〔Original〕

Feasibility and Safety of Microvascular Anastomoses Within Previously-Dissected Neck Regions

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***Abstract* :** The selection of appropriate recipient vessels is important for the success of head and neck reconstruction. Vessels located outside of previously-dissected neck regions tend to be more frequently selected due to relative ease of preparation. However, some advantages are offered regarding dead space filling and formation by using vascular anastomoses within regions previously dissected, or reusing former free flap pedicle due to their proximity to the defect. We analyzed microsurgical anastomoses in patients requiring oral reconstruction who had previously undergone neck dissection. Contralateral vascular anastomoses were preoperatively planned in 10 cases of which 9 could be successfully performed (achievement rate, 90%). Ipsilateral side anastomoses were planned in 28 cases, with 26 anastomosed as planned (achievement rate, 92.9%). There was no statistically significant difference between the two groups. Vascular anastomosis within the scar region can be performed safely, based on preoperative planning and intraoperative judgment.

***Keywords* :** head and neck cancer, reconstruction, microsurgery, salvage surgery.

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Background

Flap selection and design, and the surgical technique used for flap elevation, are vital for the success of microsurgical reconstruction. For head and neck reconstruction, recipient vessel selection is also important. In salvage operations, microsurgeons tend to avoid previously-dissected neck sites due to the presence of severely scarred fibrous tissue and the difficulty of preparing of recipient vessels. Thus, microsurgeons tend to use recipient vessels from the ipsilateral neck or from an inferior neck region outside the scar region [1−3]. Nonetheless, some publications have reported the usefulness of vascular anastomoses within previously dissected neck regions [4, 5].

In recurrent or salvage operations, a previously-dissected neck region can be suitable for vessel anastomosis if it is close to the ablation site, because there

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is no limit on pedicle length for adequately filling the dead space and for ideal flap formation. In fact, with a limited flap volume, it has the advantage of being easier to fill the dead space than when the contralateral side is used as the recipient vessels.

For this reason, we preferentially perform microsurgery in previously-dissected neck areas once we have determined that the condition of the vessel is suitable for anastomosis, and we prefer to prioritize vascular anastomoses that can be performed in the region of a previous neck dissection.

In the present study, we analyze microsurgical anastomoses in oral reconstruction patients who had previously undergone neck dissection, and we prove that it can be safely performed at that region.

Patients and Methods

We performed 38 microsurgical reconstructions in the oral area in 37 patients who had previously undergone neck dissection between January 2011 and March 2019 (Table 1). One patient underwent two reconstructions after the first neck dissection. The male to female ratio was 25:12, and the patients' ages ranged from 23 to 76 years old (mean, 58.0 years). In total, 37 of the cases involved cancer recurrence and therapeutic resection; one of the cases involved free flap failure.

We evaluated patients who had undergone mandibular, tongue, oropharyngeal, and buccal mucosal reconstructions. We excluded those who had undergone maxillary or hypopharyngeal reconstructions. This was because the use of recipient vessels in the contralateral neck region is clinically unrealistic in maxillary reconstruction, and because the defect in hypopharyngeal reconstruction is located at the median so there is no significant difference between the distance from the ipsilateral side or from the contralateral side, and there is no difference in the postoperative procedure.

Table 1. Demographic and clinical characteristics

Male: Female	25 : 12	
Ages	23-76 y.o. (Average 58.0)	
Reconstruction Site	Mandible	14
	Tongue	12
	Oropharynx	9
	Buccal Mucosa	3
Stage	I	3
	II	7
	III	3
	IV	25
Previous Radiation Therapy	19 cases (50.0%)	46-70 Gy (Average 62.0 Gy)
Interval from Previous Ope.	2 month-12years (Median 1 year)	

Fourteen patients had undergone mandibular reconstruction, 12 tongue reconstruction, 9 oropharyngeal reconstruction, and 3 buccal mucosal reconstruction. Twenty-eight patients (73.7%) had advanced cancer (stage III or IV), and 34 had been diagnosed with squamous cell carcinoma. Two patients had been diagnosed with osteosarcoma and one with malignant melanoma. Nineteen patients (50.0%) had previously undergone radiotherapy with an average radiation dose of 62.0 Gy (range, 46−70 Gy). None of the patients received anticoagulants.

