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Free Vascularized Fibular Graft

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ABSTRACT

Background: Free Vascularized Fibular Grafts (FVFGs) are currently a mainstay for extreme case reconstruction mainly due to their anatomical characteristics, reliability, and versatility in managing all bone defects cases.
Method: This paper is a review article of the journal found by the author suitable for our reference in search engines with the keywords "Free Vascularized Fibular Graft" "surgery" "postoperative" and "complications".
Results: FVFG can be used as management of bone defects such as post-trauma, infection or tumor, treatment of congenital abnormalities, avascular necrosis (AVN), arthrodesis, and pediatric pathology. Position Placement, Intercalary Resection, Bone Tumor Resection, Fibula Flap Retrieval, Allograft Preparation, Reconstruction at Recipient Site, and Intra-articular Resection need to be considered in the surgical procedure. Postoperative Monitoring in the ICU is necessary to evaluate Vital signs, flap viability, axle well as complications in patients.
Conclusion: FVFG is a choice of bone defect reconstruction techniques with good results to be considered by orthopedic surgeons.

Keywords: Free Vascularized Fibular Grafts, FVFG, Surgery post-operative, complication

INTRODUCTION

Bone defects caused by trauma, tumours, infections, or congenital anomalies are clinical problems that often cause significant defects in patients, such as spinal fusion failure, complex arthrodesis, and avascular necrosis (AVN) of femoris caput. Free Vascularized Fibular Grafts (FVFGs) could effectively manage such cases.[1]

Most cells remain alive at vascular grafts. Retain bone reformation and bones can integrate and become hypertrophy. In these cases, grafts and recipient bones are almost always unified and often exhibit healing characteristics like simple fractures. One of the graft with good vascularity that can be taken is fibula-based including its vascular supply. This graft can be pedicled or free. [1–3]

FVFG has become the most used free vascularity bone graft. FVFG was originally used to treat post-traumatic bone defects, but indications expanded to include bone defects due to congenital abnormalities, infections, tumours, problematic arthrodesis[4] and AVN caput femoris.[5] FVFG is currently a mainstay for extreme case reconstruction mainly due to its anatomical characteristics, reliability, and versatility.

RESULTS AND DISCUSSIONS

Anatomy

Fibula is a long bone with a narrow cross section and able to act as a strong cortical buffer for reconstruction of long bone defects. The fibula has a square cross section at the top and a triangle at its inferior end. [6] In adults the width can reach 1.5 - 2 cm and length 35 cm, whereas 25 to 30 cm of that length can be harvested for free grafting. The shape and length of the fibula can match the segments of the extremity bone as well as adjust the

medullary canal of the lower extremity bone. Therefore, fibula is an excellent choice to reconstruct bone damage in these places.[1.7]

The blood supply and drainage of the fibula stem is associated with peroneal blood vessels.[1,6,7] Fibula get vascularity through endosteal and periosteal vessels. [1.7]The peroneal artery, along with two peroneal concomitant veins, follows a pathway parallel to the fibula and is located between the flexor muscles of the hallucis longus and the posterior tibialis places.[1.7] (Figure 1)

Osteotomy Techniques

The unique morphological characteristics and blood supply of fibulas allow the use of fibula flaps for the reconstruction of bone defects, soft tissues, and growth plates.[8.9] Fibular flaps can be moved in a variety of configurations and compositions to suit the needs of each case. In straight configurations, fibula can be used to reconstruct relatively narrow bone segments (Figure 2). [1.7]

Figure 1. Vascularity of fibula bones.[7]

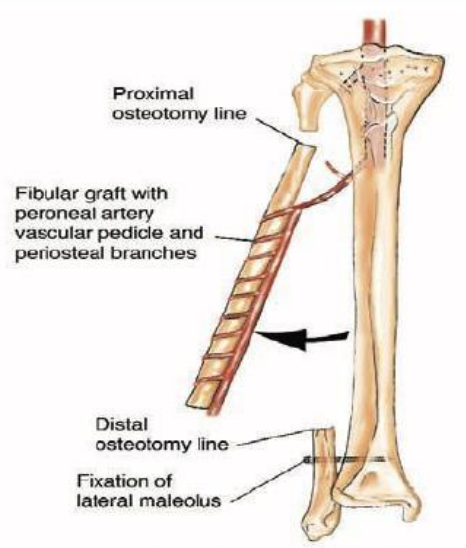

Figure 2. Graft diaphysis fibula.[7]

Longitudinal osteotomy that increases the surface area of the flap can serve as anon lay graft to improve the healing process of partial defects of the cortex. Based on the perforation of fascio-cutaneous branches in one-third of the medial and distal of the pedicle, a 20 x 10 cm long skin paddle can be transferred simultaneously to facilitate coverage of large soft tissue damage and to monitor the patency of peduncular anastomosis (Figure 3a-3).

