

Pedicated Peroneal Artery Perforator Flap for Knee Defect Reconstruction: Case Presentation and Literature Discussion

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Summary: There have been very limited data on the use of pedicled peroneal artery perforator flaps in knee soft-tissue reconstruction, especially for anterior and medial defects. Here, we present a case of proximally based peroneal artery perforator flap for knee soft-tissue reconstruction in a defect that included lateral, anterior, and medial surfaces of the knee presenting the technical challenges associated with this flap. A 15-year-old girl presented with extruded knee implant after osteosarcoma resection of femur. The defect involved the whole knee with the anterior and mostly the lateral knee surfaces. Her medical condition precluded the use of free tissue transfer. During her previous surgery, gastrocnemius muscles were detached with injured vascular pedicled and posterior tibial artery. Successful single-stage coverage was achieved using a large proximally based pedicled peroneal artery perforator flap. There are only few reports that described the use of peroneal artery flaps for knee soft-tissue coverage. The reach of a proximally based flap can be increased when it is raised on a distal perforator or when peroneal artery has a proximal takeoff. Furthermore, removing the fibula can facilitate the dissection and the reach of the flap till the most medial aspect of the knee. Pedicled peroneal artery perforator flap provides superior soft-tissue coverage with limited morbidity for knee soft-tissue reconstruction; however, flap reach is usually affected by anatomic variation. Preoperative planning can help to determine the reach of the flap and ease the dissection. (*Plast Reconstr Surg Glob Open* 2018;6:e2034; doi: 10.1097/GOX.0000000000002034; Published online 21 November 2018.)

Gastrocnemius muscle flap is perhaps the pedicled workhorse flap for some of the knee soft-tissue defect reconstruction. When it is not available, there are little more pedicled options that include reversed anterior-lateral thigh flap or peroneal artery flap.

We took interest in pedicled peroneal artery flap, and we found very few data published on this flap for knee reconstruction.^{1,2} Furthermore, there are few reported cases in which this flap was used to cover anterior knee.¹ Additionally, the flap technical modifications and alternation to expand its reach were not discussed in detail in the literature. Peroneal artery based flap was first introduced

by Taylor et al.³ as an osteocutaneous perforator flap and later modified as a septocutaneous perforator flap by Yoshimura et al.^{4,5} in 1980s having a constant blood supply to a wider area on the lateral leg.^{6,7} The versatility of this flap was shown with different designs including propeller flap, peninsular or advancement flap, proximally or distally based island flap with excellent outcome that is cost-effective, especially in areas with limited microsurgical expertise or whenever the free tissue transfer is not an option.² This article presents a case of proximally based peroneal artery perforator island flap used for soft-tissue coverage of lateral, anterior, and medial knee to cover an exposed prosthesis, describing the technical modifications that aid in flap reach.

CASE PRESENTATION

A 15-year-old girl presented with extruded distal femur implant after osteosarcoma resection involved 15 cm of the femur. The defect involved the whole knee with the anterior and mostly the lateral knee surfaces (Fig. 1).

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Fig. 1. Preoperative image of knee soft-tissue defect. Implant extrusion is seen on both lateral and medial knee sides with scarred surrounding skin and thin granulation.

During her previous surgery, gastrocnemius muscles were detached with reported vascular injury to their pedicled and posterior tibial artery. Frequent attempts for coverage with local tissue and skin grafts have all failed and resulted in extensive scarring in the tissue around the knee. The patient's condition was discussed with her primary orthopedic surgeon, in which the option of amputation was contemplated if there was a lack of soft-tissue coverage with no place for staged reconstruction as suggested. The patient presented in weak general condition following prolonged treatment, which made us lean toward pedicled option rather than exposing her to major micro-vascular surgery. Physical examination revealed a strong dorsalis pedis artery.

Computerized tomographic (CT) angiography revealed that anterior tibial artery was the dominant blood supply to the foot, with an intact peroneal artery that had good distal perforators. In the light of her clinical findings and general medical condition, we decided to design

a large proximally based pedicled peroneal artery perforator flap to cover the defect.

Technique

The skin paddle design was based on distal perforators catching a surface area of 8×19 cm of the distal part of lateral leg surface to match the defect size (Fig. 2). The flap was harvested using the traditional anterior approach for fibula osteocutaneous flap. To extend the flap reach to knee, fibula bone needed to be removed, preserving 6 cm proximal and 6 cm distal of intact fibula bone. Further extension of the reach was achieved by dividing one of the proximal perforators to allow pivoting the skin paddle around a more distal perforator. Donor site was skin grafted. The flaps skin paddle survived completely, and the lateral, anterior, and medial knee defects were closed with no tension. The patient subsequently did well with good, supple soft-tissue coverage with implant preservation.