The median interval from the previous neck dissection was 1 year (range, 2 months-12 years).

The patients were selected for ipsilateral or contralateral anastomosis according to the preoperative plan. Ipsilateral anastomoses were to be performed within the previously dissected neck region in all cases. Vascular anastomoses were attempted if the previous free flap pedicle was useful. Candidate recipient vessels were identified in the ipsilateral previously-dissected neck region based on the operative record and preoperative examination, such as by contrast CT or CT angiography. The presence of vessels seen by preoperative imaging assisted us in making the decision to anastomose in the scar region. In cases where no vessel was available, we always decided on the next candidate in the contralateral neck region or in the inferior neck region. If a total neck dissection had been previously performed and there were no recipient vessels on the ipsilateral side, the contralateral neck was selected as the recipient side.

Statistical analysis was performed with GraphPad Prism software version 6 (GraphPad Software, San Diego, CA, USA). Results were analyzed with Fisher's exact test, and P values less than 0.05 were considered significant.

Operative technique

We propose that recipient vessels within scar tissue should be identified and dissected using a careful and gentle surgical approach. We usually perform this procedure under the microscope because it is relatively easy to distinguish between vessels and scar tissue.

We perform the operation with sharp or blunt dissection as appropriate. Blunt dissection is performed using mosquito forceps, but it is very difficult to detect and dissect scar tissues around vessels. Therefore, we perform sharp dissection with a cold scalpel under the microscope, after which blunt dissection is performed using mosquito forceps when necessary (Figure 1A, B).

The surgical assistant performs countertraction with forceps, which puts tension on the dissection surface and facilitates the operation. This approach also clears the dissection surface, allowing the surgeon to easily perform fine dissection. This also enables the surgeon to perform the dissection with minimal incisional force and reduces the risk of damage to blood vessels.

We sometimes encounter oozing or microbleeding during dissection and use low-power bipolar coagulation forceps for active bleeding. Control of oozing from scar tissue permits a continuous operation.

Results

A rectus abdominis myocutaneous flap was used in 19 cases, an anterolateral thigh flap in 9 cases, a fibula osteoseptocutaneous flap in 4 cases, a combined latissimus dorsi myocutaneous and serratus anterior or rib flap in 4 cases, a forearm flap in 1 case, and a groin flap in 1 case.

Nineteen cases underwent free flap reconstruction. Pedicle flaps were used in 6 cases (pectoralis major myocutaneous and submental flaps). Thirteen cases involved tumor ablation and neck dissection alone.

According to the preoperative plan, we selected the contralateral neck site in 10 cases for the following reasons: in 3 cases, total neck dissection was performed when no ipsilateral recipient vessel was available; in 4 cases, subtotal tongue ablation and contralateral prophylactic neck dissection was performed; and in 3 cases, the defect involved the median mandible, and contralateral prophylactic neck dissection was performed. In these latter cases, the previous anastomosis vessel could not be ligated, and recipient vessels had to be sought on the contralateral side. Ultimately, 9 cases were anastomosed in the contralateral neck side, following our operative plan. The side was changed intraoperatively in one case because vascular anastomosis was possible on the ipsilateral side. The achievement rate was thus 90.0%. There was no statistically significant difference between the two groups.

Anastomosis of the ipsilateral side was planned in 28 cases. Ipsilateral anastomosis was performed within a previously dissected neck region in all cases. Of the 28 cases, 26 were anastomosed on the ipsilateral side. One patient required contralateral anastomosis and one patient was switched to a pedicle flap because we could not achieve flap blood flow. The achievement rate was thus 92.9%. Hence, we were frequently

