An Algorithm for Recipient Vessel Selection in Microsurgical Head and Neck Reconstruction

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ABSTRACT

This article details an algorithm we used for selection of recipient vessels in free tissue transfer to the head and neck. Eighty-eight consecutive free flaps to the head and neck were performed in 85 patients. The superior thyroid was the commonest recipient artery used (61%). The facial artery, used in 14% of our cases, is the choice vessel in instances where neck dissection is not performed. In these cases, we have to access the neck separately for recipient vessels and it can be exposed easily via a short (3-cm) incision. The superficial temporal artery (11%) is our choice vessel for patients with previous neck dissection or radiotherapy as it is well outside the previous operative or irradiated field. Other vessels such as the transverse cervical and end-to-side anastomosis to the carotid artery were also used when appropriate. Recipient vein selection depends primarily on the selected artery. Corresponding veins and large branches of the internal jugular vein (IJV) in the vicinity of the selected artery are preferred. When these are exhausted, the external jugular vein and end-to-side anastomosis to the IJV are considered. We found this algorithm to be reliable in identifying the appropriate vessels in all cases.

KEYWORDS: Recipient vessel, free flap, free tissue transfer, reliable, microsurgery

Microsurgical free tissue transfer is the state of the art in reconstruction of complex head and neck defects.[1] Selection of recipient vessels is one of the key decisions in ensuring success of the procedure. The absence of suitable recipient vessels precludes the use of free flaps. It is fortunate that multiple options for recipient vessels exist in the head and neck region.[1–7] Despite this, there is usually a vessel that offers the most straightforward and safe option in each case. An algorithm for selection is useful as it provides a systematic framework for which the most appropriate vessel can be selected based on individual defect requirements. This is a prospective analysis of 88 consecutive free tissue transfers, using an algorithm for the selection of recipient vessels for free flap reconstruction of various head and neck defects.

MATERIALS AND METHODS

From April 2007 to April 2009, 88 consecutive free flaps to the head and neck were performed in 85 patients. Recipient artery and vein were selected based on the

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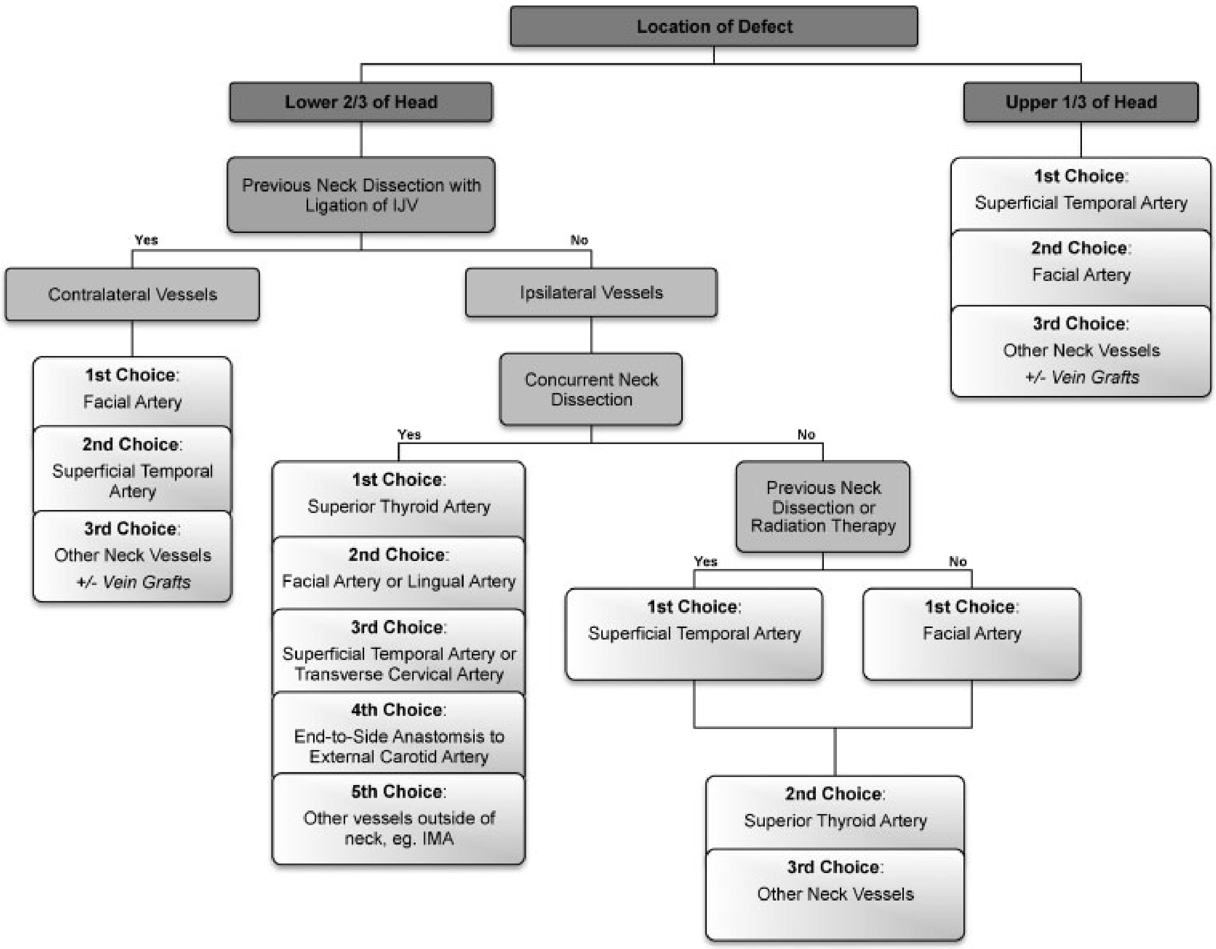

