

Vein-Supercharged Peroneal Artery Perforator Propeller Flap for Achilles Soft Tissue Coverage

Parintosa Atmodiwirjo, Laureen Supit
Jakarta, Indonesia

Background: Wounds on the distal third of the lower extremity are reconstructively challenging, as there is lack of spare local tissue to design local flaps from. The perceived alternative is to perform free flaps to cover for these defects. Drawbacks include the need for specific training to perform microsurgery, longer time required, and the probable bulkiness when donor is obtained from certain areas. The perforator propeller flap is a local island fasciocutaneous flap, designed with 2 blades of skin island of unequal length extending from each side of the perforator. As the flap is rotated, the longer blade will cover the defect.

Patient and Method: A case of soft tissue defect on the achilles is reported, with successful defect closure by utilizing a peroneal artery perforator based fasciocutaneous propeller flap with 180 degree rotation and vein supercharge to facilitate backflow. Secondary defect required split-thickness skin grafting.

Result: After surgery, muscles of the lower limb started to swell and get compromised. We removed some stitches to allow soft tissue expansion underneath the flap. After the release, flap perfusion improved. Stitches were left open for 3 days, then closure of flap edges by placing gradual traction sutures which were tightened daily. By the 7th day, flap edges were re-approximated and the skin grafts took well.

Summary: The ability of the propeller flap to rotate makes this flap highly useful and versatile for the reconstruction of distal lower limb defects. Flap dimension can be enhanced when distal part of the flap is supercharged to neighboring recipient vessels. Another advantage is the close vicinity of donor, giving better aesthetic result.⁶

Keywords: Propeller flap, perforator propeller, achilles reconstruction

Latar Belakang: Luka pada sepertiga distal ekstremitas bawah sangat menantang karena kurangnya cadangan jaringan lokal untuk mendesain flap lokal. Alternatif lainnya yaitu melakukan *free flap* untuk menutup defek. Kekurangannya yaitu dibutuhkan training khusus untuk melakukan bedah mikro, waktu yang lama, dan kemungkinan terjadinya pembesaran. Flap *perforator propeller* adalah flap lokal island fasciocutaneous berdasarkan perforator yang terdiseksi tunggal didesain sebagai 2 *blades* dari *skin island* dengan panjang yang tidak sama. Saat flap dirotasi, *blade* yang panjang menutup defek.

Pasien dan Metode: Dilaporkan kasus dengan defek jaringan lunak pada achilles, penutupan defek dengan arteri perforator peroneal yang menjadi dasar flap *propeller* dengan rotasi 180 derajat dan vena *supercharge* untuk aliran darah balik. Defek sekunder membutuhkan *split-thickness skin grafting*.

Hasil: Setelah operasi, otot pada ekstremitas bawah mulai membengkak dan terganggu. Kami membuka beberapa jahitan untuk memungkinkan ekspansi jaringan lunak dibawah flap. Segera setelah rilis, perfusi flap meningkat. Jahitan dibiarkan terbuka selama 3 hari, dilakukan penutupan pinggir flap dengan jahitan traksi secara gradual. Pada hari ke 7, pinggir flap telah teraproksimasi dan skin graft dapat 'take'.

Ringkasan: Kemampuan flap *propeller* untuk melakukan rotasi membuat flap ini bermanfaat untuk rekonstruksi defek distal dari ekstremitas bawah. Dimensi flap dapat ditingkatkan saat bagian distal dari flap terhidupi dari pembuluh darah resipien. Keuntungan lain adalah kedekatan dengan donor, menghasilkan hasil yang baik secara estetik.

Kata Kunci: Keystone flap, small perforators, perforator flap

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The distal third of the lower extremity is a challenging area to reconstruct. There is lack of spare tissue within the immediate vicinity to raise local flaps from. This leads to

the general perception that distant tissue transfer is the method of choice for reconstruction. With better knowledge of the perforator concepts we gain more options for

From the Division of Plastic Reconstructive and Aesthetic Surgery, Department of Surgery Faculty of Medicine Universitas Indonesia, Cipto Mangunkusumo Hospital, Jakarta, Indonesia.
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raising local flaps at almost anywhere in the body. Hence a free flap is no longer the only option to cover for small to medium size defects on the lower extremity.

