which, if not treated on time, leads to nonunion of the fracture and failure of the graft incorporation.[26] While practicing in the hospitals in government setups and in remote areas, orthopaedic surgeon may face problems like,

a) Not being experienced with use of advanced techniques like Ilizarov fixation for treating bone defects
b) Patients are non-compliant
c) Cost factor : patients can't afford expensive implants or allografts
d) Unavailability of allografts

In such situations, autologous fibular grafting is a superior and usefull procedure which requires simple instruments, has comparable success rate to other advanced procedures and is not at all costly.

CONCLUSION : Non vascularized fibular graft is a simple procedure that is still useful to bridge bone defects; it takes longer duration to achieve union but if used in selected patients with good vascular bed and soft tissue coverage, can yield comparable results to vascularized fibular grafts in terms of overall union. Also donor site complications are minimal. The procedure should be avoided when the recipient bed is not ideal like atrophic fracture nonunion and post-traumatic infective non- unions, bone defects with osteomyelitis. Thus, fibular grafts have versatility with respect to their uses in different conditions and their usefulness must be studied further.

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