



MANAGEMENT OF HEEL PAD DEFECT

Plastic Surgery

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ABSTRACT

BACKGROUND : Soft tissue reconstruction of the ankle and heel region is a challenging problem. The problem becomes worse because of the limited mobility and limited availability of the skin at the distal third of the leg region, unique weight bearing requirements and relatively poor circulation of the skin. Heel is the important part of the sole of the foot which is essential for smooth walking. It consists of both weight bearing and non-weight bearing part. Without the heel, the propelling function of the foot during walking is severely interrupted. Trauma is the leading cause of soft tissue loss of the heel & tendo-achillis injury. The reconstruction of soft tissue defects of the heel, non-weight bearing part of the heel around the tendo-achillis region or those involving weight-bearing part presents challenging problems. Soft tissue defects, whether from recent trauma or from chronic lesions are difficult to cover and require a well vascularised reconstruction having a good durability and sensation because of its location and repeated friction by footwear. **AIMS & OBJECTIVES :** Coverage of heel is a sort of challenge and its management option varies from simple debridement and primary closure or skin grafting to complex free tissue I transfer.

The objectives of this study are:-

1. To study the incidence & etiology of heel pad defects.
2. To analyze feasibility of the different treatment options.
3. To understand how effectively patient can be rehabilitated.
4. Complications encountered and their management.

METHODOLOGY: A total of 50 cases of age group 7 to 70yrs with heel pad defects that were treated in the department of plastic surgery at HMCH, BBSR over a period of 30 months from August 2019 to January 2022 constitute the material of this study. The collected data was entered in Performa and then analyzed. All the patients have been assessed both preoperatively & postoperatively, complications have been documented.

RESULTS & CONCLUSION :

1. Most of the patients in our series are young adults mostly male who are affected due to RTA.
2. Weight bearing part of heel (62%) is most common site with exposed bone & fracture.
3. Distally based sural artery flap were done in majority of patients i.e 29 (58%) in our study. Peroneal vessels are last to be affected by age, Diabetes mellitus or smoking, making it a safe flap in these patients.
4. Second most common flap was done distally based fasciocutaneous flap i.e 10 patients (20%), followed by Crossleg flap, Instep flap, Posterior Tibial flap and Lateral Calcaneal artery flap.
5. Cross leg flap is useful where all local flaps are not available. It is a two stage procedure with its associated morbidity.
6. The most common complication is venous congestion and flap edema & in elderly patients flap necrosis is more in our study.

Patients were advised special (MCR with Silicone insoles) shoes and foot care especially where flaps were done on weight bearing heel. Rehabilitation is an important component of the management.

KEYWORDS

INTRODUCTION

Soft tissue reconstruction of the ankle and heel region is a challenging problem. The lesions involving the lower extremity have become a common occurrence and the ever increasing road traffic accidents in our crowded cities are their main Cause. The plastic surgeon has to face a variety of special problems in dealing with b defects of the leg and foot. The management becomes more difficult in more distal defects. The problem becomes worse because of the limited mobility and limited availability of the skin at the distal third of the leg region, unique weight bearing requirements and relatively poor circulation of the skin. This issue is further complicated when there is an exposed tendo-achillis tendon with or without injury. This arises from the fact that the tendon itself is relatively avascular. This tendon is a vital organ of locomotion, when exposed requires early coverage to avoid impeding, like infection, dessication and susceptibility to future tear and delay in coverage makes reconstruction of the tendon and subsequent coverage difficult. The calcaneum is the largest human tarsal bone. In standing position, the heel is at the lowest position; the slow return of blood by gravity, is conducive to breeding of bacteria.

Heel is the important integrated part of the sole of the foot which is essential for smooth walking. It consists of both weight bearing and non-weight bearing part. Without the heel, the propelling function of the foot during walking is severely interrupted. Trauma is the leading cause of soft tissue loss of the heel.

The reconstruction of soft tissue defects of the heel, non-weight bearing part of the heel around the tendo-achillis region or those

involving weight-bearing part presents challenging problems for plastic surgeons. Soft tissues defects, whether from recent trauma or from chronic lesions are difficult to cover and require a well vascularised reconstruction having a good durability and sensation because of its location and repeated friction by footwear.

ETIOLOGY OF HEEL PAD DEFECTS

1. Trauma
2. Neuropathic foot
3. Infective ulcers (Post cellulitic etc)
4. Vascular disease
5. Metabolic diseases (Diabetes etc)
6. Tumors

CAUSES OF NEUROPATHIC FOOT

1. Diabetes
2. Post Traumatic Neurological
3. Hansen's Disease
4. Syringomyelia
5. Meningomyelocoele,
6. Congenital Insensitivity to pain
7. Tabes dorsalis
8. Chronic alcoholism

AIMS AND OBJECTIVES

1. To study the incidence of heel pad defects.
2. To study the aetiology of defects.

3. To analyze feasibility of the different treatment options.
4. To know advantages and disadvantages of various treatment options.
5. To understand how effectively patient can be rehabilitated.
6. Complications encountered and their management.

REVIEW OF LITERATURE

HISTORY

The reconstruction of soft tissue defects in the distal lower extremity has for centuries, perplexed the most innovative of surgeons.

Hippocrates¹ (460-370 BC) described amputation as a last resort for distal leg injury. Celsus (25 BC-50 AD) described the rules of wound management and concluded that amputation of limb should be through viable tissue. Ambroise Pare (1509-1590) recommended amputation through viable tissue and closure of stumps to fit prostheses. Pierre-Joseph Desault (1744-1795) coined the term *debridement* and described Primary & Secondary amputation of limb. Ollier (1825-1900) first described the concept of immobilization & plaster cast for limb.

In 1854, Hamilton first described the cross-leg flap. Filatov (1917) and Gillies (1920) described tubular pedicle flap. The advent of microsurgery occurred in 1970s which revolutionized plastic surgery. In 1973, O'Brien, Daniel and Taylor described free groin flap for lower limb. In 1976, Baudet described free latissimus dorsi flap. In 1976, Harii described free gracilis flap. Then Robinson described Dorsalis pedis fasciocutaneous free flap. In 1978, Chang described Radial fasciocutaneous forearm flap. In 1981 Ponten described and defined myocutaneous and fasciocutaneous flaps. In 1983 Taylor first described the reconstruction of the first metatarsal bone by a free fibula flap.

In 1990s Argenta found that negative pressure on a wound would decrease edema, decrease bacterial count, promote contraction of the wound, and, with sponge dressing, promote granulation. With better understanding of heel pad and flap physiology newer treatment options are bound to evolve.