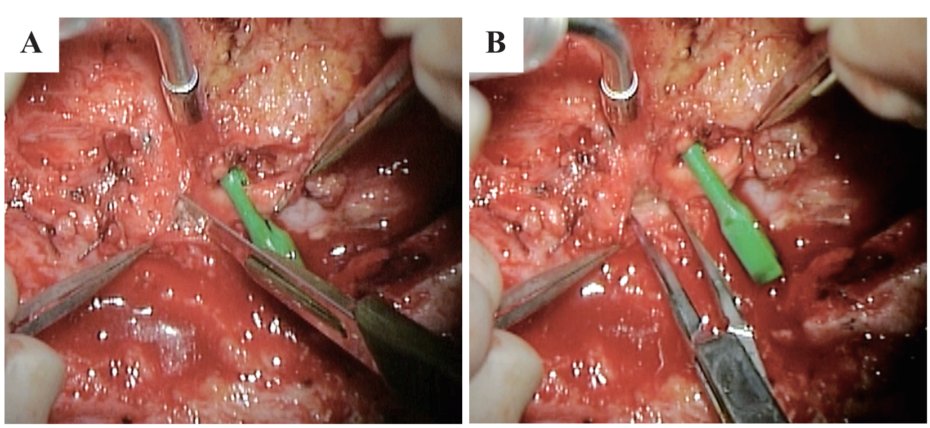

Figure 1. Dissection techniques. A: Arterial dissection performed with a scalpel under the microscope. The assistant performed countertraction with forceps, which puts tension on the dissecting surface and facilitates the operation. B: Blunt dissection using a mosquito clamp.

able to anastomose at the ipsilateral site, in line with the preoperative plan (Table 2).

We also analyzed how often we were able to reuse the pedicle of a previous free flap as the recipient vessel. Twelve patients underwent a secondary free flap operation and were anastomosed on the ipsilateral side. We were able to anastomose four arteries and three veins to the recipient part of previously transferred free flap vascular pedicles. We also anastomosed three arteries and three veins to the donor part of previously transferred free flap vascular pedicles. We used alternative vessels in five arteries and six veins because we could not reuse the previously transferred free flap vascular pedicle or because there was another suitable recipient vessel. We were able to anastomose 58.3% of the arteries and 50.0% of the veins to the previously transferred free flap vascular pedicle (Table 3).

In total, 27 cases (27 arteries and 42 veins) underwent anastomosis to the ipsilateral side. The superior thyroid artery was frequently used as a recipient artery, followed by the previous free flap pedicle (donor/recipient side). The other arteries were facial, lingual, external carotid, and occipital maxillary. The most-used vein was the internal jugular vein, followed by the external jugular vein. The other veins were free flap pedicle (donor/recipient side), common facial, facial, and retromandibular (Table 4). The diameters of these vessels were sufficient.

There were no incidences of thrombosis in this series. We compared the rate of postoperative thrombosis between previously-dissected neck cases and another series of oral microsurgical reconstruction cases from around the same period of time. In 301 cases with no previous neck dissection, there were two cases of thrombosis. There was thus no significant difference versus the cohort of previously dissected neck cases (P=1.000) (Table 5). Vascular anastomosis within a previously-operated neck dissection region did not increase the rate of thrombosis formation.

Postoperative complications occurred in 12 cases (32.4%), wound infection in 7, a fistula in 3, and partial flap necrosis in 2. There were two grade III complications (requiring surgical, endoscopic, or radiological intervention) according to the Clavien-Dindo classification [6]. One patient with a fistula subsequently experienced rupture of the anastomosed artery. This case was salvaged using a pectoralis major myocutaneous flap on postoperative day 14. Another patient with neck wound infection experienced rupture of a carotid artery and underwent embolization. He had no need for additional

Table 2. Achievement rates of contralateral and ipsilateral sites according to the preoperative plan.

Preoperative Planning		Results		Achievement rate
Contralateral*	10 cases	Contralateral	9 cases	90%
		Ipsilateral	1	
Ipsilateral	28	Ipsilateral	26	92.9%
		Contralateral	1	
		Pedicle flap	1	

*Contralateral side: No recipient vessels on the ipsilateral side or needed neck dissection on the contralateral side.

Table 3. Results for reuse of the previously transferred free flap vascular pedicle

		Artery (cases)	Vein (cases)
Former transferred free flap vascular pedicle	recipient site	4	3
	donor site	3	3
Alternative vessel		5	6

Table 4. Recipient arteries and veins

Artery	number	Vein	number
superior thyroid	12	internal jugular	19
facial	2	external jugular	10
lingual	2	common facial	3
external carotid	2	facial	2
occipital	1	retromandibular	2
maxillary	1		
free flap pedicle (donor/recipient)	7	free flap pedicle (donor/recipient)	6

Table 5. Postoperative thrombosis rate

	Thrombosis	
Previously Neck Operated Cases (38 cases)	0 (0%)	No Statistical Difference (P=1.000)
No previous neck dissection cases (301)	2 (0.007%)	

salvage surgery. These two patients were successfully discharged from the hospital. The overall flap survival rate was 97.4%. Complications occurred in eight of the irradiated patients and in four of the nonirradiated patients (P=0.295).

