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Case Report

Use of the vastus medialis perforator flap to treat defects around the knee

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Abstract: *Background and aim:* Soft tissue reconstruction around the knee joint is usually complex for reconstructive surgeons. Defects in this area are largely caused by trauma, chronic infection, tumor, and surgical infection. This article presents the experience of using the vastus medialis perforator flap for reconstruction. *Materials and methods:* A total of 28 patients who had undergone reconstructive surgeries at the Second Affiliated Hospital and Yuying Children's Hospital, Wenzhou Medical University, from December 2010 to December 2015 were enrolled. Age, sex, defect size, comorbidity, etiology, flap size, complication, follow-up, and postoperative range of knee joint were recorded and analyzed through a retrospective chart review. *Results:* All 28 flaps survived. In all, 22 of the 28 patients achieved full functional range of motion by the third month. Two patients had a 10° limitation in knee extension and four cases had restricted knee flexion. Necrosis occurred in five cases; three were partial necrosis and two were superficial necrosis. Two patients were healed using conservative treatment, and the remaining three cases were reconstructed with a full-thickness skin graft in two and directly sutured after debridement in one. All patients were satisfied with their aesthetic and functional results. *Conclusion:* The vastus medialis perforator flap is a reliable option for reconstructing soft tissue defects around the knee.

Keywords: Vastus medialis perforator flap, soft tissue defects around the knee joint, reconstructive

Introduction

Reconstructing soft-tissue defects around the knee remains a formidable task for reconstructive surgeons. Common etiologies include defects resulting from trauma, tumor excision, poorly healing wounds, chronic infection, or orthopedic hardware needing sturdy coverage. The objectives of the surgery were to provide a settled soft-tissue cover, restore a favorable function to the joint [1, 2] and achieve an aesthetically pleasing result. Various options can be employed, such as local fasciocutaneous flaps, free flaps, and muscle flaps; the chosen flap should have well-vascularized perfusion to ensure wound healing and facilitate any concomitant orthopedic procedure [2]. Meticulous debridement, planning, and execution of a reasonable operative procedure are important in the management of a patient's wounds. Outlining a reconstructive plan requires considering the simplest technique likely to achieve wound closure with minimal donor-site morbidity [3-5]. If a soft-tissue defect around the knee requires flap coverage, the vastus medialis perforator flap is a reliable, pliable, effective, and durable option. The use of this flap was first pioneered by H. Zheng *et al.* in 2008 [6]. In this article, we reported our experience with perforator flaps to cover knee defects.

Patients and methods

A vastus medialis perforator flap was used in 28 patients with soft tissue defects around the knee joint. For each case, the following data were collected and recorded: age, sex, etiology, defect size, flap size, complications, follow-up, and postoperative range of knee joint. In all, 19 of the 28 patients were male and 9 were female. Ages ranged from 23 to 67 years old, with an average age of 45.8 years old. Defects occurred

Table 1. Date of the patients

Patient NO.	Age/ Sex	Etiology	Defect size (cm)	Comorbidities	Flap size (cm)	Complication	Follow-up (months)	Knee joint function
1	56/M	Traffic accident	8*6	HTN	9*7	No	10	Full range
2	67/M	Traffic accident	7*4	None	8*5	No	7	Full range
3	47/M	Skin ulcer	3*2	None	6*3	No	6	Full range
4	50/M	Traffic accident	8*4	HTN	20*4	No	11	Full range
5	44/M	Traffic accident	9*6	DM	10*6	Partial necrosis	14	Full range
6	62/F	Traffic accident	5*2	DM/ART	8*3	No	14	Full range
7	60/M	Skin ulcer	4*2	DM/ART	8*2	Partial necrosis	3	Limitation of knee flexion 30°
8	49/F	Traffic accident	5*7	None	10*12	No	6	Full range
9	45/M	Traffic accident	7*9	None	8*10	No	15	Full range
10	41/F	Traffic accident	5*6	None	7*9	No	7	Full range
11	23/M	Skin ulcer	6*8	None	8*10	Partial necrosis	24	Full range
12	26/M	Traffic accident	6*8	None	8*10	No	9	Terminal 10° extention deficit
13	45/M	Traffic accident	5*6	ART	7*9	No	21	Limitation of knee flexion 30°
14	49/F	Traffic accident	2*5	None	4*15	Superficial necrosis	8	Full range
15	33/M	Traffic accident	2*2	None	8*4	No	15	Full range
16	35/F	Traffic accident	6*3	None	7*5	No	6	Full range
17	37/M	Traffic accident	6*2	None	7*3	No	9	Full range
18	57/M	Tumble	5*4	None	6*6	No	13	Full range
19	51/M	Traffic accident	9*6	DM	10*7	No	7	Full range
20	50/M	Skin ulcer	6*3	None	7*5	No	17	Full range
21	56/M	Traffic accident	8*6	HTN/DM	9*7	No	10	Limitation of knee flexion 30°
22	28/F	Traffic accident	5*3	None	6*4	No	12	Full range
23	56/F	Traffic accident	6*3	HTN	7*5	No	7	Full range
24	24/M	Skin ulcer	5*6	None	7*9	Superficial necrosis	4	Full range
25	61/F	Traffic accident	5*3	None	6*3	No	11	Full range
26	66/M	Tumble	6*4	HTN/DM	8*5	No	15	Terminal 10° extention deficit
27	37/M	Traffic accident	9*6	None	10*7	No	7	Limitation of knee flexion 30°
28	28/F	Traffic accident	4*2	None	8*3	No	12	Full range

