Distally-based vastus lateralis muscle flap: A salvage alternative to address complex soft tissue defects around the knee

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Summary
Repeated soft tissue injuries around the knee represent challenging clinical situations where functional prognosis of the joint is often poor, especially in the presence of total knee arthroplasty (TKA). When gastrocnemius muscle flap techniques have already been used and failed, therapeutic solutions become rare. The authors suggest a regional solution to salvage these cases by the transfer of distally-based vastus lateralis muscle flaps. Four clinical operations of this muscle flap transfer are described, with three around TKA revision and one case of a post-traumatic knee amputation resulting from a compound open knee injury. Technical details of the intervention are presented. In all cases, skin closure was achieved, even if distal marginal necrosis was seen in two cases related to the type of muscle flap vascularisation. Final joint mobility was always poor (45° on average). Distally-based vastus lateralis muscle flaps represent a salvage procedure to correct iterative soft tissue defects around the knee that threaten short-term joint function. These muscle flaps do not require microsurgical anastomosis.

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Introduction
The treatment of soft tissue defects in the knee region is a frequent problem not only in orthopaedics but also in bone-joint traumatology. Among possible therapeutic options, coverage procedures with medial, lateral gastrocnemius or soleus muscle flaps are a common recourse, complemented secondarily by thin skin grafting. When these flaps fail, soft tissue defects threaten survival of the segments involved. Distally-based vastus lateralis muscle flaps represent a technical salvage solution from this perspective. A study by Wang et al. [1] demonstrated the constancy of three penetrating arteries from the superior lateral geniculate artery at the level of the distal quarter of the vastus lateralis, of which...
at least two may vascularise the vastus lateralis after ligation of its artery from the lateral circumflex artery of the thigh. The rotation arc around these penetrating arteries allows coverage of the anterior and antero-inferior aspects of the knee, or the popliteal cavity.

The authors report a series of clinical cases clarifying specific components and indications of this technique.

Surgical technique

The procedure is performed under general anaesthesia with the patient in the supine position. A cushion is placed under the ipsilateral buttock, producing discrete internal rotation of the limb to be operated, thus exposing its anterior aspects but especially the side of the thigh, up to the posterior median line. The procedure is undertaken without a tourniquet because of the need to dissect the origin of the circumflex artery of the thigh, in the proximal and medial part of the incision. Cutaneous projection of the distal arterial branches of the flap is drawn with reference to the patella (Fig. 1). The approach is from the side of the thigh. After opening the fascia, the anterior and posterior limits of the vastus lateralis muscle are identified, and the muscle mobilized on these two limits (Fig. 2). Separation of the vastus lateralis muscle from other components of the quadriceps, in the proximal portion of the muscle near its femoral insertion, exposes the vascular pedicle of the quadriceps from the circumflex pedicle of the hip (Fig. 3).

Preservation of the proximal and distal insertions of the muscle, at this stage, facilitates dissection because of tension placed on the vascular pedicle to be dissected. The pedicle of the quadriceps and nerve branches towards the vastus lateralis are ligated. The vastus lateralis muscle flap is raised in an anterograde manner from its femoral insertion up to the distal third of the thigh (Fig. 4), with respect to the three penetrating arteries from the superior lateral geniculate artery, which are the pivot of the muscle flap. Based on the anatomical work of Wang et al., harvesting safety requires the maintenance of a non-dissected width-of-a-hand area above the superior side of the patella, relative to the position of the last three penetrating arteries. The flap is mobilized after verifying its viability up to the area to be covered. It is reversed 180° so that its superficial side deepens in the implanted position. Cutaneous coverage may be immediate or delayed by a thin skin graft.

Clinical cases

Case No.1: Mr R.H., a 60-year-old man without a medical history, was operated in December 2005 for a left total knee arthroplasty (TKA) for tricompartmental knee arthritis. The surgical outcome was early, active infection on the material with rupture of the patellar ligament at its proximal part. A synovectomy was performed. Bacteriological sampling showed contamination by methicillin-sensitive Staphylococcus aureus. Because of a persistent purulent fistula, the patient was re-operated 15 days later by TKA removal with setting of a monoblock cement spacer with antibiotics. Intravenous antibiotics were maintained for 3 days and then changed to an oral bactericidal dose. Cutaneous necrosis of the antero-medial approach was then observed, which justified a medial gastrocnemius musculo-cutaneous flap at 2 months to cover the soft tissue defect. At 6 months after removal, a postero-stabilized TKA, with reconstruction of the patellar ligament by an ilio-tibial band, was carried out. The intervention was followed by necrosis of the antero-inferior part of the knee. The patient was then transferred to our department. On day 45 after TKA replacement, the patient was operated by TKA ablation and placement of a cement spacer. Shortening caused by implant ablation permitted closure of the cutaneous tissue defect. The absence of contaminants in the samples led to rapid revision on day 15 after removal, with the placement of an Axel® (B-Braun) hinge prosthesis and distally-based vastus lateralis flap, allowing volume re-expansion for implant insertion in association with complete coverage of the operated area. The proximal muscle tendon was fixed after bony transfixion.
distally. Partial distal necrosis occurred but did not prevent placement of the skin graft. Cutaneous healing was seen in 1 month. At 1-year follow-up, active knee flexion was limited to 45° with a 10° deficit of active extension. The knee was pain-free, and walking was possible without crutches.

