

# Successful Balanced Gait after Reconstruction of the Weight-bearing Mid Plantar Region Using a Free Contralateral Medial Plantar Flap

Ryo Karakawa, MD  
 Hidehiko Yoshimatsu, MD  
 Hiroki Miyashita, MD  
 Yukiko Kuramoto, MD  
 Tomoyoshi Shibata, MD  
 Tomoyuki Yano, MD

**Summary:** Although soft tissue sarcoma, especially in the sole of the foot, is a rare disease, weight-bearing region reconstruction considering postoperative gait is needed. For functionally satisfactory sole reconstruction, it is important to cover the weight-bearing region with a nonbulky but durable skin paddle that can withstand a significant amount of shear pressure. We herein present a case in which a free contralateral medial plantar flap was used for reconstruction of the weight-bearing mid plantar region for a 41-year-old man who suffered from mid-foot sarcoma. Gait analysis was performed 6 months after the operation with the lower limb loading gauge sheet, and the result indicated that postoperative balanced gait was obtained. The free medial plantar flap transfer after sole sarcoma resection has several advantages. First, the characteristic of this flap with solid anchoring to deep tissue to resist shearing makes it possible to lower the chances of postoperative ulceration. Second, the medial plantar flap has optimal thickness and good color and texture match for sole reconstruction. Third, a sensate flap can be achieved if the medial plantar nerve is included. Although further clinical investigations such as long-term follow-up will be required to confirm its efficacy, this method would be one option for treating sole sarcoma. (*Plast Reconstr Surg Glob Open* 2019;7:e2456; doi: [10.1097/GOX.0000000000002456](https://doi.org/10.1097/GOX.0000000000002456); Published online 30 September 2019.)

**R**econstruction of the weight-bearing region is challenging. Skin grafting is not a suitable option because the skin graft does not have enough durability to bear the weight; flaps are usually used to cover the defect of the weight-bearing area. Among many flap options, postoperative prognosis of the weight-bearing region is controversial.<sup>1-3</sup> The pedicled medial plantar flap is regarded as a good choice for weight-bearing heel reconstruction. However, this pedicled flap often cannot be used for defect of mid-foot region because the medial plantar artery and vein are usually damaged.

Soft tissue sarcoma occurring in the sole of the foot is rare in clinical practice.<sup>4</sup> Recently, limb salvage has become the standard treatment of lower extremity sarcoma.<sup>5</sup> The primary amputation rates are now in the range of 3%–16%.<sup>5</sup> There are few reports in which postoperative

gait is evaluated after the limb salvage reconstruction for sarcoma defect at the sole of the foot.<sup>6</sup>

We herein report a case in which postoperative balanced gait was obtained after the weight-bearing mid plantar region was reconstructed using a free contralateral medial plantar flap for treatment of mid-foot sarcoma.

## CASE REPORT

A 41-year-old male presented to our department after resection of a tumor at the sole of his left foot, which was diagnosed as synovial sarcoma. In the prior surgery, an excision followed by primary closure was performed at another hospital and histopathological analysis revealed Federation Nationale des Centres de Lutte Contre Le Cancer system grade 2 synovial sarcoma with positive surgical margin. Therefore, additional surgical wide resection, followed by immediate reconstruction using a free flap was planned.

Additional surgical wide resection with 1–2 cm margin, including quadratus plantae muscle, lateral plantar artery, vein and nerve, and medial plantar artery, vein, and nerve was performed. The defect after tumor ablation was 7 × 7 cm (Fig. 1). Because the medial plantar artery and vein were resected with the tumor, the local medial plantar flap could not be used. An 8 × 8 cm free medial plantar flap was

*From the Department of Plastic and Reconstructive Surgery, Cancer Institute Hospital of Japanese Foundation for Cancer Research, Tokyo, Japan*

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**Fig. 1.** Intraoperative view after additional surgical wide resection.



**Fig. 2.** An 8 × 8 cm free medial plantar flap was elevated from right sole of the foot.

elevated from the sole of the right foot (Fig. 2). The flap was not elevated as a sensate flap because there was no usable recipient nerve due to the wide resection. The right medial plantar artery was anastomosed to the left posterior tibial artery in an end-to-side manner. Two venae comitantes of the right medial plantar artery were anastomosed to the 2 left posterior tibial veins in an end-to-side fashion, respectively. The skin defect at the donor site was covered with full-thickness skin graft harvested from lumbar area. The histopathological analysis of the second surgery revealed no residual tumor. The radiation therapy was not performed. The postoperative course was uneventful and the free medial plantar flap survived completely (Fig. 3). Dangling was started on postoperative day 8, partial weight bearing was allowed on postoperative day 10, and full weight bearing was allowed on postoperative day 16.



