Reconstruction of Large Heel Defects Using Gracilis Muscle Free Flaps

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Heel pad has anatomically unique structure to withstand static body weight and dynamic shear-force provoked by various exercises. And there are not enough soft tissue of similar texture in the adjacent area. These factors makes the heel reconstruction a difficult work.

Numerous methods have been introduced for the reconstruction of heel defects. Those methods include flexor digitorum brevis muscle island flap (Hartrampf et al., 1980), instep island flap (Morrison et al., 1983), supra-fascial flap, lateral calcaneal flap, free muscle flaps (May et al., 1985; Stevenson and Mathes, 1986) and musculocutaneous flaps. The choice depends on the location and the size of defect.

The ideal flap for heel reconstruction should provide (1) adequate padding, (2) protective sensation, and (3) stability and durability to withstand the shear-forces. Several local flaps, including instep island flap, seem to satisfy these requirements, but local flaps cannot be used for moderate to large defects. Among the free flaps available for large heel defects, nothing seems to fully satisfy the ideal requirements.

Although cutaneous sensibility is not provided, gracilis muscle free flap method have many advantages. This method seems to be a very reliable and effective one in reconstruction of large heel defects without leaving considerable donor defects, functionally and aesthetically.

PATIENTS AND METHODS

Patients
Since 1993, seven patients (1 female and 6 males) of moderate to large heel defects had been reconstructed using gracilis muscle free flaps by the Department of Plastic Surgery at Yeungnam University Hospital. The youngest patient was 19 years old and the oldest one was 48 years old. The majority of defects were traumatic origin. A summary of clinical details of the patients is given in table I.

All patients, except one osteomyelitic patient, were free from bony involvement, and a patient with total heel defect had concomitant Achilles tendon avulsion from its insertion. Arteriograms
were routinely performed for the evaluation of questionable vascular status.

Preoperative and postoperative foot-prints were taken for the assessment of weight-bearing status. Patients resumed ambulation with partial weight-bearing after the fourth postoperative week and full weight-bearing by the eighth postoperative week. Deep pressure sense and cutaneous sensibility was checked in four patients who have been followed more than 1 year. The follow-up period was from 6 to 38 months.

Operative Technique

Arteriograms were routinely performed for the evaluation of questionable vascular status. Contralateral gracilis muscle was used in every cases. After careful preoperative design, about 15 cm of vertical incision was made on contralateral upper thigh, which was centered over the dominant vascular pedicle, i.e., 8-10 cm below the pubic tubercle. Additional small distal incision was necessary for freeing of the the distal postion of the flap(Fig.1). With identification and preservation of vascular pedicle, gracilis muscle was freed from adjacent muscles. In every case, medial plantar or posterior tibial vessels was used as recipient vessels. After prompt and prudent micro-anastomosis of vessels using end-to-end technique, the transferred gracilis muscle was fixed on the heel defect with 3-0 vicryl sutures. Motor nerve to the gracilis was not repaired. The gracilis muscle with proximal pedicle provided flexibility of shaping the heel. Total heel defects can be completely covered by spiral shaping of the gracilis muscle. For marginal defects, horse-shoe shaping was adequate and defects including posterior ankle could be covered by sigmoid shaping (Fig.2). Split-thickness skin graft was done over the gracilis muscle. It was necessary to place a suction drainage beneath the muscle flap. Multiple stab incisions were made on skin graft for the evacuation of hematoma and transudate from the denervated gracilis muscle. Compressive dressing was unnecessary. Profuse yellowish discharge was continued from the muscle for more than 10 days.

