Distally based Non-Axial Fascial Hinged Flaps: Useful Adjunct to Resurface Traumatic Soft Tissue Defects of the Distal Leg

Neeraj Kant Agrawal[1], Mahendra Kumar Gupta[2]

ABSTRACT

Introduction: Resurfacing soft tissue defects of the posterior distal leg is a magnanimous surgical task. Numerous surgical options exist but they are aesthetically displeasing. This has propelled us to explore the ideal flap and microscopic examination of deep fascia helped in the evolution of non-axial fascial hinged flap as almost ideal cover. This flap is based on a suprafascial and subfascial plexus. With this objective the study was undertaken and surgical experience, planning and safe dimensions of such flaps were described and discussed.

Material and Methods: Thorough flap planning for soft tissue defects on the distal leg, dimensions of the defect, preoperative assessment of the donor tissue and surgical execution were carried out. Different parts of the flap, dissected and undissected, were mathematically calculated based on the anatomical and vascular knowledge and surgical experience.

Results: The mean age of the 42 patients was 35.02 years (range 18-56 years). Majority were males in the age group of 21-40 years. The mean size of the flaps was 25.55 cm^2, largest flap 10 cm and 6 cm wide. The average hospital stay was 21.09 days and follow up of 4-18 months. Complications were occasional and responded to conservative management and patient counselling.

Conclusion: The distally based non-axial fascial hinged flaps is extremely useful for small to moderate size defects of posterior distal leg defects and gives gratifying results. The fact that it is thin, stable, durable along with reconstruction done in one stage adds to the value of the flap.

Keywords: Fascial Flaps, Distal Leg, Defects, Axial, Nonaxial, Vascularity

INTRODUCTION

Reconstruction of soft tissue defects of the distal one third of the leg, especially over the Achilles region, is a daunting task for the reconstructive surgeon. The relatively tight and specific contour of the skin, compromised vascularity and susceptibility to repeated trauma makes the reconstruction an uphill task. Thin and pliable donor tissue is as important as the anatomical knowledge of the reconstructive surgeon. Flaps of different constituents have been described and the surgeon is tempted to execute the simpler flaps such as local and locoregional axial fasciocutaneous and adipofascial flaps. Even after such successful coverage, recurrent ulceration in the shoe-contact area and flap bulkiness while wearing shoes may frustrate patients.[1] They are also associated with significant donor side morbidity and poor cosmesis at the recipient site.[2] Free flaps are also a viable alternative but marred by a long learning curve and microsurgical expertise. Therefore, we extensively searched for a local reliable vascularized tissue of minimal bulk. A defect based turnover fascial flap was found to fulfil the requirements[3] and its vascularity was studied in great detail. Distally based fascial flaps have a leading edge in treating such defects in comparison to other standard flaps because of their thinness, reliability, and minimum morbidity of the donor site, which can be closed directly with such flaps. It has additional properties of being stable, conforming to any contour and hasslefree tendon gliding.

Vascular anatomy of fascial flaps

The deep fascia of the lower leg is a vascularized structure that has three vascular plexuses associated with it. The suprafascial plexus on the suprafascial portion of the deep fascia and the subfascial plexus on the underside of the fascia receive their blood supply from the adjacent septofascial and musculofascial perforators. The intrafascial plexus is a much finer plexus, which lies between the collagen bundles. Its blood supply comes largely from fine arteriolar branches of the suprafascial and subfascial plexuses.[4] The fascial plexus has a predominant axiality, which is further associated with the direction of orientation of the parallel collagen fibres that form the fascial layer itself.[2] When a fascial flap is raised, the deep fascia loses that part of its blood supply from the subdermal plexus which runs in the fat adjacent to dermis and also detached from the subcutaneous plexus. This significantly reduces the safe dimension of the fascial flaps as compared to fasciocutaneous or adipofascial flaps. Microscopic examination of the deep fascia in lower limbs of cadavers has highlighted the potential use of non-axial fascial flaps.[5]