Case

The patient was a 76-year-old woman who had undergone mandibulectomy and suprahyoid neck dissection with scapular flap reconstruction in a previous operation. She received 60 Gy of additional radiotherapy, but relapsed 14 months later and underwent mandibulectomy, full-thickness buccal resection, and inferior neck dissection (Figure 2). We planned reconstruction using the rectus abdominis myocutaneous flap. She had a low body mass index of 19.0, and anastomosis at the inferior neck resulted in a flap containing too little fat tissue to ensure adequate flap volume. Accordingly, we selected a superior neck region within the area of the previous neck dissection. We dissected and prepared recipient vessels under the microscope. We then anastomosed the inferior epigastric artery and thoracodorsal artery, which was located in the previously transferred flap pedicle, and inferior epigastric vein and common facial vein, which was an alternative vessel. We were able to fill an adequate flap volume, without over filling at the defect (Figure 3). The postoperative course was uneventful.

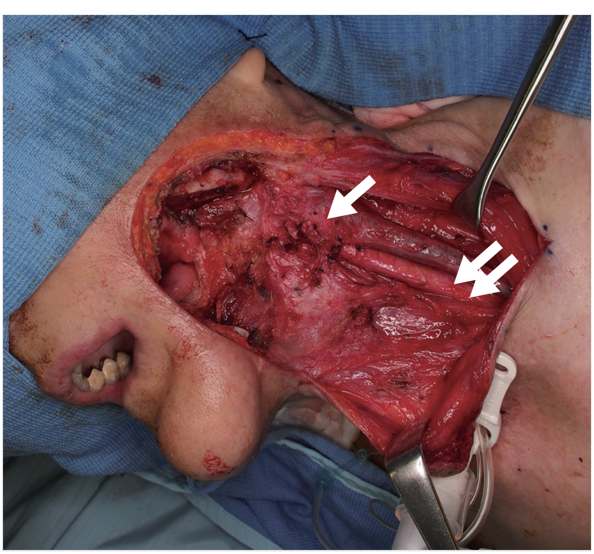

Figure 2. A patient with a full-thickness buccal defect after mandibulectomy and inferior neck dissection. There were two recipient sites, one in the superior neck region within the scar (↑) and one in the inferior neck region (↑ ↑).

Discussion

The success of salvage operations for recurrent head and neck patients relies on margin-free resection and the prevention of postoperative complications. Surgeons performing ablation should avoid downstaging surgery to ensure patients' adequate prognosis. Hence, defects tend to be large and require adequate flap filling. Reconstructive surgeons should also focus on postoperative function when performing the operation.

Advances in microsurgical techniques and modalities have reduced morbidity and improved success rates. Salvage surgery with a second free flap is reliable and guarantees a high success rate (94.7%, 98.7%) [7, 8]. Reliable free flap transfer is the main concern of surgical routine, with functional and aesthetic aspects also playing a role, as in the primary surgery. No

Figure 3. A vascular anastomosis was performed in the superior neck region within the scar. The recipient vessels were the thoracodorsal artery, which was the previously transferred flap pedicle, and a facial vein. We were able to adequately fill the flap volume, without over-filling at the defect.

thrombosis occurred in our series, and only one patient required an additional operation; he was rescued with a pedicled pectoralis major myocutaneous flap. Our overall flap survival rate was 97.4%.

The success of microsurgical free tissue transfers for head and neck reconstruction depends on the quality and location of the recipient vessels [3]. Second free flap operations are performed based on the absence of the availability of some optical vessel near the ablative region and the presence of significant scar tissue in the previously operated neck field. The authors of a publication concerning microsurgical reconstruction in a previously-operated neck advocated various useful recipient sites to solve these problems [1−3, 9].

Almost all of the available literature suggests that previously-operated ipsilateral neck lesions should be avoided because of the disrupted anatomy, scarring, and fibrosis. The following algorithm for avoiding a previously operated neck is readily acceptable. The first choices should be the transverse cervical artery/vein or contralateral external carotid artery and internal/external jugular vein without vein graft. Otherwise, possible recipient vessels are vein grafts to the contralateral neck or the use of the cephalic vein. In some locations, the recipient vessels that can be considered are the internal mammary artery/vein and the superficial temporal artery/vein.

