

A Novel Endoscopic-Assisted Harvesting of Pedicled Freestyle Fasciocutaneous Flaps

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Abstract: The endoscopy-assisted technique has been demonstrated in harvesting muscle flaps; however, for pedicled freestyle fasciocutaneous flaps, few studies have applied this technique. We present a surgical procedure utilizing endoscopic-assisted method to identify the perforators of pedicled freestyle fasciocutaneous flaps for the reconstruction of soft tissue defects.

From August to December 2012, 9 consecutive patients underwent endoscopic-assisted harvesting of fasciocutaneous flaps for the reconstruction of soft tissue defects. All of the defects were caused by trauma with tendon or bone exposure. Postoperatively, all patients were requested to return for outpatient follow-up visits for at least 3 months.

The age of the 9 patients (8 men and 1 woman) ranged from 20 to 79 years (median 59 years). The defects ranged in size from 2×2 to 6×8 cm². Two patients received anterolateral thigh transmuscular perforator flaps, 5 patients received fibular septocutaneous perforator flaps, and 2 patients received medial gastrocnemius transmuscular perforator flaps. The median incision length was 10 cm, and the median operative time was 120 minutes. None of the patients had intraoperative complications, and intraoperative bleeding was minimal (<50 mL). At the end of the 3-month follow-up period, none of the patients had any complications on either recipient or donor site, including total or partial necrosis of the flaps, flap dehiscence, hematomas, seromas, wound infections, or any conditions that indicated additional unplanned operative procedures. All of the patients had surviving flaps.

Our results demonstrated that the endoscopic-assisted method could be a valuable and reliable alternative in harvesting pedicled freestyle fasciocutaneous flaps.

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INTRODUCTION

Soft tissue defects are common injuries usually treated with flaps, especially when there is exposure of tendon or bone. Despite advancements in flap surgery, there is still a failure rate of 2% to 4%, and this is even higher in perforator-based flaps.¹ Even if technically successful, some perforator flaps become partially necrotic and then fail. A possible reason is individual variations in perforator anatomy, which can be congenital or secondary to previous trauma or surgery. A study on 20 cadaver legs reported that the number of cutaneous perforators ranged from 3 to 7, and the external diameter also ranged widely from 0.3 to 1.5 mm.² This anatomical variation in perforator characteristics is a challenge when harvesting the perforators.

Precise preoperative perforator mapping would greatly facilitate the design of the flaps and in planning the procedures, and consequently minimize the morbidity of donor site and increase the survival of the flaps. Conventionally, identifying adequate perforators for fasciocutaneous flaps depends on preliminary direct exploration, indirect Doppler mapping, or both.^{3,4} Openly and directly harvesting perforators provide the most convincing evidence; however, this causes a large amount of damage to the donor site. A handheld acoustic Doppler scanner is one of the most common tools for Doppler sonography; however, several studies have reported inconsistent results.^{4,5} Therefore, several alternative modalities have been developed to preoperatively localize the perforators, including color duplex ultrasound, contrast-enhanced ultrasound, computed tomography angiography, and magnetic resonance angiography.^{6–8}

Unlike these indirect modalities, endoscopic-assisted surgery is a direct approach to harvest perforators. Many studies have demonstrated the endoscopic-assisted technique in harvesting muscle flaps.^{9–11} However, for fasciocutaneous flaps, a type of perforator flap, few studies have applied this technique. In this study, we present a surgical application of this technique, prospectively utilizing endoscopy to identify the perforators of fasciocutaneous flaps for the reconstruction of soft tissue defects.

MATERIALS AND METHODS

Subjects

From August 2010 to December 2012, we performed endoscopic-assisted harvesting of fasciocutaneous flaps for the reconstructing of soft tissue defects in 9 consecutive patients. All procedures and follow-up visits were conducted by the same plastic surgeon who has been board certified for 10 years. This study was approved by the institutional review board, and all patients gave written informed consent.

