ANTERIOR TIBIAL ARTERY PERFORATOR PLUS FLAPS FOR RECONSTRUCTION OF POST-BURN FLEXION CONTRACTURES OF THE KNEE JOINT

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SUMMARY. Background. Post-burn flexion contractures of the knee may arise even with adequate treatment of the burn injury. After release of the contracture, most of these defects require flap coverage. Here we describe the application of the perforator plus flap concept in the management of these contractures. Method. Between December 2010 and December 2011 five female and two male patients with knee contractures were operated on using a perforator plus flap from the anterior tibia artery perforator. In one patient both sides were operated on and the rest had unilateral surgeries. All patients had mature scars and the etiology was thermal burn injury. All these contractures were categorized as Category 4 and Level 3 by the ICIDH guidelines with an average contracture angle of 87.5 degrees. The flap was raised after release of the defect and a Doppler study located the perforator below the fibular head. The base of the flap was kept intact at all times. The flap was then transposed towards the defect and inset in a tensionless manner. Results. All flaps survived well with marginal necrosis in only one flap, providing stable coverage to the knee joint. The average residual contracture was around 10 degrees and the average range of flexion was 10-120 degrees. Conclusion. The perforator plus flap can be an excellent choice in defects over the posterior aspect of the knee where important neurovascular structures and tendons are exposed. Level of evidence: Level IV.

Keywords: perforator plus flaps, post-burn contracture, knee

Introduction

Conservative management of deep partial- or full-thickness burns, as also the development of complications like infection in the burn wound, can lead to the development of post-burn contractures. This is ascribed to healing by secondary intention whereby the myofibroblasts contract in an attempt to close the relative tissue deficiency that is present. This is most prominent over a joint like the knee and there is no strong evidence that static splinting prevents these contractures in the post-burn period even though splinting has been advocated to prevent contractures. Advances in burn management have led to a decreased incidence of post-burn contractures although patients still present with them, the knee joint being involved in approximately 22% of all large joint contractures. In the early stages of knee contractures, the skin and the joint capsule, with its associated ligaments, and the tendons and neurovascular structures are involved. Later on, there can be an associated subluxation or dislocation of the articulating bones, which greatly compounds the management.

Management of flexion contractures of the knee can be problematic. Physiotherapy may help in the early stages when the scar is soft and pliable, but with established contractures, the management is essentially surgical. This consists in releasing the contracture and covering the resultant defect with a skin graft or a local or free flap. Other supplementary procedures assuming importance in the management of these contractures include tendon lengthening for long-standing contractures and the application of external distractors as well as a variety of osteotomies. Flap coverage is the best option following release of post-burn contractures since to a large extent it prevents recurrence and has a much better aesthetic outcome. Flaps can be of various types, random pattern, musculocutaneous and fasciocutaneous flaps. Diverse locoregional fasciocutaneous flaps can be harvested based on the local perforator anatomy of a particular region. Perforator flaps are robust and can be applied in either pedicled or free fashion. They have an important role in the reconstructive process since the sacrifice of functioning muscle or other neurovascular structures is avoided.

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The failure rates of pedicled perforator flaps can be drastically curtailed with the use of the “perforator plus” concept in which the blood supply to a flap from a perforator is augmented by blood supply from the flap base. In our case series, the “perforator flap” concept was applied to reconstruct post-burn contractures of the knee joints after adequate release of the scar.

Patients and methods

Between December 2010 and December 2011, seven patients with post-burn contractures of the knee had their contractures released and reconstructed with a perforator plus flap coverage based on the anterior tibial artery perforator at the lateral aspect of the knee joint. The patients were five females and two males suffering from thermal sequelae. All of them had inadequate splinting in the post-burn period contributing to the formation of contractures. The age range was from 28 to 45 yr, with a mean age of 34 yr. Of these patients, two females presented bilateral lower-limb involvement. The patients presented to us 10-12 months after their initial burn injury and none of them had any surgical procedure for management of their contractures (Table I).

