The double muscle gastrocnemius-soleus flap in resurfacing large lower limb defects: Modifications and outcomes

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ABSTRACT

Introduction: Larger soft tissue defects over critical areas of the lower limb involving the knee and proximal two thirds of the tibia present a challenge to the reconstructive surgeon. Options include a large free flap or pedicled local flaps. The gastrocnemius or soleus flap alone is not sufficient. Combined gastrocnemius-soleus flaps can be used adequately without the need to resort to free flaps. We review the use and outcomes of the combined pedicled gastrocnemius and hemi-soleus double muscle flap to cover large defects of the leg and discuss our technique.

Material and methods: A retrospective review of the patients who underwent the pedicled double muscle (gastrocnemius and soleus) flap for wound resurfacing in our institution between 2008 and 2013 was performed. The patients' case notes were analyzed and data collected included their age, comorbidities, wound characteristics, surgical procedures and post-operative outcomes and complications.

Results: There was a total of ten double flaps in ten patients; eight due to trauma and two due to infection. Mean follow up period was 12 months. All flaps achieved primary healing without major complications. There were two cases of minor complications: flap tip necrosis and superficial infection. Nine patients were able to achieve ambulation without aid at final follow up.

Conclusion: The combined pedicled gastrocnemius and hemi-soleus double muscle flap is a useful alternative for reconstruction of large critical soft tissue defects around the knee and leg.

1. Introduction

Soft tissue defects exposing critical structures around the knee and upper two-thirds of the leg are commonly resurfaced utilizing local pedicled muscle flaps. The gastrocnemius muscle flap is usually used for the knee and upper third of the leg, and the soleus muscle flap for the middle third of the leg^{1–3}. However, a single pedicled muscle flap is inadequate for larger critical wounds. This is usually so for continuous wound defects across the knee and proximal to middle thirds of the leg. An option for coverage is a large free flap but this comes with its inherent risks.

A local flap solution to this problem is the utilization of a combined pedicled gastrocnemius and hemi-soleus flap, first described in 2004 by Hyodo et al.⁴ This flap utilizes either the medial or lateral head of the gastrocnemius, which is combined with a hemi-soleus as a contiguous double muscle flap based on the inter-muscular perforators between them. Pu et al.⁵ further modified on this technique, using the gastrocnemius and soleus as a single unit for coverage of mid-tibial wounds. The limitation of the above two techniques was that the intra muscular

perforators were preserved, hence limiting the reach of the flap.

Our case series reviews the use of the combined pedicled gastrocnemius and hemi-soleus double muscle flap to cover large defects of the leg, which would otherwise be reconstructed with free flaps. We also describe our technique with modifications to the original description to increase the reach of the flap.

2. Methods

We performed a retrospective review of patients with large soft tissue defects of the lower leg, who underwent the pedicled double muscle (gastrocnemius and soleus) flap for wound resurfacing. A total of ten patients were identified from our institution's flap registry. The surgeries for these patients were performed within the institution between 2008 and 2013. The patients' case notes were analyzed and data collected included their age, comorbidities, wound characteristics, surgical procedures and post-operative outcomes and complications. The patients were also surveyed via telephone to evaluate their satisfaction with the aesthetic and the functional result of the flap with

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Fig. 1. Left Lower limb upper and middle third defect exposing the tibia.

the flap. The patients' responses to four items were graded using a Likert scale from 1 to 5 (1 = excellent, 2 = good, 3 = satisfactory, 4 = unsatisfactory, 5 = unacceptable). Approval from the hospital ethics committee was obtained prior to the conduct of this study.

2.1. Surgical technique

The flap dissection was performed with the patient positioned supine under general anaesthesia and tourniquet control. The incision was extended distally towards the tendo achilles in the posterior midline until the conjoint tendon of the soleus and gastrocnemius muscles was identified at the length as distal necessary. The individual muscles for harvest were first identified in the area. The gastrocnemius and soleus muscles were identified and raised separately as individual muscle flaps (Fig. 1 and Fig. 2). The more superficial gastrocnemius head was raised first before the hemisoleus. When the medial gastrocnemius was harvested, it was dissected free in a distal to proximal manner, while preserving the pedicle arising from the sural artery, and then split from the lateral gastrocnemius muscle along the midline raphe. The intermuscular perforators between the gastrocnemius and soleus were sacrificed. The distal tendinous insertion of the muscles at the tendo achilles was traced and divided. Next, the medial hemisoleus was dissected free in a similar fashion from distal to proximal, starting at the tendo achilles insertion. The muscular portion of the hemisoleus was used as the flap and was raised based on the proximal pedicle from the posterior tibial artery. The medial hemisoleus was split from the lateral

Fig. 2. Medial gastrocnemius and soleus harvested as individual units.