ANATOMY



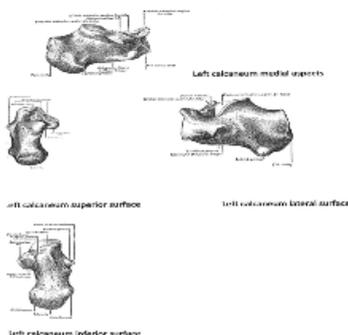
The weight of the entire body rests on the feet. The heel supports and cushions the shocks of the body by forming an important constituent of both longitudinal and transverse arch.

Comprised of many separate parts

1. Calcaneum
2. Achilles Tendon
3. Bursal Sac
4. Fat Pad
5. Thickened Layer of Skin

CALCANEUM

Calcaneum is designed to withstand weight bearing.

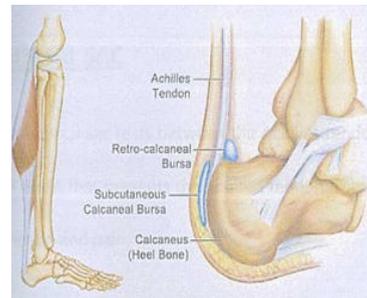


It has a relatively thin cortex. Traction trabeculae radiate from the inferior cortex, and compression trabeculae converge to support the anterior and posterior articular facets, leaving a "neutral triangle" between them with sparse trabeculations.

Thalamic portion- The condensed cortical bone just inferior to the posterior particular facet Thickening of the cortex is also seen in the regions of the sustentaculum tali, medial wall, and critical angle of Gissane.

It has four articulating surfaces: 3 superior and 1 anterior. The superior surface articulates with the talus. The posterior facet is separated [from the middle and anterior facets by a groove that runs posteromedially, 1 known as the calcaneal sulcus. The canal formed between the calcaneal sulcus and the talus is called the sinus tarsi. The triangular anterior surface of the calcaneus articulates with the cuboid. The lateral surface is flat and subcutaneous, with a central peroneal tubercle for the attachment of the calcaneofibular ligament centrally. The sustentaculum tali are seen at the anterior aspect of the medial surface. The groove inferior to it transmits the flexor hallucis longus tendon. The neurovascular bundle runs adjacent to the medial border of the calcaneum which is a key element in the surgical management of calcaneal fractures.

ACHILLES TENDON



The Achilles tendon connects the calf muscle to the heel bone. This tendon is one of the thickest tendons in the human body. When the calf muscle shortens, it pulls on the heel bone so that the foot is pushed downwards. This assists in walking, running and movement. The Achilles tendon is the muscle tendon of the triceps surae, a "three-headed" group of muscles—the soleus and the two head of the gastrocnemius. The main function of the triceps surae is plantar flexion, i.e. to stretch the foot downward. It is accompanied by a "fourth head", the slight plantaris muscle, the long slender tendon of which is also attached to the heel bone but not visible.

BURSALSAC

The bursal sac rests between the Achilles tendon and the heel bone. It's a pouch of liquid that prevents the Achilles tendon from rubbing on the bone and creating friction and pain.

SKIN AND PAD OF FAT

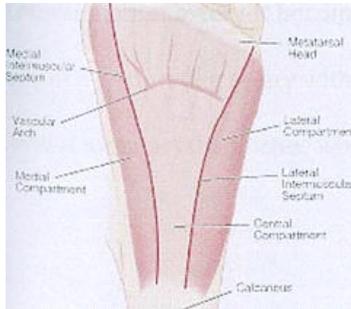
The heel pad which is located beneath the calcaneum, consists of dense strands of fibrous septa and closely packed fat cells. Human evolution determined progressive changes in both the skeleton architecture and the soft tissue of the (foot. Most important modifications are reduction of the distal area of the I phalanges and the enlargement of the proximal bones. Overlying skin and soft tissue also changed, acquiring non-shearing and padding properties. The skin of the foot, except for the sole, is similar to skin in other regions of the body. The epidermis is thin in the newborn but becomes thicker as a reaction to weight pressure. Hair and sebaceous glands are present only in the dorsum. Eccrine glands are diffused in the sole. Heel pad is around 18 mm thick and epidermal thickness is around 0.64 mm. The subcutaneous fat is poorly present in the dorsum but is very thick and granular in the sole, where it is divided by the retinacula. The fat pad protects and cushions the heel bone. It is a literal layer of fat between the heel bone and the skin in the heel area. It can be felt starting at the edge of the heel almost to the edge of the arch. The retinacula are connective fibres between the dermis and the plantar fascia that build a sort of "shock absorber" for the standing position or during movements. Plantar aponeurosis is strong connective tissue stretched between the inner tubercle of the calcaneum and 5 metatarsal heads. The plantar aponeurosis fixes the skin of the sole, and protects deeper structures. It helps in maintaining the longitudinal arch.

Numerous septi departing from this fascia divide foot muscles into 3 compartments.

Superficial Layer: Abductor Hallicus, Flexor digitorum brevis, Abductor digiti minimi.

2nd Layer: Tendon of the Flexor Hallucis Longus, Tendon of the Flexor Digitorum Longus, Quadratus plantae, Lumbricals
3rd Layer: Flexor hallucis brevis, Adductor hallucis, Flexor digiti minimi
4th Layer: Dorsal interossei, plantar interossei, Tendon of tibialis posterior, Tendon of peroneus longus

COMPARTMENTS OF FOOT



Four compartments on plantar aspect-

- Medial-** Abductor hallucis and Flexor Hallucis Brevis
- Lateral-** Adductor Digiti Minimi, Flexor Digiti Minimi Brevis
- Central-** Flexor Digitorum Brevis, lumbricals, adductor hallucis, Quadratus Plantae Interosseus- Seven interosseus

BLOOD SUPPLY OF PLANTAR FOOT

The arteries of the sole of the foot are derived from the Posterior Tibial Artery. It splits into the medial and lateral plantar arteries.

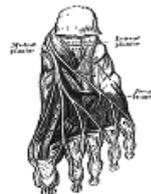
Medial plantar artery - It passes along the medial part of the sole of the foot and terminates by branching into digital branches.

Lateral plantar artery - It becomes the plantar arterial arch which anastomoses by way of a perforating artery with the dorsal pedis artery. The arch gives rise to several metatarsal branches which split into digital vessels.



