Case Report

Delayed Stepwise Rotation for the Salvage of a Congested Perforator-Pedicled Propeller Flap in Distal Lower Extremity with Severe Edema: A Case Report

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ABSTRACT

A perforator-pedicled propeller (PPP) flap is often employed for reconstruction of the distal lower extremity. However, flap congestion that often causes flap necrosis occurs in the propeller flap. Although several procedures have been reported previously, a preferable method for preventing congestion and rescuing massive flap necrosis in PPP flap cases is undetermined.

A healthy 41-year-old man who sustained a pilon fracture in his right leg required soft tissue reconstruction because of strong edema that did resolve even after a staged protocol. A PPP flap pedicled with a perforator from the posterior tibial artery was harvested and rotated 180° to cover the defect. After reconstructive surgery, the flap developed severe congestion indicating the possibility of near-total flap loss. The flap was rescued by rotating it back to where its perfusion was stable. It was then rotated again in stages into the targeted position every 2 to 3 days over a period of 7 days. The flap was rescued and the wound was healed.

Delayed in-stage rotation of the flap was one of the options for salvaging a PPP flap from congestion especially in cases with severe soft tissue edema such as pilon fracture.

Key words: congestion, flap salvage, perforator-pedicled propeller flap, tibial fracture

Introduction

The perforator-pedicled propeller (PPP) flap is a preferable option for soft tissue reconstruction of the distal lower extremity. However, its complication rate, which includes the possibility of flap necrosis associated with flap congestion, is considerably high1. Even a near-total flap loss is of concern if the flap develops severe congestion. Although several kinds of procedures have been reported to avoid coverage failure by flap necrosis2-6, these require a comparatively long time for completion7 or a preoperative plan, presupposing a partial flap loss8.

This study focused on a case of distal leg reconstruction with a PPP flap that developed severe congestion and required salvaging procedures. The congestion could have caused total flap necrosis. However, the flap was successfully rescued in a shorter duration than that required for the conventional delayed procedure by rotating it back to where its perfusion was stable and following a stepwise placement in the targeted position.

Case presentation

A healthy 41-year-old man presented to the emergency department with pain and swelling on his right leg after a fall in a 2 m deep ditch. He was diagnosed with a closed distal tibia epiphysis fracture (pilon fracture). Vascular injury was excluded according to clinical symptoms and CT scans. A staged protocol was employed to mitigate soft tissue swelling followed by open reduction and internal fixation (ORIF) 2 weeks later. A titanium rocking plate was successfully placed on the distal tibia without significant vessel injury. However, the surgical wound could not be closed directly because the soft tissue swelling recurred after the operation. The wound was left open to be treated with negative pressure wound therapy (NPWT).
Even after continuous NPWT for 5 weeks, the wound was not covered by granular tissue. The clinical symptoms and blood tests did not indicate the presence of infection. The wound needed to be covered with a propeller perforator fasciocutaneous flap. The flap was pedicled with a perforator from the posterior tibial artery 10 cm proximal to the medial malleolus, with the assistance of ultrasonography and color Doppler imaging. The flap was 21 × 5 cm in size to cover the 7.5 × 3 cm size defect. The pedicle perforator was 2 mm in diameter and 2.5 cm long from its bifurcation from the posterior tibial artery. The connective tissue surrounding the pedicle was carefully dissected to prevent a squeezing band. The flap was rotated 180° from its original position to cover the defect and close the donor site (Fig. 1).

The flap did not show any signs suggestive of malperfusion after surgery. However, prolonged capillary refilling time and erythema were observed the day after flap coverage (Day 1), and the entire flap developed purpura and blister, which suggested severe congestion on Day 2. Thus, flap salvage procedures were required. The sutures around the flap were removed, and the flap was returned to its original position (0° position), accordingly. The flap skin already developed severe purpura making it impossible to assess flap perfusion based on skin color. Alternatively, the color of blood exuding from the flap edge was used as an indicator of flap perfusion. During the procedure, a 90° flap rotation was attempted with the assumption that perfusion recovered at the 0° position. However, the blood perfusion was insufficient at the 90° position, which was indicated by the dark red color of the blood. The flap was finally rotated back into an 80° rotation (Day 2, 36 h after the flap surgery). Subsequently, the flap was rotated every 2–3 days as far as the flap perfusion allowed. As a result, the flap successfully rotated to 135° on Day 4 and 180° by Day 7. The flap was sutured on the skin around the wound and anchored with wound dressing materials to avoid distortion during these procedures. Even on Day 7, the flap was only roughly anchored to the skin to be able to raise concerns regarding flap perfusion. On Day 9, the defect was covered by the flap; however, the flap edge and a part of the donor site were left open around the pedicle to avoid torsion (Fig. 2a-c, Fig. 3). During the salvaging period, the injured leg was kept unloaded and the patient was allowed to use a wheelchair with his legs elevated.