**Fig. 3.** Postoperative view at 3 mo after the surgery.

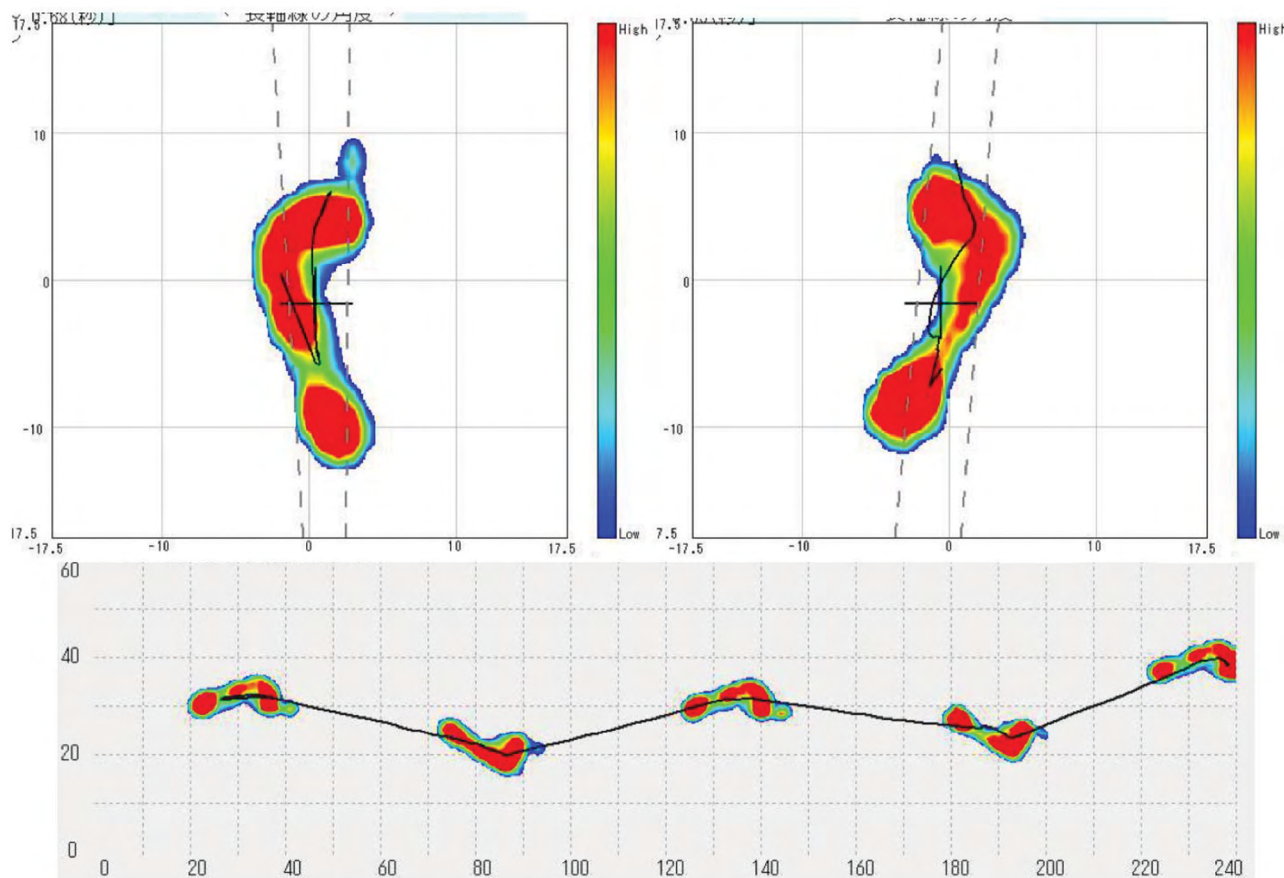
Gait analysis was performed 6 months after the operation with the lower limb loading gauge sheet (Walk-way MW-1000, Tokyo, Japan). The examinee walked on a sensor sheet at his normal walking speed and the pressure distribution and the gait cycle were recorded for both feet. Static plantar pressure measurement showed the same pressure distribution in both feet (Fig. 4). The gait analysis is summarized in Table 1. The peak force at the moment of foot flat was 782.04 N in left foot and 804.58 N in right foot, respectively. Average gait cycle, stance phase, swing phase, and double stance phase were 1.08, 0.70, 0.38, and 0.17 sec in left foot, and 1.09, 0.70, 0.39, and 0.15 sec in the right foot, respectively.