Figure 1 Our algorithm for selection of the recipient artery for head and neck defects. IJV, internal jugular vein.

algorithms presented in Figs. 1 and 2 respectively. These algorithms were formulated based on a combination of past experiences, literature review, and personal communications. Seventy-three patients were male and 12 were female. The mean age was 56 (range 19 to 73). In patients with previous head and neck surgeries, operative records were carefully reviewed and the following, in particular, were noted: duration since previous surgery, previous neck irradiation, previous neck dissection, and whether the internal jugular vein (IJV) was ligated.

Preoperatively, in patients with previous neck surgery and irradiation, the quality of the neck skin was noted. In patients with evidence of radiation-induced skin damages, any unnecessary incision on the irradiated skin was avoided as these tend to heal poorly. Exploration for recipient vessels was therefore planned outside the zone of radiation. In the virgin neck, the external jugular vein (EJV) was marked with a permanent marker. This served as a reminder for the resecting surgeon to preserve or avoid the vein when feasible. When the superficial temporal or facial artery was planned as the recipient vessel, the vessel was palpated and examined with a handheld Doppler. The presence of a strong pulsation upon palpation and a loud, phasic, and pulsatile Doppler signal confirmed the availability of these vessels. These vessels were then marked to aid intraoperative localization.

Once resection was completed, the defect was assessed and the dimensions of the needed flap finalized. The recipient vessels were then explored prior to committing to a free flap as the availability of good-quality recipient vessel is a prerequisite for free tissue transfer. The recipient artery and vein were then mobilized for a length of 1 to 2 cm. Once the recipient vessels were prepared, they were covered and kept moist with papaverine-soaked gauze. Flap harvest was then commenced. When the flap was ready, size match between donor and recipient vessels and adequacy of pedicle length were finalized before the flap was divided. Partial inset of the flap was performed to secure the flap in place. Microsurgical anastomosis could then proceed. With the exception of visceral flaps, we usually performed the arterial anastomosis first. Good venous return from the unrepaired venae comitantes upon completion of the arterial anastomosis confirmed flap viability. This also allowed the surgeon to select the better-flowing vein

