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내시경 피판채취법을 이용한 미세수술적 족부 재건

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Microsurgical Foot Reconstruction Using Endoscopically Harvested Muscle Flaps

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Purpose: Reconstruction of soft tissue defects of the foot often requires free-flap transfer. Free muscle flap transfer and skin grafts on the muscle has been an option for these defects. Here we present our experiences of foot reconstruction using an endoscopy-assisted free muscle flap harvest.

Methods: Using endoscopy-assisted free muscle flap harvests, four patients with soft tissue defects of the foot were treated with a free muscle flap and skin graft. The gracilis muscle was used for two patients and the rectus abdominis muscle for two. A single small transverse skin incision was placed on the lower abdomen for the rectus abdominis muscle. A small transverse skin incision on the proximal thigh was the only incision for harvesting the gracilis muscle flap. The small incisions were enough for the muscle flap to be pulled through.

Results: The flaps survived successfully in all cases. Contours were good from both functional and aesthetic aspects. No breakdowns or ulcerations of the flap developed during long-term follow-up. Resultant scars were short and relatively hidden. Functional morbidities such as abdominal bulging were not noted.

Conclusion: Endoscopy-assisted harvest of muscle flap and transfer with skin graft is a good option for soft tissue defects of the foot. Morbidities of the donor site can be minimized with endoscopic flap harvest. This method is preferable for young patients who want a small donor site scar.

Key Words: Foot reconstruction, Free flap, Endoscopic harvest

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I. INTRODUCTION

Reconstruction of weight-bearing surfaces of the foot is difficult because of its functional complexity. Reconstruction with local flaps is ideal for relatively uncomplicated small defects, but free flap transfer provides the best solution for reconstruction of complicated, large defects of the weight bearing regions.

Ideal weight bearing resurfacing should provide adequate contour to wear normal shoes, thick durable keratinized skin, protective sensation, and a solid anchorage to the deep structures to resist shearing forces.[1] Although no single method of reconstruction can offer these factors, free transfer of a muscle flap covered with a skin graft has been an excellent method of reconstruction.[2,3]

With the advancement and refinement of microvascular technique, aesthetic results of reconstruction and morbidities at the donor site have become factors that are as important as functional results. Donor site morbidity is a factor that surgeons should consider in determining methods of reconstruction, especially in young patients. Here we present our experiences with foot reconstruction with free muscle flaps harvested with endoscopic assistance to reduce donor site morbidity.

II. MATERIALS AND METHODS

A. Patients

Four patients underwent foot reconstruction with free muscle flap transfer and split -thickness skin graft on the flaps (Table I). Rectus abdominis muscle were used in two patients and gracilis muscle flaps in two patients. All muscle flaps were harvested using an endoscopic technique. Patient ages ranged from 18 to 42 years. All

but one patient were females. The etiology of soft-tissue defects were: traffic accident, sequel of burn scar, excision of malignant melanoma, and a diabetic foot infection. All the defects were on the weight bearing portion of the sole or heel. The follow-up period ranged from 24 to 51 months, with a mean of 29.8 months.

B. Surgical technique

1. Rectus abdominis muscle transfer

An 8 cm transverse incision was made on either side of the lower abdomen for endoscopic harvest of the rectus abdominis muscle flap (Fig. 1). The anterior rectus sheath was incised transversely between the medial and lateral margins of the rectus abdominis muscle, about 6

Table I. Patient Characteristics

Patient No.	Age/ Sex	Cause	Location	Flap type	Defect size (cm^2)	Follow up period (months)	Revisional procedure	Light touch cutaneous sensation*	Deep pressure sensation	Abdominal hernia, bulging
1	F/42	DM foot	Heel+ Sole	Rectus abdominis	200	15	None	None	Present	None
2	F/20	Trauma	Heel	Gracilis	77	51	None	None	Present	-
3	M/36	Malignant melanoma	Sole	Rectus abdominis	112	29	None	None	Present	None
4	F/18	Burn scar	Heel	Gracilis	40	24	None	None	Present	-