It was demonstrated in anatomical dissections that the suprafascial membrane could be used as a vascularized pedicled flap. Although the viability of the fascial flap was

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difficult to determine, the flap was propagated.[6,7]

Brunelli (1988) described the use of small fascial flaps based on a random blood supply for coverage of small distal limb defects but the small size of the flaps limited their usefulness.[8] Pedicled fascial flap in a single case was also reported for repair of a defect over the knee joint.[9] and the Achilles region.[10] Sporadic works have been carried out using axial fascial flaps.[10,11] but research has been limited on the use of non-axial or random fascial flaps.[12]

The aim of the study was to describe and discuss our surgical experience in terms of feasibility, planning and safe dimensions of the flap with clinical outcome of distally based hinged fascial flaps for reconstruction of soft tissue defects over distal third of leg.

MATERIAL AND METHODS

The study was conducted in the Department of Plastic Surgery, Banaras Hindu University, Varanasi from October 2012 to September 2019. A total of 42 patients with soft tissue defects of the distal leg were prospectively studied for reconstruction using non-axial pedicled fascial flaps.

Only soft-tissue defect of the posterior distal third of the leg with adequate movements of the foot at tibio-talar and sub-talar joints were included in the study. Patients who sustained Achilles tendon injury, rupture or infective necrosis and which required tendon debridement were excluded from the study. Patients with local copious purulent discharge from the wound were poor candidates for surgery. Limited mobility or stiffness of the ankle joint, patients with uncontrolled diabetes mellitus, severe comorbidities, uncooperative children and psychiatric patients were excluded from the study. Patients reactive to viral markers were operated with extreme care and precautions. Anticoagulants, if any, were discontinued a week prior to operation.

In the pre-operative visit dimensions of the defect, availability of the local donor tissue, tentative dimensions of the fascial flap and the incision site were planned for surgical execution. The incision is modified and fashioned to avoid any proximal scars or adherent soft tissues.

Surgical technique

A wide excision of ulcer was carried out with removal of the fibrotic skin till pliable skin is available at the edges of the defect, exposing the Achilles tendon in the base of the wound. The edges of the excised ulcer were also undermined by 5mm to 10mm for appropriate suturing of fascial flap deep to the undermined skin of the ulcer.

Lazy-S incision was made in continuity with proximal edge of the excised ulcer (Fig 1) and farther than the proposed proximal edge of fascial flap. Generous undermining of subcutaneous tissue was performed to identify the deep fascia (Fig 2). A fascial flap of adequate dimension as per pre-operative planning was dissected out meticulously and carefully from the underlying epimysium (Fig 3).

The flap was planned about 4-5cm proximal to proximal edge of the defect (Fig 4). This distance was calculated considering 2cm as undissected base which bears the vascularity of the fascial flap whether random or axial. Another 0.5cm is required for generous flap folding to prevent kinking, twisting or jeopardising the vascularity. The longitudinal dimension of 2.5cm was calculated for the bridge segment, that of the defect in the Achilles region was added and 0.5cm was added for suturing deep to the undermined skin flap of the defect (Fig 4). Thus, the flaps raised were 1 cm wider than the width of the defect and were 3-3.5 cm longer than the length of the defect. The flap was then turned over through 180^0 to cover the defect and tucked to the under surface of the previously undermined edges (Fig 5).

The donor site was primarily closed in layers as far as, but not over, the flap pedicle (Fig 6). Adequate haemostasis was achieved and an intermediate thickness skin graft was used to cover the fascial flap (Fig 6). The skin graft was perforated for flap monitoring, drainage and prevention of haematoma. Light absorbent non-compressive dressing was done to avoid any constriction over the flap. The ankle joint immobilised with foot in 30^0 plantar flexion using a plaster slab on the anterior aspect of leg.

