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Surgical Reconstruction of Heel Deformities Presents a Challenging Task

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Abstract:
Because of its structure and function, the heel a weight-bearing area always poses a rebuilding difficulty. The free radial artery forearm flap, the free latissimus dorsi muscle flap, and heel defect cases resulting from trauma, tumors, pressure ulcers, non-healing ulcers with infections, and cross-leg flaps were all examples of reconstructive procedures that were performed.
Aim: Finding the most robust flap that gives the injured region instant feeling and movement was our goal.
Methodology and Materials: A retrospective observational research encompassing 30 patients of hind foot abnormalities with flap alternatives as previously mentioned was carried out. Early mobility, the recovery of feeling to the affected area, flap survival, durability, recurrence, and patient satisfaction were all taken into consideration while evaluating the results.
Results: The study discovered that trauma, with a plurality of men, was the most common cause of trophic ulcers in our area, followed by tumors and trophic ulcers. Similar feelings are felt in the opposite foot's instep area and the repaired area with the medial plantar flap.
Conclusion: In summary, for small to medium-sized lesions, we advise medial plantar flaps because they offer the patient a resilient covering with a low recurrence risk and a protective pressure feeling and touch.
Keywords: Surgical reconstruction, Heel deformity, MedialPlantar Flap, Fascio-cutaneous, Softt issue, Trauma.

Introduction:

An essential part of the foot's sole, the heel is necessary for forefoot propulsion and weight bearing. The heel pad, which serves as the calcaneus' substrate, is made up of closely spaced fat cells and thick filaments of fibrous septa. The fibrous septa, which are made of collagen fibers, form large, airtight chambers that hold onto fat. The heel pad reduces vibrations and attenuates the peak of dynamic forces by acting as an efficient shock absorber [1,2]. When you walk, some of the impact energy that deforms the heel pad is lost as heat, and the rest is recovered by the elastic rebound that follows. Burns, infections, trauma, or tumors are common causes of soft tissue loss in the weight-bearing area of the heel [3]. Plantar tissue is the perfect material for sole resurfacing because it possesses special qualities that no other bodily tissue can match. The lack of identical or nearly comparable tissues complicates reconstruction [1]. Before beginning the reconstruction process, it is necessary to take into consideration the sensation of the weight-bearing heel as well as the state of the blood flow in the posterior tibial artery, which is the major blood supply to the sole of the foot [2].

In recent years, the medial plantar artery flap has shown great promise as an alternative to traditional methods of treating heel wounds with soft tissue. In 1979, the medial plantar sensory membrane was originally shown by Shanahan and Gingrass as a technique to hide heel deformities [4]. In the original description, the abductor hallucis musclethought to be the main artery supplying the skin over the midsolewas included in this flap [4]. It wasn't until 1981 that Harrison and Morgan showed the world the first island fasciocutaneous flap variation [5]. This kind has cutaneous branches from the abductor hallucis and flexor digitorum brevis. One fascio-cutaneous flap is the medial plantar flap. Inside the flap, the plantar fascia, a cutaneous branch between the abductor hallucis and flexor digitorum brevis, supplies blood [6]. The fasciocutaneous perforators and medial plantar artery cutaneous branch are in this sulcus. After dissecting the nerve stem, the medial plantar nerve flap is removed [7].

Transplanting one type of tissue into another with little donor risk, being naturally sensitive, being a one-stage, cost-effective procedure, having axial vascularity for more mobility, limitations of the medial plantar fascia, instep injuries that prevent a flap, posterior tibial artery trauma that prevents a flap, and being involved with an unsalvageable ab

Since the development of microvascular surgery, free flaps have frequently been the favored technique of restoration for major lesions of the heel and foot due to tissue constraints and injuries to the vascular pedicle area [11–13]. The surgery is limited, nonetheless, by its intricacy, surgical skill, superb operating room with critical care unit support, collaboration, and steep learning curve [14]. Reversal sural flaps and cross leg flaps are two examples of regional pedicle flaps that have shown to be very successful in restoring large heel lesions [11–14]. These flaps are further limited by their inadequacies and complexity. Therefore, this study aimed to evaluate the advantages, disadvantages, and problems of the medial plantar flap with those of other pedicle flaps used in heel reconstruction as well as to identify the grounds for heel pad repair in our patients.