The inclusion criteria were patients who had traumatic soft tissue defects with tendon or bone exposure (Figure 1A). The exclusion criteria were patients who had peripheral arterial occlusive disease, soft tissue defects with severe infections, or a medical history suggesting a higher risk of local or general

complications. Intraoperative bleeding, operative time, and complications were monitored. Postoperatively, all patients were requested to return for outpatient follow-up visits for at least 3 months.

Surgical Technique

Under anesthesia, the patients were laid in the supine position, and the operative field was prepared and draped. After marking the border of the temporary-designed flap on the skin, a 1-cm endoscopic incision was made and one 5-mm trocar was inserted (Figure 1B). CO₂ with 12 mm Hg of pressure was insufflated, and a virtual cavity was created for the use of a 5-mm 30°-angled endoscopic camera and standard surgical equipment, including microdissectors and retractors. Under endoscopy, the fascia was dissected directly in subfascial plane, and a perforator was identified (Figure 1C). When identifying the perforator, the exact location of the perforator was marked on the skin. The fasciocutaneous flap was then designed based on the defect size and shape (Figure 1D). The perforator was harvested with preservation of its perforator pedicle (Figure 1E and F). Flap advancement was done, and the skin defect of the donor site was closed directly (Figure 1G and H). We routinely inserted an open or closed drain to the recipient and donor sites.

RESULTS

The age of the 9 patients (8 men and 1 woman) ranged from 20 to 79 years (median 59 years). Table 1 shows the characteristics of the 9 patients. The sizes of the defects ranged from 2 × 2 to 6 × 8 cm². Two patients received anterolateral thigh transmuscular perforator flaps, 5 patients received fibular septocutaneous perforator flaps, and 2 patients received medial gastrocnemius transmuscular perforator flaps. The median incision length was 10 cm, and the median operative time was 120 minutes. None of the patients had intraoperative complications, and intraoperative bleeding was minimal (<50 mL). All of the patients tolerated the surgery well. The median postoperative duration of surgical drainage was 7 days. From postoperative day 1 to the end of the 3-month follow-up period, none of the patients had any complications on either recipient or donor site, including total or partial necrosis of the flaps, wound dehiscence, hematomas, seromas, wound infections, or any conditions that indicated additional unplanned operative procedures. All of the patients had surviving flaps (Figure 1I and J).

DISCUSSION

In this study, we reported an alternative harvesting method to identify perforators of fasciocutaneous flaps. With endoscopic assistance, these perforators could be identified under direct vision. All of the 9 patients had surviving flaps, and the wounds healed well. There was minimal perioperative blood loss, and no postoperative complications occurred.

Although Katsuragi-Tomioka et al¹² have addressed the same endoscopic-assisted harvesting method for an anterolateral thigh flap of a representative case, our study provided further experience regarding its application. In this study, we successfully identified the perforators in 2 anterolateral thigh flaps, 2 medial gastrocnemius flaps, and 5 fibular flaps. With insufflating CO₂ with 12 mm Hg of pressure, the endoscopic-assisted harvesting method was demonstrated to be able to identify the perforators in different areas of the body. The

average time needed to identify the perforator was 10 minutes, which is similar to the report by Katsuragi-Tomioka et al.¹²