Part of the soleus or flexor muscle of the hallucis longus can also be inserted with a flap to reconstruct damage to soft tissues and cover openbones.[1.7]

Transverse osteotomy can be performed through mid-diaphysis to produce two or more cortical buffers on one pedicicle (double barrel or triplebarrel) to reconstruct a wide bone segment. When periosteal vessels are transposed, the bone persists in the endosteal system. Proximal epiphysis can be included in the flap for joint reconstruction and preservation of longitudinal growth potential (in paediatric patients) after intra-articular resection of bone tumours (Figure 4). These flaps are based on anterior tibial vascular flaps or descendent geniculate arteries and are most commonly used for reconstruction after proximal humerus resection and distal radius [1–3.7]

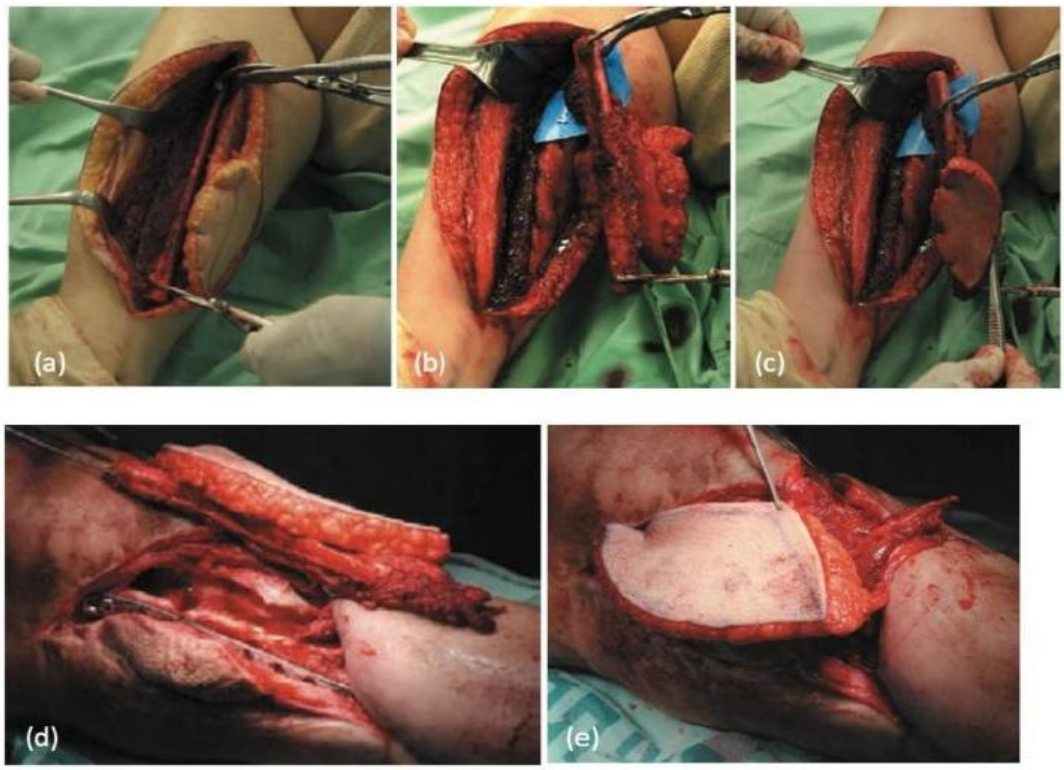

Figure 3.(a-e) Paddle skin transferred simultaneously[4]