The contractures were initially assessed for functional deficit. The average contracture angle was 87.5 degrees (range, 60-100 degrees). As per the International Classification of Impairments, Disabilities and Handicaps (ICIDH), all patients were assigned to Category 4 for the first qualifier rating and Level 3 for the second qualifier rating (Table II). Indications for the perforator flap coverage were:

1. severe limitation of ambulatory function
2. exposure of hamstring tendons and neurovascular structures following release of the contracture
3. aesthetic considerations

Surgical technique

All the patients were operated on under spinal anesthesia. A rough assessment was initially made of the expected deficit of skin cover following contracture release based on the dimensions of the extended lower limb on the normal side or on the dimensions of a person with a similar stature and sex when both lower limbs were involved. The perforator was next located on the lateral aspect of the leg using a hand-held Doppler and the outline of the flap to be elevated was marked over the lateral leg and drawn slightly larger than the expected defect to allow for primary contraction of skin after incision. The transverse length of the expected defect was marked in a vertical direction along the length of the flap using the lo-

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age</th>
<th>Sex</th>
<th>Etiology</th>
<th>Time since burn (months)</th>
<th>Side</th>
<th>Scar type</th>
<th>Size of flap (cm)</th>
<th>Perforator distance from fibular head (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29</td>
<td>M</td>
<td>Thermal</td>
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<td>F</td>
<td>Thermal</td>
<td>9</td>
<td>Right</td>
<td>Mature</td>
<td>7 x 18</td>
<td>1.5</td>
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<td>3</td>
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<td>F</td>
<td>Thermal</td>
<td>10</td>
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<td>4</td>
<td>32</td>
<td>F</td>
<td>Thermal</td>
<td>12</td>
<td>Left</td>
<td>Mature</td>
<td>6 x 16</td>
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<td>7 x 18</td>
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<td></td>
<td></td>
<td></td>
<td>11</td>
<td>Right</td>
<td>Mature</td>
<td>7 x 17</td>
<td>2.1</td>
</tr>
</tbody>
</table>

For most people the ability to carry out an activity is not an ‘all or nothing’ phenomenon. Activities may be carried out with varying degrees of ease or difficulty, or as components of different types of behaviour. Activities may also be carried out using technical or other aids, or with the help of another person. This classification is therefore designed to be used in conjunction with two qualifiers that indicate the manner of accomplishment of the activity.

The first qualifier rates degree of difficulty of accomplishment of the activity and is rated as follows:
0 no difficulty
1 slight difficulty
2 moderate difficulty
3 severe difficulty
4 unable to carry out the activity
9 level of difficulty unknown

The second qualifier is optional and describes any personal or non-personal assistance used in accomplishment of the task. Assistance is rated as follows:
0 no assistance needed
1 non-personal assistance (including the use of assistive devices, technical aids, adaptations, prosthesis, wheelchair, cane and other material help)
2 personal assistance (where the task is carried out with the ‘help’ of another person, where ‘help’ includes supervision as well as cuing and/or physical help)
3 both non-personal and personal assistance
9 level of assistance unknown
cation of the perforator as a fulcrum for flap transposition. A tourniquet was next applied without exsanguination of the limb. All the patients had a thick scar over the posterior aspect of the knee joint. Upon contracture release, the sciatic nerve and the biceps femoris tendon became exposed in most cases. Adequate straightening of the knee joint was then accomplished by stretching supplemented with Z-plasty of the contracted hamstring tendons. The tourniquet was next released and confirmation of the vascularity of the limb was ensured followed by adequate haemostasis. The fasciocutaneous flap was then raised from distal to proximal until the selected perforator was reached using loupe magnification. Additional perforators encountered during elevation of the flap were ligated. The dissection plane was just below the deep fascia and adequate care was taken to ensure that there was no damage to the superficial peroneal nerve, which lay at close proximity. The base of the flap was retained in every case and the flap was then transposed and inset in a tensionless manner using 3-0 vicryl sutures. The donor site was covered with a split-thickness skin graft. The dimensions of the elevated flap varied from 14 to 18 cm in length and from 6 to 8 cm in width. Post-operatively, the flaps were not subjected to any form of special monitoring and no anti-coagulant pharmacological agents like aspirin or clopidogrel were used. Parenteral prophylactic antibiotics were used for a total of 3 days. After complete healing, the patients were subjected to a standard physiotherapy program.