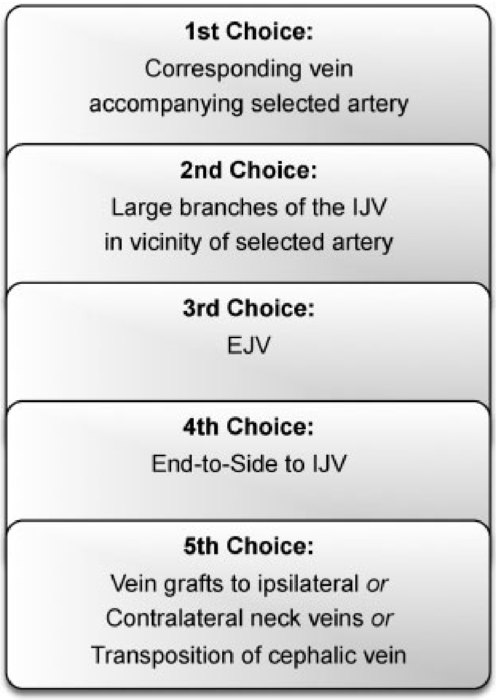

Figure 2 Our algorithm for selection of recipient vein.

Table 2 Arteries Used Based on Algorithm

Recipient Artery Used	*n* (%)
Superior thyroid	54 (61)
Facial	12 (14)
Superficial temporal	10 (11)
Transverse cervical	4 (4)
Lingual	3 (3)
End-to-side to the external carotid	5 (6)
Pectoral branch of the thoracoacromial	1 (1)

for anastomosis if a single venous anastomosis was planned. Upon completion of arterial and venous anastomoses, flap inset was completed and the wounds closed.

RESULTS

Table 1 gives a summary of the flaps used. Table 2 is a summary of the recipient arteries used based on our algorithm. As most of our cases were primary intraoral cancer with neck dissections, the ipsilateral superior thyroid artery was the commonest recipient artery selected (61%; Fig. 3). The facial and the superficial temporal vessels were our preferred vessels when we needed to access and locate the recipient vessels ourselves, as they could be easily exposed via short and inconspicuous incisions in the neck and in the preauricular region, respectively (Figs. 4 and 5). The facial artery was our choice vessel for contralateral defects as it is close to the midline. The superficial temporal was particularly useful in patients with previous neck dissections and irradiation as it is well outside the previous operative field. The transverse cervical (Fig. 6) and end-to-side to the external carotid were used in situations where previous neck dissections and/or free flaps had exhausted the more commonly used vessels.[8] Apart from the vessels mentioned, the only other vessel we used was the pectoral branch of the thoracoacromial artery (Fig. 7) in one case.[3,4,9,10] This was a third free flap for that patient, and other vessels had previously been used. This pedicle was sizable (>1 mm) and could reliably be used.[11] Its use, however, precluded the future option of the ipsilateral pedicled pectoralis major flap.

Table 3 gives a summary of the recipient veins used. Ninety-seven venous anastomoses were performed with two venous anastomoses done in nine patients. The selection of recipient vein depended primarily on the artery selected. The veins accompanying the superficial temporal, facial, and transverse cervical were reliably sizable. These were used in all cases in which these vessels were selected. The vein accompanying the superior thyroid was less predictable. It had a tendency to either merge with adjacent veins of the lingual or facial arteries, forming venous trunks (lingual-facial, thyrolingual, thyrofacial, and thyrolingual-facial trunks), or it was hypoplastic.[12] These trunks were large, making microanastomosis easier. Their location, however, was highly variable and usually not in the immediate vicinity of the superior thyroid artery.[12] One would therefore have to take this into consideration when planning the vessel repair. We used the vein accompanying the superior thyroid in only 21 of our 54 cases (39%). The rest of those cases used other alternatives down the algorithm such as large branches or trunks of the IJV. The EJV was used as the recipient vein in eight cases, where six of these were sole venous anastomosis (Fig. 8).[13] End-to-side anastomosis to the IJV was done in 16 patients. Vein graft was used in one case (1%) in which the contralateral vessels were used.[7] In majority of cases (97%), ipsilateral recipient vessels were used. Contralateral vessels were used in only 3 (3%) cases. In all