After being introduced by Ponten¹³ in 1981, fasciocutaneous flaps have been widely used in reconstruction surgery. Fasciocutaneous flaps are advantageous in soft tissue reconstruction due to their availability and versatility, and because they avoid sacrificing muscular function of the donor site while filling the dead space with a matching volume of fasciocutaneous tissue.¹⁴ Fasciocutaneous flaps have been successfully used in reconstructing various soft tissue defects, including open tibial defects,¹⁵ chronic osteomyelitis,¹⁶ and pressure sores,¹⁷ in a freestyle manner. The concept of a freestyle flap was demonstrated by Wei and Mardini¹⁸ in 2004. In a case series of 13 freestyle flaps harvested from the thigh, Wei and Mardini showed that freestyle flaps can be harvested based on any vessel that has a Doppler signal. In the same report, they further discussed the disadvantages of freestyle flaps, including the possibility of inaccurately mapping the location of skin vessels.¹⁸ A handheld acoustic Doppler scanner is the most widely used tool in harvesting perforators, easy to learn, portable, and available in most hospitals.¹⁹ However, its sensitivity is so high that it sometimes detects inadequate arteries, which cannot be taken as perforators. In addition, background noise decreases its specificity, and several previous studies have criticized the reliability and accuracy of the handheld acoustic Doppler scanner.^{5,20} In a prospective study by Khan and Miller,²⁰ the positive predictive rate of a Doppler scanner to detect perforators in the upper and lower extremities ranged widely from 50% to 93%. For vessels with small diameters, the false-positive results were unacceptably high, and the authors concluded that the reliability of the Doppler scanner depends on the size of vessels. Another study on perforators in anterolateral thigh flaps reported that the positive predictive rate of the Doppler scanner ranged from 89% to 94%, and the accuracy decreased as the body mass index increased. The authors concluded that the handheld Doppler scanner should be used with caution in flap design because of the inconsistent accuracy.⁵

To overcome the shortcomings of the handheld Doppler scanner, color duplex sonography seems to be a good solution. Even though many studies have reported a higher accuracy than with acoustic Doppler in perforator mapping, there are still some limitations. Color duplex sonography requires a trained specialist, and may not be accurate when the perforators are too small, fascia is too tight, or arteries are tortuous.²¹ With advancements in imaging technologies, contrast-enhanced ultrasound,⁷ magnetic resonance angiography,^{22,23} and computed tomography angiography⁸ have been applied in perforator mapping. All of these imaging tools can provide important and accurate information about vascular anatomy; however, the cost, potential allergy to the contrast agent, amount of time needed for the procedure, and radiation exposure are frequently countered problems.

In contrast to the imaging tools, which identify perforators indirectly, the endoscopic method identifies the perforators directly. Endoscopic-assisted surgery was initially applied in plastic surgery for facial surgery with brow lift surgery,²⁴ corrugator muscle resection,²⁵ and augmentation mammaplasty.²⁶ With the use of endoscopic assistance, donor site harvesting has also been reported in muscle flaps,^{9–11} adipofascial flaps,^{27,28} and visceral flaps.²⁹ Under endoscopy, the perforators can be identified directly by the operating surgeon. Regarding the reliability and accuracy of the different methods of harvesting perforators, the results of endoscopic



FIGURE 1. Endoscopic-assisted harvesting of pedicled fasciocutaneous flap. A man aged 20 years had a soft tissue defect with exposure of bone and tendon at the left pretibia region (A). After marking the border of the temporary-designed flap on the skin, a 1-cm endoscopic incision was made. E: endoscopic incision (B). Under endoscopy, a perforator was identified under direct vision. F: fascia, P: perforator, M: muscle (C). The exact location of the perforator was marked on the skin, and the flap was also designed and marked. E: endoscopic incision (D). The perforator was harvested with preservation of its perforator pedicle (E and F). The flap advancement was done (G), and the skin defect of the donor site was closed (H). Postoperatively, the wounds in recipient site (I) and donor site (J) both healed well, and the fasciocutaneous flap survived well.

TABLE 1. Demographics and Clinical Information for 9 Patients Who Underwent Endoscopic-Assisted Harvesting of Pedicled Freestyle Fasciocutaneous Flap for Reconstructing Soft Tissue Defects