In 1991, Hyakusoku first termed the 'propeller flap' to describe an adipocutaneous flap based on a random subcutaneous pedicle. He designed a skin island with its length largely exceeding its width, made of two portions extending from either side of the pedicle shaped almost like the blades of a propeller.¹ In 2006, Hallock designed a flap with a skin island similar to that of Hyakusoku's but based it on a skeletonized perforating vessel, making it a perforator based fasciocutaneous propeller flap.² The flap can be rotated up to 180° to either clockwise or counterclockwise. The longer arm of the skin island is used to resurface the defect, and the other shorter arm is positioned over the donor site of the longer arm. This typically facilitates a direct closure of the donor area, but if there is remaining surface uncovered, skin grafts can be utilized. The following figure illustrates the perforator propeller flap design.

The Advisory Panel of the First Tokyo Meeting on Perforator and Propeller held on June 28 to 29th 2009 reached a terminology consensus on propeller flaps to define the different propeller flaps with particular regard to the perforator propeller flaps.³ A propeller

flap is defined as: an island flap that reaches the recipient site through an axial rotation. Every skin island flap, except those which reach the recipient site through an advancement movement, can become a propeller flap. In regards to classifying a propeller flap, the surgeon should specify the type of nourishing pedicle, the degree of skin island rotation, and when possible the artery of origin of the perforator vessel. Hence when describing a propeller flap it is stated in example as propeller flap based on a single perforator of the posterior tibial artery, rotated 180 degrees.

The nourishing pedicles of propeller flaps may be subcutaneous pedicled, perforator pedicled, or supercharged perforator flap. The supercharged propeller flap is a modification of the perforator pedicled propeller flap. If a long propeller flap is needed and the isolated perforator vessel is not providing an adequate arterial or venous flow, an extra perforating vessel can be added microscurgically as an adjunct to the main perforator. This is illustrated in Figure 2.

PATIENT AND METHOD

Thirty-two year-old male sustained injury in a motorcycle incident which resulted in a posterior left lower limb wound with rupture of the achilles tendon. Tendon was repaired by orthopaedic surgeon, with soft

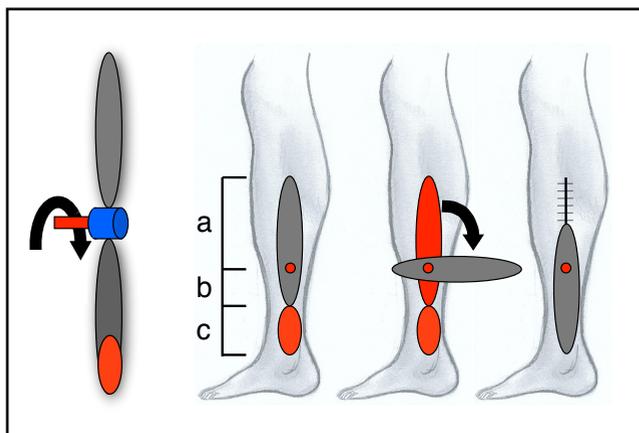


Figure 1. Design of the perforator propeller flap to cover for an illustrated distal lower limb defect: (a) represents the longer arm of the flap, (b) the shorter arm, and (c) the defect