## DISCUSSION

In the setting of sarcoma surgery, radical resection and limb salvage surgery are recommended.<sup>7</sup> Reconstructive technique such as pedicled or free tissue transfer is essential for limb salvage and safe resections.<sup>8,9</sup> Although soft tissue sarcoma, especially in the sole of the foot, is a rare disease, weight-bearing region reconstruction considering postoperative gait is needed.<sup>4</sup>

For functionally satisfactory sole reconstruction, it is important to cover the weight-bearing region with a nonbulky, but durable skin paddle that can withstand a significant amount of shear pressure.<sup>10</sup> The prognosis of the weight-bearing region reconstruction has caused controversy. The pedicled ipsilateral medial plantar flap can be considered an optimal procedure of sole reconstruction not only for covering the weight-bearing area of the heel but also for the forefoot and middle plantar region.<sup>11</sup> However, donor-site morbidity such as postoperative unbalanced gait is commonly seen in the case using free medial plantar flap.<sup>12</sup> On the other hand, reconstruction using a free flap from non-weight-bearing area, such as the rectus abdominis flap, the latissimus dorsi flap, the scapular flap, and the anterolateral thigh flap, is likely to result in ulceration of the reconstructed area due to weak deep tissue anchoring power of those flaps.<sup>10,13</sup> Some articles reported that thoracodorsal artery perforator flap is a favorable option in plantar reconstruction as it does provide durable coverage and fast recovery.<sup>14</sup> However, because the patient did not desire the back wound, we did not choose thoracodorsal artery perforator flap.

There are few reports in which postoperative gait is evaluated after the weight-bearing reconstruction using a free contralateral medial plantar flap.<sup>6,12,15</sup> In these reports, the indications for the weight-bearing reconstruction were injury or chronic wound. Moreover, they reported that it was quite difficult to obtain postoperative symmetrical gait after the reconstruction using a free contralateral medial plantar flap.<sup>12</sup> In the reported case, the contralateral free medial plantar flap was used for reconstruction to prevent ulceration. As a result, well-balanced gait was obtained at postoperative 6 months. Gait analysis with the lower limb loading gauge sheet (Walk-way MW-1000) demonstrated the same pressure distribution and average gait cycle in both feet. In the case, the peak force divided by the body weight was 11.67



**Fig. 4.** Above: Static plantar pressure measurement shows the same pressure distribution in both feet. Below: Gait analysis and dynamic plantar pressure measurement.

**Table 1. Foot Measurement**

Parameter	Left Foot (Affected Side)	Right Foot (Donor Side)
Peak force (N)	782.04	804.58
Peak force/BW (N/kg)	11.67	12
Gait cycle (s)	1.08	1.09
Stance phase (s)	0.7	0.7
Swing phase (s)	0.38	0.39
Double stance phase (s)	0.17	0.15
Stride (cm)	100.5	101.1
Step length (cm)	48.7	52.3
Stride width (cm)	12.9	11.4
Toe-out angle (°)	14	12

All measurements were performed with the lower limb loading gauge sheet (Walk-way MW-1000).

BW, body weight; N, Newton.

$m/s^2$  in left foot and  $12.0 m/s^2$  in right foot, respectively. A previous study, in which the ground reaction force variables were analyzed in hemiplegic patients ( $n = 20$ ) and healthy volunteers ( $n = 20$ ), reported that the peak force divided by the body weight was  $11.53 \pm 0.15 m/s^2$ .<sup>16</sup> Therefore, we concluded that well-balanced normal gait not only in the reconstructed foot but also the donor side foot was obtained after reconstruction.

The free medial plantar flap transfer after sole sarcoma resection has several advantages. First, the characteristic of this flap with solid anchoring to deep tissue to

resist shearing makes it possible to lower the chances of postoperative ulceration.<sup>10,11</sup> Unlike in reconstruction of a diabetic foot, recurrence of sarcoma has to be considered in every ulceration after sarcoma treatment. Second, the medial plantar flap has optimal thickness and good color and texture match for sole reconstruction. Third, a sensate flap can be achieved if the medial plantar nerve is included.<sup>11</sup> One of the drawbacks of this method is the delay of start of walking. However, we strongly believe that this is acceptable for expected long-term result.

## CONCLUSIONS

We experienced a case in which postoperative balanced gait was obtained after the weight-bearing mid plantar region was reconstructed using a free contralateral medial plantar flap for reconstruction after mid-foot sarcoma resection. Although further clinical investigations such as long-term follow-up will be required to confirm its efficacy, this method would be 1 option for treating sole sarcoma.

*Ryo Karakawa, MD*

Plastic and Reconstructive Surgery  
Cancer Institute Hospital Japanese Foundation for Cancer  
Research  
3-8-31, Ariake, Koto-ku  
Tokyo 135-8550, Japan  
E-mail: [ryo.kyara@gmail.com](mailto:ryo.kyara@gmail.com)

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