**Case report**

A 35-yr-old female patient presented to us with bilateral flexion contracture of the knees following a 42% TBSA burn injury sustained 10 months earlier. As per the medical records, she had burn wound sepsis, which led to delayed healing and the development of contractures over the
posterior aspect of the knee joints. The knee contractures were surgically released at one-month intervals. At the second surgical operation the patient had a mature scar over the posterior aspect of her right knee with a range of movement of only 50 degrees (Fig. 1). She was operated on under spinal anaesthesia and the flap markings were made outlining a flap of 7 x 17 cm over her lateral leg. The perforator was located using a hand-held Doppler at a distance of 2.1 cm from the fibular head (Fig. 2). The contracture was released next and passive stretching brought the knee back into a completely extended position (Fig. 3). Tendon lengthening was not required in this particular instance. The flap was next raised until the perforator was reached (Fig. 4). Using this point as a fulcrum, the flap was transposed to the defect covering all the neurovascular structures and hamstring tendons which became exposed following release of the contracture (Fig. 5). The donor site was covered with a split-thickness skin graft (Fig. 6). The post-operative range of motion was 5-125 degrees at the end of one month’s follow-up and the knee presented pliable and stable coverage (Fig. 7).

Results

At the time of writing this manuscript, the follow-up was six months for five patients, three months for two, and one month for one side in one patient out of two with bilateral involvement. Of the two bilaterally affected patients, one was operated on both sides using the perforator plus flap technique while the other had this technique employed on one side and split-thickness skin grafting on the other, followed by post-operative splinting. The perforator was located on average 2.3 cm from the fibular head overlying the septum (range, 1.5-3.5 cm). Additional perforators were located distally to the first perforator but these were not maintained while elevating the flap. Raising did not entail sacrifice of any major nerve and sensation was preserved in the flap as also distally to it. Distal limb oedema was not encountered in our patients following flap harvest. One patient presented wounds over the region of the flap harvest which did not prevent flap elevation or compromise its survival. No infection developed in the post-operative period in any of the patients. The average operative time was 90 min (range, 70-110 min). The average hospital stay was 10 days. Post-operatively, the average residual flexion contracture was 10 degrees (range, 5-20 degrees). The average range of motion of the knee joint was 10-120 degrees (range, 0-130 degrees) (Table III).

Discussion

The aims of operating on a patient with post-burn contracture of the knee are multifold. A flexion contracture of
the knee is a considerable functional problem to the patient and is better prevented than treated. Splinting of the knee joint in extension in the immediate post-burn period can prevent the formation of these contractures, which can be quite resistant to treatment even though a recent study has questioned the value of splinting in prevention of flexion contractures. Associated procedures commonly used include the use of bandages, elastic garments, and intraleisional steroid injections. In the early stages, the scar over the posterior aspect of the knee joint is soft and early physiotherapy can improve the range of motion of a contracted joint which is obviously not possible in the later stages. Soft tissue contractures may result in joint subluxations in a few patients. The aims of treatment are to minimize scar tissue over the flexor surface of the joint, restore the normal position of the joint, reinstate total range of motion of the affected joint, and prevent recurrent contractures with their attendant morbidity. Following scar release or excision, defects can be covered using skin grafts, fasciocutaneous and muscle flaps, and free flaps. Skin grafts are not usually advocated for coverage because adequate contracture release may entail exposure of neurovascular bundles and hamstring tendons; moreover, a long period of splinting may be required in the post-operative period to prevent recurrence. In addition, when skin grafts are used in the popliteal fossa, the long-term results are equivalent to musculocutaneous flap coverage. Free flaps as well as pedicled flaps all produce excellent results but most tend to sacrifice a major vessel. Locoregional flaps may however have a limited arc of rotation and free flaps are labour intensive and time consuming, and microvascular failure leads to total flap loss.