Fig. 3. Medial gastrocnemius used to cover proximal third tibia and soleus to cover middle third tibia.

hemisoleus longitudinally for wound coverage depending on the extent of the mid-tibial wounds. The procedure was similar for raising the lateral gastrocnemius and lateral hemisoleus muscle flaps. This extension was used in extensive wounds in which the reach was beyond that of one half of the gastrocnemius and soleus.

After raising both muscles, the medial gastrocnemius flap was used to resurface the proximal portion of the tibial wound, while the hemisoleus muscle was placed to cover the distal portion of the wound (Fig. 3). The muscle fascia was scored to increase the surface area of the muscle flaps where necessary.

Depending on the extent of the knee or tibial wound, the lateral gastrocnemius or the lateral hemisoleus (or both) can be mobilized in addition to the medial gastrocnemius and medial hemisoleus. In our study, we found that when the gastrocnemius and hemisoleus was raised separately, the muscles could extend the reach of the double muscle flap. However this procedure could only be done if the gastrocnemius and soleus muscles were not injured.

3. Results

Ten double muscles flaps were performed in ten patients. There were seven male and three female. The average age of the patients was 36 years old (range 21–59). Only one patient had medical comorbidities of hypertension and hyperlipidemia.

The indications for the flap were primarily for Gustilo 3B open fractures in eight patients, and infected arthroplasty implants in two patients. The size of the defects ranged from $10 \times 5 \text{ cm}^2$ to $30 \times 20 \text{ cm}^2$. The defects extended superiorly proximal to the knee joint line in two cases and were confined to inferior to the knee joint line in the other eight cases (Table 1). The combined medial gastrocnemius and medial hemi-soleus flaps were used for wound coverage in eight cases. The lateral gastrocnemius and lateral hemi-soleus flap were used in addition in the remaining two cases. The muscle flaps were covered with a split thickness skin graft primarily in seven cases and as a delayed procedure in three cases.

The average time from surgery for definitive flap surgery was seven days for the eight patients with open tibia fractures. For the two patients with infection it was done after the infections were controlled. The average length of follow up was 12 months (range 6–48 months).

All the flaps survived and achieved primary healing with no major complications in our series of ten patients. There were two cases with minor complications (Table 1). One flap developed flap tip necrosis (infection case), and one flap with superficial infection of the split thickness skin graft (trauma case). The patient with the tip necrosis required debridement of the necrotic area and primary closure was achieved. It was found intra-operatively that there was bone cement within the knee was tenting on the flap causing flap tip necrosis. The superficial skin graft infection healed with dressings and antibiotics. There was no significant donor morbidity in the patients. The average length of stay was 28 days. Post hospital discharge, no patient required

Table 1
Summary table of wounds and flap outcomes.