Blood supply of plantar foot

NERVE SUPPLY OF PLANTAR FOOT

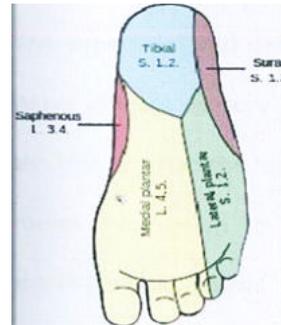


The medial and lateral plantar nerves supply the muscles as well as the skin on the sole of the foot. They are branches of the tibial nerve. Medial plantar nerve - It supplies the abductor hallucis muscle, flexor digitorum brevis, flexor hallucis brevis (in the third layer) and 1st lumbrical muscle.

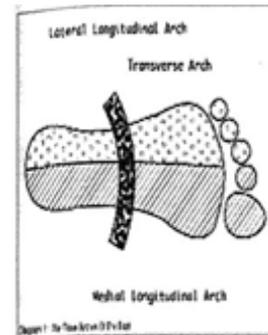
Lateral plantar nerve - It supplies the remaining muscles in the sole of the foot. In 3 way, it is similar to the ulnar which supplies most of the

small muscles of the hand. The muscles supplied are the: abductor digiti minimi, accessory flexor quadratus plantae, adductor hallucis, flexor digiti minimi brevis, interossei and lumbricals 3, 4, 5.

SENSORY INNERVATIONS OF THE SOLE OF THE FOOT



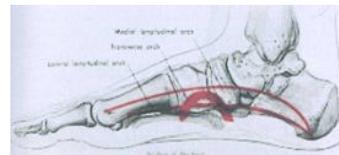
ARCHES OF THE FOOT



Tarsal and metatarsal bones are arranged in longitudinal and transverse arches.

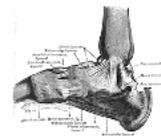
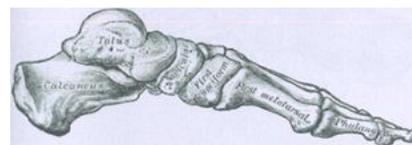
There are 3 arches: Medial Longitudinal Arch, Lateral Longitudinal Arch and Transverse Arch.

Bony arches maintained by - Interlocking bones, plantar ligaments, plantar aponeurosis, and action of plantar muscles.



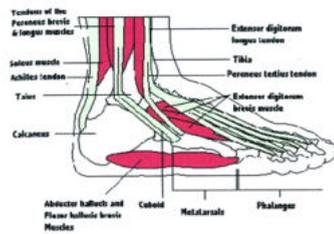
Longitudinal arch composed of medial and lateral arches

Medial longitudinal arch - Higher arch than lateral, composed of calcaneus, talus, navicular, and three cuneiforms, three medial metatarsals. Talar head is keystone. Strengthened by - Tibialis anterior tendon and Peroneus longus tendon.

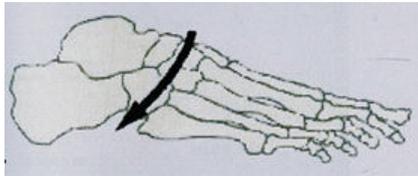


Lateral longitudinal arch - Flatter than medial. Passes on the ground when standing. Composed of calcaneus, cuboid, and lateral two metatarsals





Transverse arch -Formed by cuboid, cuneiforms, bases of metatarsals. It has pillars formed by lateral and medial longitudinal arches. It is maintained by Peroneus longus tendon.

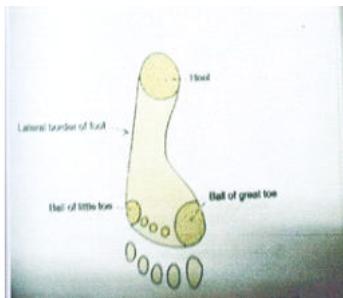


FUNCTIONS OF THE ARCH

1. Distribute body weight
2. Shock absorbers for body weight,
3. Make foot adaptable to changes in surface.

HEEL PAD FUNCTIONS

1. Weight distribution during walking
2. Shock absorber
3. Pressure bearing



Weight bearing points

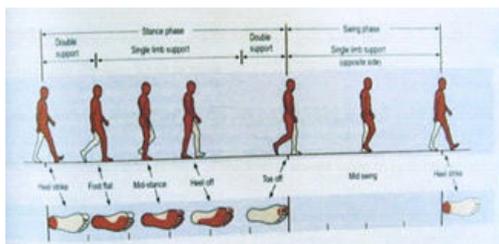
GAIT ANALYSIS

The rhythmic alternating movements of the 2 lower extremities which result in the forward movement of the body. Simply stated, it is the manner in which we walk.

Normal gait depends on the fine-tuned interlinked function of bones, joints, muscles and skin.

It has 2 phases

1. swing phase, 38%, stance phase, 62% on the ground



RECONSTRUCTIVE LADDER PREFERENCE TO HEEL PAD

- Direct closure
- Skin Grafts
- Local and Regional Flaps
- Distant Pedicle Flaps
- Free Flaps

SIMPLE DIRECT CLOSURE

IF attainable, first line of wound closure is Primary or delayed primary intention. indications- Uncomplicated wounds resulting from low energy mechanisms.

Contradictions-extensive soft tissue loss, heavy contamination, high energy wounds

DIRECT CLOSURE

Simplest and often most effective means of achieving viable coverage in acute settings. ST pin may be used in avulsed heel flap to anchor it to the bone. May need to "recruit" more skin to achieve a tension free closure. Decreasing wound tension can be accomplished by: Relaxing skin incisions, "Pie crusting" of the skin under tension (perpendicular to the direction of tension) or application of negative pressure wound therapy

NEGATIVE PRESSURE THERAPY

The Vacuum Assisted Closure (V.A.C.)-Therapy based upon interdisciplinary pretreatment (debridement, control of infection, circulation and metabolism and pressure relief) the growth of granulation tissue succeeds in a very fast time. The V.A.C.-Therapy safe and very quick, in spite of the difficult ulcer location at the heel. Topical negative pressure wound therapy (TNPWT) has the potential to accelerate healing of diabetic foot ulcers and decrease incidence of amputation.

A retrospective study by Frykberg & Williams found diabetic foot ulcers were less likely to result in amputation when treated with NPWT compared to 'control' wound care. Similarly, Armstrong & Lavery discovered diabetic foot amputation sites treated with NPWT were more likely to heal and at a faster rate than similar wounds treated with standard moist wound care.

Advantages: Increased revascularization, Increased granulation tissue formation, Decreased bacterial count, Decreased seroma formation, Wound contracture.

Disadvantages: Costly Device, unable to see wound when sponge is in place.