Table 1. Clinical details of the patients

<table>
<thead>
<tr>
<th>No</th>
<th>Sex/Age</th>
<th>Cause</th>
<th>Defect area</th>
<th>Follow-Up (month)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M/37</td>
<td>cancer</td>
<td>marginal heel</td>
<td>38</td>
<td>previously one-leg amputated state</td>
</tr>
<tr>
<td>2</td>
<td>F/41</td>
<td>trauma</td>
<td>marginal heel</td>
<td>31</td>
<td>concomitant Achilles tendon avulsion injury</td>
</tr>
<tr>
<td>3</td>
<td>M/26</td>
<td>trauma</td>
<td>total heel</td>
<td>25</td>
<td>EHL tendon injury</td>
</tr>
<tr>
<td>4</td>
<td>M/18</td>
<td>trauma</td>
<td>marginal heel</td>
<td>21</td>
<td>failed instep-island flap</td>
</tr>
<tr>
<td>5</td>
<td>M/48</td>
<td>chronic ulcer (osteomyelitis)</td>
<td>total heel</td>
<td>19</td>
<td>spinal injury 20 years ago</td>
</tr>
<tr>
<td>6</td>
<td>M/33</td>
<td>trauma</td>
<td>marginal heel</td>
<td>18</td>
<td>varus deformity of involved foot with marked limping</td>
</tr>
<tr>
<td>7</td>
<td>M/25</td>
<td>trauma</td>
<td>marginal heel</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 1. Two short incisions were used for the harvesting of gracilis muscle to avoid long linear scar on medial thigh.

Fig. 2. Flexibility of shaping the gracilis muscle according to the
A: spiral shaping for the total heel defect.
B: horse-shoe shaping for marginal defect.
C: sigmoid shaping for the defect of heel and posterior ankle
RESULTS

All seven gracilis muscle free flaps were completely survived and donor site wounds were healed uneventfully. Initially, the flaps were very bulky and did not match with the foot size. But during the first two months, the muscle rapidly atrophied and by the third postoperative month, the muscle volume became quite adequate for the heel pad. Profuse yellowish transudate from the muscle was noted in every case until postoperative 10 to 14 days.

Partial weight-bearing started at 4 weeks postoperatively. In every patient, postoperative footprint demonstrated convincing use of the reconstructed heel for weight-bearing (Fig. 3). Six patients out of total seven were able to walk naturally without a special shoe. One patient of only one-leg could walk by himself with the aid of a clutch without any pain and he was included in the normal walking group. The other patient of chronic ulcer with osteomyelitis of calcaneus still shows limping, however his walking ability was markedly improved.

As this method does not provide protective sensibility, every patient was educated for the successful maintenance of their reconstructed heel before discharge. The importance of self-care was emphasized during the education.

There were several minor complications. Partial skin graft loss occurred in four patients. Two of them were treated with small skin grafting and others were managed by conservative treatment. Grafted skin on muscle flap tolerated well and there were no break down, ulceration, and hyperkeratosis on the reconstructed heel.

Fig. 3. Postoperative foot-print demonstrated convincing use of the reconstructed heel for weight-bearing.
Cases Review

Case 1.
A 37-year old man with only one-leg, developed squamous cell carcinoma on his scarred, deformed left heel where he got a train-injury at 20 years ago. He also lost his right lower leg from that injury. He underwent excision of the cancer and the defect was covered with flexor digitorum brevis (FDB) muscle flap and skin graft. Pain-free walking was not possible due to deficient heel padding and 6 months postoperatively small ulceration was formed at the flap margin. Biopsy confirmed cancer recurrence and he was transferred to Yeungnam University Hospital. Wide excision was performed and FDB was partially re-elevated around the margin. Free gracilis muscle was harvested from the amputated Lt. thigh. Medial plantar vessels were used as the recipient vessels. After microanastomosis, gracilis muscle flap was fixed around FDB muscle flap as a horse-shoeshape. Part of gracilis muscle was inserted under the elevated FDB muscle flap for the addition of padding. Medium split-thickness skin graft was harvested from the amputated thigh and applied on the muscle flap. Multiple stab incisions

Fig. 4. (Above, left) Preoperative view shows a soft tissue defect and exposed calcaneus bone. (Above, right) Postoperative radiograph showing reinsertion of Achilles tendon using inter-osseous wiring. (Below, left) Immediate postoperative view. (Below, left) Immediate postoperative view. (Below, right) Favorable result is seen at 6 months postoperatively.
were made on skin graft. Total operation time took 6.5 hours. The patient was kept on appropriate antibiotic coverage for 2 weeks. Postoperative course was uneventful. This patient with only one-leg shows satisfactory weight-bearing with the reconstructed heel for the past 2 years (Fig. 4).