Table 1 Types of Flaps Used

Flaps Used	*n* (%)
Anterolateral thigh	43 (49)
Fibula osteoseptocutaneous	26 (30)
Radial forearm	11 (12)
Rectus abdominis	4 (5)
Latissimus dorsi	1 (1)
Scapula	1 (1)
Jejunum	1 (1)
Colon	1 (1)

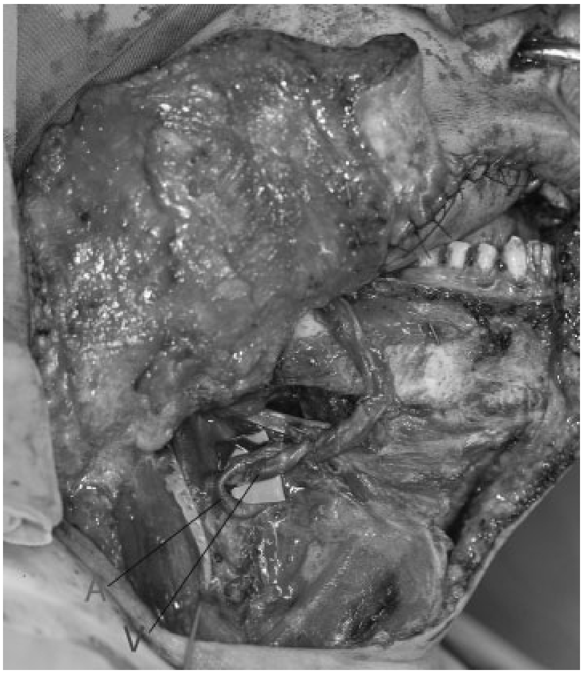

Figure 3 The superior thyroid artery (A) is our preferred vessel for head and neck defects with the neck exposed by neck dissection. It is usually protected within the carotid sheath and therefore not usually damaged by neck dissection. The vessel runs from cranial to caudal toward the thyroid gland and therefore needs to be mobilized sufficiently for transposition cephalically toward the defect. V, vein.

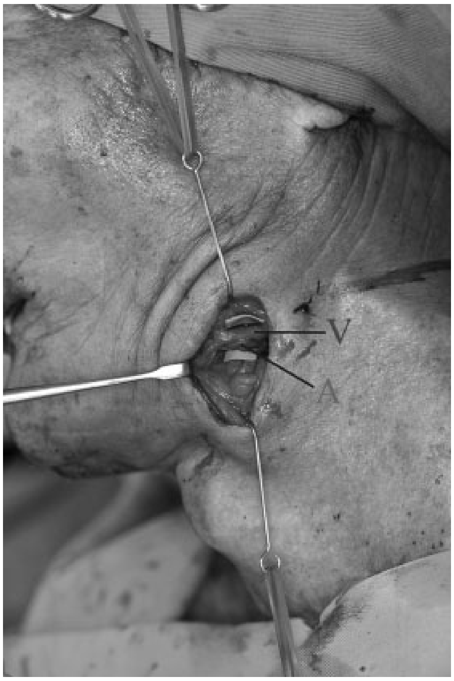

Figure 4 The facial artery (A) and vein (V) can be exposed via a 3-cm incision, 1 cm below the border of the mandible centered on the site over which the artery is palpable. It is the choice vessel for cases where the neck is not dissected as the vessel is superficially located and can be exposed via a small incision. It is also the preferred vessel for contralateral defects as it is the closest vessel to the midline as well as the vessel with the most favorable configuration.

three cases, the primary indication for the use of the contralateral vessels was previous ligation of the ipsilateral IJV and postoperative irradiation of the neck.

