Turn over split fascial flap - a refinement for resurfacing shin defect

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Abstract: Moderate size defects of the shin of tibia are frequently encountered following trauma and infection. They may be associated with or without a fracture. Such defects require resurfacing by a flap. Many different types of flaps have been described but most of them proved to be more bulky than desired. Although these procedures cover the defects successfully the results they produce are not aesthetically appropriate. The flap looks bulkier because the native subcutaneous tissue is thin over the shin and distal leg. Hence a search for a vascularized tissue of minimal bulk for suitable resurfacing was initiated. A turnover fascial flap fulfilled the requirement. Such a flap can be made thinner by splitting its distal part into two layers while maintaining a common vascular fascial pedicle with both the layers of the fascia. This allowed a larger surface area to be covered. Such refinement is based on the following parameters (a) fresh cadaveric dissection, (b) demonstration of live microcirculation individually in the superficial and deep layers of the deep fascia and (c) intraoperative fluorescein study of the split fascial flap. The technique has been used in 5 cases over the upper and middle third of the shin of tibia. The split fascial flap was turned over and inset in the defect and covered with a split skin graft. The donor site was primarily closed. The functional and aesthetic results were highly satisfactory. The follow up of 18 months proved the durability and usefulness of the flap.

Keywords: Split fascial flap, shin defect, lower limb reconstruction

Introduction

Shin defects of moderate dimension are frequently encountered following trauma and infection. Flaps of different constituents which have been described are bulky and thus fall short of the desired functional and aesthetic result. The concept of a split fascial flap emerged in search of a thinner flap. Three relevant parameters proved adequate vascularity in both the layers of the deep fascia. Thereafter, it was successfully used in 5 clinical cases. The technical intricacies have been mentioned in detail. Long term follow up proved that it is a simple, effective, durable, single stage procedure with appropriate aesthetic result.

Materials and method

The study began in January and continued till December 2010. The formal approval was taken from the ethical committee of our institute. Following parameters were taken into consideration prior to clinical application and its confirmation during surgery: (a) Fresh Cadaveric dissection of split fascial flap; (b) Demonstration of independent live microcirculation in both the layers of deep fascia; (c) Intraoperative fluorescein study of split fascial flap as described below:

(a) Fresh Cadaveric dissection was carried out on 10 limbs of 5 bodies. The popliteal artery
Turn over split fascial flap for resurfacing shin defect

was isolated and ligated proximally. A canula was inserted and secured in the distal segment. 30 ml of 50% methylene blue was injected through it. An incision was made from popliteal crease to the end of the tendo Achilles, following which an upper horizontal incision was made between the two tibial condyles and a lower horizontal incision across the two malleoli. Skin flaps were undermined on either side to expose the deep fascia on the anteromedial and posterolateral aspect. The rich suprafascial plexus containing the dye was visualized.

Thereafter three incisions were made through the superficial layer of the deep fascia, which covers the gastrocnemius muscle, keeping intact the fascial base towards the shin of the tibia. The superficial layer was meticulously dissected from the deep layer up to the base using 4x magnification. Another corresponding incision was made through the deep layer of the fascia, which was dissected from the underlying muscle through the epimysium up to the base. It was evident that the dye reached the vascular arcade of the superficial as well as the deep layer of the deep fascia called suprafascial and subfascial network respectively (Figure 1).

(b) Live microcirculation independently in both the layers of the deep fascia has been already demonstrated by us [1].

(c) In two out of 5 cases intraoperative flourescein study was carried out. Both the patients were tested for sensitivity to the dye (fluorescein sodium) by injecting 0.05 ml intradermally. The patients were operated under epidural or spinal anesthesia. 20% of flourescein dye (30 mg/kg) was injected intravenously, 20 minutes after dissecting the flaps. Twenty minutes after the injection, the operation theater was darkened with the help of dark blue curtains and UV light was focused on the flap. The personnel involved wore UV light protective eye wear. Both the layers of the split fascial flap demonstrated adequate reach of the dye upto the distal part proving adequate vascularity (Figure 2 and 3).

Photography

A medium yellow filter (Y2 of Lumix Company) capable of absorbing reflected UV and violet blue radiation was used over the camera lens for capturing the photograph in UV light. A cable-operated camera mounted on a tripod was adjusted in B-Mode. The exposure time set was 25 -30 seconds and aperture was kept at 5.6. An electronic photographic flash was directed towards the ceiling to give appropriate diffused light. In split fascial flaps fluorescence could be observed on both the surfaces of both the layers.

Plan of the flap

The flap is usually turned over the defect keeping its base about 2 cm in length and width equal to approximately two thirds of the length of the defect (Figure 4). The distal part of the deep fascia is split dissecting the deep and su-
Turn over split fascial flap for resurfacing shin defect

Perforators are preferably incorporated in the undissected base (Figure 4E). The size of the dissected flap is calculated by adding A+B+C+D. “A planning in reverse” ensures the precise dimension of the flap.

