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RESEARCH ARTICLE

Efficiency Of Medial Plantar Artery Flap in Patients With Plantar Defect: A Retrospective Study

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Abstract

Introductıon: Reconstruction of soft tissue defects of the lower extremities is a major challenge for plastic surgeons, and reconstruction options are limited. In this study, we aimed to evaluated the results of reconstructing plantar defects with the medial plantar artery flap, which is a safe and simple method for reconstruction. **Methods:** This study included patients who underwent reconstruction with a medial plantar artery flap in 15 patients with plantar defects between February 2019 and June 2021.Anatomical landmarks were marked. The flap was elevated and the dissection was extended proximally to prevent tension. **Results:** All defects were successfully reconstructed without complications except in one of 15 patients (12 males, 3 females).Due to the dehiscence of both flaps, the patient underwent a second operation for successful reconstruction. All harvest sites were reconstructed with a split thickness skin graft from the thigh. The necrotized flap area was reconstructed with a split-thickness skin graft from the thigh, which was vacuum-assisted closed after debridement. **Conclusıon:** All defects were successfully reconstructed without complications except in one of 15 patients (12 males, 3 females).Due to the dehiscence of both flaps, the patient underwent a second operation for successful reconstruction. All harvest sites were reconstructed with a split thickness skin graft from the thigh. The necrotized flap area was reconstructed with a split-thickness skin graft from the thigh, which was vacuum-assisted closed after debridement.

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Introduction

Although the reconstruction of defects in the plantar region is difficult, the treatment of tissue loss in this area is difficult both clinically and surgically. They cause significant morbidity and mortality, which can lead to osteomyelitis and subsequent amputations in patients.[1] It is very important to prevent ulceration that occurs when the defect remains open and to close the defects quickly.

The fact that the plantar region is hairless, has thick skin, supports all body weight, and has inadequate locoregional tissue complicates reconstruction of the region.[1,2] The plantar region serves as a stance surface and a counterbalance for the pressure exerted during locomotion, and the weight-bearing surface of the heel is separated by fibrous septa and consists of specialized fats.[1,2]

The vascular anatomy of the medial plantar artery (Mpa) was reviewed by Shanahan et al. in 1979.[3] It was defined as a free flap by Morrison in 1983.[4] The use of the medial plantar artery flap in the plantar region and at the heel was defined by Masquelet and Romana in 1990.[5] At the same time, the medial plantar artery is used as a vascular source for free flaps in foot defects.[5] Since then, it has been used as a local flap in foot and medial malleolar defects.[5] Its use in plantar and ankle defects is quite common reconstructed.[6]

In this study, we aimed to evaluate the use and results of the medial plantar artery flap in the reconstruction of plantar defects.

Materyal and Methods

Study Design

This single-center retrospective study was conducted between February 2019 and June 2021 in the xxxxxxxxxxxxxxxxxxxx. The study was planned in accordance with the Declaration of Helsinki and was granted approval by the Hospital Clinical Research Ethics Committee No. 1 (date 23/02/2022, decision number E1-21-2175)

Surgical technique

After preoperative preparation and planning, patients were taken to the operating room. After appropriate induction of anesthesia, the surgical area was prepared with antiseptic iodine solution and covered with sterile drapes. All surgeries and long-term and short-term follow-up of patients were performed by the same surgeon. Preoperative blood and imaging results were evaluated, and an anesthesia report was obtained. Initially, radical and complete debridement of all nonliving tissues was performed. After the boundaries of healthy living tissue were established, debridement was terminated. The use of tourniquets was avoided to separate necrotic tissue from healthy tissue. Reconstruction was performed in all patients after debridement. Flaps were planned from nonweight-bearing areas for reconstruction of the defects.

Preoperative patency of the arterial systems was confirmed by Doppler USG in all patients. In patients with diabetes, additional elective angiography was performed before surgery and found that the vessels were open.

Preoperative planning and marking

Preoperatively, the course of the posterior tibial artery and the medial plantar artery was determined topographically by Doppler. The boundaries of the flap were determined according to the size of the defect. Because the flap would contract, it was planned to be larger than the defect size. The long axis of the flap was planned parallel to the medial arch of the foot. The medial edge of the flap was not to exceed the navicular tuberosity. The lateral edge was planned as a medial longitudinal arch, which does not create pressure. The proximal margin was limited to the distal part of the calcaneal tuberosity, and the distal margin was limited to the proximal part of the first and second metatarsal heads to avoid pressureless parts of the plantar region. The areas of the flap incisions were marked (Figure 1).