* Light touch cutaneous sensation was checked by pinprick test

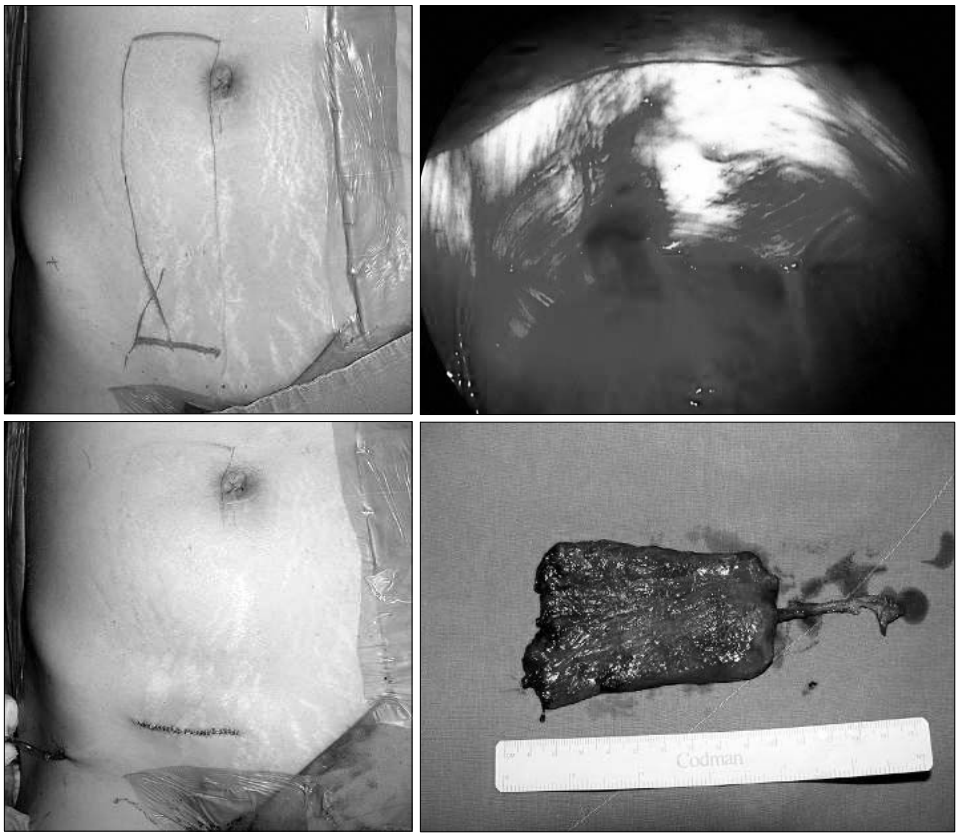

Fig. 1. Case 1. Endoscopically assisted rectus abdominis harvest. (Above, left). Incision of a single transverse low abdomen, 8 cm length. (Above, right) Endoscopic view indicating that the rectus abdominis muscle is dissected away from the anterior rectus sheath. (Below, left) After closure of the wound (Below, right) Harvested rectus abdominis muscle flap with vascular pedicle.

cm wide. The caudal portion of the rectus abdominis muscle and the proximal deep inferior epigastric vessels were dissected to their origin under direct vision through the incision. With endoscopic assistance, the undersurface of the muscle was dissected in the cephalic direction. Traversing perforators from the muscle to the anterior rectus sheath were clipped or coagulated. The optical cavity was maintained with the assistance of a 30 degree down-viewing 5 mm-diameter endoscope and an Emory endoretractor. Additional incisions were not necessary for cephalic dissection of the muscle. When the entire circumference and length of the muscle was dissected free, the most cephalic end was cut using Bovie electrocautery. The pedicles, deep inferior epigastric vessels, were clipped and cut. Finally, the caudal insertion of the muscle was transected with Bovie electrocautery (Fig. 1). The anterior rectus sheath was repaired with 1-0 prolene sutures and a lower transverse skin incision was repaired (Fig. 1). The muscle flap was transferred to the defect and a split thickness skin graft was applied to the muscle.

2. Gracilis muscle transfer

The patients were placed in the supine position with the donor thigh in maximal abduction with hip and knee flexed slightly. A 4 cm transverse incision was centered at a point one fist width below the pubic tubercle along the posterior border of the adductor longus muscle (Fig. 2). The major pedicle of the gracilis muscle was identified at the anterior border of the gracilis muscle. Under direct vision, pedicle dissection was done with the adductor longus muscle retracted upward. All of the branches to the adductor longus were either electrocauterized or clipped while dissecting the main pedicle. A 30-degree, 5 mm diameter endoscope mounted on an Emory retractor was then inserted and muscle dissection was performed with Metzenbaum scissors. The muscle was divided distally at the desired length and the proximal muscle was transected under direct vision. The pedicle was cut and the flap was pulled through the incision (Fig. 2). A skin graft was applied over the muscle flap following insetting of the harvested flap.

Fig. 2. Case 2. (Above, left) Design of a 4 cm transverse incision in the proximal thigh for endoscopically assisted gracilis muscle harvest. (Above, right) The vascular pedicle is dissected under direct view through incision. (Below, left) Endoscopic view showing distal gracilis muscle that was dissected. (Below, right) Harvested gracilis muscle flap with vascular pedicle.