Indication

FVFG in trauma, infection, and tumours

FVFG is often used for the management of extensive post-traumatic defects caused by high energy trauma as well as extensive post-traumatic non-union defects. [8,9] The approach to this injury is done in a standard way, namely the prophylaxis of tetanus and antibiotics, irrigation, and debridement of radical wounds. Immediate bone stabilization is usually achieved with an external fixator. [10] In the context of a wide injury zone with significant irreversible tissue damage/loss and a bone defect > 6 cm, FVFG can facilitate the reconstruction of one complete stage and can be done in the early stages of healing such wounds. [1,3,7]

Bone defects occur after the debridement of infected radical tissue requires a gradual approach and can rarely be treated at once. Various techniques have been commonly used, including Ilizarov distraction osteogenesis. However, it often requires long hospital treatment and is oppressed with a variety of possible complications. [11] Patients with this condition often have poor healing qualities, poor vascularity, scarring, immobile tissue, and reconstruction of osteo-cutaneous FVFG, osteo-muscular or single stage osteo-musculocutaneous may be preferred (for surgeons and patients) if successful in securing microvascular anastomosis. Appropriate blood vessels may not be available for microsurgical tissue transfer and arteriovenous fistula (AV) may be necessary to improve the success of microvascular anastomosis. [1,3,7]

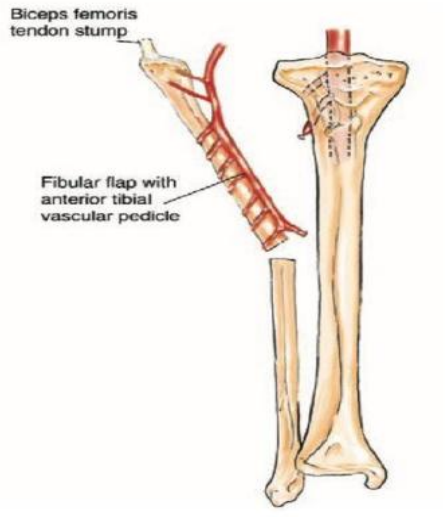

Figure 4. Proximal fibula graft[7]

FVFG in congenital abnormalities

Although it has been successful in the treatment of many congenital abnormalities, FVFG is currently most used to treat congenital pseudoarthrosis tibia (CPT) which is very difficult to treat, and many of the patients end up with amputations. FVFG is a good alternative as a one-stage corrective procedure, with 78% of patients achieving bone unification and avoiding the need for further surgery (Figure 6). Recovery in FVFG patients is relatively rapid with bone unification and hypertrophy grafting on average within four months. FVFG is usually indicated in cases with more than 3 cm defect or in case of previous failed operations. [1.7]

Figure 6. *Congenital Pseudoarthrosis of Tibia*(CPT) right tibia after FVFG.[1]

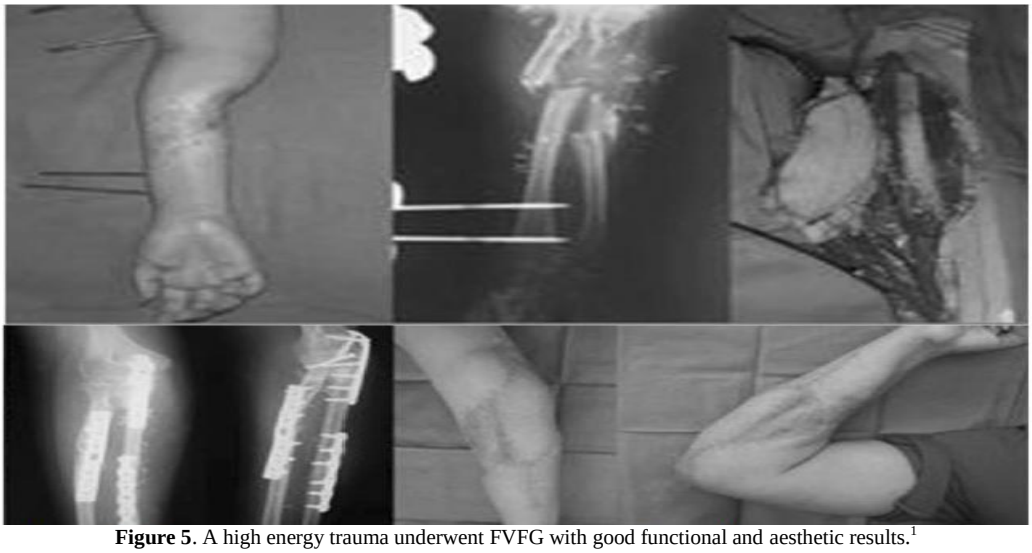

Figure 5. A high energy trauma underwent FVFG with good functional and aesthetic results.[1]