Overall flap success rate was 97%. Three flaps failed in two patients (two anterolateral thigh [ALT] flaps and one fibula-osteoseptocutaneous flap). In all cases, failure was not directly related to the recipient vessels used. One failure was due to injury of the perforator supplying the flap. The recipient vessels (superior thyroid artery and a branch of the IJV) were reused for the second free flap. The second patient had recurrent oral squamous cell carcinoma with previous neck dissection and irradiation. Excision resulted in a composite defect that was reconstructed with a free fibula osteoseptocutaneous flap for mandible and oral lining and a free ALT for external skin. The superior thyroid was used as the recipient vessel for the fibula osteoseptocutaneous flap. An end-to-side arterial anastomosis was used for the ALT flap, and this was difficult due to presence of friable atherosclerotic plaque in the external carotid.[14] The end-to-end anastomosis to the superior thyroid was much easier as the end vessel was much less affected by atherosclerosis. On postoperative day 4, the patient suffered a heart attack resulting in severe hypotension and loss of both free flaps. The patient was deemed not fit for further surgery and eventually died of a carotid blowout.

DISCUSSION

In general, healthy vessels of good caliber and distant from irradiated tissues are preferred.[1] The vessels must be dissected atraumatically under loupe magnification and a sufficient length of the vessel mobilized to facilitate easy positioning during microsurgical anastomosis. The vessel must be pulsating well and upon division have

Figure 5 The superficial temporal artery and vein. This is a reliable vessel that can be exposed via a nonconspicuous retrotragal face-lift incision. It is invaluable in cases with previous neck dissection and irradiation as it is outside the zone of radiation and surgery.

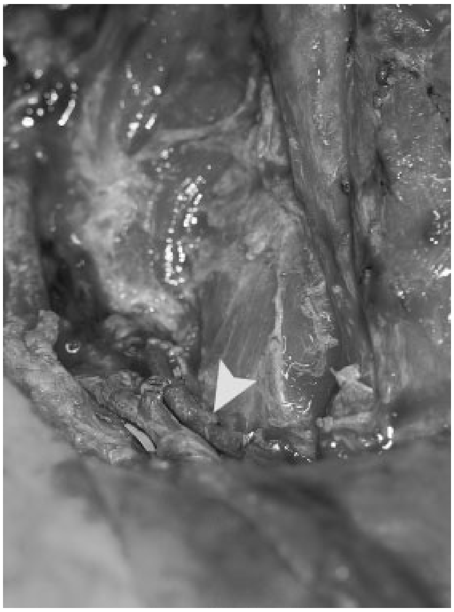

Figure 6 The transverse cervical artery (arrowhead) and vein are usually available in cases when other neck vessels have been used or ligated.

a pulsatile flow as a final confirmation of vessel quality prior to anastomosis. Several sets of recipient vessels are readily available in the head and neck. These are (from caudal to cephalad) the transverse cervical, superior thyroid, lingual, facial, and superficial temporal vessels.[7] The arterial anatomy is quite constant except for the lingual and facial arteries that sometimes arise from the external carotid as a common trunk called the lingual-facial trunk.[15] The superior thyroid is our first choice for lower face defects with concomitant neck dissections. It is favorably sited for lower face defects and usually protected within the carotid sheath and undisturbed by the resection, providing a reliable, untraumatized vessel

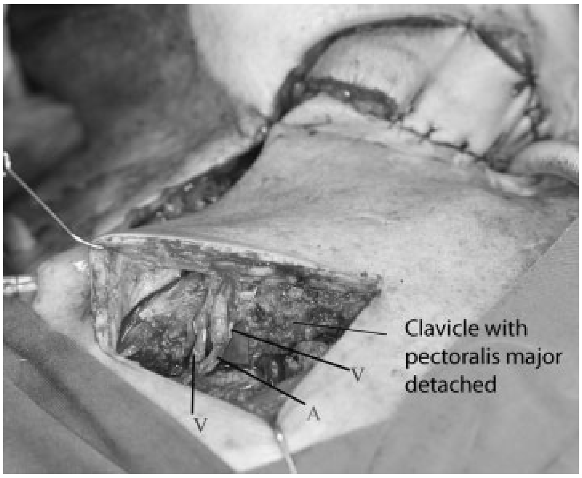

Figure 7 The pectoral branch of the thoracoacromial trunk can be used in the vessel-depleted neck. A, artery; V, vein.

