Received: 31 December 2016 | Revised: 25 August 2017 | Accepted: 18 September 2017

DOI: 10.1002/micr.30250

CLINICAL ARTICLE

WILEY MICROSURGERY

Foot and ankle reconstruction with vertically designed deep inferior epigastric perforator flap

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Abstract

Introduction: The deep inferior epigastric perforator (DIEP) flap is one of the most commonly utilized flaps of reconstructive surgery. Although the horizontal flap design is the most commonly used, this flap can be vertically designed to avoid drawbacks such as excessive tissue dissection, relatively reduced flap perfusion, and scarification of the contralateral flap opportunity. The aim of this report is to present our case series for foot and ankle reconstruction with vertical designed DIEP flap.

Patients and methods: The free vertically designed DIEP flaps (VDIEP) were used in eight patients (7 male, 1 female) whose age is in a range of 20–66 years for soft tissue reconstructions in the ankle and foot region over a five-year period. The range of defects' size was from 8 × 5 cm to 15 × 7 cm and the causes were electrical burn, trauma and diabetic foot infections.

Results: Flap dimensions varied from 10 × 6 cm to 17 × 9 cm. All the flaps had two or more perforators, and all flaps survived completely. There were no early or late complications. We followed up the patients for 10 months in average. We observed no functional problems, especially in main motions of foot and ankle like eversion, inversion, flexion or extension except one patient. Donor site scars were acceptable in all patients.

Conclusions: The VDIEP flap may be an option for selected lower extremity soft tissue reconstructions, and it may be an alternative to classically designed abdominal flaps.

1 | INTRODUCTION

The free deep inferior epigastric perforator (DIEP) flap is widely used in many surgical areas today, but mainly in breast reconstruction (Beausang et al., 2003; Santanelli, Paolini, & Renzi, 2008; Santanelli, Paolini, Renzi, & Persechino, 2007). Preservation of muscles to provide the ability to transport skin and soft tissue in the desired amount, preparation in the desired form and shape to correct asymmetry and contour irregularities, and ease of dissection are the main reasons for the widespread use of the DIEP flap (Van Landuyt et al., 2005). However, in the classically designed DIEP flap, excessive tissue dissection to hide scarring, relatively reduced flap perfusion, and sacrification of the contralateral flap that may be used for a second option may be considered as disadvantageous. To overcome these disadvantages, the flap can be modified and vertically designed (Tan, 2009). Tan used the vertical designed flap in various tissue defects and 2 of them was for foot and ankle reconstruction (Tan, 2009). To our knowledge, there are no large case series for foot and ankle reconstruction with vertical designed DIEP flap in the literature. In this report, we present the results of the use of the free vertically designed DIEP flap (VDIEP) for soft tissue reconstructions of the foot and ankle in a series of cases.

2 | PATIENTS AND METHODS

From January 2010 to November 2015, 8 (1 female, 7 male) patients with tissue defects in their lower limbs were treated with VDIEP flaps. The average age was 44.6 years (20 to 66). The causes of injury were electrical burn (one patient), trauma (five patients), and diabetic foot infection (two patients). Defect measurements ranged from 8 × 5 cm to 15 × 7 cm. Flap Size, numbers of perforator and complication/flap survival and final outcomes were recorded. Foot function index (FFI) was used to evaluate the postoperative functional outcomes.