Materials&methods:

From August 2010 to September 2012, this study was conducted at the Department of Plastic & Reconstructive Surgery. Patients with heel deformities who were connected with the departments of general surgery, neurosurgery, and orthopaedics at AHRCC, S.C.B. Medical College and Hospital in Cuttack participated in this study. All patients with heel deformities resulting from excision of squamous cell carcinoma or malignant melanoma, neuropathic ulceration, or trauma were included in the study.

Thirty of the sixty patients in the research received therapy with a medial plantar flap cover. The remaining thirty cases were classified as pedicled flaps and treated with cross leg flaps and reverse sural flaps. The whole history and relevant information were recorded in compliance with the proforma that was filled out. These patients received regular follow-up care. Their results and consequences were tracked, and when more surgery was needed, it was done.

Procedures:

In every instance, a portable Doppler examination was carried out to verify medial plantar vascular blood flow and to identify the peroneal perforators before to surgery. Exclusion from the trial was granted to patients with severe peripheral vascular disease, big defects, or minor injuries including damage surrounding the malleolus and a gross laceration of the lower leg. Anesthesia, either spinal or epidural, was used during the surgery. After the extremity has been exsanguinated, a pneumatic tourniquet is used to elevate the flap in a dry field. The skin paddle was developed based on the defect size after the pattern was prepared and measurements were taken. Reverse planning was done for every patient.

Medialplantarflap

Patients who were candidates for the Medial Plantar Island flap had lesions that measured between 6 and 8 centimeters in length and width, had an undamaged instep area of the foot sole, and had a patent posterior tibial artery that extended into the medial plantar artery.

Flapplanning:

It is necessary to draw a footprint on plain paper in order to determine which parts of the foot are capable of supporting weight and which parts do not. While the foot is not bearing weight, the perforator may be found near the lateral border of the abductor hallucis muscle; here is where the flap should be focused. Along with the medial border of the plantar aponeurosis, there is a line that connects the medial sesamoid of the great toe to the posterior center of the heel. This spot on

the foot may be identified by this line. The table displays the actual measurements of the flap, which are prepared in reverse according to the predicted problem.

Flapelevation:

Distal flap extension should be two cm below metatarsal heads. Incising and deepening the medial border of the anterior period of the peritoneum (APP) is needed to break the abductor hallucis fascia. Dissecting the muscle continues until it reaches the septum that links the exor digitorum brevis and abductor hallucis. Instead of cutting the septum, it is traced to the metatarsal bone. Abductor hallucis medial retraction was needed to see the NV bundle. You can see the medial plantar neurovascular bundle best toward the septum's proximal end. Next, locate the posterior tibial artery division. Medial fold border extends three millimeters postero-inferior to medial malleolus tip. The abductor hallucis muscle and its vascular branches must be split for neurovascular bundle proximal dissection. Four or five millimeters is the pedicle length. The medial plantar nerve or posterior tibial nerve's main stem typically produces a unique branch. This branch has two subbranches. The medial branch serves the medially facing great toe, whereas the lateral branch supplies the instep. Both branches are in the foot. With a loupe, the main branch and instep-supplying lateral branch are plainly distinguishable. Around the medial plantar aponeurosis, little nerve branches are often cut. Next, carefully cut the plantar aponeurosis slips without damaging the toes' common nerve trunks. Following this, the AP's distal edge is sliced. Last, cut the plantar aponeurosis along its lateral border and most lateral section. Before reaching the septum that connects the exor digitorum brevis and abductor hallucis muscles, the aponeurosis entering the appendix is dissected. After forming the septum, the procedure is repeated. The plantar aponeurosis' proximal end is severed. Insert the flap into the defect and sew it in one layer over a suction drain. Split skin transplants may address donor defects. A plaster of Paris slab immobilized the leg for seven days. It was safe to bear weight after four weeks.

Reversesuralfasciocutaneousflaps

If the insufficiency was more concentrated on the back of the heel (8 cm to 11 cm in length and 5 cm to 8 cm in breadth) and the patient did not have any injuries on the side of the lower leg that could affect the flap's vascularity, a reverse Sural fasciocutaneous flap operation was considered.