Nearly the entire flap survived the salvaging procedures except for the tip, which incurred full-thickness necrosis. The necrotic part was debrided and treated with NPWT from Day 31. The remaining raw surface was closed with a split-thickness skin graft. A fistula remained at the tip of the flap, even on Day 53, when the patient was discharged. Nevertheless, his wounds finally healed in 2 months (Fig. 2d).
A PPP flap is one of the favorable options for the reconstruction of a defect in the distal lower extremity. Since soft tissue with rich blood perfusion (which is available for a local flap) is scarce in the distal leg region, a free flap has often been employed for reconstruction. However, free flap transfer requires micro-anastomosis of the pedicle, which is a resource-intensive procedure and includes a risk of total flap loss. A PPP flap is regarded as a better alternative instead, especially in cases with medium to small defects. A PPP flap streamlines the need for micro-anastomosis, which is commonly difficult to perform in injured legs. Furthermore, reconstruction with a PPP flap meets the traditional “like with like” principle that recommends replacing the defect with a tissue of the same kind for aesthetically favorable results and cost-effectiveness.

Another alternative for lower leg reconstruction is a distally based sural flap. Even though a distally based sural flap has a reliable blood supply and is suitable for lower leg reconstruction, its complication rate is still similar to that of the PPP flap, which is around 20%. Some measures to avoid complications in distally based sural flap include delaying the procedure and performing super drainage. However, these procedures require a longer time or are challenged by the burden of microsurgery. The other alternative is the adipofascial flap for the coverage of lower leg defects. However, this requires a skin graft on the flap, which makes the flap monitoring difficult. In the present case, the PPP flap was employed against all these alternatives to ensure the reliability of blood supply, streamline...
microsurgical burden, and ensure the feasibility of postoperative monitoring.

The complication rate of the PPP flap is still considerably high. Venous congestion can cause both partial and near-total loss of the flap; thus, it is a major complication in reconstruction with the PPP flap\(^1\). Congestion is thought to be associated with factors such as the degree of flap rotation, size of the pedicle, and dissection of the connective tissue around the pedicle. Wong et al. reported that a pedicle needs to be larger than 1 mm in diameter and longer than 30 mm in length\(^1\). While it is regarded the degree of pedicle torsion is one of the critical factors for vascular patency, it is insisted that even a 360° rotation is possible when thorough dissection around the pedicle is performed\(^1\). Moreover, Song et al. reported that a PPP flap has a preferable direction of rotation in each case. Depending on the anatomical features of the perforator, intraoperative blood flow measurement is needed to assess the direction\(^1\).

Reflecting on the considerable incidence of flap congestion, measures to avoid coverage failure and to salvage the congested flap have been reported. Indocyanine green fluorescence angiography, an established modality for intraoperatively assessing perfusion of the free flap, is reported to be useful in the PPP flap\(^1\). The immediate auto-closure of the donor site possibly causes tension on the pedicle; thus, delayed closure is suggested to avoid flap congestion\(^6\). In addition to these preventive measures for congestion, there are several other salvaging procedures reported. Bloodletting treatment by stabbing the flap\(^3\) or externalizing the congested vein\(^4\) may also be considered to save the flap from congestion. Delayed defect coverage has also been reported for the mitigation of partial flap necrosis\(^6\).