FVFG in avascular necrosis

Vascularized graft can be used in AVN management in various anatomical locations, most used in young patients with hip AVN (Figure. 7). AVN hips tend to develop rapidly and culminate in degenerative hip arthritis. The results of a number of surgical techniques are unpredictable, especially in the final stages ofFicatdisease.[10] The use of FVFG is to reduce intraosseous pressure by eliminating necrotic tissue, preventing subchondral collapse and revascularization of caput femoris. Packing defects with allograft bone

chips or calcium sulphate crystals is recommended before implanting FVFG. Only 8% of patients needed joint replacement in one study, and surgery delays were up to seven years in 70% of patients in another research report. FVFG has also been successful in treating adolescents with post-traumatic AVN, increasing the Harris Hip Score (HHS) from 60.4 to 94.2, and seems to provide more successful results than other joint preservation procedures. Ultimately, the success of FVFG depends on the aetiology, stage and size of the AVN.[1,7,12]

FVFG in arthrodesis

FVFG can be used for joint arthrodesis after tumour resection, in cases accompanied by infection or when soft tissue with poor conditions after radiotherapy and chemotherapy. FVFG is also an effective treatment in treating a variety of spinal pathologies, including broad segmental defects and where spinal fusion has failed to use other conventional methods, such as non-vascular bone grafts.[1.7]

Contraindications and Special Considerations

There are several contraindications to FVFG, for example in the case of systemic conditions and common circumstances where there are cardiovascular and haematological abnormalities that can affect peripheral blood flow or when the patient's compliance is low and if the patient's condition does not allow extended on-weight-bearing periods and rehabilitation. Another consideration to consider is the location of the donor. The history of injuries that cause fibula deformity, vascular injury, history of lower limb injury and vascular neglect are also contraindicated. The presence of infection and suspicion of recurrence of tumours at the donor recipient's location is contraindicated that must be known at the time of examination at the donor receiving location. [1,3,7]

Operating Techniques

Pre-operative planning for FVFG begins with screening and exclusion of patients with peripheral vascular disease, deep vein thrombosis or previous damage to blood vessels. Surgeons should be aware that 8% of the population will experience hypoplasia or the absence of one or both anterior and posterior tibialis arteries, a condition called peroneal arteria magna, and the taking of FVFG in these patients may interfere with the crural circulation of the patient. [1–3.7]

Figure 7. Avascular necrosis (AVN) in caput femorisafterFVFG 6 years.[1]

The design of the flap depends on the pathology needs of the patient and whether tissue other than bone is needed. In each case, it should be remembered the peroneal artery should not be separated from the fibula bone during grafting. It should be noted that the main nutrient artery enters the fibula in the middle third of the bone, and

sometimes in its proximal part, therefore FVFG must cover that part of the bone. The size of the defect will determine the required bone length, at least 6 cm from the proximal and 4 cm from the distal fibula should be left in the donor place. Lateral surgical approach is the most common approach bone flaps: Gilbert's modification of Taylor's original posterior approach is required when removing osteo-muscular or proximal epiphyseal flaps. [1–3.7]

Position Placement

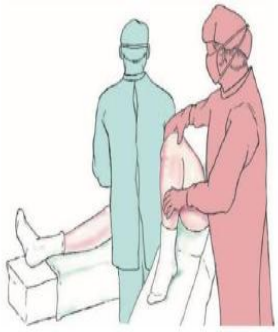

Figure 8. Placement of the patient's position during the FVFGprocedure [7]