SKIN GRAFTING thickness (STSG) skin graft

Advantages -May be meshed, Large area can be covered, require less revascularization, temporary coverage

Disadvantages -Poor cosmesis, Limited durability, Contracts over time, Donor site problems, Pain and Infection

Full thickness (FTSG) skin graft

Advantages -No wound contracture, increased sensibility, increased durability, better cosmesis, and Primary closure of donor site

Disadvantages - Cannot mesh, Recipient site must have rich vasculature

LOCAL AND REGIONAL FLAPS MEDIAL PLANTAR FLAP

It is based on superficial or deep branch of medial plantar artery. Pivot point of flap is tarsal tunnel.

The MPA flap has proven its place in reconstruction of the hind foot over the years since its first description by Harrison and Morgan. It replaces "like tissue with like," an important issue in the sole, with its specialized fat pad that contains fibrous septae that protect against trauma from shearing.

In Zulfiqar Ali Chaudhry et al³⁹ study, twenty one flaps were carried out in 21 patients. One flap underwent necrosis, and delayed healing was seen in 4 cases. Total flap survival was 98%. Minor revision of the flap or its pedicle was required in 3 cases. With a mean follow-up of 12 months, there were recurrences of ulceration in 2 feet. They concluded that medial plantar artery flap is a reliable flap for heel coverage. It is durable and long lasting even in insensate feet.

haw and Hidalgo³⁸ reviewed the anatomy of the plantar flap and its clinical applications. The flap is elevated superficial to the plantar fascia to avoid disruption of the normal plantar structures and to maximize sensation distally and over the heel. Sensation is preserved by including the medial calcaneal nerve and by limiting the intraneural dissection of the medial and lateral plantar nerves. This is a durable and

reliable flap for heel coverage, but it cannot reach the posterior and vertical portions of the heel.

In study of Koshima et al³⁷-three cases of island medial plantar artery perforator flaps were successfully transferred for coverage of the plantar defects. This perforator flap is different from the medial plantar flap based on the medial plantar artery. The flap has no fascial component and is nourished only with the perforator of the medial plantar vessel.

Fathy F Khodair et al³⁷ found that island fasciocutaneous flap based on medial Plantar artery flap provides an excellent coverage alternative for moderate sized eel defects and should be considered flap of choice for anterior and middle heel defects and also used as free flap.

LATERAL CALCANEAL ARTERY FLAP

Lateral calcaneal artery flap originally described by Grabb and Argenta³⁶ in 1981 is an axial pattern Fasciocutaneous flap that is simple, stable and sensate.

The Pivot Point - Upper Lateral Malleolus.

Disadvantages of the flap are that donor site *requires grafting, which is put on* the periosteum giving a depression, and causes a poor cosmetic appearance. Patients also have sensory disturbance at the lateral part of the dorsum of foot.

In study of MP Suri et al¹⁷, it was preferred in small sized *isolated posterior heel* defects with exposed tend Achilles or calcaneum and normal skin in flap vicinity. According to them peroneal vessels are last to be affected by age, diabetes mellitus or smoking, making it a safe flap in these patients.

In their series of seven patients Hovius et al³¹, two donor sites showed secondary healing and one donor site showed hyperkeratosis resulting from inappropriate planning of the flap.

SD. LinS. et al³¹ described lateral calcaneal artery flap for non weight bearing heel defects in their study. In their series of 12 patients, five of the donor sites I showed minimal donor site loss which required no further intervention.

INTRINSIC MUSCLE FLAP

Three muscles are used -

1. Abductor Hallucis
2. Flexor Digitorum Brevis
3. Abductor Digiti Minimi



The retrospective study of Ortak T. et al⁴⁶ presented the clinical results of 11 patients who received a proximally based abductor hallucis muscle flap for coverage of calcaneal defects. The mean patient age was 43 years (range, 23-69 years). Four patients were women and 7 were men. Seven were non-diabetic patients with neurologic deficits of varying etiology or patients who had pressure ulcers after prolonged hospitalization. Four patients had diabetes with or without neurological deficits, and 6 patients had calcaneal osteomyelitis. In 6 patients, the origin of the muscle was dissected and rotated over the defect. The flap was elevated as an island flap in 5 patients. Postoperatively, partial flap loss was observed in 1 patient, who was then treated successfully with a fasciocutaneous flap. Two patients developed seroma and hematoma at the donor site, which resolved uneventfully after surgical drainage. The 6 patients with calcaneal osteomyelitis showed no recurrence after 1 year of follow-up. The abductor hallucis muscle flap provides enough stability and sufficient blood supply for calcaneal defects up to 3 x 6 cm.

Schwabegger AH et al⁴⁵ utilized the abductor hallucis muscle as a pedicle flap (distally or proximally-based) with or without conjoined

regional fasciocutaneous flaps offers a successful and durable alternative to microsurgical free flaps for small to moderate defects over the calcaneum region, medial ankle, medial foot and forefoot with exposed bone, tendon.



In study of Stevenson TR et al⁴⁴, an innervated flexor digitorum superficialis musculocutaneous flap resulted in primary healing of heel ulcer. Full weightbearing ambulation was resumed 8 weeks postoperatively.

Ikuta Y et al⁴³ in their study concluded that rotational transfer of a musculocutaneous island flap composed of the flexor digitorum brevis muscle is the best procedure currently available for covering and reconstructing the weightbearing area of the heel and its posterior area from the histologic and functional points of view.

In Chu H et al⁴² study, Between July 2002 and October 2010, 8 patients with skin and soft tissue defects in the lateral foot and the heel were treated. There were 6 {males and 2 females with an average age of 42 years (range, 28-65 years). The {locations were the left foot in 5 cases and the right foot in 3 cases. Defects were {caused by ulcer of the heel in 2 cases, by poor healing of incision after calcaneus fracture surgery in 1 case, and by crushing in 5 cases. The defect size ranged from 15 cm x 1.0 cm x 8.0 cm x 2.6 cm. The disease duration was 30 minutes to 26 months. The result of bacterial culture was positive in 2 cases. After 9 to 15 days of debridement and dressing change, defects were repaired with the abductor digiti minimi muscle flap of 5.6 cm x 1.5 cm to 7.6 cm x 1.8 cm at size. The donor site was sutured directly.



LOCAL AND REGIONAL FLAP SURAL FLAP

Ponten⁵ was the first to report a fasciocutaneous flap from the sural angiosome in the year 1981 on the use of 23 proximally based fasciocutaneous flaps.

In 1983 Donski and Fogdestam⁴⁹ described fasciocutaneous flap in sural region, based on the perforators of peroneal artery. They described their experience in three cases. After this report, the sural flap was largely unmentioned in literature between 1983 and 1992.