Case No.2: Mr C.S., aged 59 years without a history of cigarette smoking, presented an open proximal left tibia Cauchois type III/Gustilo type IIIB fracture, with major soft tissue damage but normal arteriography. After debridement and trimming, the tibia was stabilized by a hybrid external fixator associated with buried pins. A local medial gastrocnemius musculo-cutaneous flap was done at 1 month. Three months later, a cortico-cancellous bone graft was placed because of a delay in left knee union. The consequences were infection with fistula. Several successive interventions were necessary for consolidation, such as lavage, ablation of the tibial plateau pins and of the external fixator. Full weight-bearing was possible by the 16th month after trauma. At 3-year follow-up, mobility of the knee was limited to 50° of flexion, without a deficit of active extension, and a left TKA revision type prosthesis, postero-stabilized with tibial augments, was proposed for this post-traumatic knee arthritis. Necrosis resulted in the anterior knee side. At 30 days, total coverage by a lateral gastrocnemius muscle flap was attempted. Proximal disunion on the approach required a complementary solution of coverage by distally-based vastus lateralis muscle flap. At follow-up, the knee was pain-free but mobility was limited to 30°. The patient, who was not satisfied, requested knee fusion, which was performed at 1½ years after the TKA, with re-use of the distal vastus lateralis flap approach, that is, detachment of the medial periphery of the transposed muscle.

Case No.3: Mrs D.F. (Fig. 5), aged 46 years, was operated for recurrence of a grade II fibrosarcoma of the superior tibial extremity, resected 9 years earlier. The previous intervention consisted of entire resection with the placement of an endo-prosthesis of the knee and a medial gastrocnemius muscle flap to cover the anterior aspect of the knee. Lateral recurrence 4 years later required major resection in conjunction with reconstruction by acrylic cement and a lateral gastrocnemius muscle flap, plus maintenance of the endo-prosthesis. Another recurrence, at 9 years after the initial intervention, needed complete revision with extensive resection and major cutaneous excision taking recurrence of the cutaneous injury into account. Resection compatible with carcinologic surgery led to the ablation of part of the previous flap, of the patellar ligament and a wide surface of the antero-lateral side of the knee. The previous TKA was removed and replaced in the same operation by a new rotating-hinge endo-prosthesis. The objective of soft tissue reconstruction was to cover the entire prosthesis and to repair the extensor apparatus. A distally-based vastus lateralis flap was raised, and the superficial muscle aponeurosis was used to reconstruct the patellar ligament. The functional result at 2 years of follow-up was satisfactory, with restitution of active extension and flexion being possible up to 45°. The patient died 3 years later from multiple metastases without her knee being revised surgically.

Case No.4: Mr B.M., a train accident victim aged 16 years, presented with a Gustilo type IIIC open leg fracture with loss of cutaneous tissue, bone and nerves in association with a homolateral open Schatzker type V fracture of the tibial plateau, without soft tissue loss. The severity of the pluritissular injuries led to leg amputation. The stump was covered by thin skin grafts, and no local flap was possible because of muscle damage. Osteosynthesis of the tibial plateau fracture by screws and plate was undertaken. Cutaneous disunion occurred at day 30, antero-laterally, above the skin graft (Fig. 6). The longitudinal aspect of the cutaneous tissue loss associated with joint communication led to a distally-based vastus lateralis flap, with secondary skin grafting.

Discussion

The distally-based vastus lateralis flap is a pedicle muscle islet flap of second intention; it is a rescue flap in cases

![Figure 5](https://example.com/figure5.png)

Figure 5  Distally-based vastus lateralis flap for extensive reconstruction post-tumor; a: planned (a1) and actual (a2) cutaneous resection after endo-TKA; b: harvest of the distal vastus lateralis flap (b1), inversion and coverage (b2); c: esthetic and functional result at 1 year.
Distally-based vastus lateralis muscle flap

Figure 6  Soft tissue loss after open proximal limb injury and necessary amputation; a: fistulizing lesions and level of amputation on open Gustilo type IIIC fracture; b: cutaneous design of distally-based vastus lateralis flap transfer; c: final aspect after turnaround and skin grafting.

of failure or the impossibility of another transfer. It is suitable for extensive longitudinal soft tissue loss around the knee and allows reconstruction of the extensor apparatus if necessary.