The perforator plus flap concept improves flap vascularity and particularly venous return by maintaining the cutaneous pedicle. This can be especially of value because the located perforator may not be accompanied by a vein in all cases. Dissection up to the level of the perforator ensures a wide reach of the flap. It has been shown that in the leg, the muscles of its anterior compartment are supplied from one angiosome whereas the skin of the leg tends to get its supply from two or more angiosomes. The area in the upper lateral part of the leg is supplied by the anterior tibial artery and its recurrent branch whereas the peroneal artery takes over as it goes down the leg. This concept was used in flap elevation in which a perforator from the anterior tibial recurrent artery just below the fibular head was used as the primary supply to our flaps. The advantages of using this flap include the provision of tissue possessing a perfect colour and texture match, which allows for optimal contouring of the posterior aspect of the knee joint and causes minimal donor site morbidity. The defect created by raising the flap entailed coverage with a split-thickness skin graft only over a well-vascularized bed of muscles. The pliability and thinness of the flap ensured excellent mobility of the knee joint following post-operative rehabilitation. There was minimal chance of recurrence since the popliteal fossa was covered in all cases. We have even succeeded in utilizing this flap, with no complications, in patients with previous superficial second-degree burns of the donor site when an adequate Doppler signal was obtained. Operating times are not much increased and no specialized instruments are needed. Furthermore, this flap is easy to teach and has very low morbidity. Close attention should be paid to the

### Table III - Results of Surgery

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age</th>
<th>Sex</th>
<th>Side operated on</th>
<th>Duration of surgery (min)</th>
<th>Preoperative contracture angle (degrees)</th>
<th>Residual contracture angle (degrees)</th>
<th>Postoperative range of flexion (degrees)</th>
<th>Follow up (months)</th>
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<td>M</td>
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<td>70</td>
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superficial peroneal nerve which, because of its proximity to the flap, may be injured during the dissection, although no such injury occurred in our series.

**Conclusion**

The perforator plus flap based on the anterior tibial artery perforator is a robust flap which can be used to effectively cover defects of the posterior aspect of the knee joint. We have used this flap in the reconstruction of post-burn contractures of the knee joint but it may have a wider clinical application with a role to play in defects caused by tumour extirpation or trauma where the neurovascular structures are exposed along with the hamstring tendons.

**RéSUMÉ. Contexte général.** Les contractures en flexion du genou causées par les brûlures peuvent survenir même si le traitement a été correct. Après la libération de la contracture, la plupart de ces défauts t la couverture moyennant l’emploi d’un lambeau cutané. Nous décrivons l’application de la méthode «perforateur plus lambeau» de ce type de contracture. **Méthode.** Cinq femmes et deux hommes atteints de contractures du genou ont été opérés utilisant un lambeau perforateur plus lambeau provenant de l’artère tibiale. Dans un seul cas le patient a été opéré aux deux côtés, tous les autres ont été traités unilatéralement. Tous les patients présentaient des cicatrices matures et l’étiologie pendant la période décembre 2010 jusqu’à décembre 2011 était de brûlure thermique. Toutes ces contractures ont été classifiées dans la catégorie 4, niveau 3 par les directives ICIDH avec un angle de contracture moyen de 87,5 degrés. Le lambeau a été soulevé après la libération du défaut et une étude Doppler du perforateur situé en dessous de la tête du péroné. La base du lambeau a été constamment maintenue intact en tout temps. Le lambeau est ensuite transposée vers le défaut et encadré en manière sans tension.

**Résultats.** Tous les lambeaux ont survécu bien avec nécrose marginale dans un seul lambeau et ils ont fourni une couverture stable à l’articulation du genou. La contracture résiduelle moyenne était d’environ 10 degrés et l’amplitude moyenne de flexion était de 10 à 120 degrés. **Conclusion.** La technique du perforateur plus lambeau s’est démontrée un excellent choix dans le cas de défauts sur la face postérieure du genou quand des structures neurovasculaires importantes et les tendons sont exposés. Niveau de preuve: IV niveau.

**Mots-clés:** perforateur plus lambeau, contracture post-brûlure, genou

**BIBLIOGRAPHY**


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