

FUNCTION-SPARING TIBIALIS ANTERIOR PIVOTED MUSCLE FLAP FOR RECONSTRUCTION OF POST-BURN AND POST-TRAUMATIC MIDDLE-THIRD LEG DEFECTS WITH EXPOSED TIBIA

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SUMMARY. Reconstruction of the middle third of the leg is a challenging procedure. The tibialis anterior muscle flap can be useful in reconstruction of the middle third of the leg with exposed tibia. The aim of this work was to evaluate the efficacy of tibialis anterior pivoted muscle flap for reconstruction of the middle third of the leg with functional preservation. This study, performed in the Plastic, Reconstructive and Burn Unit, Menoufiya University Hospital, Egypt, included 16 patients (13 males and 3 females) during the period February 2007/May 2010: seven post-burn and nine post-traumatic patients with post-burn middle-third leg defects with exposed tibia. Their ages ranged from 14 to 67 years. A function-sparing lateral split tibialis anterior pivoted muscle flap was used in all the patients. Follow-up ranged from six months to two years. Partial flap loss occurred in one patient (6.25%), there was no post-operative haematoma or infection, and only one case of wound dehiscence (6.25%), managed by secondary suture. No donor site morbidity or any significant functional impairment was observed, and the subjective aesthetic results were satisfactory. Lateral split tibialis anterior pivoted muscle flap is a useful, simple technique, allowing rapid, durable and reliable coverage of middle-third leg defects without significant impairment of function and without sacrificing major nerves or vessels in the foot, and without any donor site morbidity.

Keywords: tibialis anterior, leg reconstruction

Introduction

One of the most challenging areas in plastic and reconstructive surgery is the closure of soft tissue defects of the middle third of the leg. Traumatic wounds, burns, and tibial fractures in the lower leg frequently expose the bone. The poor vascularization and subsequent poor healing encountered in this region often lead to prolonged exposure of bone or tendons, resulting in infection.¹

Full-thickness burns to the skin over the tibia present a difficult wound coverage problem. When periosteum is present, skin grafting is a potential coverage option but may lead to unstable long-term coverage. When there is no periosteum, debridement, stimulation of granulation tissue, and skin grafting remain an option, albeit an historic one. These wounds often require muscle flap coverage. Leg reconstruction is often divided into thirds. The superior one-third can reliably be covered with the gastrocnemius muscle flap, preferably the medial head. The middle third can be effectively covered with the soleus flap and the distal third, less reliably, with a reversed soleus flap

or free tissue transfer. The soleus flap may cause some functional impairment in lower extremity motion, while free flaps have potential donor site morbidity. The tibialis anterior muscle flap has been described for coverage of leg defects with exposed tibia.²

Moller-Larsen and Petersen³ made an important contribution to the concept of muscle flap coverage of the exposed tibia by employing a medial longitudinal split of the tibialis anterior muscle. It has been observed that the tibialis anterior muscle also lends itself to lateral longitudinal splitting into two halves. The outer half can be rotated 180 degrees to cover the exposed bone, and split-skin grafting of the muscle completes the procedure.

Aim of the work

The aim of the work was the evaluation of the efficacy of the tibialis anterior pivoted muscle flap for reconstruction of the middle third of the leg with functional preservation.

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Patients and method

This study, performed in the Plastic, Reconstructive and Burn Unit, Menoufiya University Hospital, Egypt, included 16 patients (13 males and 3 females) during the period February 2007/May 2010. Seven post-burn patients and nine post-traumatic patients presented with middle-third leg defects with exposed tibia. Their ages ranged from 14 to 67 yr. A function-sparing lateral split tibialis anterior pivoted muscle flap was used in all the patients. Follow-up ranged from 6 months to 2 yr.

