PROXIMALLY BASED MEDIAL HEMI-SOLEUS MUSCLE FLAP EMPLOYED FOR MODERATE-SIZED PRETIBIAL DEFECTS OF THE MIDDLE THIRD OF THE LEG

Muhammad Saaiq[1], Irfan Ullah[2], Ikram Ullah[3]

Correspondence

[2]Irfan Ullah, Assistant Professor, Burn and Trauma Center, Hayatabad, Peshawar

: +92-314-9076335

: drirfann@gmail.com

[1]Assistant Professor, National Institute of Rehabilitation Medicine (NIRM), Islamabad, Pakistan

[3]Assistant Professor, Institute of Kidney Diseases, Hayatabad, Peshawar

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ABSTRACT

OBJECTIVES

This study was undertaken to document the clinical indications and outcome of proximally based medial Hemi-soleus muscle flap for coverage of moderate-sized complex pretibial defects of the middle third of the leg.

METHODOLOGY

This descriptive case series was conducted at the Department of Plastic Surgery, National Institute of Rehabilitation Medicine (NIRM), Islamabad and Burn & Trauma Center, Hayatabad, Peshawar, over five years. (i.e., from November 01, 2016, to December 31, 2021). It included all adult patients of either gender whose complex pretibial wounds of the middle third leg were managed with proximally based medial Hemi-soleus muscle flaps.

RESULTS

The mean age was 31.40±9.83 years, ranging between 19-47 years. All the patients had complex post-traumatic defects secondary to road traffic accidents. There were 9(33.3%) patients with minor defects (i.e., measuring ≤2×2 cm^2), whereas 18(66.6%) patients had medium-sized defects (i.e., ≥2×2 cm^2 and ≤7×5 cm^2). Their hospital stay ranged between 9-15 days with a mean stay of 11.92±3.1 days. All the flaps (100%) survived. Partial skin graft loss was encountered among three patients (n=3;11.1%).

CONCLUSION

The study provides a good evidence base regarding the usefulness of the flap in managing complex defects of the leg. It is recommended to carry out similar studies internationally. These should help improve our findings and come up with further refinements.

KEYWORDS: *Hemi-Soleus Muscle Flap, Soleus Muscle, Pretibial Defects of Middle Third of the Leg. Reconstruction of Lower Limb Defects.*

INTRODUCTION

Lower limb trauma continues to pose unique management challenges to plastic surgeons. The associated open fractures predispose to issues such as osteomyelitis, non-union, prolonged morbidity and even the need for amputations. All these compounding issues demand robust soft tissue coverage so that these complications are averted, and early recovery is ensured.[1,2,3] Complex pretibial defects of the middle 3rd of the leg present challenging reconstructive scenarios. The coverage options include local fasciocutaneous, muscle and adipofascial flaps; perforator propeller flaps; and free flaps. The free flaps are indispensable for significant complex defects which are not amenable to reconstruction with local flaps. The local muscle flaps constitute robust coverage tools for managing small to medium-sized pretibial defects with exposed bone or osteosynthesis plates. The additional advantage of the muscle flaps is that they bring robust circulation to the recipient site, which in turn helps combat local infection and expedites the local healing process.[4,5,6] The current study was carried out to evaluate the outcome of proximally based medial Hemi-soleus muscle flap for managing moderate-sized complex pretibial defects of the middle third of the leg.

