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Free medial plantar flap connection with a posterior tibial artery flap and its modification for combined dorsal and plantar foot defects – two case reports

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Summary

Reconstruction of large soft tissue foot defects were considered a difficult issue due to weight-bearing function of the foot. The reconstruction becomes more difficult when both plantar and dorsal soft tissues are involved. The options for the reconstruction were variable, in 2016 Hao Wu et al. presented a combined flap for coverage of combined fore-foot plantar and dorsal soft tissue defects. We used combined flaps in two cases and present our experience in this article.

Key words

soft tissue foot defects – combined soft tissue foot defects – combined medial plantar and posterior tibial flap

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Introduction

Skin defects of the foot represent a challenge, especially plantar foot defects due to different structural anatomy and functional demands compared to other sites of the body.

The sole is designed to tolerate weight bearing, the glabrous skin has thick epidermis and the dermal epidermal junction is tightly anchored to the bone by fibrous septa, reducing shearing forces and protective sensation. The subcutaneous fat is arranged in the chambers between fibrous septa, providing shock absorption function [1,2].

Several types of flaps were designed to cover these defects with controversies regarding the best flap that produce similar characters to plantar skin, especially for large sized defects [3].

Local flaps, especially the medial plantar flap, are considered the first choice in replacing these defects considering the rule of replacing "like with a like principle". Unfortunately, this is not applicable for large sized defects [3–6].

Combined dorsal and plantar soft tissue defects are considered large-sized defects that require free tissue transfer for reconstruction [7].

In 2016 Hao Wu et al. described a combined free medial plantar and posterior tibial artery flap for combined fore-foot dorsal and plantar defects [8].

They used the sensate medial plantar flap to cover the plantar fore-foot defect, and the posterior tibial artery flap to cover dorsal defect; anastomosis was done to the dorsalis pedis vessels.

However, this combined flap has a limitation; being used only for fore-foot defects with amputated toes.

We used this combined flap in reconstruction of two cases.

One case had combined dorsal and plantar fore-foot defects, we followed the same steps of Hao Wu et al. description. In the other case, we had a combined dorsal and plantar hind foot defects; thus, we modified their flap to suit this condition by including the abductor hallucis muscle in our flap.

Anatomic basis

The posterior tibial artery is one of the terminal branches of the tibio-peroneal trunk (a terminal branch of popliteal artery) that passes posterior to the popliteus muscle and pierces the soleus muscle. It runs in the posterior compartment of the leg in the septum between the superficial and deep muscles group.

The distal part of the artery is superficially running underneath the skin, being anterior and parallel to the tendo-achillis.

It has ten branches in total; circumflex fibular, nutrient, muscular, perforating, communicating, medial malleolar, calcaneal, fibular, lateral plantar and medial plantar arteries [9].

The skin perforators arise from the artery at variable distances. There are three groups of perforators for the posterior tibial artery at the following distances proximal to the medial malleolus: 1. 4–9 cm, 2. 13–18 cm, and 3. 21–26 cm. Perforators with the largest caliber usually present in the proximal two--thirds of the leg [10].

Before entering the tarsal tunnel, it divides into two terminal branches – a lateral plantar artery and a smaller medial plantar artery.

The medial plantar artery at first lies deep to abductor hallucis, in the septum between the abductor hallucis and the flexor digitorum brevis and ends at the base of first metatarsal. It passes along a medial border of first toe where it ends by anastomosing to the first dorsal metatarsal artery.

It has two branches superficially giving rise to the skin perforators and a deep branch supplying the abductor hallucis.

The abductor hallucis muscle arises from medial calcaneal tuberosity, flexor retinaculum, and plantar aponeurosis and inserts into the medial side of the great toe proximal phalanx [11].

It has a major proximal vascular pedicle and two distal minor pedicles (classified as type two muscle) [12].

The abductor hallucis is a well-known local muscle flap, either a proximally or a distally based flap for coverage of small sized foot defects [13].