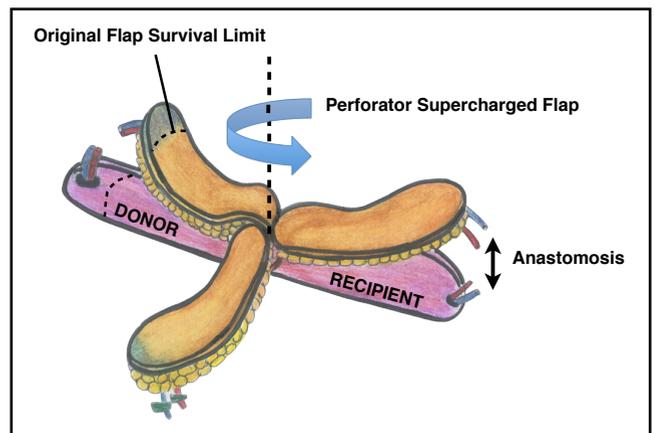


Figure 2. Illustration of the propeller perforator supercharged flap. The distal blue area of the flap is the extended part of flap requiring an additional vascular supply. Flap supercharged by anastomoses of distal blood vessels onto recipient site provides the necessary blood supply to the distal propeller flap

tissue defect over it sutured primarily. The patient presented to our plastic surgery clinic one year after the injury with a chronic ulcerated wound on the left achilles region (Figure 3). The ulcer produced minimal secrete and was not malodourous. Patient was able to perform normal gait. Ankle stability and range of motion was within normal limit. The ulcer posed occasional pain for the patient and he was not able to comfortably fit a shoe on the left foot. Upon examination a 4 cm by 4 cm round ulcer was found on the left achilles region, surrounded by a thick irregular hyperpigmented fibrous tissue. Fibrous scar tissue was also found on the base of the wound. Pain was minimal upon palpation.

Flap Design

Patient was laid prone under regional anesthesia. The leg was elevated, and thigh pneumatic tourniquet was used. The ulcer and its surrounding unhealthy soft tissue was excised, creating a defect with a size of 8 by 6 cm with exposed achilles tendon. A handheld 8-MHz Doppler ultrasound scanner was used to locate the most distal reliable perforator artery on the lateral and medial side of the foot. One single reliable perforator was identified on the lateral side of the foot and marked. With the perforator as the flap pivot point, a provisional propeller flap design was drawn (Figure 4). First, the axial length of the defect was measured (8 cm, Figure 4 point c), then the



Figure 3. Patient presented with a chronic non-healing ulcer on the posterior lower limb after repair of achilles tendon rupture one year prior to presentation. **Left** : posterior view. **Right** : lateral view.

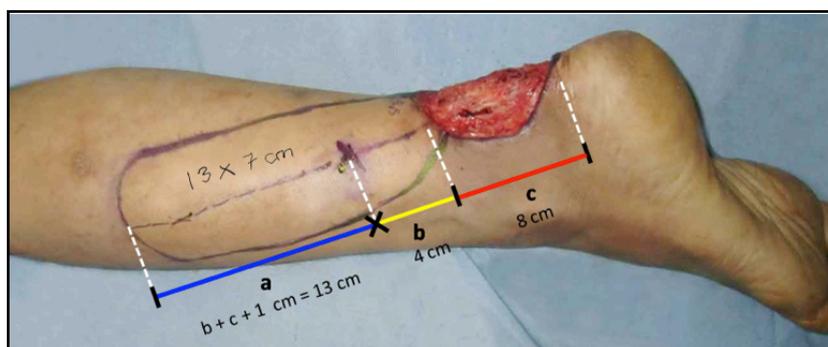


Figure 4. Design of the perforator propeller flap to close a distal limb defect with exposed achilles tendon. Point c is the axial length of the defect, point b is the distance between proximal edge of defect to the perforator as the pivot point, point a is the value of c plus b added by 1 cm. Width of the flap is determined by the width of defect added by 1 cm (0.5 cm on either lateral side), with the lateral distance equally divided on either side of the perforator.

distance between the perforator to the proximal edge of the defect was measured (4 cm, Figure 4 point b). The two values were added and then transposed proximally from the point of perforator, along the axis of the peroneal artery as the main source vessel (8 cm plus 4 cm). One centimeter was added to the value, to facilitate flap contraction later, and marked (Figure 4 point a). This forms the proximal limit of the flap. The flap length is point a and b added together. Next, the width of the flap was designed. This is determined by measuring the width of the defect, and 0.5 cm is added on each side of the flap to allow for flap contraction and facilitate its inset without tension (6 cm plus 1 cm, amounted to 7 cm in flap width). The width of the flap must be centered in regards to the perforator, with lateral dimensions being of equal distant toward the perforator. This prevented unequal traction toward one side of the perforator when flap is rotated to cover the defect.