Operative technique

A meticulous planning in reverse was done using a piece of lint. The distal part of the lint was split into two layers alike the proposed flap. These two layers were moved sagitally in opposite direction over the wound to cover it. This gave us an accurate idea of how much these layers needed to be dissected toward the base (Figure 5), and also explained how the sliding of the two layers of the fascia would cover a larger area when compared to a fascial flap with both the layers intact. On an average the two layers of the deep fascia were dissected from one another by 2.5 cm keeping an undissected common fascial base adjacent to the defect (Figure 6). This maneuver enhanced the surface area at the distal width of the flap by about 2 cm. It is preferred to incorporate at least one sizeable perforator in the undissected base. Following this dissection the flap was replaced at the donor site for 15 to 20 minutes in order to release the vascular spasm. Once sufficient bleeding was observed from the margins, the flap was turned over the defect. The deeper layer was slid proximally and the superficial layer distally over the defect (Figure 7). The margins of

Figure 3. Showing the reach of the fluorescein dye on both the surfaces of both the layers of split fascial flap.

Figure 4. Plan of split fascial flap. (A & B) split deep and superficial layers of the deep fascia, (C) unsplit deep fascia equal to the dimension of the base, (D) part that turns over, (E) undissected base, (F) the defect, (A, B, C & D is dissected).

Figure 5. ‘Planning in reverse’ of split fascial flap for a middle third shin defect, demonstrating how by splitting the two layers the surface area of the flap increases as compared to unsplit fascial flap.
Turn over split fascial flap for resurfacing shin defect

the flap were sutured to the subcutaneous margin of the defect. The split fascial layers were covered by a thin perforated skin graft and secured by marginal stitches (Figure 8). The donor site was sutured primarily. A firm dressing was applied. The flap was inspected after 24 hours to spot any hematoma.

Result

In fresh cadaveric dissection on 10 lower limbs it was observed that the superficial layer was thinner than the deeper layer. We could visualize adequate vascular network in both the layers of the deep fascia suggesting that a common pedicle should be able to provide necessary circulation. This thought was augmented earlier by the demonstration of microcirculation in both these layers individually by the authors. The intraoperative fluorescein study of split fascial flap also demonstrated the reach of the dye up to the tip of both the layers. All these three relevant parameters proved the adequacy of vascularity for safe clinical use of split fascial flap.

In five cases such flaps were used successfully. All the patients were non-smoker males. None of them had associated systemic disease. All were young adults between 25-30 years. Four had post traumatic defects and one was following cellulitis. In cases of trauma, the duration between injury and reconstruction varied from 6 to 8 weeks. In the post infective case, the reconstruction was done after 6 weeks. Three out of five defects were located at the upper third of tibial shin. The other two were located at the middle third of shin. In post traumatic cases, associated fracture of the tibia was stabilized.

Figure 6. Both the layers of deep fascia has been bisected distal to the common fascial base.

Figure 7. Both the layers have been sutured to the subcutaneous tissue to cover the bone.

Figure 8. Thin skin graft has been applied to cover the flap.

Figure 9. Eighteen months follow up showing gratifying functional and aesthetic result.
Turn over split fascial flap for resurfacing shin defect

earlier by internal fixation. The dimension of the defects ranged from 4 to 6 cm in length and 2 to 4 cm in width (Table 1). The dimension of the flap ranged from 6 to 8 cm in length and 2 to 4 cm in width. The addition of both the layers after splitting formed the width of the flap. Four flaps were medially based on the posterior tibial axis and one was laterally based on the peroneal axis. Prior to reconstruction the wounds were dressed with normal saline and antiseptic lotion. Prior to resurfacing the wound swab was sent regularly till the wound became healthy and free of infection.

All the five cases healed uneventfully. The graft ‘take’ was complete in every case. The average hospital stay was of 14 days. The donor site healed with a linear scar. A follow up extending up to eighteen months proved the durability of the flap with gratifying aesthetic result (Figure 9). It did not produce any extra bulk over the shin and merged perfectly with the contour. Following points were taken into account for assessing the result.

(a) Contour, matching with the adjacent area. (b) Durability proved by following up. (c) Minimal linear scar at the donor site. (d) Satisfaction of the patient.