Surgical technique

The integrity of the anterior tibial, the dorsalis pedis, and the posterior tibial was assessed perioperative by hand-held doppler in both legs.

Adequate debridement was carried out in a recipient site.

The dorsalis pedis vessels were traced proximally medial to the extensor digitorum brevis and just lateral to the extensor hallucis longus tendon; the inferior and superior extensor retinaculum was incised to explore the proximal part of the vessels. The vessels were traced in the distal leg above the superior extensor retinaculum deep to the extensor tendons. In two cases, anastomosis was made in the distal leg just above the superior extensor retinaculum.

The saphenous vein was traced proximally to the level of expected anastomosis.

Recipient's vessels were clamped by vascular clamps before being used for anastomosis to assess vascularity of the foot. We did not explore the posterior tibial vessels.

The terminal end of the superficial peroneal, saphenous first plantar digital and calcaneal nerves were identified in the field and traced proximally to a healthy level.

The contralateral leg was used for the flap harvest. The harvest was carried out under a tourniquet.

Although Hao Wu et al. recommended harvesting the posterior tibial artery flap first, we started by harvesting the medial plantar flap. We designed the flap in the instep area. Usually, we start by incising the medial flap border exposing the abductor hallucis that was retracted to expose the septum between it and the flexor digitorum brevis.

Once the septum was identified and the minor skin perforators at the distal part were recognized, we dissected to the proximal part of the septum where the superficial branch of the medial plantar artery and the main perforator were identified, branches to the muscles were ligated. In the second case, we preserved the deep branch supplying the abductor hallucis. A sensory branch usually enters the flap at the level of the main perforator that was traced to the medial plantar nerve.

After identification of the artery and the perforator, the plantar border of the flap was incised, exposing the flexor digitorum brevis that was retracted to identify the septum.

Digital branches were identified and protected.

Then we incised the distal end of the flap and ligated the distal end of the medial plantar artery and dissected the flap in a retrograde manner, reaching to the abductor hallucis. In the first case, we incised it to expose the proximal part of medial

Fig. 1. A and B were plantar and dorsal components of the defect.

Fig. 2. A) flap design, B) flap harvest, C) flap after separation with its two components, D, E) donor-site morbidity and F) flap after insetting. White arrow in F pints to posterior tibial flap while black one points to medial plantar flap.

plantar vessels, while in the second case we harvested it from its insertion and origin, keeping its vascular pedicle.

Then we ligated the lateral plantar artery and followed the posterior tibial artery to the distal end of the posterior tibial artery flap.

For posterior tibial artery flap, we designed the flap from the medial border of the tibia to mid-line posterior.

Usually, we start by incising the posterior border of the flap. A deep fascia over the superficial muscle group anterior to tendo-achillis is incised.

The superficial group was retracted, exposing the septum between the superficial and the deep muscle groups, through which the posterior tibial septocutaneous perforators were identified.

After that we incised the anterior flap border, reaching the septum.

Fig. 3. Four years follow up A) medial plantar, B) posterior tibial flaps, C, D) the patient is weight-bearing well.

The saphenous nerve was identified and harvested with the flap, while the saphenous vein was dissected out of the flap. The deep muscular branches were ligated and the posterior tibial artery was freed to the proximal end of the flap.

The tourniquet was deflated and both flaps were left to ensure adequate perfusion.

First, we started by suturing the medial plantar flap to the plantar defect during the flap inset in both cases.

In the first case, the exposed segment of the vessels was passed through the web space and the posterior tibial artery flap was then sutured to the dorsal defect while suturing its distal part to the medial plantar flap to cover vessels and the fore-foot.

This was not applicable in the second case; as it is a hind-foot defect with intact remaining foot parts.

We passed the exposed segment across lateral border of the hind-foot and covered it by abductor hallucis muscle.

The proximal ends of the posterior tibial vessels were anastomosed to the dorsalis pedis vessels in the first case, and to the anterior tibial vessels in the second case.