Anatomical consideration of the tibialis anterior muscle

The tibialis anterior muscle originates from the lateral condyle of the tibia, the upper half of the lateral surface of the tibia, the interosseous membrane, and the crural fascia, while its insertion is at the base of the first metatarsal and cuneiform bones. The muscle is situated superficially in the anterior tibiofibular osteofascial compartment between the tibia medially and the extensor digitorum longus and the extensor hallucis longus muscles laterally and beneath the fascia of this compartment.⁴ The muscle fibres are arranged in circumpennate form, i.e. like the spokes of a wheel, and are inserted into an internal axial tendon which extends along most of the length of the muscle. The tendon is situated in a somewhat anteromedial location on cross-sections of the muscle, with a rather large bulk of muscle fibres on its lateral portion. On the outer surface of the muscle its fibres are arranged longitudinally and more or less parallel to each other.⁴

Blood supply to the muscle

The anterior tibial artery is situated between the interosseous membrane and the anterior tibial muscle. The artery is anatomically represented by a line drawn from a point midway between the outer tuberosity of the proximal head of fibula to another one on the centre of the ankle joint distally midway between the medial and lateral condyles.

The tibialis anterior muscle is characterized by a rather abundant network of blood vessels along its length. The segmental arteries originating from the anterior tibial artery ramify predominantly transversely around the semi-central tendon of this circumpennate muscle. Smaller vessels are oriented longitudinally. On the anterior aspect of the muscle, some vessels perforate the overlying fascia directly to the skin.

Technique

The following technique is used for lateral longitudinal splitting of the tibialis anterior muscle:

1. General anaesthesia, patient in supine position.
2. The tibialis anterior muscle is identified at the lateral border of the defect. It is then undermined and

retracted laterally together with the deep fascia overlying the tibialis anterior muscle.

3. The intermuscular septum is identified between the tibialis anterior muscle and the extensor digitorum longus and extensor hallucis longus muscles.
4. Longitudinal splitting is initiated as far laterally as possible along the muscle girth and proceeds in a posteromedial direction. As the split is deepened, an anatomic plane appears to develop from the origin to the insertion of the tibialis anterior muscle, and major blood vessels are not compromised.
5. The outer half of the muscle is dissected and elevated as a separate flap and pivoted like a book 180 degrees around its longitudinal axis to cover the tibial defect. The muscle is secured medially to the deep fascia, tibial periosteum, and/or to the freed flexor digitorum longus muscle.
6. Preservation of the inner half and medial part of the muscle can maintain the tibialis anterior muscle function.
7. A split skin graft is applied on to the muscle, and a light non-compressive dressing completes the procedure.

Results

This study (*Figs. 1-6*) concerned 16 patients (13 males and 3 females) presenting post-burn (7 patients) and post-trauma (9 patients) with a middle-third leg defect and exposed tibia. All defects were reconstructed using a bilateral split tibialis anterior pivoted muscle flap. The follow-up period ranged from 6 months to 2 years.

Partial flap loss occurred in one patient (6.25%), there was no post-operative haematoma or infection, and wound dehiscence was seen in only one case (6.25%), managed by secondary suture. There was no donor site morbidity and no significant functional affection. The subjective aesthetic results were satisfactory (**Table I**).

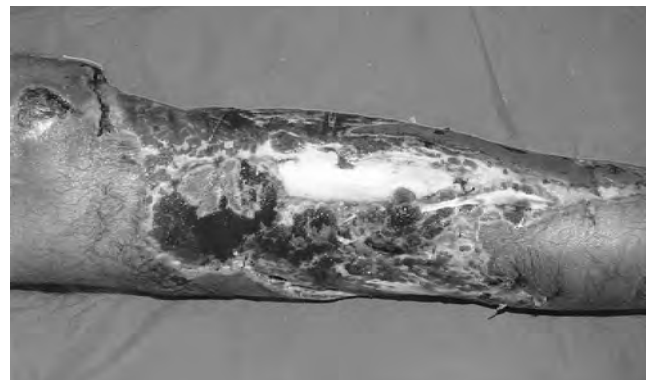


Fig. 1 - Post-traumatic leg defect with exposed tibia.