Flapplanning:

The midsection of the back of the leg was where this fasciocutaneous flap began. The reverse sural flap is supported by a tiny network of blood vessels that extend from the sural nerve, which is near to the lateral malleolus and connects distally to the septocutaneous branch of the peroneal artery. At all times, the pedicle needs to be three cm wide, and the sural nerve and tiny saphenous vein must be contained within the flap.

Flapelevation:

Following the completion of the reverse planning process, the deep fascia was always included at all edges, and the dissection was performed in the order of proximal to distal. In the proximal part of the flap, between the two heads of the gastrocnemius muscle, and in the distal part, between the sural nerve and the short saphenous vein, superficial sural veins and the sural nerve were found. In both places, they were found. Typically, the pivot point is situated around 4 to 5 centimeters distant from the lateral malleolus's midpoint. This is because the pivot point is located somewhat below the Doppler-mapped perforators. Following the elevation of the flap to a location that was six centimeters in front of the lateral malleolus, the heel deformity was successfully concealed by moving the flap. Three to four centimeters was the width of the carrier

pedicle. During the process of grafting the donor site of the flaps, the split-thickness skin graft was the primary approach that was utilized. After a period of three weeks, the pedicle was disassembled and returned to the donor region. Additionally, the flap that was still present in the recipient area was reinserted.

Crosslegflap:

Concerns were expressed about the vascularity of the reverse sural or medial plantar flap when there was damage in the lateral and medial malleolar regions. Additionally, the cross-leg flap was done when the heel area defect was more than 11 centimeters by 8 centimeters.

Flapplanningandflapelevation

In order to properly arrange these flaps, it is essential to provide patients and their attendants with prior information regarding the possible possibilities, the location of the limbs, the necessary nursing care, the duration of the hospital stay, and the donor site morbidity. Avoiding cross-legging and straining the flap requires meticulous preoperative preparation, with an emphasis on situating the donor limb with a relaxed pedicle. It was common practice to use distal perforator perfused retrograde fasciocutaneous flaps from the posterior tibial artery (medial flap) or the peroneal artery (lateral flap) to raise cross-leg flaps, although there were two other methods that could be used if the procedure was deemed appropriate. Using a portable Doppler, it was discovered that every patient had perforators before to the surgical procedure. We saw that there were almost always constant perforators between 4 and 8 centimeters, and as a result, we maintained the base of the flaps at around 8 centimeters from the malleoli that corresponded to them. A distance of eight to ten centimeters was kept between the top limit of the flap and the line of the knee joint. Depending on the extent of the defect, the flap's maximal breadth, which was posteriorly up to the mid-calf line, was about the same. It was decided to cut three sides of the flap, which resulted in the flap becoming more thin in the direction of the centre. It was decided to do the subfascial dissection in the operational plane. In order to immobilize both legs in respect to one another, a plaster cast was utilized with the purpose of immobilizing them both proximally and distally (to the flap). Twenty-one days after the first flap division, the re-insetting procedure was often performed. During the initial few days after surgery, each flap was examined to see whether or not it had venous congestion, arterial compromise, hematoma beneath the flap, pedicle lie, and excessive pedicle compression from the dressing. Following a period of five days, the donor area was dressed. It was decided to outfit the recipient region on different days each week. On the tenth day after surgery, the sutures are removed if the postoperative phase is not filled with any complications. The process of ambulation was started with the use of an 8 mm MCR insole. Our normal trial walking regimen was carried out on the patients. This regimen consists of walking for five minutes at a time, two or three times a day, with the duration of each session gradually increasing. At the conclusion of each session, a check was performed to look for any symptoms of trauma. Over the course of just one week, they were able to sustain their entire weight, provided that there were no problems. After seeing the patient once a month during the first three months, then once every three months for the next six months, the patient is seen once a year at the very least. This is the minimum frequency of attendance. During the follow-up period, any specific concerns that were brought up by the patients were noted, and any problems that were associated with the donor and recipient sites were ultimately treated.