The saphenous nerve was sutured to the superficial peroneal nerve in both cases, while the medial plantar flap sensory nerve was sutured to the first digital nerve in the first case and to the distal end of the calcaneal branch in the second case.

Case description

Case No. 1 (Fig. 1–4)

A 28-year-old male patient has amputated toes with skin loss extending to the mid-foot dorsally and plantarly due to a car accident in 2019. The patient was on a vacuum assisted wound dressing for 5 days after initial debridement; then the defect was reconstructed by a combined flap. The posterior tibial flap size was 15 × 8 cm and this flap was used for the dorsal defect, while the medial plantar flap size was 9 × 7 cm and this flap was used for the plantar defect.

A common pedicle length was 4 cm (proximal to the proximal edge of the posterior tibial flap).

The remaining raw area covered by STSG (5 × 4 cm on medial side and 8 × 5 on lateral side).

Vascular anastomosis was performed to the anterior tibial artery and its comitant veins.

The saphenous nerve of the posterior tibial flap was anastomosed to the superficial peroneal nerve of the recipient site.

The sensory branch of the medial plantar flap was anastomosed to the medial plantar digital nerve of the big toe.

Anastomosis was done above the extensor retinaculum.

A follow-up of 4 years showed good flap survival, texture and sensibility.

A static foot scan showed reduced total contact pressure area; that means the patient is trying to protect the injured limb unconsciously.

Case No. 2 (Fig. 5–8)

A 14-year-old male patient had a degloving injury with a skin loss over the ankle and the foot and plantarly over the hind-foot due to a motorbike accident in 2020. Debridement and vacuum assisted wound dressing was performed