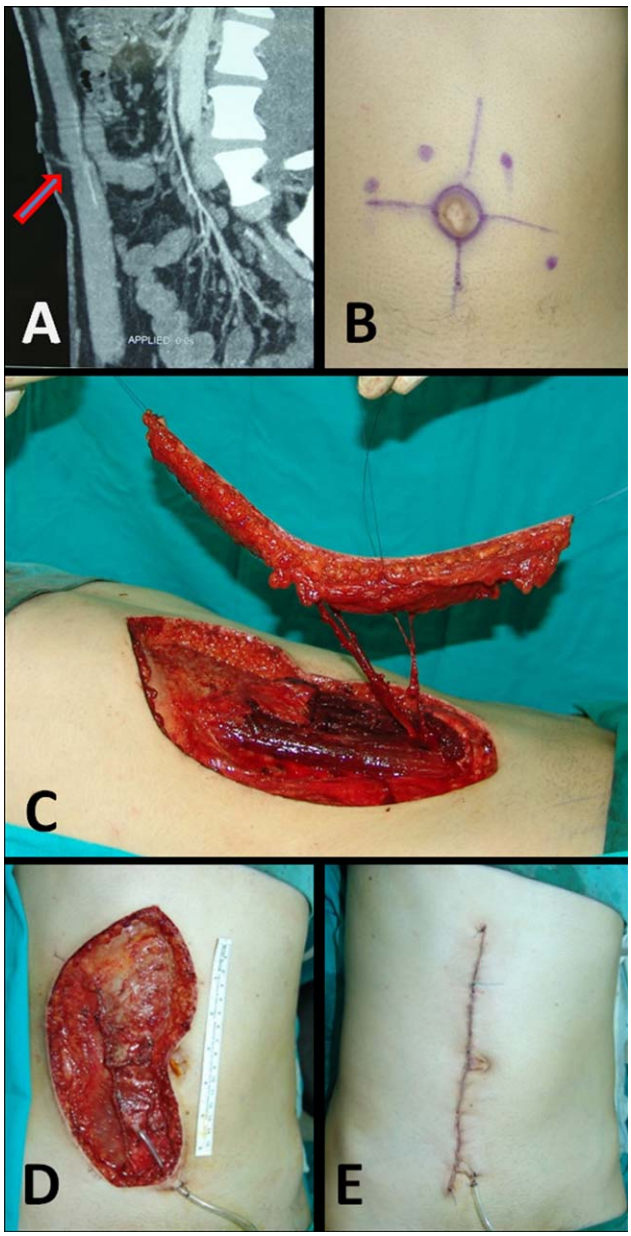

FIGURE 1 Technical details of flap preparation (A) Computed topographic angiogram mapping perforator of the deep inferior epigastric artery the anterior rectus sheath is demonstrated (*red arrow*), (B) Preoperative view of skin marking of localization perforators, (C) Raising of the flep on four perforator, (D) Primer repair of rectus sheath, (E) Skin closure primarily without tension

2.1 | Surgical technique

The umbilical perforators of VDIEP flap were mapped with preoperative computerized tomography (CT) assist (Figure 1A).

The medial row perforators which were identified via CT prior to the operation were marked with a skin marker, using a handheld Doppler, in the supine position (Figure 1B). Flaps of the appropriate sizes with at least two perforators were designed for the defects. All operations were performed by two teams of surgeons. One team prepared the recipient site and recipient vessels in the lower extremity while a second team prepared the VDIEP flap. The preparation of the recipient site and the flap dissections were performed under 2.5X loupe magnification. Anastomoses were performed under the microscope. (Carl Zeiss Microscopes, Göettingen, Germany)

The dissection was initiated with a lateral incision and continued medially and inferiorly. After incising the skin and subcutaneous tissue, the medial row perforators were preserved on the rectus sheath. During the inferior and lateral incision, the superficial epigastric vein was also preserved and included in the dissection. In the case of developing a venous congestion in largely planned flaps, a second vein anastomosis was performed using the superficial epigastric vein. The rectus sheath was incised, leaving a small piece of fascia around the perforators. All perforators of the appropriate caliber were included in the flap. The perforator was put inside the rectus muscle up to the external iliac vessels. The medial incision was completed, and the flap became a complete island flap (Figure 1C). When necessary, flap debulking was performed at this stage. In the donor area, fascia and skin were repaired primarily (Figure 1D,E). After the flap was detached from the donor site, it was irrigated with heparinized solution and was adapted to the recipient area. Anastomoses were performed end-to-end or end-to-side. Postoperatively, all patients received 5,000 units of intravenous heparin infusion for seven days. From day three to day six, an elastic bandage was applied and controlled foot stepping exercises were done. From the seventh postoperative day, walking was allowed.

3 | RESULTS

All patients had 3–8 perforators in sufficient calibration within a 5 cm radius circle marked around the umbilicus. All the flaps were harvested with at least two perforators and contained only skin. The anterior wall fascia and the skin of the abdomen were primarily sutured. The mean flap size was 12 × 8 cm. Operation times were from 290 to 370 minutes which were recorded. We observed no flap loss in our VDIEP flap series in foot and ankle tissue reconstructions. There were no complications in the early and late periods (Table 1).

No secondary procedures were performed on the flaps, except one patient who had flap debulking surgery in the late period. This flap can be harvested thin so the adaptation of the flap in the recipient sites was excellent. There were no early or late complications in the donor areas. The average follow-up time was 10 months. We observed no functional problems, especially in main motions of foot and ankle like eversion, inversion, flexion or extension except one patient. After debulking surgery, this patient would be able to do main foot motions. The FFI form has three domain, which are pain, disability, and activity limitation. Lower FFI scores indicate better functional result. The average score of total FFI was 10.75 (range 0 to 25.20) for three domain. The mean score was 3.25 (0 to 7.8) for Pain, 6.25 (0 to 21.1) for Disability, and 1.25 (range 0 to 4) for Activity Limitation.