Results & Discussion:

For the purpose of this investigation, we performed surgery on sixty patients who had soft tissue abnormalities in the heel region and monitored their progress. Thirty of these patients underwent

pedicle flap reconstruction, thirty underwent medial plantar flap reconstruction, twenty-six underwent reverse sural fascio-cutaneous flap reconstruction, and four underwent cross-leg flap reconstruction.

Table 1: Age distribution

Age(inyears)	No.ofCases	Percentage(%)
0–10	0	0
11–20	8	13.3
21–30	13	21.7
31–40	2	3.3
41–50	4	6.7
51–60	15	25
morethan60	18	30
Total	60	100%

According to our findings, the age group was responsible for the highest proportion of instances (33, which is equivalent to 55%). The patients' elevated incidences of neuropathic ulcerations (diabetes, Hansen's disease, and spinal cord injuries) and malignancies were the primary factors that led to this phenomenon. The age group that is under 30 years old has the lowest frequency of road accidents. This is because the frequency of traffic accidents is greater. 44.8 years was the average age of the group as a whole. 19 of the sixty patients that participated in our research were female, whereas 41 were male. In terms of males to females, the ratio is 2.15 to 1. Males make up a significant number of patients because of their larger propensity to engage in activities that take place outside, the neuropathic ulceration that follows, their susceptibility to severe injuries, and their risk of recurrent trauma injuries (RTA). On the other hand, females had a higher risk of developing malignant melanoma, which was responsible for six out of the nine cases (M:F = 1:2). According to the findings of our study, driving accidents that resulted in the loss of the heel pad were the most prevalent cause of heel deformities, accounting for 33.3% of all cases. The majority of neuropathic ulcerations, which accounted for 28.3 percent of all cases, were brought on by neuropathy and leprosy, which emerged as the second most prevalent cause of the condition. There were three incidents that took occurred after either spinal cord injuries, neurological issues, or both of these kinds of traumas. A total of twenty percent of the cases had burns and infections that resulted in the removal of the heel pad.

Despite the fact that there was no evident separation between the two, the bulk of heel anomalies that were observed in our research were in the posterior heel. Accidents on the road were the culprits for the majority of them, followed by the excision of cancer. Neuropathic ulceration is the medical condition that is most frequently responsible for anterior and medial heel deformities. RTA and burns account for a significant amount of the anomalies that occur in the lateral heel. It is consistent with the theory that Chaudhry et al. [15] proposed, which said that only five of the twenty-one cases that were investigated were found in the anterior heel, while fifteen of the cases were found in the posterior heel. These findings are in agreement with the hypothesis. In order to facilitate comparison, we included a comparable quantity of reverse sural flaps and pedicle flaps, in addition to cross-leg and medial plantar flaps. For reverse sural flaps, the best flap choice is determined by a number of factors, including the location and size of the defect, the presence of an intact instep region, an atraumatic pedicle area near the lateral malleolus, a normal medial plantar vessel (for medial plantar flaps), and a well-picked perforator as determined by a Doppler study. All of these factors are described in the previous paragraph. A

cross-leg flap was utilized in situations where the flaps were deemed to be improper. A skin grafting technique known as split-thickness was utilized in order to cover the donor site.
According to the findings of our research, the medial plantar flap cover for heel deformities required an average of 110 minutes, but the reverse sural required just 85 minutes. It took an average of 97 minutes to complete the cross-leg flaps. A statistically significant difference ($p < 0.05$) was noted when comparing the mean length of surgery between the medial plantar flap and other pedicle flaps. Surgery for a cross-leg flap took longer than usual because of the steps used to ensure the patient's comfort after the procedure. On the other hand, a medial plantar flap cover takes longer than usual because, while harvesting the flap, the medial plantar nerve branches are isolated from the main trunk and directed to the instep area under loupe magnification. This allowed for the flap to be harvested more quickly.

Table2:Etiological factors.