The patients are placed on their back with his thighs open on the operating table for the repair procedure of bone defects in the lower extremities. Hips and knees of the donor extremities are bent subsequently (Figure 8). The first team, responsible for performing tumour resection (blue), is placed along the medial or lateral side of the recipient extremity. The second team (red), responsible for the taking of fibula flaps from the donor extremities, is placed along the lateral aspect (Figure 8). To minimize the duration of surgery, if the patient's position on the operating table allows, a fibular flap is taken while the recipient site is being prepared, the procedure may be primary bone tumour resection or spacer removal that has been used in previous operations for reconstructive purposes. [1–3.7]

Intercalation Resection

Based on established rules, the fibula is vascularized in a straight and simple configuration sufficient to reconstruct bone defects in the upper extremities due to its narrow cross-sectional diameter. The reconstruction of defects in the lower extremities requires graft materials with a larger diameter as additional mechanical support is required. Double barrel fibular flaps can be used to reconstruct femur and tibia defects up to 13 cm long. Longer defects may require support from allograft, which can provide the initial stability necessary for bone healing, graft merging, and subsequent hypertrophy of fibula. Combined reconstruction techniques with allograft and vascularized fibulas, as described by Capanna et al, provide such stability and are the preferred methods of reconstruction to correct long intercalary defects in the lower extremities. [1–3.7]

Bone Tumour Resection

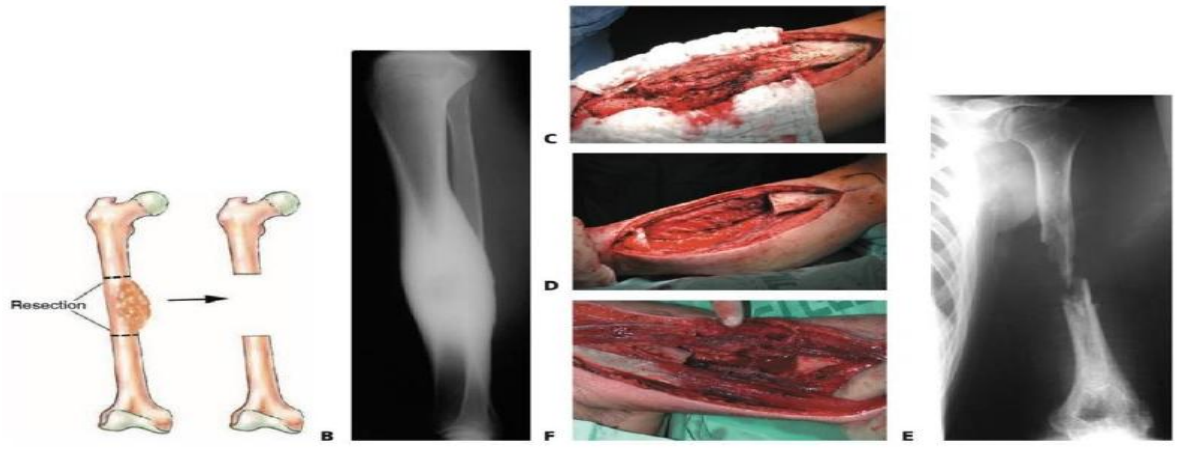

Figure 9. A. Wide-edge diaphyseal tumours leave a long-intercalated bone defect. **B.** broad *low grade* diaphyseal osteosarcoma. **C.** Photo of an intraoperative tumour. **D.** Large intercalated defects after extensive tumour resection. **E.** loss of many bones and pathological fractures associated with acute osteomyelitis in humerus diaphysis. **F.** resection of infected bone tissue leaves a long bone defect. [7]

Bone tumours are removed according to standard techniques, and the length and diameter of intercalated bone defects are then measured. (Figure 9)

Fibula Flap Retrieval

Using an anterolateral incision in the contralateral leg, an intercalary fibular segment longer than 6cm from the bone defect is taken, along with nutrient artery and periosteal cuff (Figure 10 A, B). If there is large skin defect, the fibular flap is taken with the part of the skin supplied by the same peroneal artery, which allows tension-free skin closure as well as early detection of the flap's impaired viability. If a long bone segment is required and the osteotomy is performed close to lateral malleolus, screw fixation to the tibia is recommended to prevent valgus deformity and ankle instability (Figure 9B). [1–3.7]

Figure 10. Removal of fibula graft. **A.** fibula graft retrieval. **B**. Intercalary fibular segment, lifted with nutrient *artery* and periosteal cuff.**C.** Fibula grafts are removed to cover the damage and to monitor flap viability. [7]

