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End-to-patch anastomosis for microvascular transfer of free flaps with small pedicle

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End-to-patch;
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Summary *Background:* Although perforator-to-perforator anastomosis in supermicrosurgery may be used in transferring free flaps with small vessels, it is still difficult in certain situations that include potentially infected wounds. Moreover, it is limited to smaller flaps. Anastomosis of large vessels is still safer for transfer of a large flap for most surgeons. The harvesting of a patch of the parent artery together with the perforator supplying the flap allows the surgeon to perform an anastomosis between the vessel ends of larger caliber, and possibly with greater anastomotic success.
Method: When the vascular pedicle of a free flap is < 0.8 mm, an option is to take a cuff of the major artery for an end-to-patch anastomosis. From 1983 to 2013, this method was applied to the anteromedial thigh (AMT) flap (seven cases), the groin flap (81 cases), and the free Becker's flap (five cases). When a patch was taken from the femoral artery, direct anastomosis for the major artery was performed using 5/0 Prolene sutures, followed by coverage with local soft tissue. When a patch was taken from the ulnar artery, a patch of vein graft was used for repair of the ulnar artery. In one case, a segment of the femoral artery was harvested with an AMT flap and a segment of a sartorius muscle flap; the compound tissue was transferred to the neck with the femoral artery to replace the left carotid artery. In the donor site, the defect of the femoral artery was reconstructed with an artificial graft.

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Results: The flaps had no failure or partial necrosis, but one patient developed bleeding from the femoral artery 2 days postoperatively. It was treated by adding one more suture for the femoral artery and coverage with the sartorius muscle. In the ulnar artery, the patients did not complain of cold intolerance and the postoperative angiogram showed good patency of the ulnar artery after an average follow-up of 1 year.
Conclusion: For the majority of plastic surgeons, this method provides a reliable and comfortable anastomosis when transferring a flap with small vessels. The only concern is to repair the donor artery carefully and ensure coverage of the repair site with local tissue.

Introduction

Supermicrosurgery is the anastomosis of vessels with a diameter of <0.8 mm. The technique is often used in some free flaps known to have naturally small perforator pedicles.[1–3] Examples include the anteromedial thigh (AMT) flap, the free groin flap, and the ulnar artery perforator (Becker's) flap. During conventional supermicrosurgery, an end-to-end anastomosis is performed to coapt the recipient and donor pedicles, and this procedure may be technically difficult to perform for an inexperienced microsurgeon, may require a longer operative time, and may be associated with postoperative complications including vessel thrombosis. Thus, the free flaps described above are less commonly used due to the difficulties listed. The senior author designed the end-to-patch technique as a method to overcome the technical challenges associated with perforator-to-perforator anastomosis.

The AMT flap can be chosen as an alternative to the anterolateral thigh flap especially when anterolateral thigh perforators are small or absent. Among the sources of perforators of the AMT flap, the perforators from the femoral artery hinder the anastomosis because of their small diameter, which is usually <0.8 mm.[4,5]

There are many advantages associated with the use of a free groin flap. These include concealment of the donor-site scar, relatively thin thickness, possibility of being raised together with the iliac bone, and presence of non-hair-bearing skin. However, the disadvantages of this flap include small diameter of the pedicle, relatively unreliable vascular anatomy, and limited pedicle length.

The free Becker's flap has advantages including thinness, pliability, and presence of non-hair-bearing skin. There is a reliable and consistent perforator located 3 cm proximal to the wrist crease. This perforator can be used as a pedicle without sacrificing the ulnar artery. But, the diameter of the perforator is usually <1.0 mm[6]

The supermicrosurgery technique has a steep learning curve and it requires expensive instruments and material. Supermicrosurgery has been successfully used for the transfer of free flaps with small vessels, but it remains a difficult technique in certain situations, such as wounds that are vulnerable to infection. Moreover, it is usually limited to smaller flaps. For most surgeons, anastomosis of large vessels is still safer for transfer of a large flap. With the confident application of the end-to-patch anastomosis technique, especially by inexperienced microsurgeons, the indications for these classic free flaps may be expanded.