Figure 1: The planning and marking of the flap borders.

Dissection

The incision was made to include the skin, adipose tissue, and superficial fascia of the foot. Dissection of the flap began at the distal edge, and the free edge of the flap was elevated at the distal incision site. For the first few centimeters, the plantar fascia was cut with a sharp size 15 scalpel, followed by Metzenbaum scissors for safe dissection. The operation was performed with a combination of blunt and sharp dissection. The plantar fascia was separated from the flexor digitorum brevis muscle, taking care to spare the long flexor tendons and their crossing sensory nerves during this dissection. The anatomic location of the medial plantar artery was marked. (The medial plantar artery is located deep in the intermuscular septum between the abductor hallucis muscle and the flexor digitorum brevis muscle, lateral to the tendon of the flexor hallucis longus muscle). Later, the flap was elevated from the lateral, medial, and proximal sides. When the flap was elevated from the medial side, the paratenon of the abductor hallucis tendon and its peritendinous structures were preserved. During lateral dissection, the incision was deepened, the plantar fascia was included in the flap, and the flexor digitorum brevis muscle was lateralized to expose the pedicle. The distal, lateral, and medial edges of the flap were elevated, and the posterior tibial artery was visualized proximally under the retinaculum flexorum. The medial plantar artery was ligated distal to the flap. The proximal portion of the abductor hallucis longus tendon was transected to increase the length of the pedicle, and the medial and lateral plantar arteries were visible at this level. The dominant pedicle and accompanying concomitan veins were preserved and elevated. Pedicle length was increased by dissection in the direction of the posterior tibial artery.[7]

Dissection with a 2.5-fold magnification of the surgical loop reduces the risk of vascular injury. The use of the automatic retractor in the intermuscular septum between the muscles facilitates dissection. The vascular structure should be dissected proximally so that the flap is free of tension in the defect area.

Statistical analysis

For the statistical analysis, Statistical Package for the Social Sciences -SPSS 25.0 was used. Descriptive statistics for numerical variables are mean, standard deviation, median, min-max. expressed as values.

Results

Between February 2019 and June 2021, 15 patients with plantar defect were admitted to our clinic. 12 of these patients were male and 3 were female. The average age of the patients ranged from 44±19,2 years. The largest flap size was 6 x 6 cm, and the area ranged from 10 to 36 cm2. The number of patients with additional concomitant diseases was 5. All of these patients underwent surgery at least once. Data on the cases are shown in Table 1.

Table 1.Clinical and demographic findings of the study population

Case	Age	Sex	Etiology (year)	Defect Area	Defect Diameter (cm)	Duration of hospitalization (day)	Complication	Comorbidite
1	21	Male	Gunshot injury	Heel	6X4	14	None	None
2	42	Male	Diabetes mellitus	Heel	7X4	10	None	Hypertension, Diabetes mellitus
3	44	Male	Traffic accident	Plantar	7X5	12	None	None
4	18	Male	Traffic accident	Plantar	4X4	11	Dehissans, Necrosis	Hypertension, Diabetes mellitus
5	51	Female	Traffic accident	Heel	5X5	10	None	Hypertension,
6	50	Male	Diabetes mellitus	Heel	5X4	21	None	None
7	61	Male	Traffic accident	Plantar	7X3	15	None	None
8	46	Male	Diabetes mellitus	Plantar	6X5	10	Dehissans	Hypertension, Diabetes mellitus, Atherosklerosis
9	43	Female	Traffic accident	Plantar	6X2	12	None	None
10	63	Male	Traffic accident	Plantar	5X4	9	None	Hypertension, Atherosklerosis
11	54	Male	Gunshot injury	Heel	4X4	28	None	None
12	25	Female	Traffic accident	Heel	4X3	10	None	None
13	20	Male	Traffic accident	Heel	5X4	12	None	None
14	19	Male	Gunshot injury	Plantar	5X2	11	None	None
15	24	Male	Traffic accident	Heel	4x4	10	None	None

Cases

Case 2: The patient, injured by a traffic accident, with skin and subcutaneous necrosis on the heel, was taken by the orthopedic service because he had no bone pathology. The necrotic area was debrided and the bone was exposed. It was decided to make a medial plantar artery flap for the bony defect at the heel. A 7x4 cm medial plantar artery flap was planned. The flap was elevated and a hemovac drain was placed under the flap. The flap was sutured to the defect area with 3/0 monofilament suture in the subdermal plane. Then the skin was reconstructed by suturing with 3/0 polypropylene suture (Figure 2a). The defect of the flap in the donor site was reconstructed with a split thickness skin graft (STSG) taken from the anterolateral aspect of the lower extremity thigh. The donor site of the flap was reconstructed with stsg taken from the anterior aspect of the thigh. A tieover dressing was applied to the graft. Three days later, the tie-over dressing was opened. No complications occurred in the donor site.