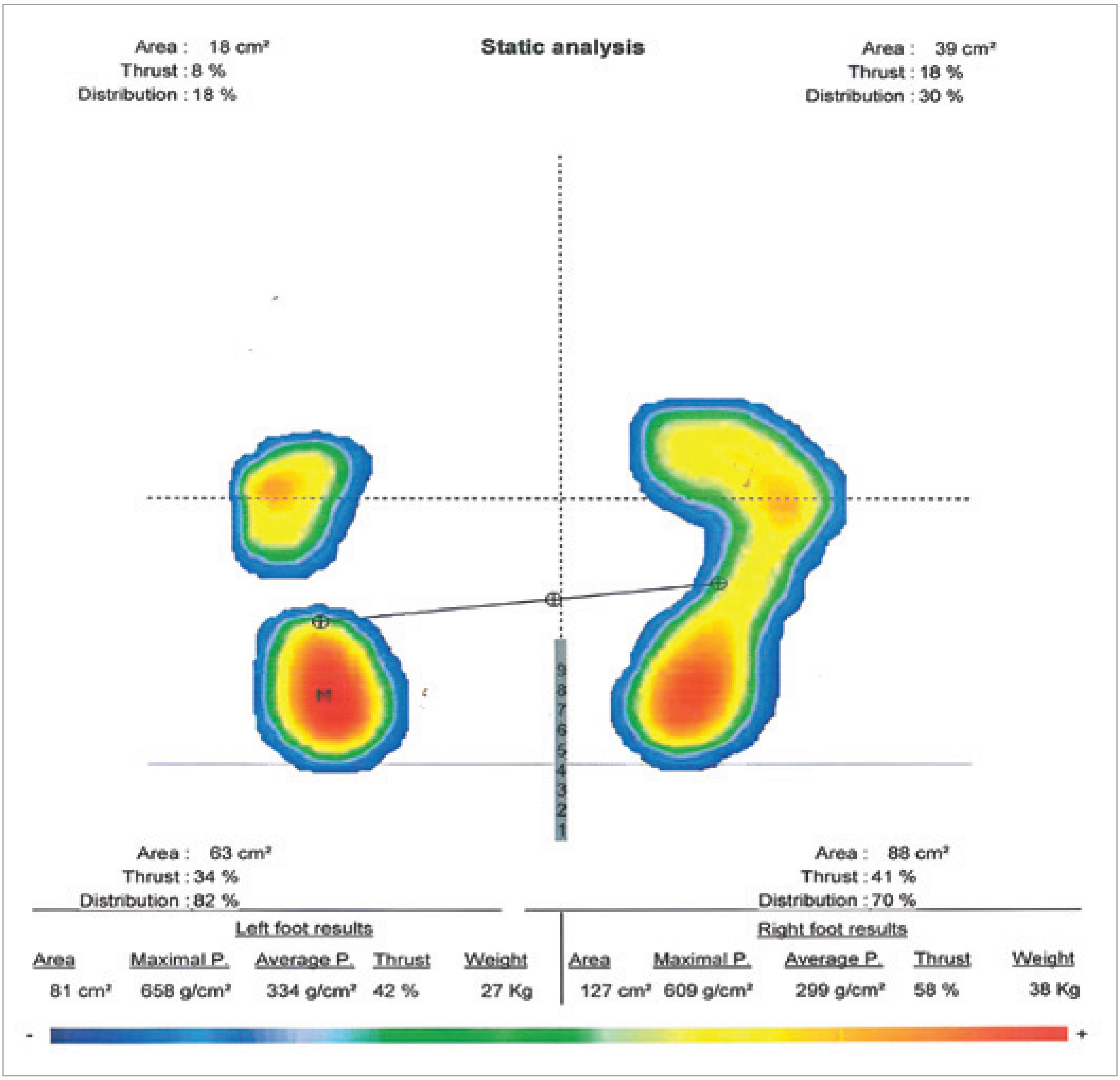

Fig. 4. Static plantar pressure measurement.

for 1 week, then the defect was reconstructed by a combined flap. The posterior tibial flap size was 17 × 9 cm and the flap was used for a dorsal defect, while the medial plantar flap size was 11 × 6 cm and this flap was used for a plantar defect. The abductor hallucis muscle was used to cover the exposed vascular segment. The remaining raw area was covered by STSG (10 × 6 cm on the medial side and 9 × 3 cm on the lateral side).

Vascular anastomosis was performed to the anterior tibial artery, one deep vein and the other vein to saphenous vein.

The aphenous nerve of the posterior tibial flap was anastomosed to the saphenous nerve of the recipient site. The sensory branch of the medial plantar flap was anastomosed to the calcaneal branch. Anastomosis was performed in the distal leg deep to the extensors.

A follow-up lasting 1 and 3 years showed good flap survival, texture and sensibility.

A static foot scan showed a slight reduction in contact pressure area, compared to a normal side.

Discussion

The foot is a specialized part in the body designed to withstand weight bearing, and to provide shock absorption, elegant shape and protective sensation.