In 1992 Masquelet et al⁴ then reintroduced the sural flap, popularized and renamed this flap as the sural neurocutaneous island flap, with complete, concise description of relevant anatomy and surgical procedure. After this distally based sural fasciocutaneous flap has been the mainstay in the reconstruction of the lower leg, heel and foot defects.

In 1994 Hasegawa et al⁴⁸ proposed a new terminology for this flap; distally based sural artery island flap.

Taylor and Pan²⁹ in the year 1997 described the sural angiosome as one of the four angiosomes of the leg.

Nakajima et al³⁰ have demonstrated the presence of neurocutaneous perforators and venocutaneous perforators arising from the small arteries accompanying the sural nerve and the lesser saphenous vein, respectively.

The presence of smaller collateral veins that accompany lesser saphenous vein that help in venous drainage by bypassing the saphenous valves has been demonstrated by latex perfusion study in Duke University Human Fresh Tissue laboratory.

Bishara et al⁴⁷ have described the advantages of use of distally based sural flap as an alternative to cross leg flap for distal foot defects.

Xu⁷ in the year 2008 suggested that including the lesser saphenous vein in the pedicle is not sufficient for venous drainage and to prevent venous congestion. He suggested ligating the lesser saphenous vein at the pivot point.

STANDARD REVERSE SURAL ISLAND FLAP

The standard technique of reverse sural island flap elevation suggested by Al Qattan⁵⁷ entails elevating the flap from the junction of the proximal third and distal two thirds of the leg, a region where the sural nerve with its vasa neborium commences its suprafascial course.

The pivot point is approximately 7cm proximal to the lateral malleolus and posterior to the fibula. The axis of the pedicle is oblique and can be located precisely by the course of the lesser saphenous vein. The length of the pedicle is determined by the arc of rotation required. The width of the pedicle was never less than 5cm.

To facilitate safe usage of flap in difficult and special conditions, several modifications have been already made to the technique, such as delaying, exteriorising the pedicle, a wider than usual pedicle, mobilising the peroneal perforators in the intermuscular septum, supercharging, leaving a skin extension over the pedicle and harvesting a midline cuff of gastrocnemius muscle with the flap.

VARIOUS MODIFICATIONS OF DISTALLY BASED SURAL ARTERY FLAP

1. Peninsular flap
 2. Delayed reverse sural artery flap
 3. Inferiorly based sural incorporated fasciocutaneous flap
 4. Super sural neurofasciocutaneous flap
 5. Sural fasciomusculocutaneous flap
 6. Super charged reverse sural flap
 7. Sural fasciocutaneous cross leg flap
- Nerve sparing distally based sural flap

FASCIOCUTANEOUS FLAP

In the leg clinically useful systems of vessels supplying fasciocutaneous flaps are posterolateral, anterolateral and medial septocutaneous vessels, perforator flap, sural and small saphenous axial system.

Type - musculocutaneous, septocutaneous and direct cutaneous. In the fasciocutaneous tissue complex, there are basically three nutrient vessel plexi that course it. The most superficial is the fine dermal plexus.

Deep to this is the larger caliber subdermal plexus with horizontal and I vertical components. The deepest plexus is suprafascial.

PERFORATOR FLAP

The concept of perforator vessels based flap has evolved from this improved I understanding of flap perfusion. Extensive clinical experience has since confirmed I that perforator flaps are safe and reliable in achieving the goals of reconstruction I while at the same time minimizing the degree of donor site morbidity.

I Where muscle is not needed it has been shown that it can be selectively left I behind undamaged during flap harvesting without jeopardizing its safety.

On the other hand, when a muscle or bony component is needed, it can often be harvested on its own vascular pedicle, separate from the fasciocutaneous component, to allow for greater freedom of tailoring the flap to the defect and its subsequent inset. This forms the basis of the compound or "chimera" flap.

The advantages of the perforator flaps are (1) muscles and their function are preserved; (2) the main vascular trunks are spared; (3) it is possible to make a more specific reconstruction, replacing "like with like" (even performing compound or chimeric flaps); (4) the donor site can often be closed primarily; (5) the general morbidity is reduced;

Local perforator flaps have the particular challenge of design and execution having to be centred on the perforator vessels. In the lower limb the main perforators arise from the three major vessels - the posterior tibial, the peroneal and the anterior tibial arteries.

DISTANT AND FREE FLAPS CROSS LEG FLAP

The first successful cross leg flap was described by Hamilton⁵² in 1854-62. Elegant description of operative technique was given by Stark⁵³ in 1952-64. It is still one of the commonly employed flaps for cover of the lower leg, tendoachilis region, ankle and foot. The most favourable donor site is the upper, posteromedial aspect of calf of the other leg with the base of the flap placed anteromedially in a vertical direction. Flaps may also be raised as superior, inferior or laterally based. The length should not exceed breadth of the flap in conventional cross leg flaps.

The flap is raised including the deep fascia. This inclusion allows increased length breadth ratio of the flap. Flaps of length: breadth 24x10 cm has been raised without complications. The recipient site is adequately prepared before flap inset. The donor site of the flap and carrying segment are skin grafted. The extremities are immobilized in the desired position either parallel or crossed as the situation demands. This is done by plaster of paris fixation commonly and sometimes with external fixator. Other methods used are elastocrappe and crepe bandage, Steinman pin fixation. Elevation assists in venous and lymphatic drainage. The flap is usually divided after 3 weeks. This period of three weeks is not rigid. The time of delay / division can be determined with reasonable certainty I when the flap can stand on its own and be weaned from its pedicle by using the technetium scan. This usually permits the division of the pedicle at an earlier [time, about two weeks. Delay procedure is often necessary before division. I Physiotherapy during immobilization and after division usually helps early restoration of function. Larger the area of inset, faster and better the 'take' of flap. Pressure sores must be avoided by adequate padding and cushioning over pressure points.

The disadvantages of cross leg flaps are thromboembolic complications, joint stiffness, pressure sores and lateral popliteal nerve palsy. Increased number of general anaesthesia and total days of hospitalization as compared to local flaps or free flaps along with discomfort and inconvenience to the patient means this procedure can't be taken lightly. But considering the safety and certainty of success of this method, it is a good alternative for lower leg and not defects.

As suggested by Barclay et al¹⁶, the design of the cross-leg flap has been changed to include the deep fascia of the leg. At present, cross-leg flaps are transferred as fasciocutaneous tissue units with a length: width ratio of 3:1 or 4:1.

Long et al⁵⁴ reported the use of current external fixation technology for cross-leg fasciocutaneous flaps.