Note: M: male; F: female; HTN: hypertension; ART: arteriopathy; DM: diabetes mellitus.

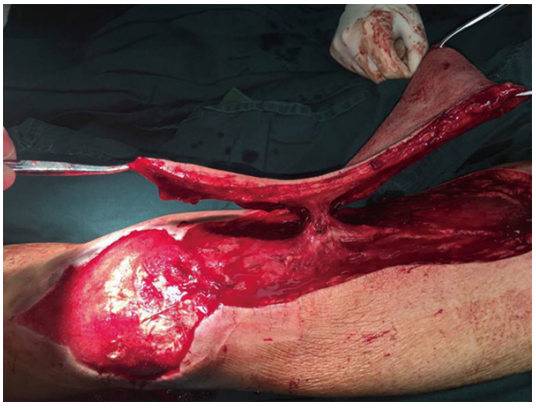

Figure 1. The pedicle of the vastus medialis perforator flap during the transformation.

after traffic accidents accompanied by open fractures in 21 cases, 5 were due to skin ulcers, and 2 were falls. The defects occurred on one side in all patients. The defects were located on the superolateral aspects of the knee (N = 16), on the infrapatellar region of the knee (N = 3), and in the suprapatellar region or involving the knee (N = 9). Defect sizes ranged from 4 to 63 cm^2 (average, 28.1 cm^2). Three patients had diabetes alone, and four had a combination of diabetes and hypertension or arteriopathy. There were no underlying diseases in 18 patients. Initial treatment began with aggressive debridement of bone and adjacent soft tissues and the removal of foreign materials and infected, non-viable, fibrotic, and granulation tissues. Before reconstructive procedures, patients received an average of two debridements. Subsequently, the vastus medialis perforator flap was applied. All patients were evaluated for the viability of the flap and for function-

Figure 2. A: The defect filled with the Antibiotic-PMMA bead on the anterior knee region; B: Planning of the flap; C: Elevated flap based on the pedicle supported by the perforator; D: The harvested flap insert into the defect; E: Early postoperative result; F: 7 days after the operation.

Figure 3. A: A circular defect on the left anterior knee region; B: Anterior view of late postoperative result.

al range of movement at the knee joint compared to the contralateral knee joint. The follow-up period ranged from 3 to 24 months (mean, 10.7 months). A summary of the patients is shown in **Table 1**.

Surgical technique

A Doppler probe was used preoperatively to locate the medial vastus medialis artery and the most appropriate perforator vessel. Two lines were drawn, one from the midpoint of the inguinal groove to the medial femoral condyle, the other from the middle and lower third of the first line to the midpoint of the upper margin of the patella. After vigorous debridement, flap designs and orientations were noted on the skin and around the sited perforators to ensure that the most appropriate flap was chosen. Under epidural or general anesthesia, patients were placed in a supine position with the hip flexed, the injured leg slightly abducted, and a tourniquet was applied on the thigh. The flaps were dissected with a longitudinal incision over the lateral margin of the flap down to the deep fascia and then the subfascia was dissected until the appropriate perforator site was identified. The location of the flap or the medial margin was modified depending on the perforator. Ultimately, the dimensions of the flap to be elevated were outlined (**Figure 1**). Then the raised flap was rotated around the vascular pedicle and adapted to the defect. During the procedure, retrograde dissection was performed around the pivotal perforator to allow further release of the vessels to minimize any unnecessary strain on the pedicle. Over-tight postoperative bandaging compromised vascular circulation and flap survival, so a simple window

Figure 4. A: Soft tissue defect with the exposure steel wire on the anterior knee region; B: Early postoperative result.

was made in the dressing to permit easy monitoring in the ward. All cases received appropriate postoperative antibiotic therapy. All patients were followed up periodically until the wound site was healed and the donor had healed completely.