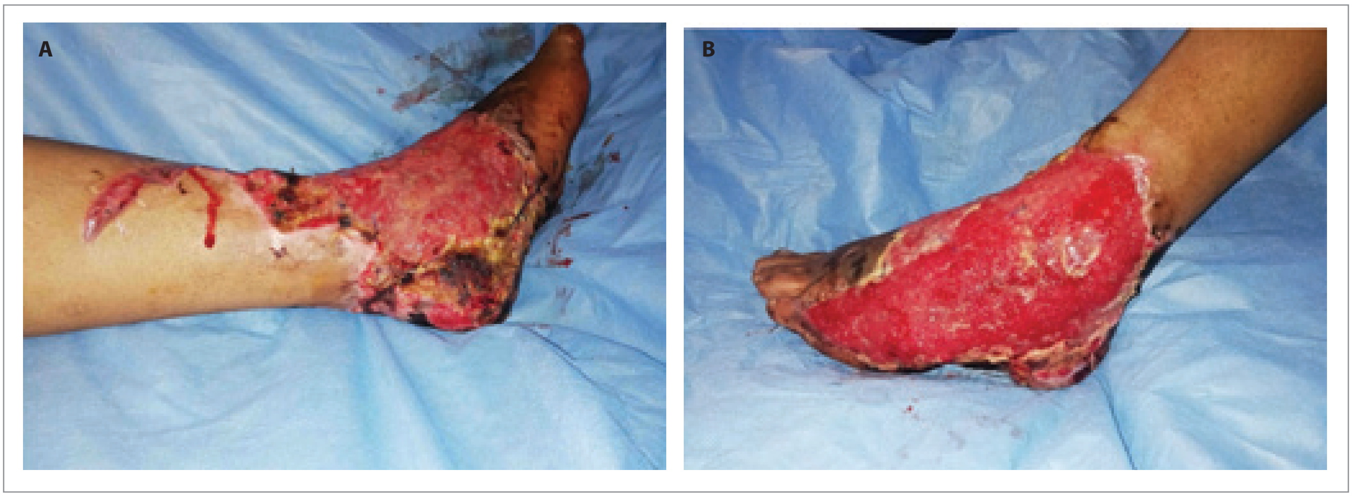

Fig. 5. Dorsal and plantar components of raw area.