Kim JY et al⁵⁵ described pedicled cross-leg flaps may not substitute free flap surgery, it may be an alternative to free flap.

FREE FLAPS FOR HEEL

Cutaneous- Groin flap, Scapular, Para scapular
Fasciocutaneous - Radial, Lateral arm, Dorsalis pedis
Muscular- Latissimus dorsi, Gracilis, Anterior serratus
Osteocutaneous -Fibula

Advantages - one stage procedure, variety of donor sites, various sizes available, cosmetically acceptable donor site defect, early mobilization, improved vascularity of flap.

Disadvantage- Lengthy operation, Lack of availability of recipient vessels, vascular thrombosis.

Durham JW⁵⁶ reviewed six free flap reconstructions of the weight-bearing surface of the heel the use of the posterior tibial perforator flap can provide coverage of defects utilizing short operative time with minimal complications by preserving the underlying muscles and major arteries while being technically less demanding. Although most of the studies mention that the perforators emerge at 4-26 cm from the intermalleolar line, in this study there was always a perforator at the level of medial malleolus that could easily be identified with the Doppler probe preoperatively.

MATERIALS & METHODS

A total of 50 cases of age group 7 to 70yrs with heel pad defects that were treated in the department of plastic surgery at HMCH, BBSR over

a period of 30 months from August 2019 to January 2022 constitute the material of this study. The collected data was entered in Performa and then analyzed. All the patients have been assessed both preoperatively & postoperatively, complications have been documented.

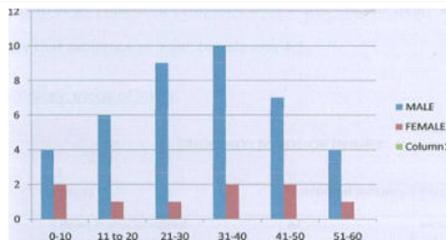
OBSERVATION & DISCUSSION

In the present study 50 patients with defects in heel, who underwent different coverage methods were included and analyzed. The data was analyzed under following subgroups.

1. Age and sex distribution

TABLE 1: AGE AND SEX DISTRIBUTION

Age(in years)	Male	Female	Total	Percentage
0-10	4	2	6	12%
11-20	6	1	7	14%
21-30	9	1	10	20%
31-40	10	2	12	24%
41-50	7	2	9	18%
51-60	4	1	5	10%
>60	1	0	1	02%
TOTAL	41	9	50	100%



In this study, age of the patients ranged from 7 to 70 years with a mean age of 30.9 years. The most common age group involved was the 21 to 40 years (44%). This is because of the fact that most victims were male between 20-40 years and two wheelers are the most common means of transportation. Heel injuries are associated with accidents involving two wheelers.

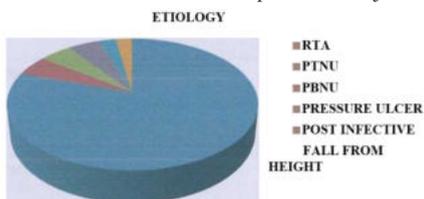
Majority of the patients in our study were male. This male preponderance is seen in all age groups. The male: female incidence is 41:9 in our series. Males are mostly victims due to more outdoor activities. In study of MA Kalam et al¹⁹, most common age group involved was 25-35 years (45%).

2^ Etiology: mode of injury

TABLE 2: ETIOLOGY: MODE OF INJURY

Mode	Number of patients	Percentage
Road Traffic Accident	32	64%
Posttraumatic nonhealing ulcer	2	4%
Postburn nonhealing ulcer	2	4%
Pressure ulcer	2	4%
Post infective	1	2%
Fall from height	1	2%
Diabetic ulcer	5	10%
Trophic ulcer	2	4%
Machine injury	1	2%
Railway	1	2%
Fall of heavy object	1	2%
TOTAL	50	100%

Trauma was the most common cause of these defects accounting for 76% of cases in our study. 64% of these were due to road traffic accidents, which is the commonest cause of heel injuries. Diabetic ulcer is 2nd most common (10%) cause of heel defect in our study. Two wheeler accidents are the commonest culprits of heel injuries.

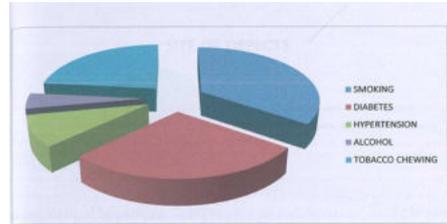


3. Coexisting diseases and habits

TABLE 3: COEXISTING DISEASES AND HABITS

Coexisting Disease and habits	No of patients
Smoking	15
Diabetes	12
Hypertension	4
Alcohol	2
Tobacco chewing	10

The above table shows the incidence of co-existing systemic illnesses and habits ' of our study patients. Smoking and tobacco chewing had a significant bearing on the survival of flap. Two of the patients who had complete flap loss and five of the patients with partial flap loss were smokers. One patient with diabetes had complete graft loss. 1 One patient who was alcoholic and uncooperative postoperatively had partial flap and graft loss.

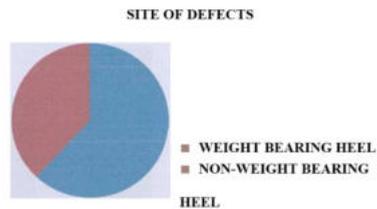


In Kamath BJ et al²⁵ study of 48 cases, 1 flap loss had occurred in a diabetic patient, one complete flap loss had occurred in a diabetic patient as described by Nakajima et al³⁰.

4. Site of defects

TABLE 4: SITE OF DEFECTS

Site of defect	Number of patients	Percentage
Weight bearing heel	31	62%
Non-weight bearing heel	19	38%
Total	50	100%



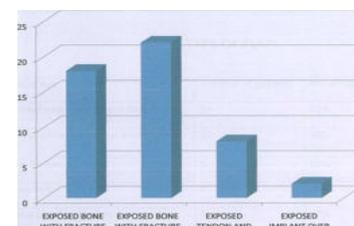
In our study of 50 patients, 31 (62%) patients had defects on weight bearing heel and 19 (38%) patients had defects on non-weight bearing heel.

In study of MP Suri et al¹⁷, of 50 patients, 39 (78%) patients had defect over non-weight bearing heel and 11(22%) patients had defects on both weight and non weight bearing heel.