Patients and methods

From 1983 to 2013, soft tissue defects in 93 patients were reconstructed with the AMT flap, the groin flap, and the free Becker's flap using the end-to-patch method by the senior author (H.C.C.; Table 1). The flap-raising technique and the selection of recipient vessels were performed in the usual manner. An end-to patch anastomosis was performed when the diameter of the pedicle was <0.8 mm. Cases of use of the AMT flap, in which the pedicles did not originate from the femoral artery, were excluded from this series; the cases in which the pedicle originated from the descending branch of the femoral artery or directly from the deep femoral artery were included. In cases where a free groin flap was harvested, the superficial circumflex iliac artery (SCIA) was included as a pedicle. In cases where the free Becker's flap was used, the dorsal ulnar artery perforator was used. The flaps were raised in the usual manner and retrograde dissection was performed to trace the perforator to the parent vessel. The artery was then harvested including the flap perforator as well as a patch of the parent vessel.

Proximal and distal control of the femoral artery was initially obtained with the use of bulldog clamps. The patch was then harvested by cutting an elliptical cuff of the femoral artery surrounding the flap perforator. Considering the morbidity of the donor vessels, when a patch was acquired from the femoral artery, the size of the patch was about 1–1.2 mm and direct repair was performed using 5/

Table 1 Recipient sites of this series.

Flaps	Location				
	Head and neck	Upper limb	Lower limb		Total case number
			Leg	Foot	
Anteromedial thigh flap	7				7
Groin flap	8	28	41	4	81
Free Becker's flap		5			5

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0 Prolene™ sutures under microscopic guidance, followed by coverage with local soft tissue (Figures 1 and 2). When a patch was taken from the ulnar artery (Becker's flap), a vein graft patch taken from the greater or lesser saphenous vein was used for repair of the secondary ulnar artery defect, because the ulnar artery is relatively smaller than the femoral artery and direct closure can reduce the patency of the ulnar artery. The vein graft patch was repaired with 10/0 nylon under microscopic guidance to prevent thrombus formation (Figure 3).

The flap artery was anastomosed to the recipient artery using conventional microsurgical instruments and 10/0 nylon sutures in an end-to-patch manner (Figure 4). Postoperatively, the anastomotic patency of the flaps was determined clinically by flap color, bleeding on pinprick, and handheld Doppler examination of the pedicle wherever applicable. The anastomotic patency of the donor artery was assessed by clinical monitoring of the skin territory supplied distal to the location from where the arterial patch was taken. In the case of the ulnar artery as a donor site, postoperative angiography was performed to confirm its patency after an average follow-up of 1 year.

The authors performed a retrospective review of the flaps harvested with an arterial patch from 1983 to 2013. The end points of the study included postoperative flap pedicle patency and flap viability, donor arterial patency, complications including postoperative pedicle vasospasm, and need for reoperations.

Results

From 1983 to 2013, end-to-patch anastomosis was performed in AMT flaps (seven cases), groin flaps (81 cases), and dorsal ulnar artery perforator flaps (five cases). The indications for reconstruction varied, and reconstruction was performed according to the location, size, and skin color (Figure 5). In these 93 cases, the mean follow-up period was 5.5 years (range, 6 months to 18 years). None of the patients complained of donor-site morbidity related to the groin flap and the AMT flap. In the ulnar artery, the patients did not complain of cold intolerance and the angiogram 1 year postoperatively demonstrated good patency of the ulnar artery with no aneurysm or pseudoaneurysm near the donor-site vessel including the ulnar and femoral arteries. The flaps did not show failure or partial necrosis, but there was one case of bleeding from the femoral artery 2 days postoperatively due to a loose ligature at the donor-site artery. This was treated by applying another suture around the femoral artery, and after confirming that there was no leakage of blood from the femoral artery, soft tissue coverage with the sartorius muscle was performed.