Periodic flap monitoring via the perforations in the skin graft was done. Any hematoma, if present, was drained and signs of infection looked for. Uncomplicated uptake of skin graft was an indirect sign of viability of flap. Patients were discharged on proper graft uptake and removal of sutures. Proper counselling was done regarding the care of the flap, cleaning and frequent application of an emollient.

Patients were followed up for weekly consulation for 3 weeks and monthly for next 6 months. All the data were recorded and tabulated. Photographs were obtained on every visit. Quantitative variables were statistically analysed by mean, median, standard deviation and maximum and minimum value.

RESULTS

The 42 patients included in the study were found to have mean age of 35.02±9.89 years with the range of 18-56 years and median age 35.5 years. 38 patients were males and only 4 were females. 26 patients (61.9%) were in the age group of 21-40 years. Four patients had well controlled diabetes but were shifted to insulin prior to surgery. 7 patients were

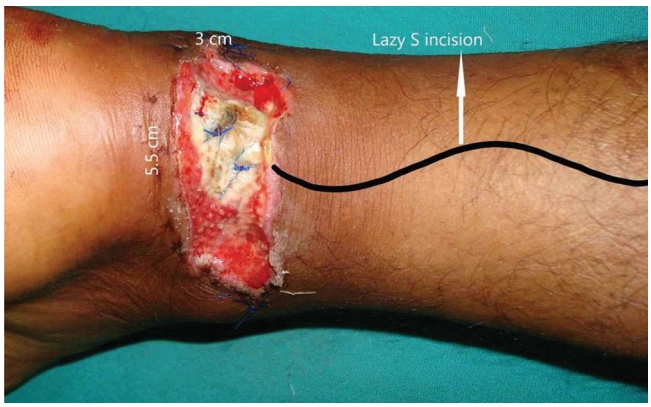

Figure-1: A 5.5x3 cm soft tissue defect over the posterior aspect of distal third of left leg with necrosed Achilles tendon in the floor. A lazy S incision given in continuity with the proximal edge of the defect.

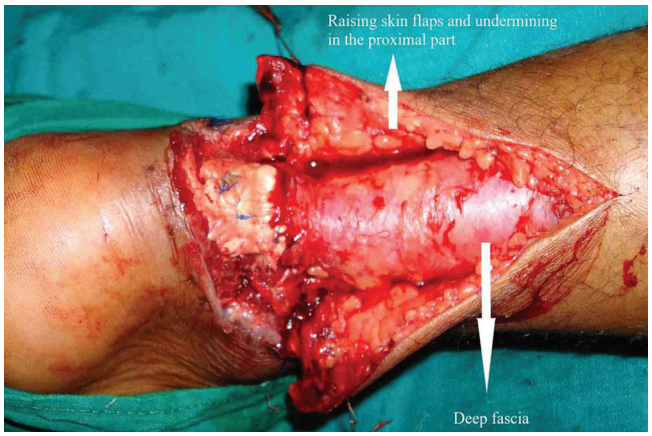

Figure-2: Skin flaps on either side of the incision raised or undermined to expose the deep fascia of the leg.

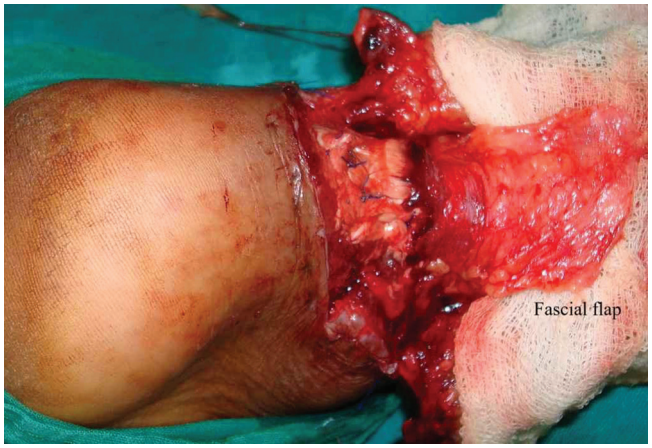

Figure-3: Fascial flap raised as per preoperative and peroperative planning which is discussed in detail in Fig 4.