III. RESULTS

In all patients, the flaps and the skin grafts survived completely without delayed healing. Weight bearing was possible in all patients. The contour of the reconstructed foot was good at long term follow up and normal footwear was possible in all cases. They gained deep pressure sensations. The grafted skins were durable during long term follow up (up to 51 months) and recurrent ulcers did not develop.

No patient had abdominal hernia or bulging, which was tested by performing Valsalva maneuvers in the standing and sitting positions. All patients were questioned about donor site morbidities but no patient reported impairment of activities of daily living or noticeable motor power weakness. The patients were satisfied with the scar at the donor sites regarding its location and length. Donor site morbidities such as abdominal hernia or motor power weakness were not noticed in these patients.

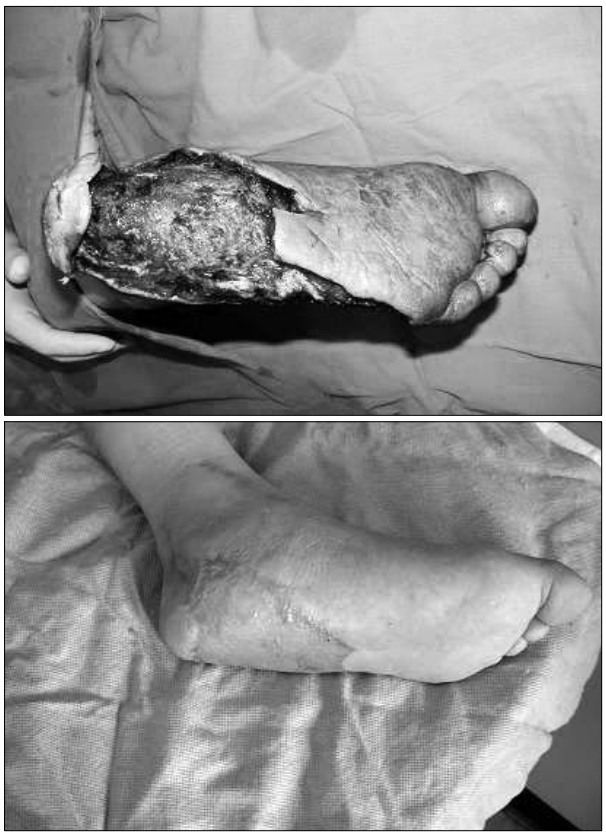

Fig. 3. Case 1. (Above) Intraoperative photograph showing an extensive soft tissue defect after debridement of a DM foot. (Below) 2 month postoperative view after microsurgical reconstruction with rectus abdominis muscle flap and skin graft that showed good foot contour and no wound problems.

Case 1.

A 42 year-old female patient presented with a diabetic foot ulcer. The extent of necrotic tissue was on the posterior, lateral sole, and heel. All necrotic and infected tissues were removed by debridement, which exposed underlying bony structures (Fig. 3). The defect size was 200 cm^2 with an irregular bony surface. Free muscle flap transfer with skin graft was planned to provide adequate reconstruction of this three-dimensional extensive soft tissue defect. A 15 cm length of rectus abdominis muscle flap was harvested with an endoscopy-assisted technique as described above. The harvested rectus abdominis muscle flap was transferred to the defect and split thickness skin was grafted on the muscle flap (Fig. 3). The patient was followed up for 15 months with excellent foot contour and without skin-breakdown. Although a pinprick test showed no light touch cutaneous sensitivity, deep pressure sensitivity was confirmed to be present at long term follow up. Donor site morbidity was minimal with acceptable scarring and no abdominal hernia was found.

Case 2.

A 20 year-old female patient presented with a soft tissue defect on her left heel (Fig. 4). She had an open fracture on her heel caused by a traffic accident when she was 3 years old. Although the fracture was corrected, she experienced problems with walking because of the pain and tenderness of her heel. Wearing normal foot-wear was also impossible due to the deformed contour. Scar tissues were excised under general anesthesia and 77 cm^2 sized defects with calcaneal bone exposure were developed. A 9.5 × 4.5 cm sized-gracilis muscle segment was harvested using an endoscopic technique. The muscle flap was transferred to the defect and split thickness skin (12/1000 inch) was grafted on to the muscle flap. During 51 months of follow up, contour of the heel remained good and no break-down of the skin was observed (Fig. 4). She was able to wear normal foot-wear and walk without pain or tenderness. A pinprick test showed no light touch cutaneous sensitivity but deep pressure sensitivity proved to be present at long term follow up. Scarring of the donor site was inconspicuous and the patient was satisfied with the result (Fig. 4).