Some publications mention the usefulness of microsurgical anastomoses in a previous neck dissection area [4, 5]. To prevent postoperative complications, the dead space should be filled with a flap that has a large volume of subcutaneous or muscle tissue. In addition, to maintain postoperative function, an adequate skin paddle is needed to achieve the ideal flap form. For this purpose, recipient vessels close to the defect are useful, even those with significant scar tissue. In our patients, we frequently used recipient arteries in the upper neck region that were close to the defect, such as the superior thyroid artery, unless this was the first free flap pedicle. We also commonly used internal and external veins in the upper neck region because they have an adequate diameter and backflow for anastomosis. Circumferential dissection of the internal vein at the scar legion is difficult; thus we usually dissect it only as needed for anastomosis.

Branches of the external carotid artery and the internal/external jugular vein have a dependable anatomical appearance, length, and caliber. Indeed, they are the first-choice recipient vessels for head and neck microsurgical reconstruction. For salvage operations, the recipient vessels should also have a sufficient quality and location for anastomosis. Recipient vessels need to have adequate diameter and flow. If the distance between the expected recipient artery and vein is too short, it is not suitable for microsurgical reconstruction, and alternative options must then be considered, such as recipient vessels in the contralateral neck or inferior neck region.

We believe that preoperative planning is essential for the success of the subsequent microsurgery. Recipient vessels should be identified and confirmed using contrast CT or CT angiography, which can determine which arteries and veins are present in the previously dissected region and can be used as recipient vessels. It is also important to be aware of the previous operative procedure in the surgical records, in terms of the type of neck dissection and the vessel preservation or irrigation performed. In our cases, many anastomoses were performed according to the preoperative plan. The success rate of anastomoses on the ipsilateral side following the preoperative plan was 92.9%. Only three patients required the use of a different side of the neck from that specified in the preoperative planning.

The final decision on whether to use the selected recipient vessels should be made during the operation. Surgeons must determine whether the vessels are of sufficient quality for microsurgery. Vessels that can be identified preoperatively by enhanced CT often have preserved lumens, and their caliber is often sufficient for anastomosis, but in some cases the vessel has no flow and cannot be used as a recipient vessel. Agents such as lidocaine may be applied externally to prevent vasospasm, but another recipient vessel should be chosen if there is no sufficient flow in a reasonable time. For arteries, it is important to ensure that there is enough arterial flow. For veins, it is important to make sure that there is venous backflow. In cases where we have selected a recipient vessel that was the vascular pedicle of the previously transferred free flap, we cut the pedicle and check the arterial bleeding or venous backflow from the cut end of the vascular pedicle. If the arterial bleeding/venous flow is inadequate or the vessel quality is insufficient, we change the recipient vessel to that of the preoperative alternative plan. Indeed, we changed the recipient vessels from the ipsilateral to the contralateral side in one patient. This patient had no suitable vessels for microsurgery in the bilateral neck, so we performed the reconstruction using a pectoralis major myocutaneous muscle flap. It is difficult to determine preoperatively the patency of the branch of the internal vein or the first transferred flap vein relative to the artery; therefore it is essential to check the quality of the vein intraoperatively, or to select an alternative vein, whether internal or external, without hesitation. Nakayama reported that it was more difficult to reuse the vein of a previously transferred pedicle than the artery [4]. Their findings are in line with our experience.

We believe that atraumatic and careful dissection is vital when using recipient vessels in scar tissue. The appropriate use of surgical instruments is essential for atraumatic surgery in dissections within scar tissue, with a need for both sharp and blunt dissection in each operation. Sharp dissection with a cold scalpel is particularly effective for scar tissue. We prefer metallic surgical scalpel handles rather than disposable scalpels because metallic handles have the weight required for dissecting scar tissue without the need for unnecessary force. Scalpel manipulation is performed by delicately gripping the scalpel handle and feeling the difference in your fingertips between the normal tissue, such as vessels, and scar tissue being targeted. It is important to cut the appropriate layers to prevent damage to normal tissue. Sharp dissection with a cold scalpel is more likely to dissect the layers in scar tissues. A microscope and the clear view it provides help to perform this operation.