METHODOLOGY

This descriptive case series was conducted at the National Institute of Rehabilitation Medicine (NIRM), Islamabad and Burn & Trauma Center, Hayatabad, Peshawar, over five years. (i.e., from November 01, 2016, to December 31, 2021). Informed consent was taken from the patients. The study protocol followed Helsinki's Declaration-2013 revision. The anonymity of the participants was ensured. Ethical approval was taken from the hospital ethics committee. A convenience sampling technique was employed for recruiting the patients. All adult patients presented with complex pretibial defects of the middle third of the leg, with a maximum dimension of up to 7×5 cm^2, were included. The defects were stratified into three size categories of small (≤2×2 cm^2), medium (≥2×2 cm^2 and ≤7×5 cm^2) and significant defects (≥7×5 cm^2). The large defects were excluded from the study as they needed reconstruction with flaps other than the medial Hemi-soleus. Also excluded were patients with traumatically crushed or contused soleus muscle or its pedicle, known peripheral vascular disease, diabetes mellitus and multiply injured patients with associated life-threatening issues. All the patients had an initial clinical evaluation with standard clinical protocols. They were admitted indoors for the definitive reconstruction under general or spinal anesthesia. Standard wound management protocols were followed. Fracture fixation was undertaken, wounds were initially debrided, followed by Vacuum-assisted closure (VAC) therapy where indicated.[3] Patients who had clean wound beds underwent immediate flap reconstruction. Elevation of the medial Hemi-soleus muscle flap proceeded under tourniquet control, with the patient in the supine position. The leg was slightly rotated externally, whereas the knee was slightly flexed over a folded surgical gown. The skin incision was marked 2 cm behind the medial edge of the tibia along the distal half to the distal two-thirds of the leg. The incision started midway between the medial malleolus and the Achilles tendon and extended proximally, most to as far as the junction of the middle and proximal thirds of the leg. The incision was deepened to divide the deep fascia along the skin incision line, safeguarding the nearby saphenous nerve and vein. The sheath around the Achilles tendon was incised. Here is the plane's identification between the soleus and gastrocnemius and the soleus's anterior edge. The soleus lay deep into the gastrocnemius, with the cord-like plantaris tendon as a guiding landmark, running between the gastrocnemius (located superficially) and the soleus (located deep). Flap dissection was carried out in a distally proximal direction. Dissection between the soleus and gastrocnemius proceeded in literally an avascular plane and was mainly performed with the index finger. The soleus's lower part was separated from the deep posterior compartment. The intermuscular fascia separating the two compartments was left intact to safeguard the vital posterior tibial vessels and nerves. Distal division of the flap was done at a level as far as distally possible, usually at the level of the medial malleolus. Careful division of the median raphe was performed to separate the flap from its lateral counterpart. Further release of the flap was carried out proximally up to the junction of the upper and middle thirds of the leg. Several small and large perforators from the posterior tibial vessels encountered during elevation were divided and cauterized. The aponeurosis of the soleus was separated with careful finger dissection from the aponeurosis of the gastrocnemius at the adherent confluence with the Achilles tendon. Sharp dissection was performed to affect the release of the soleus fibres. The distal portion of the flap, which had been released so far, was gently held with fingers, and the lateral attachments with the fascia and the fibula were progressively released. In order to effect optimal transposition of the flap, the lateral border was released proximally as the junction of the middle and proximal thirds of the flap. The distal two-thirds of the medial Hemi-soleus was thus elevated, and a proximally based Hemi-soleus flap was ready for transposition. The pivot point of the flap lay at the junction of the upper and middle thirds of the leg. In a tension-free way, the flap was transposed onto the target defect and secured in a standard fashion. A split-thickness skin graft was used to resurface the raw area of the flap surface as well as any other granulating wound on the leg. The flap donor site wound was closed with skin staples or sutures. Postoperatively, the lower limb was kept immobilized for one week. During this period, limb elevation over a pillow was recommended. Routine standard care and monitoring of the flap were done. The flap was evaluated on the 5th and 10th postoperative days to establish flap survival or loss, skin graft loss and any other immediate complications. The demographic profile of the participants and various interventions were undertaken, and outcomes were all recorded on a proforma. Statistical package for social sciences (SPSS) (Version 17, Chicago, IL, USA) was used to analyze the data to measure the objectives. The study's primary outcome measure was survival of the flap or its failure, as noted on the 5th and 10th postoperative days. The secondary outcome measures included taking the skin graft, length of hospital stay and any postoperative complications observed within 28 days.

RESULTS

There were 27 patients, with 25(92.6%) males and 2(7.4%) females. The mean age was 31.40±9.83 years, ranging between 19-47 years. Most (81.48%) of the patients belonged to the third and fourth decades of life. All the patients had complex post-traumatic defects secondary to road traffic accidents. 09(33.3%) patients had small-sized defects, whereas 18(66.6%) patients had medium-sized defects. Their hospital stay ranged between 9-15 days with a mean stay of 11.92±3.1 days. All the flaps (100%) survived. Partial skin graft loss was encountered among three patients (n=3;11.1%). There was no mortality in the series.

