ORIGINAL ARTICLE

An early experience of reconstruction of foot tripod with free fibula flap

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Abstract

Objectives: To evaluate the role of vascularised free fibula osteocutaneous flap for reconstruction of first metatarsal bone.

Study design: Experimental Study

Setting: Plastic Surgery unit, Hayatabad Medical Complex, Peshawar from March 2015 to February 2018.

Subjects: Five male patients between the ages 24–44 years.

Material and Methods: This experimental study was conducted at the Plastic Surgery Unit, Hayatabad Medical Complex, Peshawar from March 2015 to February 2018. A total of 5-male patients underwent reconstruction of complex fore-foot defects involving the metatarsal bone and overlying soft tissues. All the defects were traumatic in nature. Vascularized free fibula oseteocutaneous flap was use to reconstruct the complex defects of foot involving the metatarsal bone.

Results: There were 5-male adult patients with post-traumatic defects of the fore-foot. The age of the patients ranged from 24-44 years and the mean age was 32-years. The indications for the reconstruction were damage to the first metatarsal bone which is an essential component of foot tripod. Initially wound debridement was done and delayed reconstruction of the metatarsal bone was performed with free fibula osteocutaneous flap. All the flaps survived completely. Problems of delayed wound healing, graft loss at donor site, donor site scarring, paresthesia in the foot were observed in few patients. All the patients were ambulant and started walking at 12th week post-operatively.

Conclusions: Free fibula osteocutaneous flap is an ideal option for reconstruction of complex defects of the fore-foot. The advantage of fibula is its adequate length and bone density which resembles the morphology of metatarsals. The flap has fewer complications and produce better structural and functional outcomes.

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Introduction:

Human foot is a complex dynamic structure which plays a dual role in the human body. In standing position it acts as support for the body. During walking and running it acts as a mobile spring board. The tripod refers to three points of contact, the bottom of the foot makes with the ground. In standing position, about one third of the total weight taken by the metatarsal pads falls on the pad under the ball of the great toe and the remainder is shared between the other toes.[1]

The first metatarsal bone contributes a major part to the foot tripod. If injured it can cause morbidity. Defects of the metatarsus result from trauma, infections and after tumor resection. High energy trauma to the foot results in serious defect of bones soft tissues.[2,3] The scarcity of local skin and muscle in the forefoot make it sus-

Figure 1: a) Complex foot defect b) After Debridement

c) 8-weeks post-op reconstruction

d) Flap donor site

e) X ray shows viable bone and good union

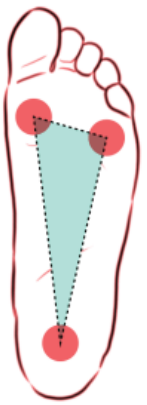

Figure 2: The foot tripod

ceptible to soft-tissue infection and osteomyelitis.[4] Open comminuted fractures along with the compromised soft tissue often result in complex defects that require urgent restoration of bones with adequate skin cover.[3,5-6]

Reconstruction of the complex foot defects remain a challenge for the surgeons. In past the complex foot defects were used to be treated either by arthrodesis or amputations.[7] The use of prosthesis after foot amputation or after shortening of any of its component does not achieve the goals of a stable foot with preserved function. Foot salvage is essential to help patient carry out basic daily activities.[8] In an effort to minimize the amputation and arthrodesis rates certain procedures have been developed. Bone grafts, free vascularized bone flaps and composite flaps have been used for reconstruction.

Non-vascularized bone grafts have been used for a century. Bone grafts are easy to harvest and require lesser operative time. However bone graft are not suitable for larger bony defects requiring more than 6 cm length.[9] Complications associated with non-vascularized bone grafts are non-union, bone resorption and fracture of the graft.