Case	Age	Sex	Location of injury	Mechanism of wound	Size of Defect	Type of Flap	Complications	Outcome
1	39	M	Upper to middle third tibia (below joint line)	Trauma	10 × 5 cm	Medial and Lateral gastrocnemius & Medial Hemisoleus	Nil	Walk and climb stairs
2	20	M	Upper to middle third tibia	Trauma	10 × 10 cm	Medial gastrocnemius & Medial Hemisoleus	Nil	Walk and climb stairs
3	21	M	Upper to middle third tibia (below joint line)	Trauma	15 × 10 cm	Medial gastrocnemius & Medial Hemisoleus	Nil	Walk and climb stairs and run
4	31	F	Upper to middle third tibia (below joint line)	Trauma	20 × 10 cm	Medial and Lateral gastrocnemius & Medial and Lateral Hemisoleus	Nil	Walk and climb stairs Unable to run
5	26	M	Upper to middle third tibia (below joint line)	Trauma	20 × 10 cm	Medial gastrocnemius & Medial Hemisoleus	Nil	Walk and climb stairs, cycle, run
6	32	F	Knee and Proximal tibia (over joint line)	Trauma	20 × 15 cm	Medial gastrocnemius & Medial Hemisoleus & Gracilis	Superficial infection of SSG	Walk and climb stairs
7	37	M	Upper and middle thirds of tibia	Trauma	30 × 17 cm	Medial gastrocnemius & medial hemisoleus	Nil	Walk and climb stairs Unable to squat
8	45	M	Upper to middle third tibia (below joint line)	Trauma	30 × 20 cm	Medial gastrocnemius & Medial Hemisoleus	Nil	Walk and climb stairs
9	59	F	Knee (over joint line)	Infected implant	11 × 8 cm	Medial gastrocnemius & Medial Hemisoleus	Flap tip necrosis	Ambulate with walking frame
10	51	M	Distal tibial shaft (below joint line)	Infected implant	14 × 8 cm	Medial gastrocnemius & Medial Hemisoleus	Nil	Walk and climb stairs Unable to squat

further surgery for the flap.

The patients who had subsequent follow-up visits had good healing of their wounds. Nine patients were able to achieve ambulation without aid and climb stairs without difficulty at the final follow up. Two patients had difficulty squatting. The mean range of knee motion was 110° (range 100–130°). The patients' responses indicated majority regarded their flap appearance to be satisfactory (6 patients) to good (4 patients). None of the patients were dissatisfied, nor had significant subjective functional impairment due to loss of the lower limb muscles for the flap reconstruction.

4. Discussion

Large wounds over the lower leg have traditionally been resurfaced with free flaps. The limitations of free flap in such extensive wounds are the lack of reliable recipient vessels, the need for microsurgical expertise, large donor flaps required for resurfacing and donor site defects. The use of the combined gastrocnemius or soleus muscle flap has many advantages, including the elimination of the need for microsurgery, making the operation simpler and faster, while providing the same quality and cosmetic result of soft-tissue coverage for an extensive tibial wound. It is also more cost effective.⁶

In the original description by Hyodo, the combined gastrocnemius and hemisoleus was raised as a single unit to cover an anterior tibial wound,⁴ with the soleus muscle component raised as a distal extension of the gastrocnemius flap, being vascularised by feeding intramuscular perforators from the gastrocnemius muscle. This is similar to Pu⁵ who used it to cover anterior tibial soft tissue defects. Van Halen,⁷ in resurfacing of large tibial defects post-resection of tibial sarcomas, used the gastrocnemius and soleus raised separately with their origins and blood supply intact, allowing each to be mobilized separately. These enhanced the mobility and reach of each muscle and allowed for resurfacing of a larger area than the methods previously described by the other authors. Hyodo and Pu had used their bi-muscle flaps to resurface the knee and upper third of the leg. We have extended its utility to resurface defects up to 30 × 20cm², extending across the knee, upper and middle thirds of the leg as well, involving the lateral hemi-gastrocnemius and hemisoleus where necessary.

In our series, we did not experience any morbidity relating to muscle flap ischaemia, and there was no increase in occurrence of the postoperative complications. It is important to note that there was no significant donor site morbidity in our series of ten patients: all were recorded to achieve full weight bearing and had limited functional deficit at final review. This is similar to previous studies, which also reported little functional donor-site morbidity in patients who had either medial gastrocnemius or entire soleus muscle flap reconstruction.⁸ Significantly, despite the utilization of both muscles, the patients were still able to achieve good functional outcome and were able to return to their activities of daily living, maintain independent ambulation, climbing stairs and squat. Our study was limited by its retrospective nature. The choice of using the double muscle flap over a free flap was a decision made by the attending surgeon and selection may be biased.

The combined pedicled gastrocnemius and hemisoleus double muscle flap is a useful alternative for reconstruction of large critical soft tissue defects around the knee and leg without resorting to a free flap. It is reliable, without significant donor morbidity and has low complication rate. It is also versatile and can be raised as a contiguous gastrocnemius-soleus flap with a longer reach, or separately as individual muscles for easier mobilization.

Conflicts of interest

There are no conflicts of interest to declare.

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