Discussion

Moderate size shin defects of the tibia are frequently encountered and the commonest cause is trauma. Several methods have been described depending upon the size and contour of the defect. Both these aspects are of significant consideration for functional and aesthetic results. The loco regional flaps are preferred wherever non traumatic adjacent tissue of adequate dimension is available. Whenever the contour of the defect is deep, a thick flap of different constituents is indicated in the form of musculocutaneous, muscle, fasciocutaneous, adipofascial and fascial flaps. The flap selection forms an essential part of reconstruction, otherwise the flap may successfully cover the exposed vital structures but may not be acceptable aesthetically by the patient or even by the surgeon. Hence, there has been a constant search for refined flaps to meet these requirements. This problem is more prominent when the defect is over the shin or distal third of leg as these areas have less subcutaneous tissue. In such a situation a split fascial flap with skin graft produces a good result with a linear scar at the donor site. To the best of our knowledge split fascial flaps have not been used clinically. Cadaveric dissection forms an important part of proving the vascular basis of flaps of different constituents including fascial flaps [2-4]. Fascial flaps incorporating both the layers of gastrocnemius fascia have been used as vertically based turnover flaps [5] or for distal leg defects [6, 7]. Elghamry AH has described fascial flap from the outer layer of tendon sheath of the ankle extensors. The flap is nourished by the sepal perforators. It was successfully used as a proximally based turn over flap with skin graft for tibial and pretibial area at the distal part of the leg. His flap is deep to deep fascia [8]. Our flap is harvested as a split fascial flap of the deep fascia over the gastrocnemius muscle. Having understood that the deep fascia over the gastrocnemius muscle consists of two distinct layers; we planned to use them clinically. There were two reasons for splitting the fascia (a) to cover a larger surface area of the defect as compared to a fascial flap, incorporating both the layers. (b) To have a more refined thin flap to maintain the contour of the shin. To prove the rationality of split fascial flaps we conducted fresh cadaveric dissection with dye, demonstrated live circulation in individual layers and intraopera-

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<tr>
<th>Patient</th>
<th>Site of defect over shin</th>
<th>Dimension of defect L x W in cm</th>
<th>Dimension of flap L x W in cm</th>
<th>Location of base</th>
<th>Results</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Upper third</td>
<td>4 x 6</td>
<td>6 x 6</td>
<td>PT</td>
<td>Healed</td>
</tr>
<tr>
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<td>6 x 5</td>
<td>8 x 6</td>
<td>PT</td>
<td>Healed</td>
</tr>
<tr>
<td>3</td>
<td>Middle third</td>
<td>5 x 4</td>
<td>8 x 5</td>
<td>PT</td>
<td>Healed</td>
</tr>
<tr>
<td>4</td>
<td>Middle third</td>
<td>4 x 4</td>
<td>6 x 5</td>
<td>PR</td>
<td>Healed</td>
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<tr>
<td>5</td>
<td>Upper third</td>
<td>6 x 6</td>
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PT- Posterior tibial axis, PR- Peroneal axis.
tive fluorescein study. The cadaveric dissection clearly demonstrated that the dye reached the vascular network of both the layers. The superficial layer contains suprafascial plexus and the deep layer has the subfascial plexus. We demonstrated live microcirculation intraoperatively in both the layers of the deep fascia in 2005. Encouraged by the above findings, we did intraoperative fluorescein study in two of our cases which adequately demonstrated dye in the superficial and deep layers of the deep fascia. The technique of fluorescein study is well established and we have used it extensively for a variety of flaps [9].

We applied split fascial flaps in five clinical cases. On an average the distal part of the fascial flap was split by 2.5 cm, in length. The length of the splitting can be judged by spreading the flap over the defect. As soon as it meets the requirement no further dissection is necessary and the flap is laid over the defect. When compared to an unsplit fascial flap a split fascial flap could cover an additional 2 cm of the defect. Delicate handling is essential while splitting the flap. We have observed that the superficial layer is relatively thinner than the deeper layer. Adequate undissected base of 1.5 - 2 cm provides the necessary blood supply. It is preferred to incorporate a perforator at the base which may be identified by pre operative audio Doppler. The length of the sagitally bisected flap should be equal to the length of the defect. About 0.5 - 1 cm of the dissected flap, just adjacent and distal to the undissected base, is utilized for turning over the flap. After exposing the deep fascia, the extent of the flap across the defect is decided by “planning in reverse” using a lint as described earlier. It is technically easier to dissect the superficial layer from an intact deep layer than raising both the layers together and then splitting them. After both the layers of the deep fascia are split, the flap is turned over the defect. To avoid torsion of the pedicle, the deep layer is moved proximally and the superficial layer distally, keeping a common base. Therefore, the subfascial surface is exposed over the deep layer and the intrafascial surface over the superficial layer to be covered with a split skin graft. In all the cases the ‘take’ of the graft was complete, once again proving the adequacy of the vascularity of both the layers. Thus one can safely use split fascial flap in moderate size defects. This is the thinnest local flap described apart from the tenosynovial flap [10].

This new concept opens another vista in the reconstructive armamentarium. There may be occasions when the surgeon has planned a fascial flap but after committing the flap may realize that it is not adequate enough to cover the vital structures. The above knowledge can also be applied to handle such situations effectively. One may also use a free split fascial flap. This procedure can be easily performed in any set up with the use of loop magnification. This study has resulted in providing adequate information regarding the utility of split fascial flap with good aesthetic results fulfilling the reconstructive requirements in a single stage.

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