Table 1: *Etiology*

Cause	N	%age
Road traffic accident	03	60
Firearm injury	01	20
Bomb blast injury	01	20
Total	05	100

Table 2: *Complications:*

Complication	N	%age
Wound infection	02	40
Partial Skin graft loss at donor site	01	20
Partial skin paddle necrosis	01	20
Sensory deficit distal to donor site	01	20

Conventional bone grafts in combination with latissimus dorsi free flap have been used for reconstruction of smaller bone defects.[10] Since the forefoot is deficient in muscles and has scarce soft tissue, it does not provide adequate vascularity to the bone graft. The graft is therefore more prone to stress fracture because the foot bears the weight of the body.[11]

Vascularised free tissue transfer has revolutionized reconstruction of complex defects. Relatively higher levels of structural and functional restorations are achieved in single stage surgery.[12] The free fibula osteocutaneous flap has distinct advantages in reconstruction of complex foot defects. Fibula has a suitable length, shape, and diameter which resembles the metatarsals. The accompanying skin paddle of the flap very much resembles the dorsal skin of the foot and hence replacement for damaged tissue is offered by like tissue. Donor site morbidity is of lesser magnitude and usually well tolerated by the patients.[13,14]

Material and Methods:

After the approval from hospital ethical committee, this experimental study was conducted over a period of 03 years from March 2015 to February 2018 at the Plastic Surgery Unit, Hayatabad Medical Complex Peshawar. A total of 5-adult patients were included in the study. Young patients between the age 24 and 44 years, having complex foot defects involving the first metatarsal bone and adjacent soft tissues were included in the study. Elderly and diabetic patients with underlying vascular pathologies, cachectic patients and those with multiple level injuries to the lower limb were excluded from the study. All the patients were received in emergency and they were admitted to the hospital. Detailed history obtained, thorough clinical examination performed and necessary investigations were carried out. Patients were counselled about the management plan along with the associated risks and benefits. Informed consents were obtained from all the patients planned for the surgery.

All the surgical procedures were performed under general anesthesia. Patients having post traumatic defects of the foot had contaminated wounds so multiple debridements were performed before definite reconstructive procedure. After the debridements, clean wounds were achieved and the patients were then planned for reconstruction with osteo-cutaneous free fibula flap. The contralateral lower limb was used as donor site for free flap harvest. Hand held doppler was used in all the patients to identify the perforating vessels supplying the flap. Skin markings were done over the perforators and the skin paddles of the flap were so designed to include at least a single perforating vessel. At the thigh level a tourniquet was applied to the donor lower limb and inflated to a pressure of 300 mmHg. Patients were cleaned and draped under general anesthesia and skin incisions were made over the markings over the donor site. Tissue dissections were made along the skin and the fascia down to the peroneus longus muscle which was retracted anteriorly and the fibula bone was identified. Fibula bone was then dissected and released from the surrounding tissues and the muscles. The peroneal artery (pedicle) supplying the flap was identified, dissected carefully and preserved. Required length of bone was marked for division. An oscillating saw was used to cut the fibula bone at the proximal and distal markings. The pedical was divided and fibula bone along with the overlying skin paddle were harvested. An adequate length of bone was preserved both proximally and distally to prevent injury to the peroneal

nerve and avoid ankle instability respectively. After the flap harvest, the muscles and soft tissues were sutured with absorbable sutures and coverage done with a split thickness skin graft. After the completion of flap harvest antiseptic dressings were applied to the donor sites of the flap and skin graft. A back slab was applied to donor leg keeping the foot in dorsiflex position. The margins of the wounds of the injured foot were refreshed and the osteo-cutaneous free flap was inset. Pedicle of the flap was anastomed to the anterior tibial artery and vein. K-wires were inserted to stabilize the free fibula and the skin paddle was stitched to the margins for coverage. Antiseptic dressing was applied and a back slab given for immobilization.

Post-operatively all the patients with free flap were started on intravenous antibiotics, parenteral analgesia and fluids. Heparin was given for three days and after that replaced by oral aspirin 75 mg twice daily for 2-weeks. The free flaps were clinically monitored for viability. With the help of crutches, the patients were mobilized out of the beds three days after the surgery. Patient were not allowed to stand on reconstructed foot for 10 to 12 weeks. Dressings over the flap donor site were changed on 5th post-operative day and the skin grafts were assessed for take. The patients remained admitted in the hospital for 3-weeks on average.

