

Knee Reconstruction following Sarcoma Resection Utilizing Pedicled Anterolateral Thigh Propeller Flap: A Case Series

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Summary: Coverage of knee wounds with exposure or violation of the joint capsule has long been a challenge to plastic surgeons. Wide resection and radiation treatment for soft-tissue sarcomas further this difficulty due to resultant diminished vascularity and soft tissue fibrosis. Traditional muscle flaps such as the gastrocnemius may be within the radiated field, limiting their arc of rotation to the knee. We present a series of exposed knee joint reconstructions using pedicled propeller flaps after sarcoma resection. Three patients diagnosed with soft tissue sarcomas underwent neoadjuvant radiation followed by wide local resection by orthopedic oncology. All patients had underlying knee joint exposure and underwent successful soft tissue reconstruction utilizing pedicled anterolateral thigh (ALT) propeller flaps. The ALT flap is widely used in plastic surgery for reconstruction of soft tissue defects due to its reliable vascularity, long pedicle, versatility, low donor-site morbidity, and large size. As a propeller flap, we demonstrate this is a viable alternative for reconstruction when the vascular plexus around the knee is unreliable after neoadjuvant radiation. Extending the ALT propeller flap with a large proximal skin paddle provides a nonmicrosurgical alternative to traditional muscle flaps at this location. The ALT propeller flap is an excellent option for reconstruction of large defects of the knee, especially in the setting of a radiated wound bed with unpredictable vascularity. In our case series, all three patients underwent successful reconstruction of exposed knee joints after resection of soft tissue sarcoma utilizing ALT propeller flaps. (*Plast Reconstr Surg Glob Open* 2022;10:e4107; doi: 10.1097/GOX.0000000000004107; Published online 9 February 2022.)

INTRODUCTION

Knee reconstruction following oncologic resection requires great thought and contemplation. Limb preservation is the primary concern, but maintenance of knee motion, cosmesis, and restoration of a watertight barrier covering the knee capsule must be considered.

Traditionally, workhorse flaps for knee reconstruction are the medial and lateral gastrocnemius muscle flaps.¹ These are reliable, robust flaps, but in the setting of oncologic resection or prior radiotherapy, the sural artery

pedicles may be unreliable and radiation fibrosis may restrict their rotation to the proximal knee. Microsurgical free tissue transfer is often the next rung in the reconstructive ladder; however, in recent times, propeller flaps have been described as innovative, nonmicrosurgical alternatives.^{2,3} These flaps have the advantage of a reliable vascular pedicle and large diameter of pliable tissue, often with improved cosmesis. Additionally, without microsurgical anastomosis, operative times and hospital acuity are diminished. We present a series of three cases in which extended anterolateral thigh (ALT) propeller flaps were used to reconstruct radiated knee wounds arising after sarcoma resection.

PATIENT A

A 56-year-old male presented with a 9 cm exophytic mass fixated to the knee capsule (Fig. 1). Core biopsy yielded an undifferentiated pleomorphic sarcoma. Staging CT scans were negative for metastasis, and he was deemed a candidate for limb salvage based on preoperative imaging and assessment (AJCC stage T2N0M0).

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Fig. 1. Pleomorphic sarcoma of the left lateral knee.

He underwent neoadjuvant radiotherapy (50 Gy) and presented for resection 6 weeks later.

Staged resection and reconstruction were completed to ensure adequate negative margins. The resection defect included the lateral knee joint capsule and measured 12×15 cm. The patella, joint surface, and knee extensors and flexors were preserved except for the lateral gastrocnemius origination. Final pathology revealed grade III undifferentiated pleomorphic sarcoma.

Reconstruction with an extended ALT propeller flap was planned. A line was drawn extending from the anterior superior iliac spine to the superolateral patella. Along this line, two perforators were identified via handheld Doppler 12 cm proximal to the superior patellar border. A propeller flap measuring 22×8 cm was designed overlying these perforators and was raised in the subfascial plane over the iliotibial band (Fig. 2).

The largest perforator was dissected down to the descending branch of the lateral femoral circumflex



Fig. 2. Anterolateral thigh (ALT) propeller flap rotated into the resection bed and donor site skin grafted.

Takeaways

Question: When the medial and lateral gastrocnemius muscle flaps are not viable; what is a reliable, local pedicled option for coverage of the exposed knee joint?

Findings: Three patients underwent excision of soft tissue sarcoma of the lower extremity, resulting in disruption of the knee capsule and successful reconstruction using pedicled anterolateral thigh propeller flaps.

Meaning: The pedicled anterolateral thigh propeller flap is a viable alternative to complex microsurgical intervention in coverage of knee joint capsule violation when the gastrocnemius muscle flaps are not available for coverage.

artery between the vastus lateralis and rectus femoris muscles. The flap was able to rotate into the defect without tension, and indocyanine green (ICG) angiography was performed intraoperatively. Immediate inset of the flap resulted in decreased flow through the skin paddle on angiography, prompting a surgical delay before inset. The donor site required a skin graft for closure. At 1-year follow-up, he had full range of motion at the knee without wounds, and clear surveillance studies (Fig. 3).