Figure 1 A

Figure 1 B

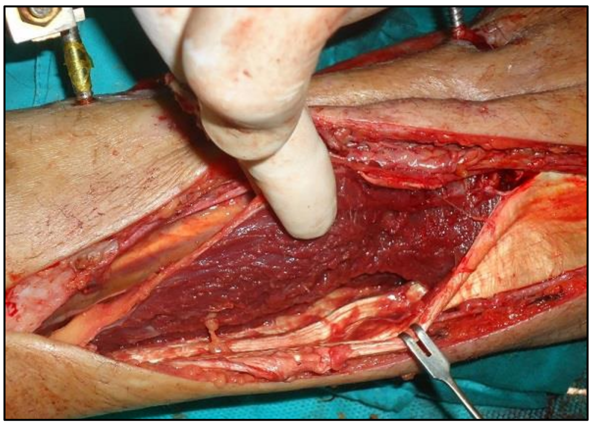

Figure 1 C

Figure 1 D

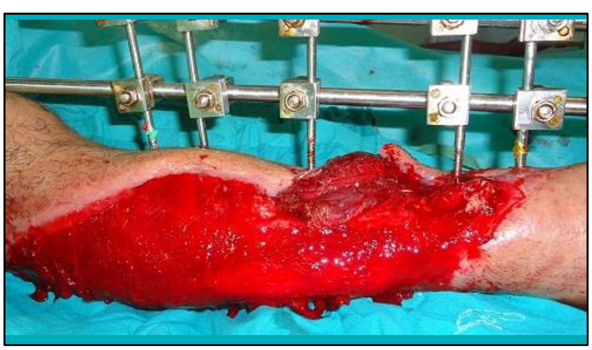

Figure 1 E

Figure 1 F

Figure 1: An adult aged 32 years encountered a road traffic accident and sustained an injury to the right leg with an open fracture of the right tibia. An external fixator was employed to fix the fracture as an emergency measure. The exposed bone was resurfaced with a proximally based medial Hemi-soleus muscle flap, whereas the remaining wound was resurfaced with a meshed split-thickness skin graft. A) The wound with an exposed tibia in the lower part of its middle third. B and C) Medial aspect of the right leg, demonstrating the incision and the exposed hemi-soleus after its careful dissection from the deeper surface of the Achilles tendon. D) The elevated proximally based Hemi-soleus muscle flap. E) Lateral aspect of the leg showing flap-inset. F) The raw flap surface and the large surface area of the healthy granulating wound on the lateral aspect of the leg were reconstructed with a skin graft.

DISCUSSION

In this study, most of the patients were relatively young and over two-thirds belonged to the third and fourth decades of life. In their published series of 30 patients, Satter T et al. from Bangladesh also reported similar involvement of younger individuals.[7] The exact explanation for the affliction of younger patients with such injuries is unknown. However, their frequent presence in risky road environments and involvement in injury-prone outdoor occupations makes them more prone to injuries, particularly in road traffic accidents.[7,8] In this study, except for two cases; all the included patients were males. All of them had acquired defects following road traffic accidents. In the series reported by Satter T et al.[7], most tibial defects were secondary to road traffic accidents. Sound knowledge of the relevant anatomy helps to execute the flap elevation safely. Here is a brief anatomic description of the soleus muscle. According to Mathes & Nahai's classification of muscle flaps, it is a type II muscle flap. It originates from the posterior aspect of the upper third of the fibula, popliteal line and posterior aspect of the third middle tibia. It inserts into the tendocalcaneus about 6 cm above the calcaneus.