5. Underlying tissue exposed in the wound

TABLE 5: UNDERLYING TISSUE EXPOSED IN THE WOUND

	Number	Percentage
Exposed bone without fracture	18	36%
Exposed bone with fracture	22	44%
Exposed tendon and tendoachilis	8	16%
Exposed implant over a fractured bone	2	04%
Total	50	100%



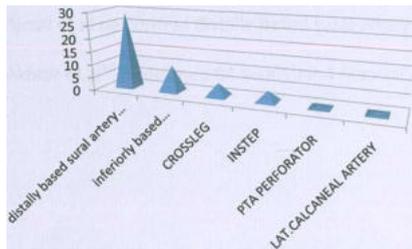
The above table shows the exposed tissue in defect and the need for flap coverage. 22 of the 50 patients had bone exposed with underlying fracture. 18 patients had exposed bone with loss of overlying

periosteum. 8 of our patients had exposed joint and tendons. 2 patients had exposed internal implant.

In the study of MP Suri et al¹⁷, 2 had calcaneum fracture and 30(60%) patients had exposed tendo Achilles and bone out of 50 patients.

TABLE 6: TYPE OF FLAP

Type of flap	Number of patients	Percentage
Distally based sural artery flap	29	58%
Inferiorly based fasciocutaneous flap	10	20%
Cross leg flap	5	10%
Instep flap	4	08%
Lateral calcaneal artery flap	1	02%
Posterior tibial artery perforator flap	1	02%



We had done distally based sural artery flap in 29 (58%) patients. Inferiorly based fasciocutaneous flap was performed in 10 patients. Delay was done in 8 patients who were diabetic or in whom there was diminished vascularity of the limb. Cross leg flap was done in 5 (10%) patients. We had not done any intrinsic muscle flap due to large defects of patients foot.

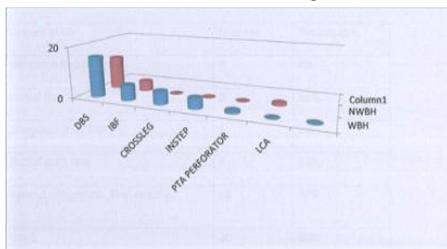
7. Type of flap with site of defects

TABLE 7: TYPE OF FLAP WITH SITE OF DEFECTS

FLAP	WEIGHT BEARING HEEL	PERCENT AGE	NON-WEIGHT BEARING HEEL	PERCENT AGE
Distally based sural artery flap	16	32%	13	26%
Inferiorly based fascio cutaneous flap	6	12%	4	08%
Cross leg flap	5	10%	0	0%
Instep flap	4	08%	0	0%
Posterior tibial artery perforator flap	1	02%	0	0%
Lateral calcaneal artery flap	0	0%	1	02%

Out of 29 patients of distally based sural flaps, 16 (32%) were done on weight bearing heel and 13 (26%) flaps were done for non-weight bearing heel defects.

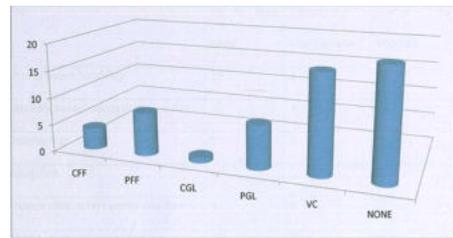
Among 10 patients of inferiorly based fasciocutaneous flaps, 6 (12%) were done on weight bearing heel defects and 4(8%) flaps were done on non-weight bearing heel. One LCA (Lateral calcaneal artery) flap was done for a small defect on tendoachilis region.



8. Complications

TABLE 8: COMPLICATIONS

Complication	Number	Percentage
Complete flap failure	4	8%
Partial flap failure	8	16%
Complete graft loss	1	2%
Partial graft loss	8	16%
Venous congestion ,Flap edema	18	36%
None	20	40%



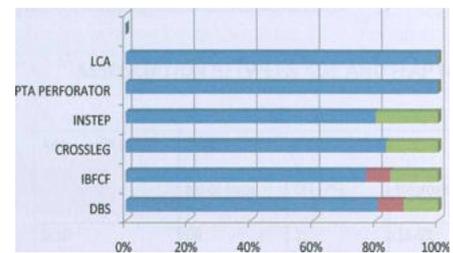
20 out of 50 did not have any complication and were absolutely fine postoperatively in our study. 18 of the flaps had flap edema or venous congestion till postoperative day 5, which settled by limb elevation or loosening of any tight dressing if any.

4 of these patients had complete necrosis of flap and another 8 patients had partial necrosis. 8 patients had partial graft loss over secondary defect or adipofascial pedicle. One diabetic patient had gradual complete loss of graft over donararea.

9. Type offlap with necrosis

TABLE 9: TYPE OF FLAP WITH NECROSIS

Flap	No of flaps done	Complete Flap necrosis	Partial flap necrosis
Distally based Sural flap	29	3	4
Inferiorly based fasciocutaneous flap	10	1	2
Crossleg flap	5	0	1
Instep flap	4	0	1
Posterior tibial artery perforator flap	1	0	0
Lateral calcaneal artery flap	1	0	0



Out of the 29 patients who underwent sural artery island flap, 3(10.3%) had complete necrosis offlap and another 4 (13.7%) had partial necrosis offlap. Out of 10 patients who underwent inferiorly based fasciocutaneous flap 1(10%) had complete necrosis of the flap and another 2 patients had partial necrosis offlap. One patient of cross leg flap and one patient of instep flap had partial necrosis of flap.

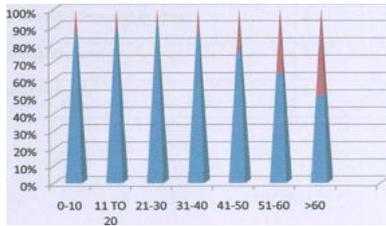
In MK Alam study¹⁹, forty five superficial sural island flaps survived without any flap loss, three flaps had distal marginal necrosis which was managed by excision followed by secondary stitches. In two cases the distal third of the flaps were lost due to inadequate post operative management (direct pressure over the pedicle) and needed excision of the devitalized part of the flap followed by closure of the defect with alternative procedures like flap advancement and skin grafting.

10. Association between age and flap necrosis

TABLE 10: ASSOCIATION BETWEEN AGE AND FLAP NECROSIS

Age (in years)	Study		
	No of flaps	CFL+PFL	Necrosis rate
0-10	06	1	16.6%
11-20	07	1	14.3%

21-30	10	1	10.0%
31-40	12	2	16.7%
41-50	09	3	33.0%
51-60	05	3	60.0%
>60	01	1	100%
TOTAL	50	12	24.0%



Above table shows flap necrosis is more in 4th-5th decade i.e 6/14(42.3%) than other age groups.