Irradiated arteries display a significantly greater thickness and higher incidence of intimal dehiscence compared with nonirradiated arteries. Arteries within the scar tissue also show a significantly increased thickness and a higher incidence of intimal dehiscence. In the suture technique recommended by Guelinckx for irradiated arteries, a microneedle is passed through the vessel wall from the inside to the outside to prevent intramural dissection [10]. Microsurgeons should pay special attention to the lumen to check for debris or injury and to ensure full-thickness bites.

The rate of complications in patients undergoing microvascular reconstruction in a vessel-depleted neck was 33.3%–34.5% in previous reports [5, 11]. Hanasono reported that, for subsequent free flaps, these were not significantly different from those observed following the initial head and neck reconstructions [5]. Our frequency of complications was 32.4%. There were also two grade III complications according to the Clavien-Dindo classification [6]. One patient required a salvage operation with a pectoralis major myocutaneous flap and another patient needed carotid artery embolization. These patients were successfully discharged from the hospital. The remainder of the patients were conservatively managed and healed. We had no fatalities.

The influence of preoperative radiotherapy on head and neck free flap reconstruction is controversial, but recent systematic reviews and meta-analyses suggest that preoperative radiotherapy increases the risk of flap failure and postoperative complications such as fistulae and recipient site infection [12–14]. Nonetheless, there is not a significant difference between irradiated and non-irradiated groups in the rate of recipient site vessel thrombosis [12]. Radiation therapy may interrupt normal wound healing mechanisms. Changes in vasculature, effects on fibroblasts, and varying levels of regulatory growth factors result in the potential for altered wound healing if radiotherapy is applied before surgery [15]. Complications such as fistulae and infections related to delayed wound healing may increase the flap failure rate.

It is imperative to use well-vascularized and even bulky tissue to avoid fistulae, wound healing disorders, and surgical reintervention. We believe that sufficient flap filling of dead space, which can be performed by anastomoses close to the ablation site, is important to prevent complications in the operated and irradiated neck.

Head and neck reconstruction with microvascular free flaps is reliable and has a high success rate, whether performed as the initial or subsequent head and neck reconstruction. Intensive perioperative monitoring and immediate re-exploration if necessary are vital. If there are signs of problems with the thrombosed pedicle, flaps can be salvaged with urgent re-exploration and an aggressive approach. However, if the free flap is in a particularly bad condition or congestive, suspected to have an inadequate blood supply, or observed to have partial necrosis or a locoregional infectious condition, another flap or ladder should be chosen to prevent fatal complications and postoperative delays [16, 17].

In terms of flap success, complications can be handled through workhorse flaps and experienced surgical teams. The workhorse flaps include the rectus abdominis myocutaneous, anterolateral thigh, radial forearm, and fibula osteoseptocutaneous flaps [18]. The harvesting of these flaps is relatively simple and straightforward. They come with a long and adequate diameter pedicle and have well-vascularized and even bulky tissue that helps to avoid fistulae, wound healing disorders, and surgical reintervention. For microvascular reconstruction in scarred and vessel-depleted necks, a long pedicle with an adequate diameter is advisable because it is easier to separate arteries and veins. In our series, the frequency of workhorse flap use exceeded 80%, and the rate of frequency of major complications from these workhorse flaps was lower than for other flaps.

Anastomoses in scar tissue areas would seem to hamper success, but they can be safely performed with adequate preoperative preparation and careful dissection under a microscope. Policies aimed at improving the surgical technique and reducing complications enhance patients' quality of life. Microvascular reconstruction has proven to be highly reliable, with consistently low rates of flap failure, even in patients with comorbidities. The expertise of the operating team seems to be the main factor determining flap success [19]. Collaboration between ablative and reconstructive surgeons may improve outcomes due to technical factors and better communication and preoperative decision-making [20].

Conclusion

In microsurgery for oral and buccal reconstruction, anastomoses in the upper neck region are useful for filling dead space and ideal for flap formation when the scar tissue is located close to the defect. Vascular anastomoses within the scar region can be safely performed through careful preoperative planning and sound judgment at the time of operation. Vessels within the scar region and the pedicles of previous free flaps are feasible and safe options for use as the recipient vessels in head and neck microsurgery.

Conflict of Interest

The authors declare that they have no conflict of interest.

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