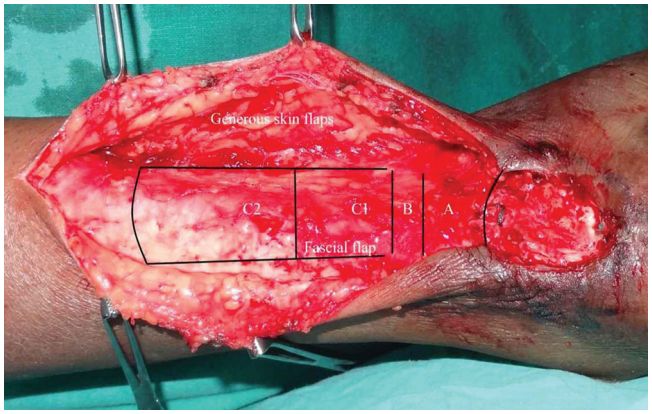

Figure-4: Photograph of the leg depicting the different parts of the hinged flaps.

A = 2 cm undissected base which perfuses the flap by vascular ramifications.

B = 0.5 cm for tension free and gentle flap folding for a hinged flap.

C1 = 2.5 cm of the dissected flap which lies over and traverses A+B

C2 – dissected part of the flap which is calculated as the length of the defect + 0.5 cm for suturing beneath the undermined edges of the defect.

Therefore flap raised is C1+ C2+0.5 cm or length of the defect + 3 cm

Width of the flap raised = width of the defect + 0.5 cm

For the defect 5.5x3 cm shown in Fig 1, flap raised will be

Length 3 cm + 3 cm = 6 cm and width 5.5 cm + 0.5 cm = 6 cm

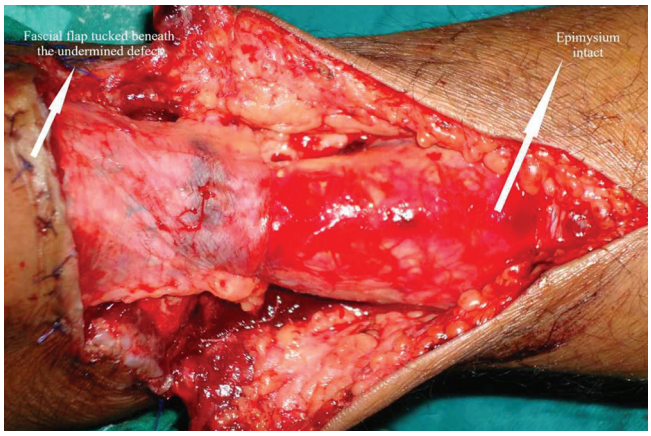

Figure-5: Fascial flap hinged and inset into the defect. Fascia tucked beneath the undermined edges of the defect. Epimysium is shown to be intact.

Figure-6: The donor site closed as far as, but not over, the flap pedicle and intermediate thickness skin graft applied.

Figure-7: The local fascicutaneous flap showing too much bulk. The skin graft on secondary defect giving a patchy and excavated appearance.

occasional smokers and 9 patients were alcoholic. 38 patients (90.48%) sustained injury due to high velocity road traffic accidents. Other 4 patients were dragged by cow or bull with the rope tied around their ankle. The flap was designed after adequate debridement of the wound and the size of the defect was calculated in cm^2. It was found to range from 15-60 cm^2 with a mean size of 25.55±9.07 cm^2. The largest dimensions were 10cm long and 6cm wide and the shortest dimensions were 5x3cm. The patients presented after substantial time had elapsed since time of injury. Patients consulted in the plastic

Figure-8: 4x2.5 cm soft tissue defect on distal third of left leg and sutured tendon seen in the floor. No motor deficit present.