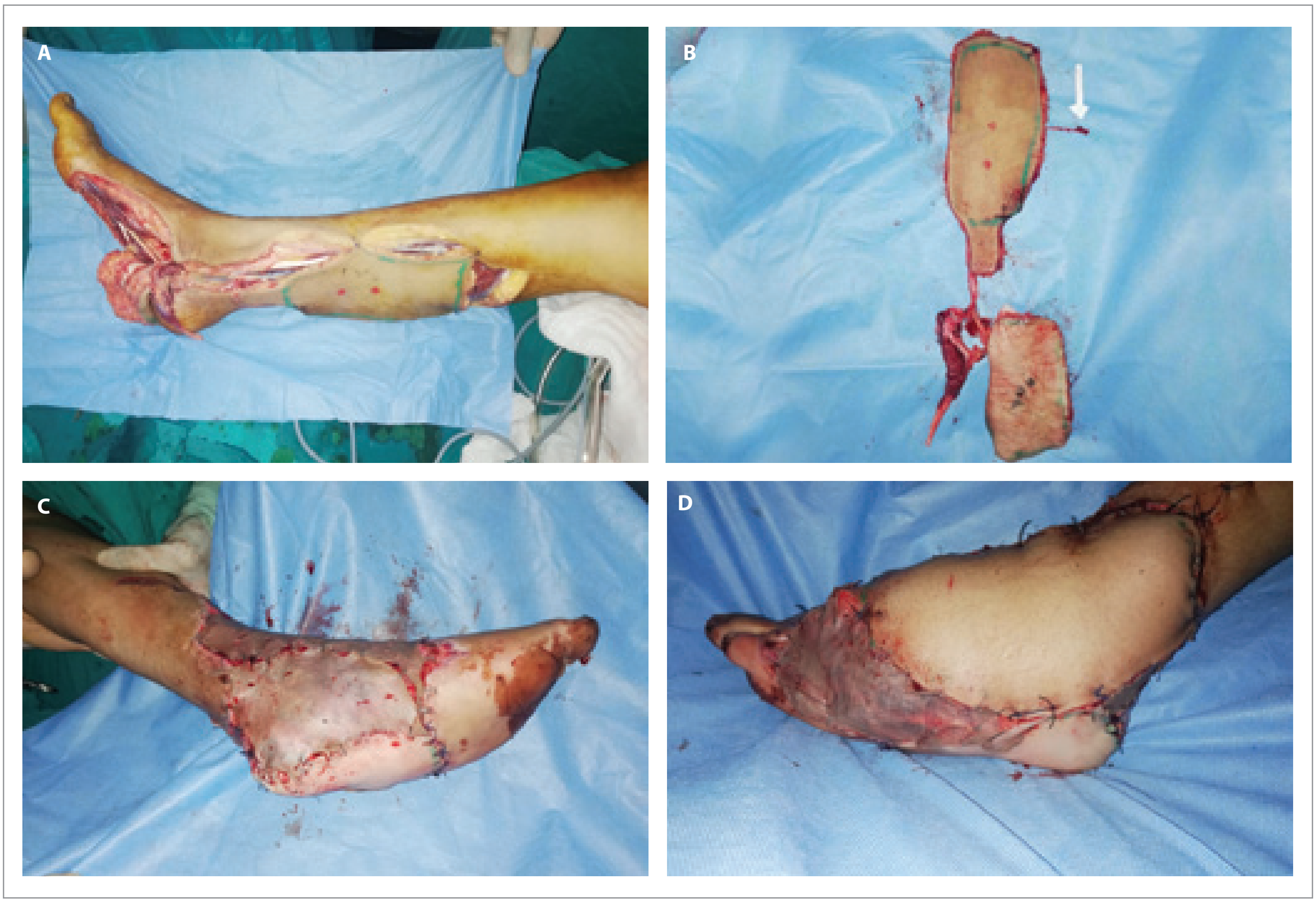

Fig. 6. A) flap design and harvest, B) flap components with white arrows pointing to neurovascular pedicle, C, D) immediate post-operative.

Soft tissue loss can occur because of trauma, which is a common cause, burns, tumors or trophic ulcers.

Flaps used for reconstructing the soft tissue defects should have properties similar to that of the foot. Unfortunately, this is only available for small-sized defects that can be reconstructed by local flaps. Large-sized defects can only be reconstructed by free flaps, either free muscle or free fasciocutaneous flaps, both of which have advantages and disadvantages.

Combined dorsal and plantar foot soft tissue defects represents a special

Fig. 7. A, B) 1 year follow-up, C–F) 3 year follow-up.