Table 3 Veins Used Based on Algorithm

Recipient Vein Used	*n* (%)
Corresponding vein accompanying the artery:	47 (48)
1. Superior thyroid	21
2. Superficial temporal	10
3. Facial	12
4. Transverse cervical	4
Large branch of the internal jugular vein	25 (25)
External jugular vein	8 (8)
End-to-side to the internal jugular vein	16 (16)
Vein graft to the contralateral neck	1 (1)

for use. As it runs caudally toward the thyroid gland, it must be mobilized sufficiently to allow sufficient length for it to be gently turned cephalically toward the defect without kinking. The vessel should be mobilized at least until the point where it divides into two branches, at which point it becomes significantly smaller. The facial and lingual arteries are used less often in such cases. This is because in cases where mandibulectomy was not done, these vessels are partially covered by the mandible, making access and microanastomosis more difficult.[16,17] In cases where the mandible was resected, these vessels are usually ligated in the resection, leaving only stumps. However, the facial artery is particular useful when no neck dissection is performed. It can be localized by palpation against the body of the mandible and exposed by a 3-cm incision centered directly over the vessel 1 cm below the body of the mandible. The marginal mandibular branch should be identified and

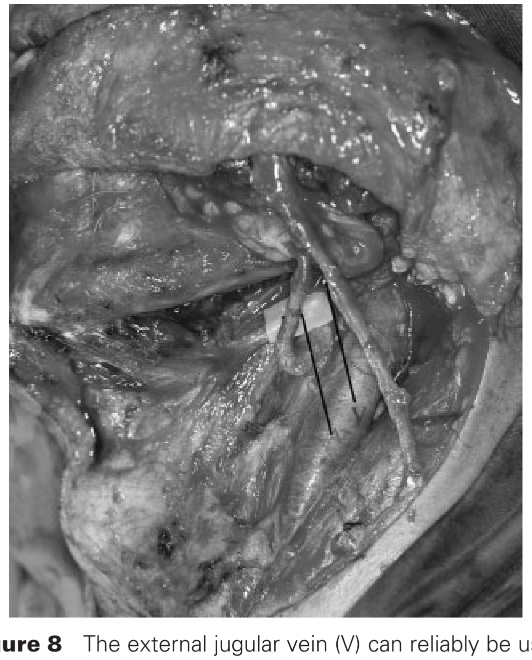

Figure 8 The external jugular vein (V) can reliably be used as the sole recipient vein. In this case, the superior thyroid artery was used as the recipient artery (A).

protected as it crosses the vessel. This nerve is located deep to the platysma muscle but superficial to the artery. The superficial temporal vessel can be readily palpated anterior to the ear above the zygomatic arch. It shows little anatomic variation[18] and is rarely affected by atherosclerosis.[19] The caliber of this terminal branch is smaller than the other branches of the external carotid artery but is quite sufficient for microanastomosis.[20–22] This vessel is particularly useful in cases of previous neck dissection and radiotherapy requiring a free flap as it is outside the zone of dissection and radiation.[23,24] It is reliable as long as the IJV was not ligated in previous surgery. Located within 5 cm of the mandible and oral cavity, it is available not only for upper but also lower head and neck defects, without the use of interpositional grafts.[25]

The transverse cervical artery can be found at the base of the neck just lateral to the lower third of the sternocleidomastoid muscle. This vessel is generally spared by previous neck dissections and is less affected by neck irradiation.[8] It originates from the subclavian artery, which is less affected by atherosclerosis than the carotid system.[26] The vessel passes laterally from its origin across the posterior triangle lateral to the scalenus anterior and the phrenic nerve. The vessel can be traced posteriorly and ligated just prior to its division into the superficial and deep branches. It can then be transposed superiorly and can reach up to the level of the greater horn of the hyoid bone. The transverse cervical vessels can be used even in severely scared neck. The caliber is usually greater than 2 mm in diameter and the longitudinal orientation of the vessels also reduces risk of kinking.[26] Care should be taken during dissection of the vessels on the left side to avoid injury to the thoracic duct.