Case 3.
A 26-year-old man had a extensive foot injury on his Rt. foot due to a traffic accident. Full thickness skin defect was seen in the sole from just proximal to the M-P joint to the entire heel. Total heel pad was lost and calcaneal bone was exposed. Arteriography revealed intact major vascular trees of the foot. After several days of wet dressing, medium split-thickness skin graft was done on plantar skin defect area except the heel territory. Heel reconstruction with free gracilis muscle was planed as the next stage operation. Just one day before the operation, he got a slip down at bed-side and his Achilles tendon was found to be detached from its insertion. During the operation, Achilles tendon was fixed with wire sutures passed through the calcaneal bone. Free gracilis muscle was harvested from contralateral thigh. Medial plantar vessels were used as the
recipient vessels and microanastomosis was performed. The gracilis muscle flap was fixed around the entire heel as a spiral shape and skin graft was applied on the muscle flap. Operating time took 8 hours. A short-leg splint was applied for 8 weeks for stable re-insertion of Achilles tendon.

Small skin graft loss occured and managed with patch graft. The muscle flap atrophied over time, enough to wear his usual shoe, while not significantly affecting its durability. But, he continued complaining mild pain and discomfortness on his ankle and heel until 6 months postoperatively. We advised him to wear a specially designed shoe for his foot. After then, he felt much better and natural walking was possible (Fig. 5).

DISCUSSION

Due to its unique anatomical structure and special function of the heel, flaps for heel reconstruction are asked for several requirements. Those requirements for ideal heel reconstruction are (1) adequate padding, (2) protective sensation, and (3) stability and durability to withstand the shear-forces produced during walking and running.

Numerous methods have been introduced for the reconstruction of heel defects. These are suprafascial and sub-fascial plantar flaps (Reiffel RS and McCarthy JG, 1980), flexor digitorum brevis muscle island flap (Hartbrampf et al., 1980), instep island flap (Morrison et al., 1983), lateral calcaneal island flap (Gang RK, 1987), free muscle flaps (May et al., 1985; Stevenson and Mathes, 1986) and musculocutaneous flaps (Skef Z et al., 1983; Stevenson TR et al., 1985). The choice depends on the location and the size of defects.

Several local flaps seems to satisfy above requirements, but local flaps cannot be used for moderate to large defects due to the size limitation. Free flap method allows coverage of large heel defects in a single operative procedures which includes groin flap, scapular flap, latissimus dorsi muscle flap, gracilis muscle flap and tensor fascia lata musculocutaneous flap. However, among the free flaps available for large heel defects, nothing seems to fully satisfy the ideal requirements. Some of them are too voluminous, some are insensate flaps. Some others lack the stability to withstand the shear-force, especially it is true for the musculocutaneous flaps.

Although cutaneous sensibility is not provided, the gracilis muscle free flap have many advantages. The major advantages are as follows: (1) The gracilis muscle free flap is relatively easy to be harvested. (2) After denervation atrophy, the volume of the muscle, is completly fit for the heel defect. If the defect is confined to the soft tissue, special shoe is seldom necessary. (3) The donor defect is minimal, aesthetically and functionally. We used two separate incisions for the harvesting of gracilis muscle flap to avoid a long linear scar. (4) The gracilis muscle with proximal pedicle provides flexibility of shaping the heel. With this muscle of adequate width and enough length, various types of large heel defects can be covered with proper curving and folding as necessary (Fig. 2). (5) the capability of skin graft-covered muscle
flap to withstand the shear-force is much better than that of musculocutaneous flaps.