Flap Elevation

Initial incision was made on the more lateral edge of flap, and carefully elevated following the subfascial plane, which is an easier approach to identify the perforator. Flap

elevation began from the most lateral side of the flap near the perforator, toward the marked perforator. Several other perforators may be identified during the course of elevation and it is best to preserve them until we can locate the main perforator pedicle as detected by the Doppler ultrasound in the initial design. Preserving the other perforators are useful in case the originally-planned perforator cannot be located. Should that be the case and the main perforator changed, flap design can be adjusted accordingly. In this case, we were able to locate the perforator as planned. Once the perforator has been located, the rest of the flap design was incised and elevated.

Special caution was taken while performing incision around proximal flap and donor area, as well as the distal end of the flap. Superficial vein with adequate diameter around the areas were preserved by vessel clamp, because these veins will serve as the donor and recipient vessels for supercharging (Figure 5). Once the flap is islanded and elevated, carefully free the pedicle of all its surrounding attachment and soft tissue for at least 2 cm around the pedicle. Gently rotate the flap and check whether any attachment is still twisting the pedicle. All the fascial strands which could



Figure 5. Above : propeller perforator flap completely islanded. Below : A single perforator pedicle branching from the peroneal artery freed from its surrounding attachments and ready to be rotated.

potentially compress the vessel should be meticulously separated. Once the flap has been completely freed, tourniquet was released. Flap was then allowed to perfuse and relax for 10 minutes. Then flap perfusion was checked by wiping flap edges with moist gauze and detects the presence of blood actively oozing from the dermal layer of flap edges.

Flap Inset

Once the flap perfusion was satisfactory, it was carefully lifted from the wound bed and rotated around its pedicle 180° clockwise (Figure 6). It is not necessary to rotate the flap beyond 180° because if a greater rotational degree is required it could be conveniently rotated in the counter direction. Try rotating the flap clockwise first, then counterclockwise, and decide which direction is more convenient to reach the defect without compression to the venae comitantes. Once the flap sits comfortably, flap was secured with skin sutures on either side of the pedicle. Make sure that the placement of sutures do not put the pedicle under traction in either proximal, distal, nor lateral direction. Penrose drain was placed on either side of the distal flap, away from the pedicle, and secured.

Vein Supercharge

After fully inseting the flap onto its desired place covering the defect, release the vessel clamps on both the flap side and the recipient site and prepare them for anastomoses (Figure 7). Irrigate and dilate veins with heparinized solution. Microsurgical anastomoses was performed using 9.0 Nylon sutures. Release vessel clamps and check vein flow patency. The rest of the flap was sutured with 3.0 Polypropelne sutures. The distal lateral part of the flap was not able to be approximated without tension, and the donor defect could not be closed with primary suturing. We must also account for the consequent swelling from tourniquet placement. It was then decided that both the distal lateral donor and proximal donor sites were covered by split thickness skin grafts obtained from the left thigh. Final defects closure is displayed in Figure 8. Skin grafts were covered with tulle dressing and tie-over

sutures on top of moist gauze with just enough pressure so as not to compromise the vein-supercharge near the grafted sites.

RESULTS

After surgery, muscles of the lower limb were started to swell as a sequelae of tourniquet usage. Twelve-hours postoperative, swelling underneath the flap reached a point where the flap started to get compromised. Some stitches were removed to allow for soft tissue expansion underneath the flap. Immediately after the release, flap perfusion improved. Stitches were left open for 3 days, then closure of flap edges was obtained by placing gradual traction sutures which was tightened each day. By the 7th day, all flap edges was reapproximated and the skin grafts took well (Figure 9).