Figure 2a: Adaptation of the flap to the defect.

Case 4: The patient, who had a lesion on the plantar region and whose pathology at an external center revealed malignant melanoma, was admitted to our clinic and hospitalized after further examination. The patient had diabetes mellitus disease. The patient's lesion was marked and excised with wide excision. Frozen result was negative. The patient had additional comorbidities such as Hypertension and Diabetes mellitus. A medial plantar artery flap was planned for the patient with plantar defect. The flap was elevated and a hemovac drain was placed at the base of the flap (Figure 3a). The flap was sutured to the defect area with an absorbable 3/0 monofilament suture in the subdermal plane. The skin was then sutured with 3/0 polypropylene suture and successfully reconstructed. The donor area was reconstructed with STSG from the anterolateral thigh. A tie-over dressing was applied to the graft, which was opened 3 days later. The graft was seen to be adherent to the base. On the same day, the patient underwent secondary operation for dehiscence at the wound site and hematoma at the base of the flap. Hemostasis was performed at the bleeding sites, and capillary haemorrhage of the flap was observed. In the following days, flap necrosis occurred due to the development of arterial insufficiency after initial venous insufficiency in the flap. Debridement was performed, the proximal medial plantar artery was ligated, and the existing area was reconstructed with STSG from the anterolateral thigh after 2 Vacuum asisted closure sessions. No complications occurred in the donor area. Neither recurrence nor wound dehiscence was observed in the late postoperative period (Figure 3b).

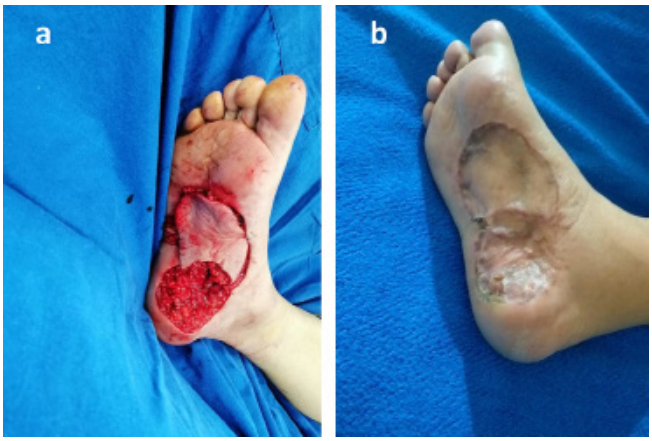

Figure 3a: Defect measured 4 cm × 4 cm after wide excision of the Melanoma in the left heel. Figure 3b: Late postoperative view (12th month) of the defect reconstructed with Split thickness skin graft from contralateral thigh after flap necrosis.

In all cases, the defects were examined for infectious diseases in terms of antibiotic therapy, and after negative culture results, they were operated. The defects were completely reconstructed in all patients. When the flaps were elevated, the plantar nerve was preserved, but although coaptation of the plantar nerve was performed in 2 diabetic patients (cases 2-8), no sensory return occurred at short and long follow-up.

After surgery, the flap was examined and closely observed 2-3 times per day for at least 10 days. All patients were discharged from the hospital after a recovery period of 2-4 weeks. Patients were followed up with controls every 4 weeks for at least 1 year, with an average of 14 months. After surgery, patients were allowed limited movement for 3 weeks. After the 3rd week, the operated foot was partially elevated from 5 minutes, and walking was allowed. Patients who did not experience complications were encouraged to return to their daily routine activities after week 5. Although a portion of the flap remained in the weight-bearing region in flaps placed at the heel, no wound dehiscence or necrosis occurred in late-stage flaps (postop 18th month) (Figure 2b).

Figure 2b: The appearance of the flap in the 18th postoperative month.