Discussion

The free groin flap is of historical importance because it was the first flap to be used for free tissue transfer and it introduced the concept of axial blood supply.[7–9] The SCIA provides the main blood supply to the flap and it originates from the femoral artery. The diameter of the artery is usually small and it can be smaller than 0.8 mm.[10,11] The vascular pedicle of the AMT flap may originate from different arteries, such as the rectus femoris branch of the lateral circumflex femoral artery, the perforator from the femoral artery, and occasionally from the deep femoral artery.[4,5] In cases where the pedicle arose directly from the femoral artery, the diameter is usually <1 mm, and in about one-third of the cases, the diameter of the pedicle is < 0.5 mm.[5] Although the free groin flap and the AMT flap have many advantages, their inherent disadvantage — short pedicle with a small diameter — makes these flaps unpopular. To overcome these disadvantages, patches >0.8 mm are made when raising the flaps; a patch from the femoral artery can ensure the safety and can make it easier to perform the anastomosis by minimizing size mismatch with recipient vessels. In some patients, the SCIA is a large artery arising from the deep femoral artery instead of the femoral artery. In these patients, the end-to-patch method was not necessary. In female patients and children, the SCIA was very small; hence, the end-to-patch method was used. In about 80% of male patients, the end-to-patch method was employed.

However, harvesting of a patch that is too large can reduce the patency of the femoral artery after repair. A proper-sized patch close to 1 mm is desirable. Usually, a 1-mm patch is relatively smaller than the caliber of the

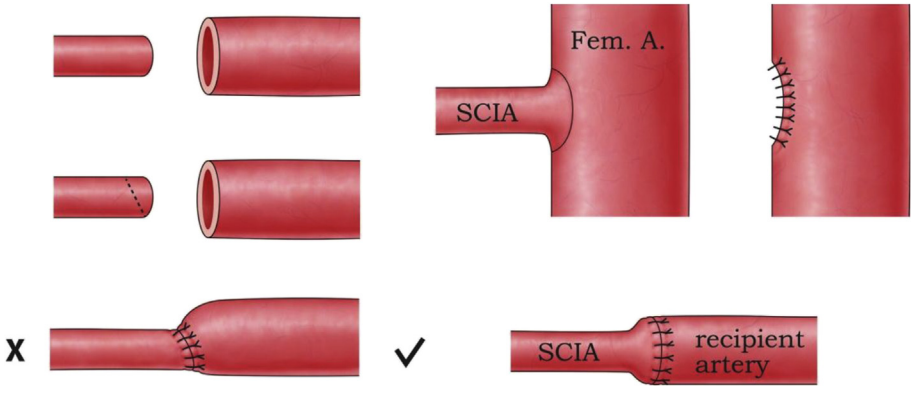

Figure 1 Illustration of the creation of a patch for anastomosis. The left panel displays a general way to overcome size discrepancy of vessels (×). The right panel displays the end-to-patch anastomosis for good flow with easy microanastomosis (v).