Underlying Pathology	**No.ofCases**	**Percentage(%)**
Posttraumaticrawarea/defect	20	33.3
Neuropathiculceration	17	28.3
Burn	6	10
Malignancy	11	18.3
Infection	6	10
Total	60	100

Table3:Early postoperative complication

Flapproblem	**Medialplantarflap(%cases)**	**Pedicledflap(Reversesural+Crosslegflap)(%cases)**
Venouscongestion	6.6	30
Graftloss	6.6	6.6
Hematoma	13.3	10
Partialflapnecrosis	6.6	11.5
Completeflaplos s		3.3

When compared to the pedicle flap group, the medial plantar flap group suffered an overall incidence of problems that was 33.3%, while the pedicle flap group did not experience any issues at all. It was determined that there was a statistically significant difference in incidence ($p < 0.05$). Venous congestion was the early postoperative complication that occurred the most frequently in the group that utilized pedicled flaps 30 percent of the time, followed by partial flap necrosis 11 percent of the time. On the other hand, 6.6% of patients who were part of the medial plantar group encountered each of these issues. Within the medial plantar group, hematomas were the most prevalent early complication, accounting for 13.3% of the cases. However, donor site graft loss occurred with the same frequency in both groups, which was 6.6%. Venous congestion, which led to partial flap necrosis, was only observed in reverse sural flaps over the course of our research. As a result of the full necrosis of the reverse sural flap in one of the patients, the cross-limb flap was utilized as a salvage method. Our research found that patients who had medial plantar flap repair had an average length of stay in the hospital of 11 days, which is much less than the average length of stay in the hospital that was seen for pedicled flap

reconstruction, which was 20 days. Patients were followed up on on a consistent basis after they were discharged from the hospital. After a month had passed, evaluations were carried out, and then again after three, six, and one year had passed. During the period of follow-up, patients were evaluated for heel sensation, ulcerations that were new or reoccurring, walking stability, the amount of time it took for them to resume daily activities, the amount of additional footwear they used, and issues that were associated with the donor site.

Table4:Hospitalstay

Typeofflap	**Meanhospitalstayindays**
Medialplantarflap	11
Reversesuralflap	19
Crosslegflap	28.5

When compared to patients who underwent pedicled flap repair, who were in the hospital for an average of twenty days, patients who underwent medial plantar flap surgery remained in the hospital for an average of eleven days. Patients were followed up on on a consistent basis after they were discharged from the hospital. After a month had passed, evaluations were carried out, and then again after three, six, and one year had passed. During the period of follow-up, patients were evaluated for heel sensation, ulcerations that were new or reoccurring, walking stability, the amount of time it took for them to resume daily activities, the amount of additional footwear they used, and issues that were associated with the donor site.

Additional sensory evaluations were carried out after a month, six months, and a year had passed in order to determine how the flaps were perceived by the participants. An evaluation was performed on the flaps to determine their sensitivity to cold, vibration (using a tuning fork), acute pain (with a disposable pin), static and dynamic two-point discrimination, and comparison with the region of the contralateral heel and instep. When it came to the ability to perceive sensations, there was not a significant difference between the groups that received medial plantar flap and contralateral heel flap, according to the statistical analysis. It is interesting to note that the contralateral heel exhibited higher two-point discriminating stimuli in response to cold and static than the contralateral heel alone. According to previous study [16,17], which demonstrated that the medial plantar flap cover had much more sensation than the contralateral normal heel in terms of cold temperature, light pressure, and static and dynamic two-point discrimination, these results and data were consistent with those findings. When it came to the epidermis, the region toward the back had the highest degree of thick and heavy keratinization. In the research conducted by [15] in 2007, there were only six patients who had medial plantar nerves that were working properly; hence, these individuals were the only ones on whom this dissection was performed upon. During the follow-up period, none of these patients experienced a recurrence of their ulcers; however, one of them did report experiencing a loss in sensation in the forefoot over the few months that followed the therapy. The results of additional study [17, 18, 19, 20] have demonstrated that flaps that are intact have a diminished sensation after surgery. Seven of the thirteen patients observed for a long time showed signs of hypo- or hypersensitivity in the forefoot, according to a research [18]. Emotional regulation was also significantly improved in another subset of study participants. There has been speculation that the medial plantar flap, ever since its description by Harrison and Morgan [5], is more long-lasting than flaps originating from extra-plantar locations, such as reverse sural flaps. This is because, among other things, it has a specific fat pad with fibrous septae that protect against shear-induced stresses and because it replaces "like tissue with like," an invaluable feature in the sole. The team of researchers