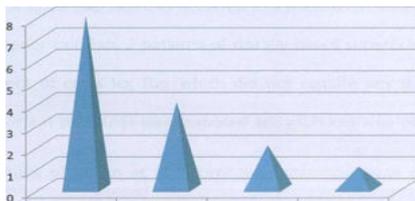
It was evident that the flap necrosis rate in patients aged above 40 years was more than the average flap necrosis rates in our study. Baumeister²⁸ also found more necrosis rates in patients younger than 20 years. But the complication rates in present study in pediatric and patients <40yrs was less than the overall flap necrosis rates. This shows that sural artery flap is safe in pediatric age group and may be used in children with success.

II. Secondary procedures

TABLE 11: SECONDARY PROCEDURES

Procedure	Number of patients
Repeat grafting	8
Flap debridement and grafting	3
Flap debridement	2
Repeat flap	1

NO OF PATIENTS



REPEAT FLAP REPEAT FLAP GRAFTING DEBRIDEMENT AND GRAFTING DEBRIDEMENT AND GRAFTING

Three patients who had complete flap loss underwent debridement offlap on day 21 and STG was done over the granulated defect. Flap debridement was needed in 2 patients with underlying osteomyelitis and necrosis of fractured calcaneum bone beneath the flap. 8 patients had undergone grafting for partial flap loss. One of the patient in our study was needed a repeat flap in form of free Latissimus Dorsi muscle flap.

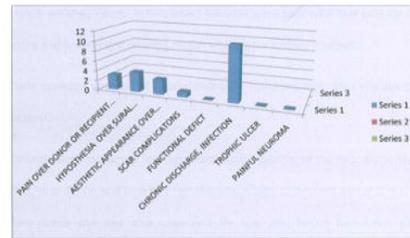
12. Follow up

TABLE 12 : FOLLOW UP

	PATIENTS NUMBER	PERCENTAGE
Pain over donor or recipient area	3	06%
Hyposthesia over sural distribuaiton or peroneal distribution	4	08%
Aesthetic appearance over donor and recipient area	3	06%
Scarcomplicatons	1	02%
Functional deficit	0	0%
Chronic discharge, infection	11	22%
Trophic ulcer	0	0%
Painful neuroma	0	0%

In our study all the patients were followed up to average 9 months (6 months -12 months). Follow up was done weekly for first month, biweekly for next three months and then once for a month. A splint with

a wide heel area is applied for 21 days. Full weight-bearing on the heel is not permitted before the sixth week. Pressure dressings (elastocrape bandage) were applied after three weeks. Active and passive physiotherapy of joints around ankle was also started on the third week. After 21 days gradual mobilization was started.



Tendo Achilis injured patients were kept in POP cast for 3weeks with ankle in neutral position and further 6 weeks without plaster slab but non weight bearing crutch walking. Tendo achilis intact patients were kept with POP cast for 2 weeks more and non-weight bearing crutch walking for further 4 weeks.

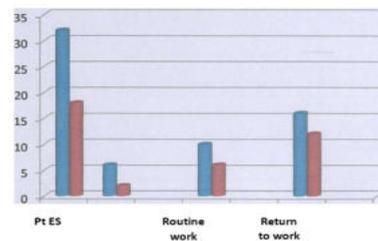
Daily massage and use of special footwear (silicone) were also explained to the patient. Patients were evaluated for flap acceptability, healing of the flap, durability of the flap, ambulation and sensation on the lateral side of the foot and also on the flap. Flap donor site was also examined for scar and keloid formation, pain and neuroma formation.

In our study, 2 patients had complained of pain over donor area. But gradually pain subsides with rest and analgesic. Four patients had complained of sural hypoesthesia, none of them had any functional deficit due to sural hypoesthesia. In three patients, the pedicle prominence over the back of the heel was cosmetically unacceptable. Even though secondary correction was offered, none accepted a second procedure. One female patient had complained of scar over sural flap donor area. She was advised pressure garment and counseling. None of our patients had trophic ulcer or painful neuromas as described in literature

13. Rehabilitation

TABLE 13 : REHABILITATION

	Weight bearing heel	Non weight bearing heel
Physiotherapy	31	19
Electrical stimulation	6	2
Ability to perform routine works	9	6



Rehabilitation is an important component of the reconstruction. In our study 13 patients with non weight bearing heel defects and 22 with weight bearing heel defects were able to resume their work. Physiotherapy was provided to all patients for and all were encouraged to walk and resume their duties along with foot care.

CONCLUSION

1. Most of the patients in our series are young adults (44%) in their active life. Males (82%) are mostly affected due to outdoor activities.
2. Weight bearing part of heel (62%) is most common site in our study.
3. Road traffic accidents are the most common cause for defects in present study. Two wheelers and rickshaw (64%) are the main cause of accidents.
4. Most offlaps were done in exposed bone with fracture in our study.
5. Distally based sural artery flap were done in majority of patients i.e 29 (58%) in our study. Distally based superficial sural artery flap is a

skin island flap that has reliable blood supply, easy and quick to elevate and major arteries are not sacrificed.

6. Peroneal vessels are last to be affected by age, Diabetes mellitus or smoking, making it a safe flap in these patients.

7. Second most common flap was done distally based fasciocutaneous flap i.e 10 patients (20%), followed by Crossleg flap, Instep flap, Posterior Tibial flap and Lateral Calcaneal artery flap.

8. Fasciocutaneous flap is simple and stable. It is preferred in small sized isolated posterior heel defects with exposed Tendoachilles or Calcaneum and normal skin in flap vicinity.

9. Medial plantar (instep) flap is a good choice in terms of sensation and early ambulation.

10. Lateral calcaneal artery flap is preferred in small sized isolated posterior heel defects with exposed tendo Achilles or calcaneum and normal skin in flap vicinity.

11. Cross leg flap is useful where all local flaps are not available. It is a two stage procedure with its associated morbidity.

'Free flap' is technically demanding option for reconstruction of heel. It becomes more bulky than usual, requires high grade of expertise and infrastructural support. Initially it is insensate, requires more time for adaptive changes of weight bearing heel.

12. The most common complication is venous congestion and flap edema in our study.

13. Elder aged patients (more than 50 years) have more flap necrosis in our study.

14. Repeat grafting on donor site is the most common secondary procedure in our study. One repeat flap (free ID) was done in our study.

15. Chronic discharge is most common complaint on follow up in our study.

16. Patients were advised special (MCR with Silicone insoles) shoes and foot care especially where flaps were done on weight bearing heel.

Rehabilitation is an important component of the management. In our study 13 patients with non weight bearing heel defects and 22 with weight bearing heel defects were able to resume their work and others were able to return to their routine activities.

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