It was observed that the donor site scar was quite satisfactory, especially in male patients.

3.1 | Case reports

3.1.1 | Case 1

A free VDIEP flap was planned for a 20-year-old male patient with a 6 × 12 cm tissue defect on the right foot and ankle due to electrical

TABLE 1 Patient's data

Case No.	Age/gender	Etiology	Defect size (cm)	Flap size (cm)	Perforator No.	Donor site closure	Complication/flap survival	Follow-up (months)	Final outcomes (Foot Function Index (FFI) score) (%)		
									Pain	Disability	Activity limitation
1	20/M	Electric injury	12 × 6	14 × 9	4	Primary closure	No/Full	6	7.8	3.3	2
2	54/M	Diabetic foot infection	10 × 5	11 × 6	2	Primary closure	No/Full	12	3.3	7.8	4
3	66/M	Trauma	10 × 7	12 × 8	3	Primary closure	No/Full	18	2.6	5.6	2
4	32/M	Trauma	8 × 5	8 × 8	2	Primary closure	No/Full	10	0	0	0
5	44/M	Trauma	15 × 7	17 × 9	3	Primary closure	No/Full	12	4.4	12.2	0
6	39/M	Trauma	9 × 5	10 × 6	3	Primary closure	No/Full	6	3.8	0	0
7	52/F	Diabetic foot infection	10 × 5	12 × 7	3	Primary closure	No/Full	12	2.1	21.1	2
8	50/M	Trauma	9 × 6	10 × 8	2	Primary closure	No/Full	6	2.1	0	0

burns (Figure 2A). The flap was elevated with three perforators of medial row. Flap size was 14 × 9 cm (Figure 2B). Operation duration was 310 minutes. The flap's artery and posterior tibial artery were anastomosed end-to-side. The patient was followed up postoperatively for six months, a good reconstruction was achieved, flap survival was 100%. There were no pain in ankle movements and walking, no defeatting was done. Patient had no complaint in shoe comfort and no complications were encountered (Figure 2C,D). No debulking was applied for the flap.

3.1.2 | Case 2

A 54-year-old male patient was referred to our clinic for a diabetic foot wound (Figure 3A). Following infection control, necrotic tissue was debrided prior to surgery. Four perforators were included in the flap and an 11 × 6 cm flap was designed (Figure 3B). Operation duration was 350 minutes. The dorsalis pedis artery was used as the recipient artery and veins were anastomosed to the concomitant veins. The patient did not have any complications in his early follow-up visits and flap was totally survived. At the end of the 12th month, the patient had

FIGURE 2 (A) Preoperative view of the defect before debridement, (B) Raising of flap on the medial row perforators of deep epigastric artery, (C,D) Postoperative adaptation of flap and postoperative aspect of donor area

FIGURE 3 (A) Aspect of wound on the right lateral malleolus before debridement (B) Vertical designed 11 × 6 cm flap including four perforator, (C) Postoperative result of the patient at 12 months follow up, (D) The donor scar are camouflaged acceptably by abdominal hairs

no pain in ankle movements and walking; also this patient had no complaint in shoe comfort. The donor area was fully healed, and the scar was camouflaged by hair on the abdominal wall region (Figure 3C,D).

4 | DISCUSSION

The horizontal planned conventional DIEP flap harvested from the lower abdominal area was described by Koshima and Soeda in 1989 (Keller, 2001; Koshima & Soeda, 1989). This flap has been used routinely in reconstructive surgeries, such as breast reconstruction due to the ability to harvest it from an anatomically well-known area and its ease of dissection. This flap is also used in lower extremity reconstruction. However, in such reconstructions, the lower abdomen region is not commonly used as a donor site because of the fatty subcutaneous tissue of this area, which requires excess dissection; other flaps, such as the anterolateral thigh flap, are better known (Tang et al., 2013; Van Landuyt et al., 2005). The VDIEP flap is essentially another form of the DIEP flap (Santanelli et al., 2007, 2008; Tan, 2009). Moreover, the VDIEP flap significantly differ from DIEP flap not just only in terms of its shape.