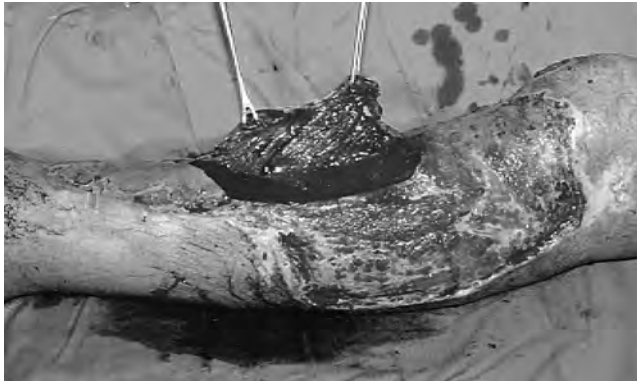


Fig. 2 - Tibialis anterior pivoted flap.

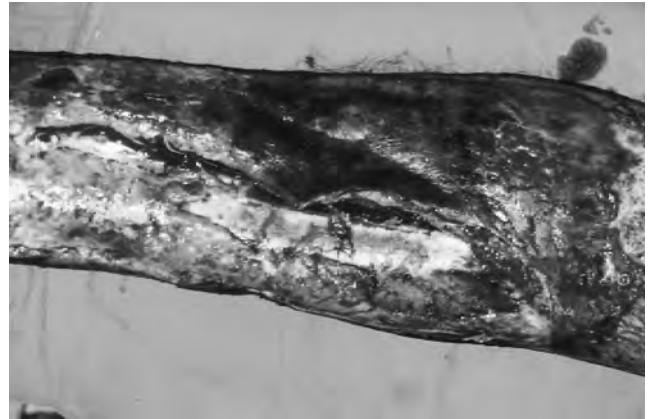


Fig. 5 - Post-burn burn defect with exposed tibia.



Fig. 3 - Exposed tibia covered with tibialis anterior pivoted muscle flap.



Fig. 6 - Post-operative result after tibialis anterior pivoted flap reconstruction.



Fig. 4 - Post-operative result.

Table I - Patients and clinical data

Patients	clinical data
Mean age	40 yr
Sex	Male, 81%; female, 19%
Trauma	Post-burn, 44% Post-trauma 56%
Leg and foot function	Good
Patient satisfaction	87.5% satisfied

Discussion

Finding an appropriate soft-tissue coverage without functional deformity and donor site morbidity to reconstruct lower extremity defects can be a difficult task because of the lack of musculocutaneous soft tissue elements available for reconstruction without major morbidities.⁵

Although microsurgical procedures provide excellent results in the head and neck region, the success rate is usually less in the lower limbs, especially in infected cases.⁶ The free flap covers the defect successfully in a one-stage operation but it requires a long operative time, an experienced, skilful technique, and good circulation at the recipient site. Free flap transfer to the lower limb in chronic post-traumatic conditions is known to have a higher complication rate with flap loss in up to 10% of cases, mainly due to the recipient vessel.⁷ The dissection of these vessels often leads to refractory spasm, due to the so-called post-trauma vessel disease.⁸

Despite recent advances in microsurgical techniques that have improved the quality of lower limb reconstruction, the coverage of lower leg defects by locoregional flaps remains indicated in selected cases. A local random-pattern skin flap has an indistinct perfusion pattern and is limited in size. The disadvantage of the muscle flap is that it may lead to functional deficit and donor site morbidity.⁹ Defects of the middle third of the tibia can be covered with a soleus flap.¹⁰ However, the functional deficit and the unacceptable donor-site scar limited the use of this technique.

Fascial and fasciocutaneous flaps can provide an excellent alternative for coverage of defects, even when bone has to be covered.¹ The medial adipofascial flap based on the vascular network supplied by the saphenous artery, and the posterior tibial artery perforators can be harvested on the anteromedial aspect of the leg and mobilized to cover defects located between the patella and the heel.¹¹ However, it causes relative hypoaesthesia at the donor site.