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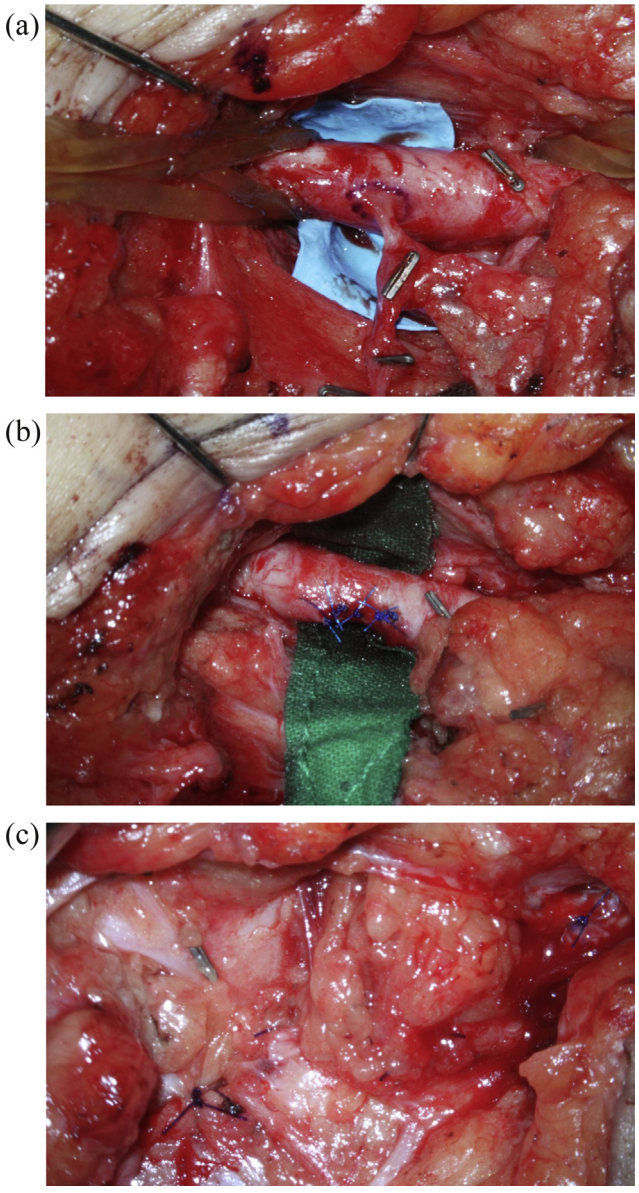

Figure 2 Procedure for the femoral artery. (a) Design for harvesting a patch from the femoral artery. (b) Under microscopic guidance, the donor site is sutured directly with 5/0 Prolene™. (c) The sutured femoral artery is covered with local soft tissue.

femoral artery, which allows acceptable direct closure of the femoral artery. However, if the source is too small to be repaired directly, venous patch application or super-microsurgery can be the alternatives. There is no standard size of the patch for direct closure; while harvesting the patch from the source artery, an important technical point is that the width of the patch cannot exceed one-fifth of the circumference of the femoral artery. In our series of AMT flaps, we excluded one case due to very small artery of AMT. In seven cases of AMT, we used the end-to-patch method. (In the other 15 cases, the vascular pedicle of the AMT flap was large enough and the end-to-patch method was not needed.) There were no cases in which the flaps were supplied by direct perforators originating from the deep femoral artery. This end-to-patch method can also be

Figure 3 The free Becker's flap. The top panel displays a conceptual illustration for the free Becker's flap. Lower panel: Unlike the groin flap, after flap harvest, the defect site of the ulnar artery is repaired by a venous patch, because of the smaller size of the ulnar artery.

applied to the deep femoral artery if the size of the artery is large enough for direct closure.

The ulnar artery flap was described by Song et al. However, the flap was introduced as a free and fasciocutaneous flap without the concept of perforator flaps.[12,13] In 1992, Becker et al. described a flap based on the ulnar artery perforator, which could be used to cover the hand in a pedicled manner.[12] Compared to the radial forearm flap, the ulnar forearm flap has some advantages including ease of donor-site concealment, as it is thinner than the radial forearm flap, and involves a non-hair-bearing area.[13] But, because of the vascular dominance of the ulnar artery in the hand and the possibility of injury to the ulnar nerve, the free Becker's flap failed to gain popularity. This end-to-patch method can provide a relatively large diameter of the pedicle without sacrificing the ulnar artery. For the vein, two vena comitantes with the artery can be used, as well as the basilic vein located in the proximal part of the flap. For the Becker's flap, because the ulnar artery is smaller than the femoral artery, the defect in the ulnar artery is relatively larger than that in the femoral artery. Hence, after taking the patch, the defect was routinely repaired with a vein patch graft. Repair of the ulnar artery was performed using 10/0 nylon.