DISCUSSION

In knee soft-tissue reconstruction, local fasciocutaneous flaps are usually limited by their size and mobility together with the status of the surrounding tissue. Local muscle flaps like gastrocnemius muscle flap on the other side are versatile and a valuable option for knee defects but at the expense of extensive dissection and donor-site deficits.⁸⁻¹⁰ Free flap can provide all the sufficient tissue for reconstruction but at the expense of operative time, micro-vascular expertise, and recipient vessel choice.¹¹ Additional effort investigated the potential use of peroneal artery perforator or soleus perforator as recipient vessels. Perforator dissection and anastomosis was shown in cadaveric and clinical assessments to be technically feasible, sparing critical limb vessels.¹²

All the options mentioned are of great utility but at some points challenged by different patient scenarios as in this case. The scarred surrounding tissue, injury to the gastrocnemius muscles and their pedicles, and injured posterior tibial artery precluded the use of those fundamental flap options. For perforator anastomosis, it comes at the expense of smaller vessel diameter together with size variability as a recipient vessel and at times the need for supermicrosurgery sittings.¹³

Peroneal artery perforator flap can provide a good option for lateral and anterior knee soft-tissue reconstruction. The use of this flap for this particular defect has been scantily described for knee soft-tissue defects^{1,2} without assessing the different variables associated with its use.

The vascular anatomy of the peroneal artery perforators has been characterized with an average number of 4 perforators per leg.¹⁴ Those perforators are mainly concentrated in the middle third of the leg and those in the distal two-thirds of the leg are predominantly of septocutaneous subtype.¹⁴⁻¹⁶ The length of different peroneal artery perforators ranged between 3.5 and 7.5 cm with an average of 4.8 cm.^{17,18} The diameter of associated perforator-vein was shown to be around 0.8 mm.¹⁹ It was shown that perforators in the lower thirds were shorter than those in the middle and upper thirds of the leg.¹⁸ In addition, pe-



Fig. 2. Intraoperative image of knee soft-tissue defect reconstruction. The pedicled peroneal artery perforator flap was designed following perforator location with handheld Doppler. Flap was raised followed by peroneal artery pedicle elevation.

Table 1. Summary of the Literature Related to Different Peroneal Artery Perforator Flaps Used in Proximal Leg Soft-tissue Defect Reconstruction

Author	Flap Type	Flap Size (cm ²)	Lower Limb Location	Donor Site	Complications
Shin, In Soo, et al.	Propeller flap	10×9	Lateral knee	STSG	None
Yoshimura M, et al.	Proximally based island flaps	15×16.5 cm	Peri-patellar	Primary closure and STSG	—
Lu TC, Wei FC.	Proximally based island flap	6×5	Peri-tibial	STSG	Venous congestions
Ha, Yooseok, et al.	Proximally based island flap	4.5×5	Knee	STSG	None
Ruan, H-J, et al.	Proximally based island flap	11×7	Anteromedial knee	STSG	None
This case	Proximally based island flap	8×19	Lateral, anterior, medial knee	STSG	None

STSG, split thickness skin graft.