In the head and neck, we generally prefer end-to-end over the end-to-side technique for the arterial anastomosis.[5] There are several reasons for this. First, vessel mismatch is less of an issue with the artery as it is with the vein. A mismatch of up to 1:2 (usually the recipient vessel being smaller) can easily be tolerated. The tough vessels can be dilated to get a better size match prior to microanastomosis. This means that in most instances, as long as an adequate stump of the recipient vessel is available, an end-to-end anastomosis can be safely and reliably performed. Second, atherosclerosis tends to affect the carotid vessels, and plaque deposition is particularly pronounced within the carotid artery due to intimal microinjury caused by higher and more turbulent blood flow. Performing end-to-side anastomosis into the common or external carotid is unsafe as suturing into the calcified plaque may cause intimal separation. The microfragments of the atherosclerotic plaque can also serve as a nidus for thrombus formation.[27] In such a situation, although the branches of the common carotid are affected, plaque deposition is usually much less pronounced the further the vessel is from the carotid artery. Quality of the vessel at branches of the carotid is therefore relatively better. The prevalence of atherosclerosis is significantly increased in patients with previous cervical radiation therapy, and aggressive screening is recommended.[14] Third, an end-to-end anastomosis supplies a fixed amount of inflow into the flap. This is usually well within the limit that the flap can accommodate. With the end-to-side anastomosis, the amount of inflow depends on the size of the arteriotomy performed on the carotid artery. The larger the arteriotomy, the greater the inflow. Venous congestion from excessive inflow is more likely with the end-to-side technique. Fourth, the neck is a highly mobile area. Performing an end-to-side anastomosis attaches the donor vessel to a relatively fixed recipient vessel (the external carotid artery). This predisposes to kinking and vessel occlusion. With the end-to-end configuration, both the donor and recipient vessels are relatively mobile, giving a greater flexibility, and are more forgiving with perioperative changes in neck positioning. Finally, potential anastomotic failure of major neck vessels like the external carotid can lead to massive bleeding.

Considerations when selecting recipient veins are somewhat different. Generally, we are more liberal with the use of end-to-side anastomosis in veins,[28–31] and vein grafts are avoided when possible.[32–35] As with other areas of the body, the veins of the head and neck accompany their arterial counterpart. However, their exact course is much more variable and they tend to be plexiform, with interconnections and fusion of adjacent veins.[2] The IJV and the EJV are the two main venous systems draining the head and neck. The IJV has the distinct advantage of facilitating venous flow by the suctioning effect of negative intrathoracic pressure generated during respiration.[30,31,36] However, the IJV may occasionally be ligated in radical neck dissection. Even when an IJV-sparing technique like functional or selective neck dissection was performed, a thrombosis rate of 14 to 33% was observed.[37–40] The EJV is a continuation of the superficial temporal vein, retromandibular vein, and the posterior auricle vein. Its superficial location makes it susceptible to compression, but it has been demonstrated to have equal patency rates as the IJV.[13] When feasible, the external jugular should be left in continuity until one is ready for the venous anastomosis. This gives the surgeon the flexibility to adjust the needed length of the vein to allow for a tension-free anastomosis.