Allograft Preparation

The allograft is cut to the same length as he boned effect and a groove is opened longitudinally by removing as many parts of the bone cortex and pars spongiosa necessarily to allow the insertion of fibula flaps into it. [2.7]

Reconstruction at recipient site

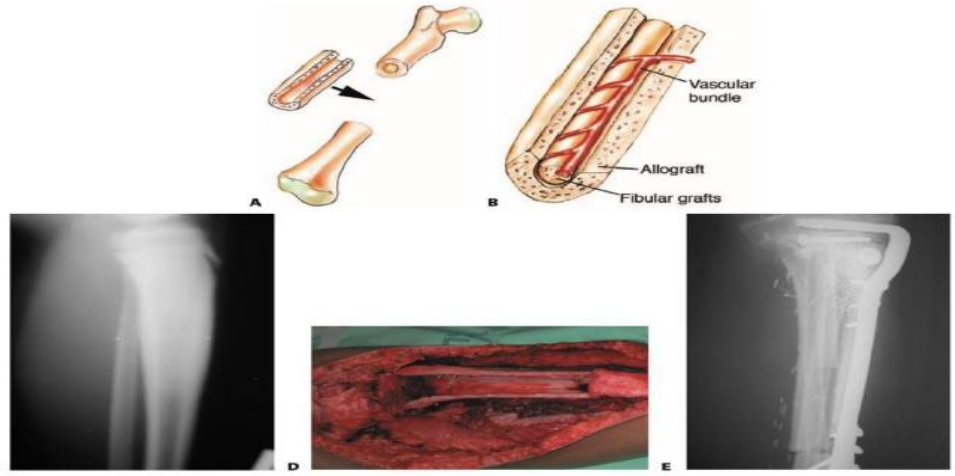

Figure 11. A. Allograft is cut and made slit for insertion of fibula grafts. **B.**Artificialdefects for the passage of vascular pedicles of fibula. **C.** The extent of proximal tibia osteosarcoma allows intercalation resection. **D.** Reconstruction of bone defects with allograft. **E.** Graft fibula in allograft medullary canal fixated *screw*.[7]

Allograft is inserted to fill defects in the bone and is mounted on the proximal and distal edges with side plates and screws (Figure 11 A, B). Intramedullary nail is also used if the allograft medullary canal is wide enough to hold both nail and graft fibulas. Using high-speed burrs, defects are created in the allograft cortex at appropriate levels to allow the passage of fibula vascular pedicles to vascular bundles of recipient extremities while avoiding traction in vascular anastomosis (Figure 11 A, B). Fibular grafts are inserted 2 to 3 cm into the medullary canal at both ends and fixated with screws (Figure 11 C–E). Fibulas can be placed in an intramedullary location, inside the allograft or parallel to it, should be located close to the edge of the original long bone resection. After vascular anastomosis is complete, autologous bone grafts, taken from the rest of the fibula flap or ipsilateral cristailiac, are used to strengthen the surface between the fibula and the recipient bone.[2.7]

Intra-articular Resection

Proximal fibula epiphysis, with varying diaphyseal lengths and with anterior tibialis blood vessels as vascular pedicles, or alternatively, inferior geniculate arteries, is used to reconstruct defects that cover one side of the articular surface. After removal of the fibula flap, the lateral collateral ligament is secured to the medial tibial meta physical part with metals lings hot to maintain the stability of the lateral knee joint (Figure 12. A). The proximal aspect of the fibula flap is mounted on radial diaphysis or humerus with side plate and screw, and the biceps tendon stump is used for attaching the soft tissue sheath of the opposite articular surface (Figure 12B-E).[2.7]

Post-Operative Care

Every FVFG postoperative patients are treated and closely monitored (vital signs and flap viability) in the intensive care unit (ICU) during the first 5 days after surgery. Administration of a high volume lactic ringer solution (1.5 times the maintenance dose) is administered to ensure high flow through anastomosis and prevent the formation of thrombus maintained for 3 days, with a gradual decrease to the normal maintenance volume within the next 2 days. [2,3,7]