No.	Age, y	Sex	Diagnosis	Defect Size, cm ²	Donor Site	Recipient Site	Operation Time, min	Incision Length, cm	Postoperative Drainage, d
1	79	Male	Left hip fracture status post Gamma nail surgery complicated with septic arthritis	6 × 8	Left anterolateral thigh transmuscular perforator flap	Left hip region	180	15	10
2	74	Male	Left femoral artery laceration with pseudoaneurysm, status after repair with vessel exposure	4 × 7	Left anterolateral thigh transmuscular perforator flap	Left inguinal region	120	7	8
3	76	Male	Right lateral malleolar soft tissue defect with bone exposure	2 × 2	Right fibular septocutaneous perforator flap	Right lateral malleolar region	120	9	7
4	74	Male	Right distal tibia–fibula comminuted fracture with soft tissue defect and bone exposure	2 × 3	Right fibular septocutaneous perforator flap	Right leg region	120	10	8
5	59	Female	Right tibia–fibula comminuted fracture with soft tissue defect and bone exposure	4 × 5	Right fibular septocutaneous perforator flap	Right leg region	120	10	7
6	55	Male	Left malleolar soft tissue defect with bone exposure	3.5 × 3.5	Left fibular septocutaneous perforator flap	Left lateral malleolar region	150	9	7
7	50	Male	Left distal tibia–fibula comminuted fracture with soft tissue defect and bone exposure	3 × 3	Left fibular septocutaneous perforator flap	Left leg region	120	13	9
8	41	Male	Left pretibia soft tissue defect with bone exposure	2 × 3	Left medial gastrocnemius septocutaneous perforator flap	Left pretibia region	120	12	7
9	20	Male	Left pretibia soft tissue defect with bone and tendon exposure	4 × 6	Left medial gastrocnemius transmuscular perforator flap	Left pretibia region	180	9	7

harvesting come close to the golden standard, the direct open exploration.

The survival of fasciocutaneous flaps depends profoundly on reliable perforators. Even though different kinds of techniques have been studied for perforator mapping, each has advantages and disadvantages.²¹ In this study, the surgical technique and results may provide plastic surgeons with an additional choice in directly harvesting reliable perforator flaps.

The disadvantages of this endoscopic-assisted method are similar to all the other endoscopic procedures. It is experience-dependent, may require a longer surgical time, and may result in anesthetic complications. Regarding the vessel injuries by the physical manipulation of endoscopy, the risk is limited because the endoscopic technique introduced herein is only for identifying the location of the perforators, not for dissecting or raising the flaps. Additionally, the vessel injuries could be similarly brought by direct open exploration. As the popularity of minimally invasive procedures increases among plastic surgeons, we believe that the limitations of the endoscopic procedure will gradually diminish.

All of our patients received direct closure of donor sites, including the patient with a flap sized $6 \times 8 \text{ cm}^2$. All the skin defects of donor sites healed well without complications. However, the careful preoperative evaluation is necessary to assess the possibility of directly closing donor sites. For a large-sized flap, skin grafting should be considered instead to avoid tension closure and dehiscence. Additionally, the arterial patency and blood flow should also be evaluated before planning the surgery because it might be impaired in older patients. The role of the preoperative evaluation is not altered by the choice of harvesting method.

There are several limitations to this study. First, the study is limited by the small sample size, and all results came from a single plastic surgeon. Second, this was a single-armed observational study, and we did not include a control group for comparison, for example, mapping the perforator with a preoperative Doppler scan. Thus, we cannot conclude that the endoscopic-assisted technique has a similar operative time to other modality-assisted techniques. The issues of the procedure being time-consuming and expensive deserve further prospective comparative studies to clarify. Because all harvesting methods have their pros and cons, further studies are warranted to compare their accuracy and reliability. A combination of different methods also deserves to be investigated. Lastly, we did not evaluate the long-term functional recovery of the flaps. However, the inflammatory and fibroblast proliferation phases of wound healing are completed approximately within 3 weeks, and a wound has reached ~70% of the strength of undamaged tissue after 7 weeks.³⁰ Thus, we believe that a 3-month follow-up period should be sufficient to evaluate the survival of the flaps.

In conclusion, by successfully identifying the perforators of free-style fasciocutaneous flaps in different areas of lower extremities, we demonstrated that endoscopic-assisted method could be a valuable alternative in harvesting perforator flaps.

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