Discussion

Defects of anatomical structures and weight-bearing parts of the foot, such as bones, tendons, joints, should be reconstructed with a flap. Reconstruction is difficult because of the limited number of flaps localized in the foot region.[8] Recently, foot defects have been reconstructed with skin-based island flaps. The general goal of reconstructing soft tissue defects in this region is to close the defect more quickly and easily by using skin with similar properties to the original skin.[9]

Cross leg flaps[10] and free flaps[11] can also be used in this area. However, in the cross-leg flap, postoperative care and immobilization are not acceptable nowadays when microsurgical methods are developed. Instead, microvascular free flaps are preferred. Most free flaps are done with flap thinning in secondary surgery. In addition, free flaps are technically difficult, require a long operative time and a surgeon trained in microsurgery.[12] These operations cannot be easily performed in small medical centers. Because of all these difficulties, pedicled flaps are preferred. There are a sufficient number of anatomic and clinical studies on the use of pedicled flaps in this region for defects in the foot.[13] The pedicled medial plantar artery flap, which we prefer, can be elevated in a short time. This flap does not need microsurgical expreience. It is a surgical technique with a rapid learning curve, as it can be performed in a single session without the need for surgery. Mpa flap is pliable, hairless, and its anatomy is reliable are important features.[14] In addition, this flap is one of the flaps that should meet all the requirements for defects in the plantar region because of its sensory feedback and thick glabrousness.[14] It has been reported that sensory recovery is more perfect in this reconstruction with tissue.[15] Although we performed nerve coaptation in two of our patients, there was no sensory recovery at late follow-up, and we think this is due to the insufficient number of patients and/or diabetes-related neuropathy because these patients are diabetic.

Another advantage of the flap is that it contains a sufficiently thick flap, donor site morbidity is minimal, the donor scar is not visible, there is no loss of function, it heals in a short time, and its vascularity is reliable.[6],[16] The medial plantar artery flap is very valuable for reconstruction of the plantar side of the foot with similar tissue. There were also no problems with the harvest site of the flap in our patients. We observed satisfactory functional gain in all patients. The gait pattern of the patients was normal, they could wear shoes and were satisfied with the cosmetic appearance of the flap.

The medial plantar artery-based flap is planned from the non-weight-bearing part of the plantar arch and is used in the reconstruction of the plantar region.[17] Since the medial plantar artery is not the dominant artery of the foot, it can be easily sacrificed.[17] It was easily used even in diabetic patients.[18] Although the number of patients in our study was limited, successful results were obtained in this flap used in diabetic patients, and additional studies are needed.

Although the medial plantar artery flap is safely used for foot defects, there are also some complications reported in previous publications.[19] Siddiqi et al.[17] reported one partial flap loss in their study of 18 patients. In a multicenter prospective study by Schwarz and Negrini, flap necrosis was reported in 1 of 51 patients, delayed healing in 4, and recurrent ulceration in 7.[18] Recurrent ulceration has been associated with diabetes-induced neuropathy.[18] In our study, the rate of dehiscence and necrosis was lower, and no ulceration was observed at all. Flap necrosis was observed in one patient. These results were similar to those of the study by Benito-Ruiz et al.[20] The reason could be the small number of patients or the antibiotic treatment we used in consultation with preoperative infectious diseases.

Khan et al reported necrosis in 1 of 16 patients. They attributed

the necrosis to impaired foot perfusion due to diabetes.[21] This is because the patency of the vessels participating in foot blood flow was confirmed by Doppler and angiography studies before surgery. However, there is a need to work with more patients on this issue. In the study by Schwarz et al, the overall complication rate (necrosis, dehiscence, infection, etc.) was 25%, and the number of patients with recovery was reported to be 11%.[18] In our study, the overall complication rate was 13,3%, and the wound dehiscence rate was 13,3%. This depends on the preoperative antibiotic treatment and glycemic control in diabetic patients.

Reconstructions with flaps of the medial plantar artery have some limitations. The disadvantage of this technique is that the foot includes the plantar apeneurosis, where the main blood flow is also located.22 Another disadvantage is that the distal vascular network cannot be relied upon to provide retrograde flow in the event of severe injury to the foot. Limitations of the flap and the risk of venous congestion are also among the limitations.23 In cases where larger flaps are required, muscle or fasciocutaneous other flaps (Anterolateral thigh flap, rectus abdominis flap...) should be preferred for defect reconstruction.

Conclusion:

The medial plantar artery flap is one of the flap options that can be used for plantar defects. It has provided satisfactory long-term results without compromising foot function and is a useful option for reconstruction of plantar zone defects. In our cases, the island flap allows the foot to move up to the instep area. The anatomical structure of this area is outside the weight bearing area of the foot and has the same characteristics as the plantar area. It has become a preferred technique in our clinic. In this study, it was found that the medial plantar artery flap is a practical and simple method that can be used for defects in the plantar region.

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