determined that the sole's ability to withstand both weight and shear pressures is due to an inherent mechanical feature. Because it gives a protective sense, this quality is also crucial in reducing walking-related accidents. The findings of the Gravem study [21] provide credence to this idea. The research demonstrates that only two of the fourteen patients who were followed for an extended period of time suffered recurrent ulceration. Ulcers appeared on three out of twenty-one feet of insensate foot patients who were followed up for a considerable amount of time in past study [15,18–20]. The MPA flap and the reverse sural flap were both subjected to a comparative investigation that was carried out by Ali et al. [22]. There was a correlation between MPA flaps and shorter healing durations and fewer difficulties; however, long-term outcomes (also known as recurrences) were not published. The researchers Benito-Ruiz et al. [23] discovered that there were no recurrent lesions in either reverse sural flaps or MPA flaps after a year or two of follow-up period [24].

Over the course of the one-year follow-up period, our research revealed that the group that had medial plantar treatment had a considerably reduced incidence of recurrent ulceration (26.6% compared to the group that received pedicle flap treatment (73.2%). After the interface, the medial plantar region (13.3%) and the pedicled flap group (46.6%) were the areas that saw the highest number of ulcerations. One third of patients in the medial plantar group experienced new ulceration sites, while twenty percent of patients in the pedicle flap group experienced this phenomenon. A total of 34.7% of patients with neuropathy experienced the development of new ulceration sites, while only 5.4% of persons who did not have neuropathy had this phenomenon. The shift in stride and foot arches was most likely the cause of this particular occurrence. Ulceration above the flap was observed in 6.6% of patients, although this was only observed in the group that utilized pedicled flaps. The group that utilized medial plantar flaps did not experience any ulceration.

Table5:Use of additional foot wear

Flap	**At 6-month follow-up**	**At1yearfollow-up**
Medialplantarflap(%ofcases)	13.3	16.6
Pedicledflap(reversesural&crosslegflap)(%ofcases)	46.6	30

71.6% of the patients showed good walking stability over the six-month follow-up period when asked to rank their walking stability as good (as before), average, or bad (unstable). Over the next six months, as patients grew used to their new feet, this rate rose to 83.3%. In the medial plantar group, 90% of patients reported good stability over the first six months of follow-up, whereas 10% indicated average-to-poor stability. The one-year follow-up showed a 93.3% rise in this proportion. The number of patients with average-to-poor stability improved from the first 6-month follow-up to the 1-year follow-up (46.6% vs. 53.3% for the pedicled flap group), whose walking was graded as satisfactory at 73.3%. For the medial plantar group, it took an average of around 30 days to get back to everyday activities, such as walking at a regular pace on your own and with or without protective shoes. On the other hand, it took the pedicled flap group around 45 days to get to this stage. This suggests that, in comparison to the pedicle flap group, the medial plantar flap, when utilized as a heel cover, allows the patient to resume daily activities much earlier (p-value). Patients can benefit financially and psychologically from this discovery.

13.3% of the cases involving the medial plantar required additional footwear between the first four weeks to six months following surgery. This footwear might take the shape of specially

constructed sandals or shoes with microcellular rubber bottoms. 46.6% of the instances were associated with the pedicle category. Thirty percent was needed in the pedicle flap group for the same results after six months to a year. Due to the statistically significant difference ($p < 0.05$), the patient has increased financial hardship and limitations on their routine activities following pedicle flap repair.

Conclusion:

To summarize, surgical repair for heel deformity presents a major challenge to both patients and medical professionals. Because of the intricate architecture of the heel, the variety of etiologies of abnormalities, and the complicated nature of related disorders, a careful and customized approach is required. Surgeons have a wide range of factors to take into account, including the characteristics of the patient, the severity of the deformity, and the desired functional outcomes. While this may seem like a daunting task, advancements in surgical techniques, technology, and research provide positive opportunities for improved outcomes and patient satisfaction. Sustained innovation and cooperative efforts by podiatrists, orthopedic surgeons, and other specialists will enhance the effectiveness of heel deformity restoration and, in the end, improve the quality of life for those who suffer from these difficult diseases.

Conflict of interest:

The authors declare that they have no conflict of interest.

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