Results

A total of 28 vastus medialis perforator flaps were used in patients with soft tissue defects around the knee joint from May 2010 to September 2015. All flaps survived. The flaps were 16-120 cm^2. In all, 22 patients achieved full functional range of motion by the third month. Two patients had a 10° limitation in knee extension and four had restricted knee flexion. Most of the donor sites were closed primarily. Small superficial necrosis occurred in two cases, and both healed with conservative treatment. Partial necrosis was observed in three cases, two of which were covered with a splint thickness skin graft; the remaining one was directly sutured after debridement. No vascular compromise or other complications were seen in the remaining patients. The length of hospital stay ranged from 7 to 80 days (average, 33.36 days). Ultimately, all patients were satisfied with the functional results and could walk comfortably (**Figures 2**-**4**).

Discussion

The knee region and proximal half of the lower leg have inherent characteristics that can make even a small defect a tremendous challenge because of exposed bones, tendons, metal fixation devices, or prostheses. Due to the lack of adequate soft tissue coverage or a stubborn infection, wound healing is markedly prolonged, leading to chronic wounds. Thin, pliable, durable, and gliding coverage of the knee joint is a pre-condition for facilitating wound healing and any concomitant procedure. To restore the contour of the knee and preserve the function of the knee joint is the main goal of soft-tissue reconstruction [7]. Various options, such as local flaps, free flaps, and muscle flaps, have been used for reconstruction. The use of several muscle flaps has already been reported to repair soft tissue defects around the knee, including the vastus mediali [8], distally based vastus lateralis [9], sartorius [10] and gastrocnemius [11]. A workhorse flap, the gastrocnemius flap is famous for its easy operative technique, better anti-infection capabilities, adequate three-dimensional defect coverage, and rich blood supply. The significant shortcomings of the gastrocnemius flap are unsatisfactory aesthetic outcomes and knee stiffness [12]. In addition, it is usually limited by defect size and location. Since Pontén [13] described the use of the fasciocutaneous flap in the lower leg in 1981, it has been an attractive choice for reconstructing defects around the knee joint [7], as it provides the closest match to the primitive tissue in complexion, volume, pliability, and tenacity [14]. However, local fasciocutaneous flaps, such as the lateral or medial genicular artery-island flap and the saphenous flap are usually associated with a sacrificed perforator or sensory disturbances around the knee joint. Use of these flaps is also limited by extensive soft-tissue defects [15]. In addition, skin grafting is usually required at the donor site, and the application is usually restricted by deeply settled underlying pedicles. Free tissue transfer can be an excellent option if local flaps are unsuitable or cannot provide adequate coverage of the defect and if local tissue transfer is

Table 2. List of the series regarding the application of the vastus medialis flaps reported in the literature

Number of cases	Defect location	Complication	Additional Procedure	Reference
2	Knee joint	None	Skin grafting (2)	[8]
3	Knee joint	None	None	[17]
1	Anterior knee	None	None	[18]
6	Around the knee (5) Inferomedial aspect of the thigh (1)	Marginal necrosis (1)	Sensitive antibiotic administration and frequent dressing change (1)	[19]

unsuitable. Free flaps have been used in knee reconstruction extensively and efficiently with the advantage of sufficient bulkiness to fill the dead space and sufficient vascularity for the bone fragments. However, the choice of an appropriate recipient vessel is vital to the success and survival of the free flap. It is often difficult to obtain an applicable recipient blood vessel in a patient due to damage from accidents or previous surgeries, and a free flap demands considerable microsurgical expertise and concentrated postoperative care facilities. In addition, it is a much more time-consuming procedure even in experienced hands and may not be available at most reconstructive centers. It has also been reported that the vascular thrombosis rate in patients who undergo free flap reconstruction of the knee is higher than in reconstruction of other parts of the limb [16].