There are several disadvantages of this method. (1) Absence of cutaneous sensibility and the possibility of subsequent ulceration. (2) This method can not be applied to the large defect that extends beyond the heel territory. Such a large defects should be reconstructed with latissimus dorsi or other larger flaps. (3) the durability of grafted skin over the muscle flap is questionable. However, there has been no complications of ulceration of heel or break down of grafted skin in our cases, and we feel this insensate, skin grafted muscle is stable and durable enough for careful patients who have learned to replace cutaneous sensibility with common sense and visual observation. As this method does not provide protective sensibility, the successful maintenance of the reconstructed heel depends on the patient him or her-self. So, it is important to educate and train them before discharge.

There were few pioneering papers for the sensory reinnervation in microsurgical reconstruction of the heel (Chang KN et al., 1986). Sensory nerve graft to skin flaps, sensory nerve to motor nerve coaptation in muscle flap, and other methods for sensory reinnervation were partially successful and encouraging. Spontaneous neurotization is known to occur from the margin of the flaps, but this phenomenon can be identifiable after many years of follow-up.

The results of walking ability are surprising, because six patients out of seven were able to resume their normal walking. But its not so surprising, if we see the fact that those patients does not have any bony problems and the candidates for this method does not have extensive defects beyond the heel territory. Preserved deep pressure sensation should have played an important role in normal walking in these patients.

In conclusion, the gracilis muscle free flap with split-thickness skin graft seems to be a favorable method for reconstruction of heel defects which are confined within the heel territory. Although cutaneous sensibility is not provided, stable and durable heel reconstruction with excellent contour is possible without leaving prominent donor defect, functionally and aesthetically.

REFERENCES


Morrison WA, Crabb DM, OBrien BM, Jenkins A:


국문 초록

유리 대퇴부근관을 이용한 발꿈치의 재건

영남대학교 의과대학 성형외과학 교실

정 재 호

발꿈치는 신체의 다른 부위에 비하여 압정난 하중을 지탱하고 있으며, 주행시에는 박대한 전단력을 받으므로 그 재건에 있어서 어려운 점이 있다. 그 동안 발꿈치의 연부조직 결손을 재건하기 위한 많은 방법들이 개발되어 왔지만, 비교적 큰 발꿈치의 연부조직 결손을 재건하는 것은 아직도 쉬운 일이다. 이처럼 큰 결손의 재건에는 주로 유리 피판술을 이용한 재건술을 사용하는데, 그 중에서도 광범 grues, 복지근, 대퇴부근 등의 근육을 이용하는 방법이 최근에 많이 이용되고 있다.

이와 같은 유리 근 피판에 피부이식을 이용하는 발꿈치 재건술은 표재성 감각기능을 재건하지 못하는 것이 단점으로 지적되고 있으나, 보행 또는 주행시 발꿈치에게 가해지는 압력과 전단력을 효과적으로 분산해 내려나라, 외관상으로도 정상에 가까운 발꿈치를 재건할 수가 있어서 좋은 방법으로 인정되고 있다. 특히, 대퇴부근은 피판을 비교적 쉽게 채취할 수 있고, 공여부에 기능적인 장애나 심한 변형을 남기지 않아서 좋은 방법이라 생각된다. 다만 크기가 비교적 작아서, 발등이나 족관절 상부에까지 이르는 광범위한 연부조직 결손에는 사용할 수 없는 점이 아쉽다.

저자는 비교적 가늘고 긴, 대퇴부근의 형태적 특장을 최대한 이용하여, 결손부의 다양한 형태 및 크기에 따라 대퇴부근을 발발급형, 나선형, S자형 등으로 적절히 형상화하여 발꿈치 결손을 효과적으로 재건하는 방법을 고안하였다. 또한, 공여부에 긴 선상 변형이 남는 것을 피하기 위하여 두 개의 작은 절개를 통해서 대퇴부근을 채취하였다. 이 방법을 이용하여 영남대학교 의과대학 성형외과학 교실에서는 1993년 이후부터 7명의 비교적 큰 발꿈치의 연부조직 결손 환자를 대상으로 육리 대퇴부근 피판술을 이용한 재건술로 성공적인 결과를 얻을 수 있었다.

핵심 용어: 발꿈치, 대퇴부근