DISCUSSION

The perforator based propeller flap can be used to cover various defects on the lower limb especially the difficult distal areas around the ankle region. The flap can be extended to reach defects on the lateral and medial border of the foot to cover for exposed calcaneous, or even up to the plantar area when supercharged. The propeller flap can also be used to provide soft tissue coverage for the middle and upper third of the leg including around the knee. In many cases, the secondary defect can be closed directly.

The main perforators of the lower limb arise from three major vessels of the leg which are the posterior tibial, peroneal, and anterior tibial arteries. Select perforators by following the course of these vessels, depending on the desired flap and defect location. In this case, it was more convenient to rotate the flap from the lateral side of the leg hence based it on the perforator of the peronal artery. Upon designing the flap the saphenous and sural nerves are preferably preserved. In a propeller flap, although more than one peforator may be identified only one main perforator should be used. The design of this flap makes the use of on each other, unless the flap rotation does not exceed 90°.



Figure 6. Clockwise rotation of the perforator propeller flap onto the achilles defect. It was ascertained that rotating the flap up to 180° did not jeopardize the pedicle and compress its venae comitantes.

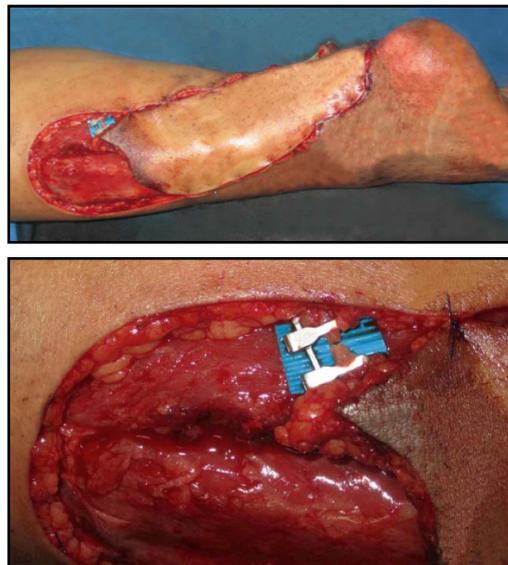


Figure 7. Above : the perforator propeller flap has been insetted onto the defect. The once-distally located vein was rotated with the flap and is then approximated to the proximal preserved vein of the donor area. **Below :** inset area is enlarged, showing the vein supercharge of the donor and recipient sites ready to be anastomosed.



Figure 6. Posterior and lateral immediate postoperative view of the perforator propeller flap after flap insetting. Proximal and lateral donor area could not be approximated thus skin grafted.ascertained that rotating the flap up to 180° did not jeopardize the pedicle and compress its venae comitantes.



Figure 9. Posterior and lateral view of perforator propeller flap 7 days after the surgery.

Like any other flaps, propeller flaps may develop complications, especially the perforator based ones. The most common complication is venous congestion. This may be due to an insufficient flow in the perforating vessel, or by inadequate release of the fascial adhesions around the pedicle especially around the vein. We anticipated this complication by accurately dissecting the perforator and freed it from its surrounding attachments and rotate the flap evenly upon the pedicle pivot point. Some studies showed that the risk of vessel kinking is less if a perforator is at least 1-mm in diameter and 3 cm in length. In our case both criterias are fulfilled, but we enhanced vascular backflow with an extra vein supercharge anastomoses. This is especially helpful in the lower extremity because of the higher risk of venous congestion compared to other more-cranial sites on the body.

SUMMARY

The locoregional fasciocutaneous propeller flap for soft tissue reconstruction on the lower limb is generally more advantageous compared to free flaps and other commonly

used regional muscle flap such as the gastrocnemius. The propeller flap produces better contour, texture, and does not require microsurgical anastomoses. Microsurgery requires the set up of special logistic, operator, instrumentations, and a generally longer operating time. This makes propeller flap a useful reconstructive tool which has good cosmetic and functional results for the lower limbs.

Parintosa Atmodiwirjo, M.D.

Plastic Surgery Division

*Cipto Mangunkusumo General National Hospital
Jalan Diponegoro.No.71, Gedung A, Lantai 4.*

parintosaa@yahoo.com

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