PATIENTS B AND C

Patients B and C had similar courses, including neoadjuvant radiation before resection of liposarcoma violating the knee joint capsule. Both underwent reconstruction with ALT propeller flaps based on perforators of the descending lateral circumflex artery. Patient B had immediate inset of the flap and patient C required a 7-day delay before inset.

RESULTS

Two of the three patients included required a 7-day delay for adequate dilation of choke vessels before inset. Two patients had smoking history, although none endorsed current use of nicotine products. All patients received 50 Gy of neoadjuvant radiation. Mean follow-up was 23.3 months (n = 3, 16–37 months) and all patients obtained stable soft tissue coverage with excellent return of knee motion postoperatively (Table 1).



Fig. 3. Twelve-month follow-up after flap transfer.

Table 1. Patient Characteristics

| Characteristic | Patient A | Patient B | Patient C |
|------------------------------|--------------------------------------|-------------------------------|-------------------------|
| Age (y) | 56 | 57 | 63 |
| Histology | Pleomorphic undifferentiated sarcoma | De-differentiated liposarcoma | Pleomorphic liposarcoma |
| Tumor size (cm) | 9.3×6.9×8.9 | 5.4×2.4×5.8 | 5.5×4.8×3 |
| Margin (cm) | 2 | 2 | 2 |
| Flap delay | 7 d | None | 7 d |
| Tobacco use | Former smoker | No | Former smoker |
| Preoperative radiation (cGy) | 5000 | 5000 | 5000 |
| Follow-up (mo) | 37 | 16 | 17 |

DISCUSSION

Lower extremity sarcoma often portends a poor prognosis, historically requiring amputation to limit recurrence. To avoid this morbidity, limb-salvage surgery utilizing neoadjuvant radiotherapy followed by excision has increased in popularity, with studies showing decreased local recurrence and equivalent overall survival compared with amputation.^{4,5} In our case series, neoadjuvant radiotherapy was utilized successfully to decrease tumor burden before surgical excision. Despite this, wide local excision often results in large soft tissue defects, requiring extensive reconstruction. Violation of the knee joint capsule necessitates a large skin paddle with adequate arc of rotation to decrease motion limitations postoperatively. This was achieved via an ALT propeller flap based on perforators from the lateral circumflex femoral artery.

Prior studies have highlighted the complexity and variability of the perforator anatomy of the ALT flap.^{6,7} Due to this uncertainty, CTA and identification of perforators via handheld Doppler was performed for all patients before flap harvest. To cover knee defects without undue tension, it is important to select a large perforator in the midthigh or distal thigh. This is further mobilized by tracing the perforator to its branch point from the lateral circumflex femoral artery to allow rotation of the flap into the defect. A large proximally extending skin paddle can then be designed on this perforator to cover all necessary exposed structures.

The combination of radiation-induced vascular changes to the surrounding soft tissue as well as concerns about long-term effects of tobacco on arterial inflow and venous outflow prompted flap delay in two patients. Intraoperative ICG angiography was used after pedicle dissection with the flap in its native position and upon inset to the defect. Any decreased vascular inflow after rotation prompted the decision to delay inset. Because venous congestion remains a limitation to pedicled propeller flap success, flap delay also allowed for visualization of the venous perforasome before flap inset at the expense of perivascular perforator fibrosis.⁸ Despite this delay in reconstruction, all patients achieved healed wounds without limitation in their knee range of motion by 3 months postoperatively.

CONCLUSIONS

Workhorse flaps for knee coverage have traditionally been pedicled gastrocnemius muscle flaps.¹ These flaps

are robust, making them an ideal choice for local coverage of knee wounds. Unfortunately, as in our patients, gastrocnemius flaps may not be an option. The wounds included in this case series were located on the superolateral knee, and in all cases, the sural arteries were compromised from radiation or surgical resection. Because of this, use of a pedicled propeller ALT flap was chosen for reconstruction.

Great enthusiasm has surrounded the pedicled propeller flap, as these can truly be “freestyle flaps” raised on any Dopplerable perforator adjacent to the wound.⁹ Propeller flaps have a 180 degree arc of rotation and bring well vascularized skin and soft tissue to the recipient site. Other advantages include reduced operative times, avoidance of microsurgical anastomoses, and lower acuity, shorter hospital stays. Despite this, pedicled propeller flaps have been described as “tedious to dissect” and can be prone to kinking and compression due to the small vessel size.¹⁰ Even with these limitations, the pedicled ALT propeller flap is a viable alternative to microsurgical reconstruction in coverage of complex knee wounds where local muscle flaps are not a viable reconstructive option.

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