SPSS version 20 was used for data analysis. Certain variables used in the study were patient's age, sex, operative time, flap donor site morbidity, flap survival. Various complications related to the procedure were post-operative infection, dehiscence, skin necrosis, delayed wound healing, ankle instability and sensory nerve deficit in foot. Simple descriptive statistics were used.

Results:

A total of 5-patients all males with mean age 31-years, range 24 years to 44 years were included in this study. All the patients had sustained trauma to the feet causing complex defects and involving the metatarsal bones. Details of traumatic cause are given in table-1.

Mixed pattern of injuries were observed in all the 5-patients. Patients had metatarsal defects with soft tissue loss. Fractures of the second metatarsals were present in 3-patients whereas fractures of 2nd to 5th metatarsals were present in 1-patient. Osteo-cutaneous free fibula flap was performed for reconstruction of the first metatarsal in all the patients while k-wire fixation performed for the simple fractures of the rest of metatarsals.

Reconstruction of metatarsal with free fibula took us 4 hours' time on average. The wounds were untidy on presentation and not suitable for primary reconstruction. In these patients debridements were performed to make the wounds clean and then secondary reconstruction of the metatarsal was performed in clean wounds. The patient remained admitted in hospital for 12 to 25 days. The patients were kept immobilized for 2-days. From third day onward patient were mobilized with the help of crutches.

All the flaps performed were successful and survived completely. Partial necrosis of the skin paddle was observed in 1-patient. Debridement of the necrosed portion and proper wound care resulted in secondary intention healing. Wound infection at flap recipient site resulted in partial wound dehiscence. However they did well with debridement and application of secondary sutures. There was partial skin graft loss over the flap donor site in one patient and the area was re-grafted. At the donor site we observed scarring in all patients. Details of complications are given in table-2.

Case: A 28 year old male with complex trauma to the foot. Debridements were performed to make the wound clean and fit for reconstruction. First metatarsal bone was reconstructed with free fibula flap (figure 1).

Discussion:

The foot is an important structure of the human body which plays its role in standing, walking and running.[15] The bones of the foot are arranged to form 3-arches which are essential for the form and function of the foot. There are

2-longitudinal and 1-transverse arch. The transverse arch is well marked between the shafts of the metatarsal bones. The weight of the body is supported by the foot tripod in standing position. This tripod is formed by the heel pad and the pads underlying the heads of the 1st and 5th metatarsal bones (figure 2).

In standing position, about ⅓ of the weight supported by the metatarsal pads falls on the pad under the ball of the big toe. During walking the weight of the body and the pressure is almost equally shared by the heel and the 5-metatarsal bones. Complex tissue defects of the foot may either arise from trauma or after tumor resection. Composite foot injuries comprise of open fractures and severe trauma to the soft tissues. Management of complex foot injuries is a challenging task for the reconstructive surgeons.[16] Reconstruction requires not only the restoration of bony structures but also necessitates the function of the foot to be restored for daily performance.[17,18]

There have been certain reconstructive options for management of complex foot defects. Non-vascularized bone grafts like fibula, scapula, rib and iliac bone have been described for small bony defects.[1,4,18] Reconstruction of complex bony defects along with soft tissue deficiency usually require some bulky flap with adequate volume to ensure proper coverage and exclude the dead space. Bone grafting and latissimus dorsi free flap have remained a treatment of choice for smaller defects however there are limitations to the procedure.[1,10]