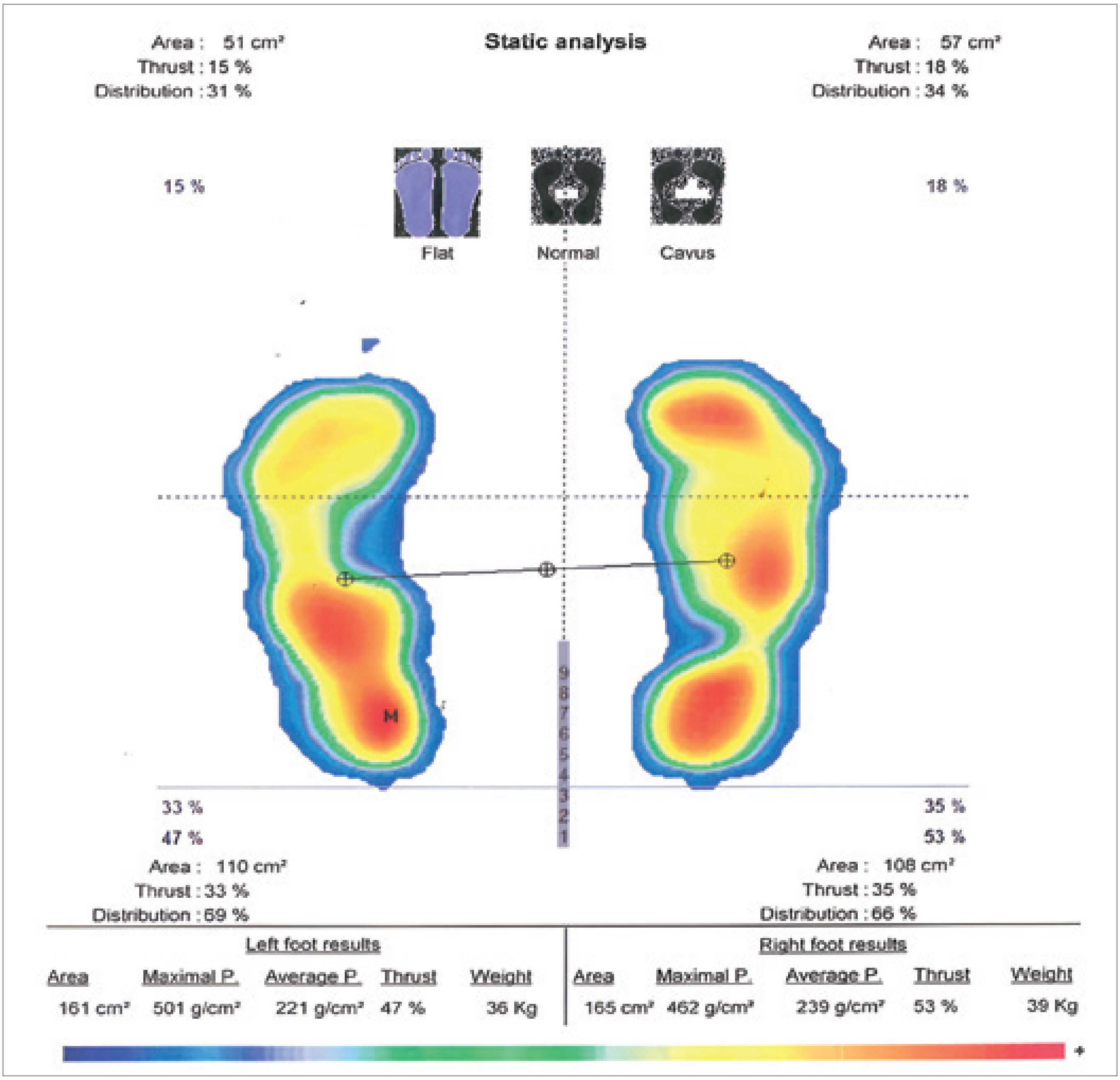

Fig. 8. Static plantar pressure measurement.

difficulty as the available options were limited.

The options include either a large fasciocutaneous or muscle flap with the difficulties in flap in-setting or two flaps using one flap as a flow-through flap increasing the operative time and difficulties and a number of anastomoses.

A combined medial plantar and posterior tibial artery flap described by Hao Wu et al. provides an excellent solution to these defects having several advantages:

- named sensory nerves for both flaps allowing better sensation recovery;
- the shape and thickness of the flap is similar to that of plantar skin;
- the medial plantar flap; when harvested deep with the plantar aponeurosis, it reduces the shearing forces;
- double flaps with a single pedicle ensuring higher survival rate;
- the posterior tibial artery flap with characteristics similar to the dorsum of the foot.

However, it has two disadvantages:

- being used only for fore-foot defects with amputated toes;
- a major leg vessel has been sacrificed (however, sometimes it is necessary).

When used for the fore-foot, the segment of the vessels between two flaps can be passed in the web space and the flaps can be approximated safely, while using the flap for combined dorsal and plantar defects of the hind foot is a good choice; however, the segment of the posterior tibial vessels between two flaps will be exposed without a cover.

Solutions for this situation:

- approximating two flaps resulting in a vascular kink that may jeopardize perfusion;
- using the posterior tibial artery flap as a flow-through flap anastomosing the medial plantar vessels to the posterior tibial vessels at the distal end of the flap, increasing the number of anastomoses and a failure rate;
- including the abductor hallucis muscle with the flap to cover the exposed segment.

The abductor hallucis muscle is a well-known flap used to cover small sized defects based either proximally or distally, with a known vascular pedicle.

Conclusion

A modified combined medial plantar flap and a posterior tibial flap are an excellent choice to reconstruct combined dorsal and plantar defects in any part of the foot.

Roles of the authors

Amr El-Sayed Ali was the chief author, built up the core of the article, and did the first case. Waleed Riad Saleh and Yasser Farouk Ragheb were the surgical team of the second case. Alhussein Ahmed and Abdul Aziz Moncef assisted in surgery and were responsible for a follow-up, photography and editing.

Disclosure

The authors have no conflicts of interest to disclose. The authors declare that this study has received no financial support. All procedures performed in this study involving human participants were in accordance with ethical standards of the institutional and national research committee and with the Helsinki declaration and its later amendments.

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