An effective schedule for delayed rotation is still undetermined, especially in cases of massive flap congestion. Although rotating back should be considered when total flap necrosis by congestion is a concern, an operation plan compatible with the conventional delayed procedure suggests waiting for 2–3 weeks for the flap to establish enhanced perfusion\(^7\). It is also posited that edema hinders the rotation of the flap into the targeted position more than 72 hours after flap elevation\(^3\). In summary, salvage procedures for the cases of PPP flap with total flap loss are still inconclusive.

In the present study, the PPP flap was applied to cover the defect in the distal lower extremity associated with a pilon fracture whose treatment is considered an orthopedic challenge because of the damage caused to the soft tissue\(^6\). Even when the staged protocol\(^7\) was employed, swelling of the soft tissue in the ORIF was unexpectedly severe. The reasons behind the swelling were unclear. Although in soft tissue damage, the use of a tourniquet might have an effect, this is not proven to increase morbidity\(^6\). Although artificial devices should not be left exposed, immediate flap coverage was impossible because the informed consent for the flap surgery was not obtained. As a temporary measure, the wound was left open, and NPWT was subsequently performed. The swelling of the soft tissue improved after 5 weeks of NPWT; however, the wound did not heal and reconstruction was needed.

After the reconstruction, the flap developed severe congestion such that it almost indicated a near-total flap loss. While the pedicle had enough diameter and its dissection was sufficiently performed, it was shorter than the safe length\(^1\) such that it might have caused congestion of the flap in this case. To salvage the flap, the delayed in-stage rotation was employed. Because of the possibility of total flap loss, a flap rescue was attempted by rotating it to a position with reliable blood perfusion. Afterward, the flap was rotated step-by-step into the targeted position and sutured to the defect through three surgeries with a 2–3 day interval over a period of 7 days. There was a dilemma in deciding the appropriate degrees of rotation with reliable flap perfusion in the procedure. According to an experimental study, perfusion of the PPP flap improves with time\(^8\). However, rotation of the flap should not be delayed beyond 72 hours as the edema and local inflammation disturb the twisting of the pedicle\(^1\). While gradual rotation is preferable for flap perfusion, the procedure needed to be completed as soon as possible for the twist of the pedicle. In the present case, the edema of the flap had already been as strong as the whole soft tissue of the leg; thus, a high degree of rotation after delayed rotation could have threatened the flap perfusion by disturbing the twist of the pedicle. Against this theoretical background, the authors’ strategy was to advance the rotation of the flap as much as the flap perfusion allowed every 48–72 hours. In the present case, a rotation was limited to 80° at the first surgery and 60° for the subsequent procedures after the second surgery because tissue edema around the pedicle threatened the patency of the twisted pedicle. Additionally, direct auto-closure of the donor site with the swollen flap was withheld because it possibly risked the flap pedicle being tensioned. Since the flap color was unreliable for predicting the blood perfusion caused by the purpura through this procedure, flap perfusion was assessed by the color of the blood exuding from the edge of the flap. Although indocyanine green fluorescence angiography is an established measure for assessing flap perfusion, it was unavailable at the facility.

The conventional delayed procedure for salvaging PPP flap from congestion takes 2–3 weeks; the present delayed stepwise rotation was completed in 7 days. Eventually, the flap was salvaged from the risk of near-total flap loss, and it could be rotated 180° to successfully cover the defect. This method is possibly preferable for salvaging cases with concerns of near-total necrosis. This could be especially useful in cases with strong soft tissue swelling, such as in patients with pilon fractures where large degrees of flap rotation are risky.

This proposal has some limitations. Although the salvage
procedure was completed in 7 days, it required three surgeries and was burdensome for the patient. Some alternative procedures for salvaging partial flap necrosis have been reported to be completed in several days with minimal surgery, thus, this proposal is not the best way to salvage a PPP flap with partial necrosis. However, the delayed stepwise rotation is worth attempting before abandoning the flap when there are concerns about near-total loss. Because the proposal is based on the results from a single case, more studies are needed to determine the best approach for reducing the complication rate of the PPP flap.

Conclusion

This article reports a case of a PPP flap in the distal lower extremity that was rescued from severe congestion. The delayed in-stage rotation of a flap, completed in a shorter period than that required for the conventional delayed procedure, is one method for salvaging a PPP flap with severe congestion and a high risk of total flap loss.

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Conflicts of interest

The authors declare no conflicts of interest associated with this manuscript.

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