IV. DISCUSSION

There has been controversy about which type of flap is better for foot reconstruction. No single type of flap provides the best options for reconstruction of soft tissue defects of the foot. The fasciocutaneous flap has been

Fig. 4. Case 2. (Left) Preoperative view of a soft tissue defect on the left heel. (Center) Postoperative view, 51 months after the gracilis muscle transfer and skin graft. The patient had good contour and normal foot wear was possible. (Right) Donor site in 51 months follow up. The scar was short and inconspicuous.

thought to have better sensitivity, and was believed to cause less ulceration of the reconstructed foot. In contrast, a skin grafted muscle flap can be easily contoured to the recipient area and causes less movement against the underlying bony structures.

A recent study demonstrated that cutaneous sensitivity does not significantly affect the presence of a recurrent ulcer and that the deep structure of the underlying skeleton is a more important factor.[4] Although it is generally believed that cutaneous sensibility is necessary to prevent foot breakdown, normal gait is not affected by the cutaenous sensitivity but deep pressure sense, which is also preserved in skin grafted muscle flap, is essential for the normal gait.[2] Therefore, reconstruction of the foot with free muscle flap coverage can provide a normal gait with sufficient volume replacement. Long term durability of the skin grafted-muscle flap also proved to be good.[5]

In traditional methods, it was necessary to make a long scar that was vertical to the RSTL (relaxed skin tension line) to harvest a long muscle flap. These scars, placed either on abdomen or thigh, are not favorable from an aesthetic view. The authors were able to minimize these shortcomings by using an endoscopy-assisted muscle flap harvest technique. Using this method, enough length of the muscle flap could be harvested, leaving a shorter scar and the direction of the scar was more favorable with regard to the RSTL.

Endoscopy-assisted harvest of muscle flaps has been introduced for rectus abdominis flap, latissimus dorsi flap and gracilis flap in reconstruction of various regions to reduce donor site morbidity.[6-9] In this series of cases, the authors found that endoscopy-assisted harvest of the muscle flap maximized the aesthetic result in reconstruction of the foot, especially in young patients.

For the endoscopy-assisted harvest of the rectus abdominis muscle, a single transverse low abdominal incision was used. A portion of the rectus abdominis muscle extending just above the umbilicus could be harvested without peri-umbilical incision. Some authors reported using a similar method, but they used a peri-umbilical incision along with a low transverse incision.[8]

The muscle lies within the tunnel of the opposing anteroposterior rectus sheath. The anteroposterior sheaths of the rectus abdominis muscle form a well-encapsulated cavity for optical instrumentation. These features make the rectus abdominis muscle a good candidate for endoscopic harvest. Because the anterior rectus sheath is preserved in this technique, adequate stability of the abdominal wall can be maintained.

The gracilis muscle flap has been used for defects less than $6 \times 12\,cm^2$ The vascular pedicle of the gracilis muscle is constant and is located between the fascial space of the adductor magnus and adductor longus muscles. For these reasons, endoscopically assisted harvest of free gracilis muscle has been thought to be a safe, relatively simple and reliable technique.[6,7] The incision can be placed in the proximal thigh, which is less conspicuous and aesthetically favorable. Therefore, the gracilis muscle is well-suited for medium-sized defects of the weight bearing portion, leaving minimal donor site morbidities. Some authors reported using a similar technique, but they used longitudinal incisions.[6] We were able to harvest the gracilis muscle flap using a single transverse incision, which resulted in a less noticeable scar and the direction of the scar was also favorable on RSTL.

With the use of endoscopy-assisted muscle flap harvest, the length of the scar can be decreased and can be placed in a less conspicuous area with an aesthetically favorable direction compared to traditional techniques of muscle harvest. Compared to a fasciocutaenous flap, this

method leaves a much shorter scar.

Long term durability of the skin grafted muscle flap can be employed by following certain principles. Removal of the bony prominence at the time of free tissue placement is necessary to prevent wound breakdown, as it allows distribution of body weight. Precise contouring of the flap when it is transferred is also important for normal foot-wearing and weight distribution. Education of the patient postoperatively is also necessary to replace foot sensibility with frequent visual observation. All the patients in this study had good long term durability without recurrent ulcer.

We consider this technique to be a preferable option for the reconstruction of foot defects in patients with an irregular surface defect, obese patients whose fascio-cutaneous flap needs further de-fatting secondarily, patients who want to minimize the length of scar, and patients who want to avoid having the scar in a conspicuous location.

V. CONCLUSION

Endoscopy-assisted harvest of free muscle flap and transfer with skin graft is a viable option for foot reconstruction of soft tissue defects, and can decrease the length of donor scars and related morbidities. This technique is recommended especially for young patients with high aesthetic concerns.

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