Complex and larger defects of the foot require an adequate length of vascularized bone along with its skin paddle for adequate restoration of the damaged or lost tissues. A vascularized free fibula osteo-cutaneous flap offers an appropriate option for reconstruction of bony defects along with the skin coverage. In current study we performed free fibula osteocutaneous flaps for reconstruction of foot defects. Yutara Yamashita in their study have reported the use of soleus muscle along the free fibula with the view to provide ample blood supply to the flap to combat tissue infection.[4] Although we performed reconstruction in clean wounds however muscle with robust blood supply can be used for defects having soft tissue infection or osteomyelitis. Anatomy of the fibula makes it a feasible option for reconstruction of metatarsal bone. Fibula is a straight bone which provides ample length for reconstruction. The shape is similar to the metatarsals and it has a mechanical strength to support the body weight.[19] Fibula is easy to harvest with predictable vascular pedicle. It has place for osteotomies and carries lesser donor site morbidity.[20]

Taylor in 1983 described the use of vascularized anterior iliac crest for the reconstruction of first metatarsal bone.[21] Although the iliac crest can be utilized for reconstruction of smaller bony defects however osteotomy is required to straighten this curved bone. The short pedicle length is a limitation to its use. Stress fracture of the grafted bone and donor site pain are the common complications of this procedure.[18,21] Vascularized free fibula flap has also been used in combination with latissimus dorsi muscle flap and rectus abdominis muscle flap. Although the combination of 2-flaps provide adequate bony and soft tissue restoration however such procedures require a prolonged operation time.[18,22]

The advent of microsurgery has revolutionized the reconstruction of the complex defects involving skeleton and the soft tissues. Microvascular free osteocutaneous flaps provide the restoration of bony and soft tissue defects in a single procedure. The provision of osteotomies in the fibula has made it feasible for reconstruction of 2 or 3 metatarsals simultaneously. Lykoudis has described the first use of multiple segmented free fibular flap for foot reconstruction.[18] In 2011 Salgado reconstructed the first and second metatarsal bones with osteotomised free fibular flap.[23]

Free fibula osteocutaneous flap is an excellent choice for single stage reconstruction of complex defects. The flap has minimal failure rate. Additional advantages of single stage procedure are, that it avoids further exposure to anesthesia, eliminates the need to re-enter a scarred wound

bed and spares the patient of subsequent staged procedures.[24] Chun-Yan Wang and colleagueshave described pedicled fibular flap as an excellent option for reconstruction of composite foot defects however the disadvantages of the procedure are venous congestion, torsion of the vessels and requirement of expertise. Moreover this flap cannot be utilized in case there are accompanying injuries to the ipsilateral lower leg.[25] While analyzing the results of various flaps in foot reconstruction, Li X and his colleagues found that post-operative wound infection was a risk factor for the pedicled flap but not for free flap. They concluded from their study that free flaps are safer and more reliable than pedicled flaps and should be the primary choice.[26]

We performed the procedure in 5-cases and the flap survived in all the five patients yielding 100% success rate. Yazar has reported complete loss of only two flaps out of 63 cases with 97% success rate.[27] Amongst 267 cases of free fibula flap performed by Tu, 262 survived yielding a success rate of 98%.[28] Salgado has reported a success rate of 100 % of flap survival in forefoot reconstruction with free fibula flap. All the patients included in the current study were well satisfied with the reconstructed foot. The patients were fully ambulated in 12 weeks time and they achieved a reasonable walk. This is in conjunction with the study of Salgado where all the patient started walking after 14th week of their surgery.[23]

Conclusions:

Free fibula osteocutaneous flap is an ideal option for reconstruction of complex defects of the forefoot. The advantage of fibula is its adequate length and cortical density which is in consistence with the morphology of metatarsals. The accompanying skin paddle is well vascularized and suitable for soft tissue coverage of the foot dorsum. Further studies are recommended to evaluate reconstruction of multiple metatarsal bones with free fibula.

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Role and contribution of authors:

Dr Syed Asif Shah, conceived concept, did the initial lay out, critically review the article.

Dr Muhammad Bilal, critically review the article and made useful changes.

Dr Irfanullah, collected the data and references, and also helped in discussion and conclusion writing.

Dr Mohammad Hamayun Shiwari, collected the data, references and helped in discussion writing.

Dr Adeeba Ahmad, collected the references and helped in interpretation of the data.

Dr Tahira Yasmeen, helped in data collection and introduction writing.

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