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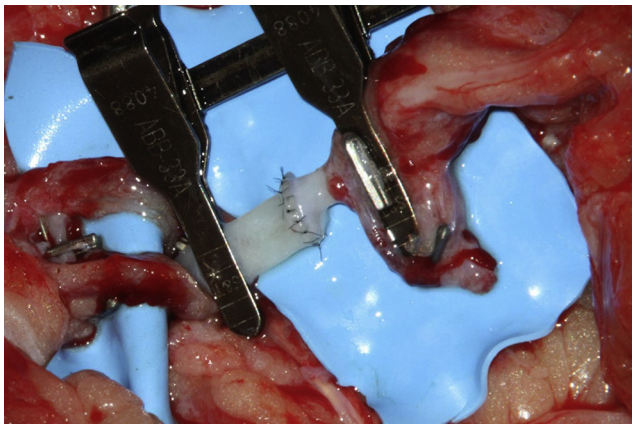

Figure 4 The flap artery (right panel) was anastomosed to the recipient artery (left panel) with 10/0 nylon sutures in an end-to-patch fashion.

No vascular complications were evident after harvesting Becker's flap on angiography after an average follow-up of 1 year. Although there was no follow-up result of angiography of the ulnar artery after >1 year, none of the patients complained of donor-site morbidity around the ulnar artery including hematoma, bulging, and cold intolerance. In this series, all of the patients were trauma patients and none of them had diabetes or atherosclerosis. If there is atherosclerosis, the arterial wall may be separated between the intima and muscle layer when a patch is harvested. These patients will face a potential risk of leak.

We select a large recipient artery (at least 1.2 mm) to provide significant blood flow to the flap, especially when the flap is large. When the diameter of the flap artery is < 0.8 mm, we use the end-to-patch method. Thus, the relative gain in the diameter of the flap artery with the patch is about 50% (from 0.8 to 1.2 mm). If necessary, the relative gain in the diameter of the flap artery can be increased to 100% (from 0.8 to 1.6 mm) when a large patch is harvested. In most cases, a 50% gain in the diameter is good enough to achieve easy anastomosis and to avoid

Figure 5 Clinical photo. The groin flap was applied to release scar contracture of the right palm. The end-to-patch method was performed for microanastomosis. (a) Preoperative view(b) Design for groin flap (c) Immediate postoperative view (d)1-year postoperative view.

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turbulence across the direct anastomosis between the arteries with discrepancy.

For postoperative management, in the case of groin flaps, the patients should be advised to take bed rest for 3 days postoperatively with the hip flexed. In our series, one patient developed bleeding from the groin wound due to ambulation immediately after surgery. Because of the high flow in the femoral artery, the possibility of thromboembolism at the repair site of the femoral artery is minimal and the patients do not require special anticoagulant therapy.

The technique of microsurgery has greatly improved over the past 20 years. Supermicrosurgery, which is defined as the anastomosis of vessels with a diameter of $<$0.8 mm, was the first new free perforator-to-perforator flap reconstructive techniques. With supermicrosurgery, there is a relatively lesser need to identify and sacrifice the major vessels compared with conventional microsurgery. Therefore, the concept of the freestyle flap was introduced. However, it is still difficult to perform supermicrosurgery in certain situations including wounds that are vulnerable to infection and cases requiring a large flap. Furthermore, another limitation of supermicrosurgery is the need for more experience with the surgical technique and the need for expensive equipment. It would also be useful to explain why the patch method is not required for veins — because if the perforator vein is small, the parent vein may be harvested together with the flap and a large-caliber vein may be obtained with the flap for anastomosis. This does not cause donor-site morbidity, unlike in the case of arterial harvest.

Conclusion

This end-to-patch anastomosis method can provide reliable and comfortable anastomosis when transferring a flap with small vessels. We can use this method for the other conventional classic flaps with small vessels. If there is an appropriate indication for the end-to-patch anastomosis, the only care that needs to be taken is to repair the donor artery carefully and to cover the repair site with the local tissue.

Conflict of interest

None.

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Ethical approval

N/A.

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