Morphologically it is a bipennate muscle with two distinct medial and lateral bellies with separate origins. In the proximal half, the bellies are blended; however, distally, these are separated by a distinct median raphe. Each medial and lateral half has an independent lush vascular supply from the posterior tibial and peroneal arteries. Each artery gives off a dominant pedicle proximally and several secondary pedicles distally along the entire length of the muscle bellies. This vascular arrangement to the two bellies of the muscle allows for safe longitudinal splitting, thus creating the medial or lateral Hemi-soleus flaps. Furthermore, the dual blood flow pattern to each belly via the dominant and secondary vascular pedicles allows its more versatile employment as both a proximally based flap and a distally based or turned down flap.[4,8,9,10] This study managed patients with the medial Hemi-soleus muscle flap rather than the total soleus or the lateral Hemi-soleus muscle flap. Using a medial hemi-soleus muscle flap helps to avoid sacrificing the total muscle, which otherwise would result in severely compromised ankle plantar flexion. The medial Hemi-soleus is preferred because it has a longer arc of rotation and enjoys better excursion towards target defects of the exposed tibia. Since its pivot point lies close to the tibia, it is easier to orient it longitudinally as an anterior transposition flap. Hence it quickly covers exposed tibial defects which are narrow but longer vertically (i.e., extending along the length of the tibial crest). As opposed to the medial Hemi-soleus, the total soleus flap can be oriented predominantly transversely or obliquely. Hence it can cover defects which are prominent in width but short in length. Owing to this obvious advantage of excursion, the medial Hemi-soleus muscle flap often covers more extended defects than what can be covered by the full soleus flap. Owing to the less bulkiness, the medial Hemi-soleus muscle flap is cosmetically superior to the full soleus muscle flap, which happens to be bulkier.[4,10,11] In this study, all the flaps survived. Ahmad I et al.[8] in their series of 40 cases, reported a complete loss of two flaps. Satter T et al.[7] reported four cases of flap loss of variable proportions in their series. The complication rate relates to several patient and surgeon-related factors. For instance, the large size of the exposed tibial defect attempted to be covered with the flap, technical errors, attempting to employ a traumatized muscle and the surgeon's experience with the flap. Additional factors that may contribute to flap failure include situations where the proximal vascular pedicles or the significant vascular supply of the limb are compromised by trauma, arteriosclerosis obliterans, or other pre-existing pathologies.[12,13,14,15,16,17,18] The published literature does not provide clear guidelines regarding the defect's exact size, which can be safely covered with the medial Hemi-soleus muscle flap. This study observed that the standard Hemi-soleus flap measured approximately 12×5 cm^2. This study followed a realistic approach, and small and medium-sized defects were managed with this flap. Coverage of more significant defects with the flap was not attempted, given the flap's recognized size and arc limitations. The inherent problem with such flaps is that the most valuable part of the flap is lost while transposing it to the target defect where only the top part of it reaches to do the needful. This study observed that owing to its deep-seated locations, the flap was undamaged in all the cases of open tibial middle third fractures. A routine pre-operative arteriogram or Doppler study was not performed among the patients included in the study.

LIMITATIONS

In this study, the functional deficit of ankle plantar flexion following the harvest of the Hemi-soleus muscle flap was not evaluated objectively. Being the chief plantar flexor of the ankle and ankle stabilizer during ambulation, sacrificing even the Hemi-soleus muscle may affect the power of ankle plantar flexion. To date, no study has specifically tried to investigate this aspect of the flap objectively. A future well-designed study on this flap aspect would help address and elaborate upon this research gap in the existing body of knowledge.

CONCLUSION

The proximally based medial Hemi-soleus muscle flap constituted a reliable coverage tool for addressing minor to medium-sized complex pretibial defects of the middle third of the tibia. The lush vascularity, the adequate arc of rotation and less flap bulk all contributed to its being a reasonable reconstructive tool. The study provides a good evidence base regarding the usefulness of the flap in managing complex defects of the leg. It is recommended to carry out similar studies internationally. These should help improve our findings and come up with further refinements.

CONFLICT OF INTEREST: None

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CONTRIBUTORS

1. ***Muhammad Saaiq*** *– Concept & Design; Data Analysis/ Interpretation; Data Acquisition; Drafting Manuscript; Critical Revision; Final Approval*
2. ***Irfan Ullah*** *– Concept & Design; Data Analysis/Interpretation; Data Acquisition; Drafting Manuscript; Critical Revision; Final Approval*
3. ***Ikram Ullah*** *– Concept & Design; Data Analysis/Interpretation; Data Acquisition; Drafting Manuscript; Critical Revision; Final Approval*