The cross-leg flap has the disadvantage of long-term immobilization and it requires several operative stages.¹²

Because of the importance of vascular "economy" in lower limb reconstruction, perforator pedicled flaps provide an excellent solution, as all these flaps spare the limb's major vessels.¹³ Reconstruction with neurocutaneous flaps is a versatile alternative to the use of local or distant muscle flaps.¹⁴

The neurocutaneous sural flap has been amply described for reliable coverage of lower leg defects without sacrificing a major vessel in the foot, but the flap's major donor deficits are the loss of sensibility along the lateral aspect of the foot and the unsatisfactory donor-site scars that are left because of the need of skin grafting.¹⁵ The risk factors, which can potentially impair successful defect coverage using the reversed sural flap and thus contribute to flap complications, include concomitant diseases, particularly diabetes mellitus; peripheral arterial disease or ve-

nous insufficiency, which increase the risk of flap necrosis five- to six-fold; and patient age over 40 years because of an increase in the co-morbidity rate, underlying osteomyelitis, and the use of a tight subcutaneous tunnel.²

The advantages of the distally based sural fasciocutaneous cross-leg flap over the standard cross-leg flap are clear, including the extremely comfortable leg positioning and the simplicity of the immobilization, made possible by the distal pedicle location.¹² The distally based lesser saphenous venofasciocutaneous flap, mobilized from the posterior aspect of the upper leg, used as an island pedicle skin flap, can also be used.¹⁶ The tibialis anterior flap procedure is a useful option for providing soft tissue to cover open tibial injuries in the middle and distal thirds of the tibia. It is limited by the transition of the muscle to the tendon in the distal third of the tibia. The tibialis anterior can be used like a pivoted flap 180 degrees around its longitudinal axis without any cutting of its tendon, so that there is no significant impairment of its function.¹⁷ The gastrocnemius musculoadipofascial flap based on the fascial plexus and cutaneous perforators of gastrocnemius muscle can be used for soft-tissue reconstruction of wider and longer areas used by the classic gastrocnemius muscle flap.¹⁸

This study covered 16 patients (13 males/3 females; age range, 14 to 67 yr), seven post-burn and nine post-trauma, suffering from middle-third leg defects with exposed tibia. All the defects were reconstructed using a lateral split tibialis anterior muscle flap pivoted 180 degrees around its longitudinal axis without major impairment of its function because the muscle is partially split, without dividing its origin or insertion with intact medial fibres. The follow-up period ranged from six months to two years. Partial flap loss occurred in one patient (6.25%) and there was no post-operative haematoma or infection; only one case of wound dehiscence (6.25%) occurred and this was managed by secondary suture. Donor site morbidity was acceptable, there was no significant functional affection, the subjective aesthetic results were satisfactory, and soft tissue coverage was achieved.

Conclusion

Lateral split tibialis anterior pivoted muscle flap is a useful, simple technique allowing rapid, durable, and reliable coverage to middle-third leg defects, without significant impairment of function and without sacrificing major nerves or vessels in the foot, and with no donor site morbidity.

RÉSUMÉ. La reconstruction du tiers moyen du membre inférieur est une procédure qui met à l'épreuve la compétence des opérateurs. Le lambeau musculaire du tibial antérieur peut se révéler utile dans la reconstruction du tiers moyen du membre inférieur avec exposition du tibia. L'auteur de cette étude s'est proposé d'évaluer l'efficacité du lambeau musculaire pivoté au tibial antérieur dans la reconstruction du tiers moyen du membre inférieur sans altération de la capacité fonctionnelle. L'étude, réalisée à l'Unité de Thérapie Plastique et Reconstructrice des Brûlures à l'Hôpital Universitaire de Menoufiya, Egypte, concernait 16 patients (13 mâles et 3 femelles) pendant la période de février 2007 à mai 2010. Il s'agissait de sept patients atteints de brûlures et neuf de traumatismes (tranche d'âge, 14-67 ans) qui se sont présentés avec des défauts post-brûlure au tiers moyen du membre inférieur avec exposition du tibia. Tous les patients ont été traités avec l'application d'un lambeau musculaire latéral d'épaisseur variable pédiculé au tibia antérieur, sans altération du fonctionnement normal. Le suivi variait de six mois à deux ans. La perte partielle du lambeau s'est vérifiée chez un seul patient (6,25%), aucun cas d'hématome post-opératoire ou d'infection n'est survenu, et il y a eu un seul cas de déhiscence de la plaie (6,25%), traité avec une suture secondaire. Aucune morbidité du site donneur ni aucune affection fonctionnelle significative n'a été observée, et les résultats esthétiques subjectifs étaient satisfaisants. La technique de l'emploi du lambeau musculaire latéral d'épaisseur variable pédiculé au tibia antérieur s'est démontrée utile et simple et en outre elle permet la couverture rapide, durable et fiable des défauts du tiers moyen du membre inférieur sans affecter significativement la fonction ou sacrifier principaux nerfs ou des vaisseaux dans le pied et sans aucune morbidité du site.