Reconstructive surgical procedures in knee operations are common, particularly for TKA revision [2,3]. The reliability and type of vascularisation of medial or lateral gastrocnemius flaps [4] make these solutions frequent and standard for orthopaedic surgeons not specialized in reconstructive surgery. Replacement solutions are controversial when these flaps fail [5]. The distally-based vastus lateralis muscle flap is a mean of coverage that should be known in iterative soft tissue defects around the knee after the failure of classical procedures. According to Wang et al. [1], their vascularisation is constant, which makes the flap reliable. Its achievement does not require microsurgery, so that the flap is feasible by an usual orthopaedic team.

However, some elements must be underlined. In two patients (cases 1 and 2), partial necrosis of the flap, discovered a few days postoperatively, needed surgical excision and could not be predicted by technical means (arteriography, dye injection, etc.). Flap vascularisation, type II in the classification of Mathes and Nahai [4], provided an explanation for this complication. Axial anterograde vascularisation predominantly associated with an artery of the quadriceps, a direct, main collateral branch of the femoral artery, leads to vascularisation of the part most proximal to the flap in a quasi-exclusive way by the principal artery, without a rapid capacity for distal re-vascularisation of the proximal part, despite an anastomotic network between the proximal and distal vascularisation [1]. Muscle necrosis occurs before vascularisation can be reversed. The consequence is the need to not rely on the most proximal part of the muscle transferred to ensure coverage of the soft tissue loss. In our practice, the flap is never pushed beyond the anterior tibial tuberosity.

The flap comes with a functional limitation of the harvested limb. This morbidity is noted clinically, at a distance from the intervention, and has been scored, by Swartz et al. [6], at 30% loss of strength in extension.

Within the limitations of distally-based vastus lateralis flap indications, the literature does not offer more than a few clinical examples of alternative solutions. "Vacuum-assisted closure” is a recent therapeutic proposal that aims to facilitate the coverage of soft tissue defects by progressive closure through negative pressure on the wound [7]. Its exact place remains to be determined. It is difficult to look at this technique as a coverage solution to these complex soft tissue defects, combining cutaneous, muscular and vascular injuries, open fracture, breached or gaping joints, but it may be used as a temporary solution (arteriography, general complication, second opinion) or in addition to a classical means of coverage. It is a recently-developed tool, used in infant and adult trauma for open fractures with moderate to significant soft tissue defects [7,8], but also in other specialties (vascular graft coverage [9], ulcers [10]). Herscovici et al. [7] reported a series of 21 patients in post-traumatic situations, among whom only seven had injuries close to the knee. In six patients with tibial injury, the average soft tissue loss was 73 cm² (5—261 cm²). Another patient with a stump after leg amputation lost 400 cm² of soft tissue. These authors mentioned nine cases of secondary free flaps, five other cases of skin grafts, and 12 cases of healing without further treatment. It is not possible to determine, by looking at this study, whether the specific results in seven patients represent a similar indication of distally-based vastus lateralis flaps. A single case was presented in iconography, with co-morbidities preventing additional surgical procedures.

The treatment of soft tissue defects by free flaps is proposed as a final solution [11,12]. In a series of 28 patients treated for skin complications after TKA, Nahabedian et al. [12] used only a single free flap. According to these authors, the choice of free muscle transfer should be limited to extreme cases where no local solution is possible. In their series, the sole death occurred after free flap transfer. Distally-based, retrograde-vascularised vastus lateralis flaps are an additional local option to avoid recourse to free flaps and address the remarks of these authors.
Other surgical solutions are radical and should be considered in complex cases of soft tissue defects after the failure of classical techniques. They are arthrodesis of the exposed joint and amputation. According to Knutson et al. [13] and Conway et al. [14], arthrodesis reduces intra-articular clutter from prostheses and avoids the need for a supple soft tissue reserve around the joint, permitting mobility even if incomplete. Thus, for Knutson et al. [13], coverage is facilitated. Amputation above the pathological joint eliminates the problem of coverage at the expense of significant loss of function, as reported by Sierra et al. [15]. Amputation as a solution should be considered in patients who previously have function limited by their underlying pathology. Distally-based vastus lateralis flaps are a conservative solution contrary to these techniques, even if joint function is not fully restored. These flaps are seen as a salvage technique and do not prevent the achievement of radical interventions in cases of inadequate outcome.

Conclusion

It is useful to know about distally-based vastus lateralis flaps and their use in soft tissue defects around the knee after eliminating simple or current technical solutions. Recourse to muscle flaps is pertinent to additionally ensure the filling of cavitary injuries, the wide coverage of bone and joint structures, and reconstruction of the extensor apparatus. Their achievement does not require microsurgical techniques or materials. Morbidity from vastus lateralis harvesting is low, and loss of function has no clinical impact because of the weak demand for mobility of the underlying joint in these complex patients.

Conflict of interest statement

None.

References