Enoxaparin is administered in post-FVFG patients to prevent deep vein thrombosis. Haemoglobin levels of patients should be maintained at 9 to 10 g / ml to lessen blood viscosity and further reduce the likelihood of anastomotic thrombus. Technetium Methylene Diphosphonate Bone Scan with single-photon Emission Computed Tomography was performed 10 days after surgery to evaluate flap viability. The recipient extremities are immobilized for 3 months (upper extremities with braces, lower extremities with plastic cast), followed by sports programme with a gradual passive range of motion (ROM). The signs of bone unification are evaluated with serial plain radiography. Bone unification is usually seen after 4-5 months in the upper extremities and after 5-7 months in the lower extremities. Partial weight-bearing is allowed after radiological evidence of bone unification has occurred and is recommended until full weight-bearing is achieved. [2.7]

Complications

Early complications include massive bleeding at the site of microvascular anastomosis due to technical errors or after failure of the formation of adequate haemostasis. Thrombosis anastomosis can also occur due to surgical techniques as well as poor selection of recipient blood vessels (limited arterial flow and/or slow venous drainage), inadequate peroneal pedicle length and vascular pedicicular torsion. Compartment syndrome at the donor site can occur due to poor haemostasis or tight close of the inner fascia (especially with enterocutaneous flaps). Long-term complications include non-union and inadequate graft hypertrophy due to inadequate vascularity at the graft site. Infection can also occur sometime after the FVGF procedure due to vascularity of the FVFG and poor soft tissue cover, as well as

due to initial debridement/ resection of the infected bone focus. Graft fractures can also occur, 35% have stress fractures in the tibialis and32% in the femur. There have been numerous reports of donor-recipient morbidity, muscle weakness, leg pain, and ankle valgus deformity, which have not been fibular transfection or too few residual fibula bones left behind.[1–3.7]

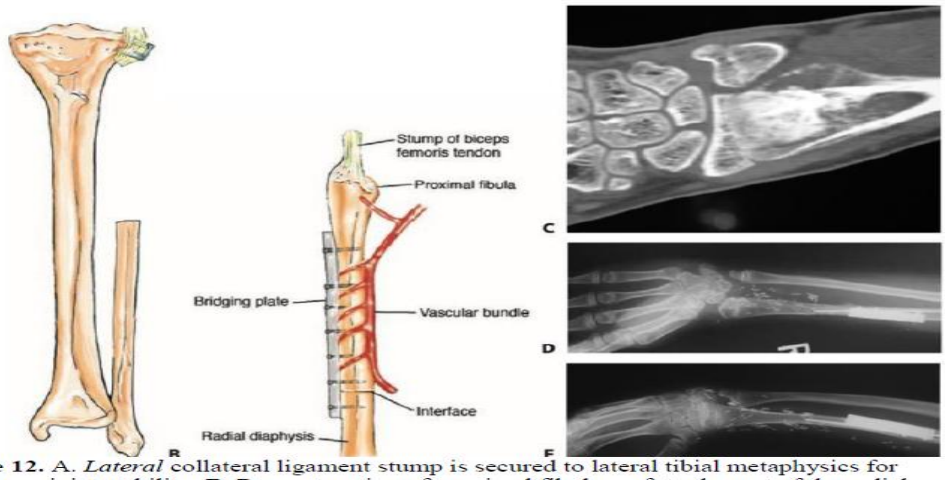

Figure 12. A. *Lateral* collateral ligament stump is secured to lateral tibial metaphysics for lateral knee joint stability. **B.** Reconstruction of proximal fibula graft to the rest of the radial diaphysis. **C.** CT osteosarcoma distal radius. **D, E.** A plain photo reconstruction of an intercalary defect with proximal fibular graft. [7]

CONCLUSION

Bone graft is a common procedure often used in all orthopaedic surgical specialties, and an understanding of the principles and techniques of bone graft is essential for the treatment of post-traumatic musculoskeletal conditions, bone development disorders, as well as for reconstructive purposes. Free Vascularized Fibular Grafting (FVFG) is a choice of bone defect reconstruction techniques with good results to consider by orthopaedic surgeons as it can provide immediate structural and vascularity support, as well as permanent osteoconductive, osteo-inductive, and osteogenic properties. Its characteristic of survival of the most cells, integration of the bone makes graft fuse well and suitable for large segmental bone defect management.

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