Mots-clés: tibialis anterior, reconstruction de la jambe

BIBLIOGRAPHY

- Hollier L, Sharma S, Babigumira E et al.: Versatility of the sural fasciocutaneous flap in the coverage of lower extremity wounds. *Plast Reconstr Surg*, 110: 1673, 2002.
- Steffen P, Baumeister Roberto S, Detlev E et al.: A realistic complication analysis of 70 sural artery flaps in a multimorbid patient group. *Plast Reconstr Surg*, 112: 129-40, 2003.
- Moller-Larsen F and Petersen NC: Longitudinal split anterior tibial muscle flap with preserved function. *Plast Reconstr Surg*, 74: 398-401, 1984.
- Nahai F, Mathes SJ: *Reconstructive surgery: Principles, anatomy and technique*, 8: 1054, 1997.
- Rooks F: Coverage problems of the foot and ankle. *Orthop Clin North Am*, 20: 723-36, 1989.
- Suominen S, Asko-Seljevaara S: Free flap failure. *Microsurgery*, 16: 395, 1995.
- Codina M: Early microsurgical reconstruction of complex trauma of the extremities. *Plast Reconstr Surg*, 78: 285-99, 1986.
- Acland RD: Refinements in lower extremity free flap surgery. *Clinics in Plastic Surgery*, 17: 733-44, 1990.
- Mancoll JS, Phillips LG.: Pressure sores. In: Achauer BM, Eriksson E, Guyuron B, Coleman JJ III, Russel RC., Vander Kolk CA (eds): "Plastic Surgery Indications, Operations and Outcomes", vol. 1, part 2, chapter 30, p. 447, Mosby St Louis, London, 2000.
- Arnold PG, Yugueros P, Hanssen AD: Muscle flaps in osteomyelitis of the lower extremity: A 20-year account. *Plast Reconstr Surg*, 104: 107, 1999.
- Heymans O, Verhelle N, Peters S: The medial adiposofascial flap of the leg: Anatomical basis and clinical applications. *Plast Reconstr Surg*, 115: 793, 2005.
- Atiyeh BS, Al-Amm CAS, El-Musa KA et al.: Distally based sural fasciocutaneous cross-leg flap: A new application of an old procedure. *Plast Reconstr Surgery*, 111: 1470-4, 2003.
- Niranjan NS, Price RD, Govilkar P: Fascial feeder and perforator based V-Y advancement flaps in the reconstruction of lower limb defects. *Br J Plast Surg*, 53: 679, 2000.
- Yildirim S, Giderogbrevelu K, Aköz T: The simple and effective choice for treatment of chronic calcaneal osteomyelitis: Neurocutaneous flaps. *Plast Reconstr Surgery*, 111: 753-60, 2003.
- Touam C, Rostoucher P, Bhatia A et al.: Comparative study of two series of distally based fasciocutaneous flaps for coverage of the lower one-fourth of the leg, the ankle, and the foot. *Plast Reconstr Surg*, 107: 383, 2001.
- Chen S-L, Chen T-M, Chou T-D et al.: The distally based lesser saphenous venofasciocutaneous flap for ankle and heel reconstruction. *Plast Reconstr Surgery*, 110: 1664-72, 2002.
- Ebraheim NA, Madsen TD, Humphreys B: The tibialis anterior used as a local muscle flap over the tibia after soft tissue loss. *J Trauma*, 55: 959-61, 2003.
- Jae CY, Gene K, Byung S et al.: Reconstruction of a lower extremity soft-tissue defect using the gastrocnemius musculoadipofascial flap. *Ann Plast Surg*, 49: 91, 2002.

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