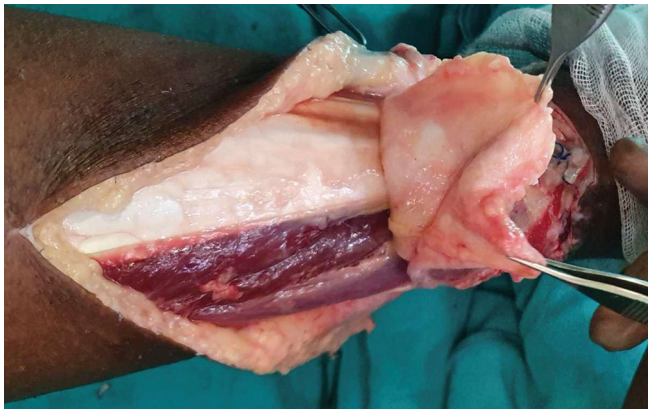

Figure-9: Fascial flap raised as per calculation explained in Fig 4.

Figure-10: Fascial flap tucked and donor site closed.

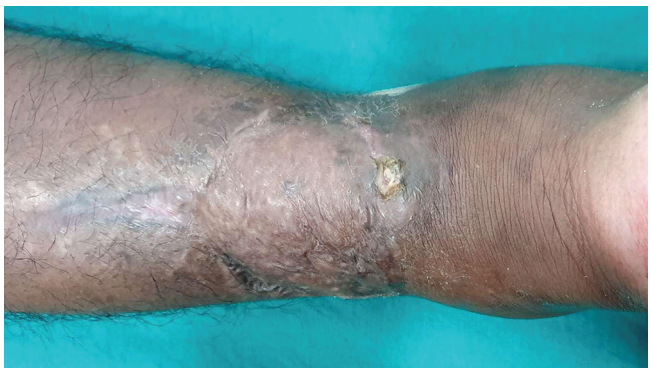

Figure-11: Skin graft was applied and the 6 months postoperative photograph shows the excellent appearance of the graft and the donor site.

surgery department after a mean period of 71.07±33.46 (range 31-211) days of the injury. The average hospital stay following surgery was 21.09 days. The follow-up period ranged from 4 months to 18 months. There was partial flap loss in 4 patients which healed by conservative management. 2 patients had complete flap loss and were managed by local fasciocutaneous flaps (Fig 7). Among the late complications 7 patients had hypertrophy at the graft suture line requiring thorough massage and customised pressure garments for 6-9 months. 3 patients had recurrent ulcerations when wearing shoes and change of footwear helped to some extent. Patients were highly contented with the flap aesthetics although 2 of the 4 females expressed concern over the thickness of skin graft. Proper counselling and ease of using the footwear alleviated their anxiety. Rest of the 40 patients appreciated the thinness of the fascial flap.

DISCUSSION

Meticulous planning and flawless execution is best exemplified by the surgical transfer of the, rather delicate, fascial flap due to its intricate blood supply. Axial fascial flaps based on deep vessel have frequently been described. It is always preferable to incorporate a well identified perforator or two in the pedicle of the flap but at times, at certain sites of the defect, it may not be possible to include such named perforators. Such anatomically complicated defects are those over the shin or distal third of leg as these areas have less subcutaneous tissue. In such situations axial or non-axial fascial flaps with skin graft produces a good result and a linear donor scar.

Other options such as fasciocutaneous flaps, adipofascial and free flaps have often been described which not only produce unwanted and unsightly bulk but also result in significant donor site scar (Fig 7). The retrograde fasciocutaneous flaps are frequently used for defects over the distal leg but an additional stage is frequently required either to detach the pedicle, correction of the dog ear or debulking the flap. Skeletonising the flap can solve most of the problems but application of skin graft over the donor site gives an unpleasant look to the extremity. The adipofascial flap is a good option though it has additional bulk and sometimes marginal necrosis may occur at the donor site.[10] Temporoparietal fascial free flap is a viable alternative but the procedure is prolonged, necessitates microsurgical expertise and seems rather amplified for a medium sized soft tissue defect of leg which could, otherwise, be resurfaced by simple local flap.