The vastus medialis flap may be a promising option for reconstructing knee defects. Although vastus medialis flaps such as the muscle flap and perforator flap have been described several times in various forms in previous studies, there have been few studies on the application of vastus medialis flaps around the knee, limited to a small number of patients (**Table 2**). We here present the largest series of cases with the use of vastus medialis perforator flaps reported in the literature. A section of the quadriceps, the vastus medialis is located in the anteromedial aspect of the thigh beneath the sartorius and medial to the rectus femoris, where it plays an important role extending the knee joint. In 1981, Arnold *et al*. [8] first described the vastus medialis as a muscle flap for reconstructing the exposed knee joint in two patients. Arnold *et al*. reported that the vastus medialis was useful only for the upper part of the knee, because it had a relatively small arc of rotation and its blood supply was provided through several muscular branches of the superficial femoral artery. In addition, skin grafts were essential as the muscle does not have its own cutaneous territory. Although their first publication described the vastus medialis muscle without cutaneous territory, later anatomic studies and cadaveric dissections showed that the vastus medialis could be elevated as a myocutaneous flap. Tobin's cadaveric study located a myocutaneous vascular supply to a large area of skin directly overlying the vastus medialis, suggesting that the vastus medialis has its own cutaneous territory [17]. Kubota *et al*. [18] still upheld the absence of skin territory in the vastus medialis muscle and reported the use in one case of a combination of the hemi V-Y flap and vastus medialis flap for the reconstruction of a knee with soft tissue loss and extensor rupture. In that study, the hemi V-Y flap moved as a rotating advancement flap and almost all of the blood supply was maintained by continuity of the skin and subcutaneous tissues. The controversy whether the vastus medialis muscle had its own skin territory continued until 2008, when Zheng *et al*. verified that the vastus medialis had its own cutaneous territory supplied by the musculocutaneous perforators given off from the muscular arteries [6]. They demonstrated that the first musculocutaneous perforator was located around the mid-point of a surface projection line (located 9.4 ± 2.4 cm above the adductor tubercle and 4.1 ± 1.0 cm medial to the vertical line on the midpoint of the patella), which was traversed by the medial vastus medialis artery between a mid-point in the inguinal groove and the medial femoral condyle. In a few cases in a subsequent study [19], they introduced coverage of soft-tissue defects around the knee using the pedicled vastus medialis perforator flap. We here present the largest series of cases with the use of vastus medialis perforator flaps reported in the literature. A section of

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The perforator flap was originally described by Koshima in 1989 [20]. Attention has been directed to improved methods of reconstruction with progress on perforator techniques. The vastus medialis perforator flap is an alternative solution for reconstructing soft tissue defects around the knee. The advantages of the vastus medialis perforator flap are: there is no need to sacrifice any main arteries or muscles; it is a time-efficient procedure with minimal donor site morbidity; the perforator site is relatively constant; the donor site and recipient area are in the same extremity, leading to less surgical injury; it is designed in a versatile form to give a better match to the defect, and the harvested area is bigger; advanced microsurgical skills and vascular anastomosis are unnecessary; the donor site is concealed and direct closure of the donor site is possible in most cases; the scar is above the knee, and the function of the knee joint will not be affected; the recipient site has the most like-to-like tissues and can provide the most appropriate tissue with lower donor site morbidity and satisfactory aesthetic results; it can be harvested as a composite flap to reconstruct the extension mechanism of the knee; it can be harvested as a sensate flap; it can be rotated an appropriate degree based on the perforator pivot to cover a medium soft tissue defect; and the flap is thin and flexible. The main disadvantage of the vastus medialis perforator flap is that the femoral neurovascular bundle may become injured unless very close attention is paid during the dissection. In our series, the harvested flap was usually larger than the defect to obtain adequate distal perfusion of blood through the lower-resistance longitudinal nutrient vascular plexus of the cutaneous nerve made by a small modification to change the flap axis [21-23].

Thin and pliable coverage is required to ensure excellent mobility of the knee joint due to its particularities, flexion, and extension, and the vastus medialis perforator flap meets these standards. The use of this flap is a reliable and reproducible procedure providing low postoperative morbidity, good daily function, and relatively satisfactory aesthetic results, without sacrificing any major vessels, nerves, or muscles. Hence, it is a suitable alternative for reconstructing medial soft tissue defects around the knee joint.

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Disclosure of conflict of interest

None.

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