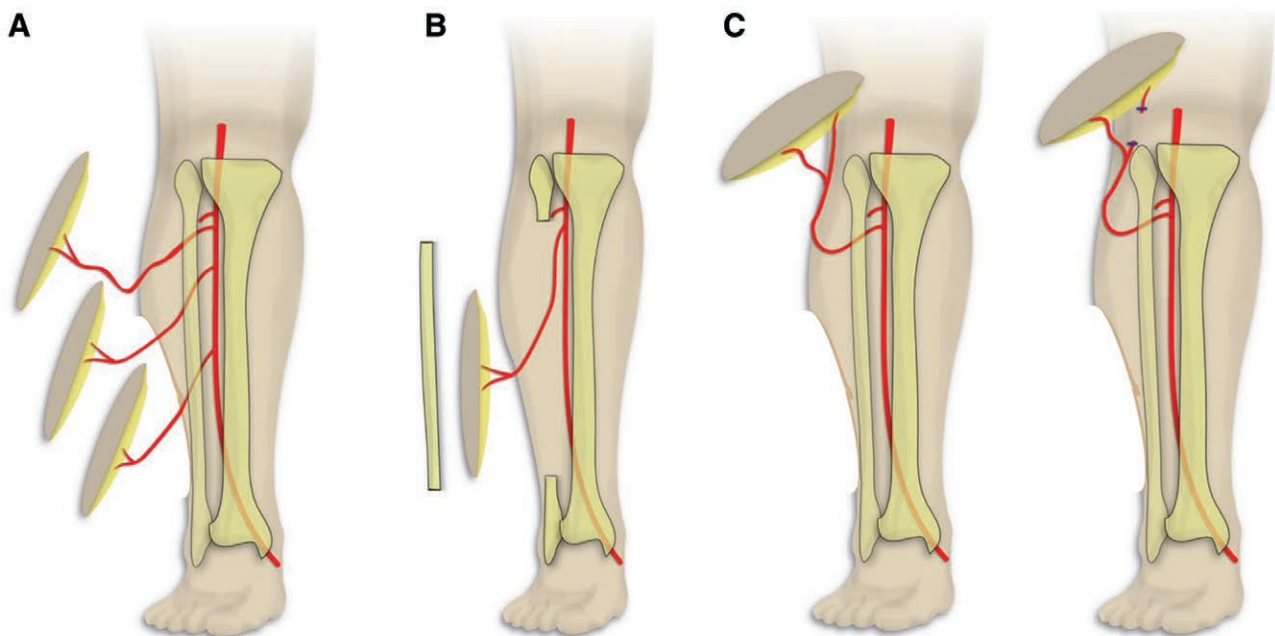


Fig. 3. Factors affecting flap proximal reach. The different factors that are proposed to affect flap reach to the knee are shown. A, It shows that early peroneal artery takeoff and the more distal the perforator location was the more favorable proximal reach this flap can have. B, The potential removal of fibula can be adopted to expand the flap reach. C, In case of multiple perforator, dividing proximal perforator and preserving distal ones might increase flap proximal reach.

peroneal artery is the most consistent vessel in the lower limb with least affection by atherosclerosis, making the different peroneal artery based flap options of crucial importance in elderly and diabetics.^{20,21}

Different flap designs were described in the literature including propeller flap, peninsular flap, advancement flap, proximally or distally based island flap with excellent outcome.²

When it comes to proximal leg soft-tissue reconstruction, the utility of this flap was shown mostly for popliteal fossa^{1,11,18} or peri-tibial^{2,5,22} soft-tissue coverage. For knee soft-tissue reconstruction, a proximally based island flap was described in few reports.¹ Other flap designs were also implemented like propeller flap²² or perforator free flap.²³ Table 1 summarizes the literature associated with pedicled peroneal artery perforator flap. Ruan et al.¹ have shown the utility of a proximally based island flap for the coverage of knee antero-medial defect with the preservation of fibula. The flap dimension was 11×7 cm with a pedicle length of 13 cm to reconstruct a traumatic knee defect. For flap dissection, the fibula was retracted from the pedicle and all nutrient vessels to the fibula were ligated, complicating the surgical dissection with potential effect on skin flap vascular supply.¹ In our case, the patient underwent resection of distal femur osteosarcoma and implant placement. Patellar tendon was preserved and repaired during her initial surgery and did not need any further reconstruction. The extensive scar tissue and associated injury to viable flap coverage options made the reconstructive plan a challenging situation. Coverage of implant was attempted with pedicled peroneal artery perforator flap as a salvage option. The flap was raised in the usual fashion of fibula osteocutaneous flap through anterior approach. After flap elevation, the fibula was removed subperiosteally to increase flap reach. We managed to cover lateral (lateral femoral condyle) and anterior (patellar tendon) surfaces with the flap easily. However, we had some difficulty in getting the medial knee surface covered. For that, we had to divide the most proximal perforator, shifting our pivot point to the next perforator and gaining few centimeters that allowed us to cover the medial surface as well; this is illustrated in (Fig. 3). The flap survived completely to its distal tip and healed as illustrated in her 6 weeks' postoperative pictures (Fig. 4).

Without careful planning, it will not be easy for the flap to reach anterior knee defects. No report in the literature discusses the technical challenges associated with this flap harvest.

Factors that will help the flap reach include proximal take off of the peroneal artery, the existence of a reliable distal perforator (the more distal the perforator is, the more length can be gained), sacrificing a proximal perforator could also increase the reach, and finally removal of the fibula as illustrated in Figure 3.

Preoperative planning is of crucial importance when conducting this flap. Handheld Doppler flow-meter allows rapid identification of perforators through different areas of interest. This, however, comes at the cost of being operator dependent with variable accuracy.²² Perforator origin variation, or when dorsalis pedis artery was impalpable,



Fig. 4. A postoperative photograph shows the reconstruction at 6 weeks follow-up, with proper flap contour and texture.

might both affect the course of the procedure and associated risks on limb perfusion.¹⁸ Other imaging modalities were usually indicated, such as CT angiography and/or magnetic resonance angiography, before flap conduction to help localize perforator of interest and to rule out any variation in limb vasculature.^{21,24}

In our patient, both preoperative CT angiography and handheld Doppler helped to properly identify perforators of interest and flap design with no effect on limb vascularity by harvesting peroneal artery in flap elevation.

The use of peroneal artery perforator flap provided a thin pliable soft-tissue coverage that had color and texture similar to those of surrounding skin. The pedicle was passed subcutaneously to reach knee defect with no complications. Some authors suggested a different route

to pass the flap pedicle like interosseous membrane to increase flap reach to medial sided defects.¹

On the short side, the use of this flap comes at the expense of harvesting one of the limb major vessels,¹⁸ the unsightly scar from donor site skin grafting,²² tedious dissection, and harvesting the fibula in flap elevation.¹¹

CONCLUSIONS

In this article, we added an additional case report describing the uses of pedicled peroneal artery flap in knee reconstruction. The technical challenges associated with this flap type were further elaborated. The case described showed appropriate reach covering majority of the knee surfaces with relative ease and safety (Fig. 4). Reliable pedicle, together with design versatility and proper defect contour, was the main advantage of this flap.

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