After weighing the advantages and disadvantages of various surgical procedures it was emphatically decided to proceed with non-axial defect based fascial flaps from the middle third of the leg and hinged to resurface the more distal defects (Figs 8-11). The vascular basis of these flaps have been attributed to the presence of rich subfascial vascular network. The intrafascial vascular network with the type and calibre of the vessels has also been described.[13] Stecco et al mentioned that numerous vessels follow tortuous paths through the different collagen layers of the fascia.[14] and

thus maintain the continuity of the horizontal and vertical vascular network. This enhances the vascularity and provides safety to the fasciocutaneous, adipofascial, and fascial tissue transfers.[11]

The landmark work of Ponten, who described fasciocutaneous flaps in 1981[15], changed the concept of random skin flap design. These flaps were limited by length-to-width ratio of 1:1 in the lower extremity but Ponten, by the inclusion of deep fascia, described the flaps with ratio as great as 3:1. Thus, these flaps derived the name superflaps. Tolhurst et al also demonstrated a 15% greater survival length in flaps that included deep fascia.[16] The exact anatomical location and dimensions of flap harvest depends the easy reach of the flap doubly verified by 'planning in reverse'. Raising a thin flap as a fascial flap needed severing of the subdermal and the subcutaneous plexus. Thus, the safe dimension decreased and was worked out to be approximately 1.5:1. The largest flap raised was 10x6cm therefore the ratio was 1.67:1. In this study we have used random or non-axial fascial flaps in 42 patients with defects over the distal third of the leg. Such random flaps which are defect based and hinged gently to lie in the raw area, without tension or torsion, are quite safe. The length:width ratio is smaller, adding to the safety of the flap. Four patients had partial flap necrosis and it was explained by the ratio increasing to 1.77:1 and upto 2:1. Complete necrosis of the flaps and consequent flap loss was encountered in two patients, the reason again being a higher length:width ratio. The ratio was 1.75:1 and 2:1. Most importantly, the width of the flaps with partial or complete flap loss was narrower and was 3-4.5 cm. It has been emphasised that the flap pedicle should be made as wide as possible to prevent postoperative arterial compromise and venous congestion.[1] We reemphasise the importance of proper patient selection to avoid harvesting narrow fascial flaps and violate the vital length:width ratio.

7 patients developed hypertrophic scars at the suture line and were supposed to be caused by cutaneous injury and irritation, including trauma and surgery. Superficial injuries that do not reach the reticular dermis never cause hypertrophic scarring, thus making it an all important skin layer.

Technical aspects of the fascial flap harvest have their own value in its survival. Generous elevation or undermining of skin flaps, at least 1.5 - 2 cm wider than the width of the proposed fascial flap, was carried out to expose the deep fascia. This undermining is of special significance as adequate width or slightly wider flap should be harvested lest one may fall short. Identification of the deep fascia, both superficial and deep layers, and its meticulous separation from the epimysium of the underlying muscles will prevent distal exposure of the tendons. It is, thereby extremely important to leave the epimysium intact.

Extreme caution is mandatory while using this technique in acute cases as the extent of damage to the adjacent tissue, fascia and its vascularity remain unpredictable. It is worthwhile waiting for 14-21 days to assess and ascertain the viability of surrounding skin and tissues to prevent unwanted complications. The importance of a thorough skeletal survey cannot be underrated and any locoregional bony injury requires rigid fixation before planning a suitable and potential flap.

It should strictly be emphasised that it is not the desired flap for weight bearing areas of the foot as the flap is extremely thin and inappropriate to withstand the friction, wear and tear of such areas.

CONCLUSION

The distally based non-axial fascial hinged flaps is extremely useful for small to moderate size defects of posterior distal leg defects and gives gratifying results. Most of the patients being young and active required flaps which were thin and did not limit the locomotion of the patient. The fact that it is also stable, durable along with reconstruction done in one stage adds to the value of the flap.

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