A more versatile flap can be obtained with a VDIEP flap without unnecessary tissue dissection by including more than one perforator in the flap. This flap can be harvested both from the lateral row and the medial row perforators (Rozen, Kapila, & Donahoe, 2011; Tan, 2009). Medial row perforators were preferred in this report because of the lower donor site morbidity with medial row perforators, as reported by Garvey, Salavati, Feng, and Butler (2011) In a study by Bailey et al. (2010) medial row perforators were more dominant, and lateral row dissection was not required. In the same study, it was shown that the possibility of intercostal nerve damage is lower in medial row perforator dissection. In our series, the preoperatively abdominal region perforators of all patients were marked with computer assisted tomography, and the most dominant perforator of the medial row as determined by the radiologist was planned to include the VDIEP flap. During the flap dissection, the lateral row perforators were left intact as much as possible. At the same time, the contralateral perforators remained intact as the dissection did not pass the midline.

In patients whose lower extremity defects are reconstructed with free flaps, things may not always go as planned, and more than one free flap may be required (Van Landuyt et al., 2005). Because of this, we think it would be judicious to preserve all of the flap options that can be maintained during reconstruction of a lower extremity in accordance with the basic principles of plastic surgery. In a reconstruction with VDIEP flaps, potential flaps on the other side are always protected for use in an unexpected emergency, as another option.

Another factor in choosing this flap is the presence of a secondary abdominal midline scar from previous surgeries. It is not possible to harvest the conventional DIEP flap without an additional procedure because the midline scar interrupts the vascular flow (Schoeller, Wechselberger, Roger, Hussl, & Huemer, 2007). Santenelli and colleagues used the VDIEP flap instead of the classic designed DIEP flap in patients with a midline scar (Santanelli et al., 2008) to avoid the formation of a second scar. We think the VDIEP flap is useful for patients who have midline scars, although we did not have a patient with a midline scar in this series.

To hide the donor area scar in the classic DIEP flap, it is necessary to remove some of the excess tissue from the contralateral area. Conversely, only the required amount of tissue is dissected in the VDIEP flap, and as a result, a vertical scar appears. However, this scar can be hidden in males because the abdominal region is hairy. In our series, the scars of seven male patients were acceptable.

The VDIEP flap can be designed to be very large by including multiple perforations (Kostakoğlu & Keçik, 1998). The mean flap size in our report was 12 × 8 cm, which is not particularly large. Due to the limited dissection in the VDIEP flap, the mean time of the operation is shortened. The mean duration of 333 minutes was recorded in this series. However, as there is not enough data in the literature, it is not possible to make an optimal comparison of the operation times (Blondeel, 1999; Smit et al., 2009). Kostakoğlu and Keçik (1998) used the DIEP flap with an oblique design in 14 cases and stated that they had partial flap loss. In that study, the flaps were large and the perforasome concept was not used for the flap design, so those factors may have caused this loss. Also, in this study, one perforator was included in the flap, and lateral row perforators were reportedly used.

For flaps elevated from the periumbilical and supraumblical regions, there is usually no need for thinning in younger patients. Because these regions contain relatively less fat than lower abdominal region. However in patients with excess subcutaneous fat, this flap can be elevated thin during harvesting or the section from the perivascular area to the Camper fascia can be removed.

One of the biggest drawbacks of classical DIEP flaps is that a DIEP flap that extends to the contralateral remote zone (zone 4) may have vascularization problems. Wong and colleagues (Wong et al., 2009) reported in their 11 abdominal flap series that the flap's blood supply may be insufficient in zone 4. It is not possible to cite a similar situation because the VDIEP flap does not cross the midline. It is enough to increase the number of perforators when it is desirable to have longer flaps. Thus, a flap that extends from the inguinal region to the xyphoid can theoretically be designed.

Even if this flap was used to reconstruct the skin defects, functional results are satisfactory enough while compared with the literature. Lee et al. performed free perforator flaps for oncologic foot skin defects and they utilized from FFI to evaluate the functional outcomes (Lee, Park, & Mun, 2017; Lin et al., 2011). Results in this study was comparable with literature.

The novelty of this report is being the first case series for foot and ankle reconstruction with VDIEP flap which seems to be a newly used flap in specific case series. We claim that this shape of DIEP flap is much more convenient in foot and ankle reconstruction with more perforators and less donor site morbidity.

5 | CONCLUSIONS

The VDIEP flap may be safe, more vascularized, and may be prepared in long and thin in terms of the flap comprise larger medial row perforator array. After with VDIEP flap reconstruction; foot and ankle could perform all movements and function properly. Because of these features, the VDIEP flap is an option for soft tissue reconstructions of the foot and ankle.

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How to cite this article: Akdag O, Karamese M, Yıldıran GU, Sutcu M, Tosun Z. Foot and ankle reconstruction with vertically designed deep inferior epigastric perforator flap. *Microsurgery*. 2018;38:369–374. https://doi.org/10.1002/micr.30250