Size mismatches are poorly tolerated in veins. Several options are available in such situations. In order of our preference, first the IJV can be explored for larger branches, particularly that of adjacent venous trunks or the retromandibular vein more cephalically. Second, if the EJV has been preserved, this vein can be safely used as the sole recipient vein. Third, an end-to-side anastomosis can be used.[41] Unlike the artery, the vein is never

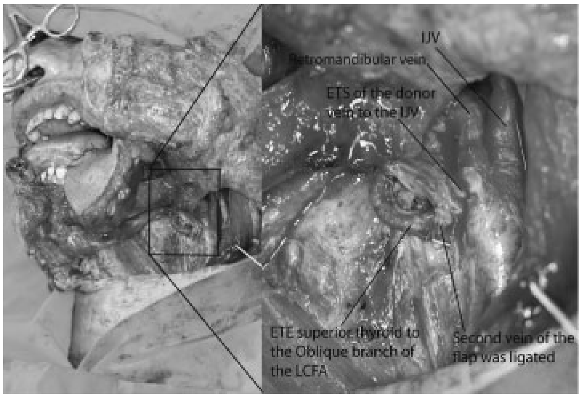

Figure 9 In this case, the anterolateral thigh flap was harvested based on the oblique branch of the lateral circumflex femoral artery (LCFA). The oblique branch was quite small (0.8-mm artery; two veins 0.8 mm and 0.6 mm, respectively). The superior thyroid was used as the recipient artery (1:2 mismatch). The venae comitantes or the artery and other surrounding veins were all significantly larger that the donor vein. The larger (0.8-mm) donor vein was thus anastomosed end-to-side (ETS) to the internal jugular vein (IJV). The flap healed uneventfully. ETE, end-to-end.

atherosclerotic. The keys to using the end-to-side anastomosis in veins are to ensure the size and site of the venotomy are accurate. As the vein tends to decompress significantly with temporary occlusion, the planned site and size of the needed venotomy has to be marked with a marking pen prior to occluding the vessel. The added advantage of the end-to-side technique is that it is the most effective way of overcoming severe vessel mismatch problem (Fig. 9). Apart from being a constant anatomy of large caliber, multiple anastomoses are possible at various levels of the neck. It is crucial to check for the presence of valves at the site of the intended anastomosis. If present, the vein should be cut back into an avalvular segment prior to anastomosis. Ultimately, the technique of anastomosis also depends on the individual surgeon's comfort level and experience. For some surgeons, performing an end-to-side anastomosis to the IJV may be more dependable than an end-to-end anastomosis to relatively smaller vessels.

The pedicle of most flaps usually consists of one artery and two veins. A single vein is usually sufficient for venous outflow in most cases but it is preferable to have two venous anastomoses. Therefore, in instances when two recipient veins are readily available, we would perform both anastomoses. In cases, however, where only a single recipient vein is available, this would still be deemed adequate and safe.[42] Also, in considering venous drainage, an equally important factor is the amount of arterial inflow. End-to-side anastomosis to a high-flow artery such as the external carotid artery would channel much more blood into the flap than an end-to-end anastomosis. The former should thus be avoided if one is only able to perform a single venous anastomosis. In such situations, a single vein may be insufficient to cope with the increased inflow.

The vessels of the contralateral neck can be used when the ipsilateral vessels are unavailable. Yazar reported the use of contralateral recipient vessels in 35% of cases requiring a second free flap for head and neck reconstruction.[7] The use of contralateral vessels are particularly useful in infective cases as it moves the microvascular anastomosis away from the contaminated field.[43] Moreover, in cases where vessels are preserved following selective neck dissection, there may be periadventitial scarring and perioperative thrombosis, which will diminish the quality and limit the choices of ipsilateral neck vessels.[3] Three factors should be considered to minimize the need for vein grafts: selecting a flap with a long pedicle, choosing a recipient vessel that is located most centrally, and appropriately insetting the flap. In flap selection, flaps such as the ALT and the radial forearm that can reliably give a long pedicle of up to 18 cm.[44,45] These flaps are therefore preferred over other flaps with short pedicles. The contralateral facial artery is the closest vessel to the midline and its orientation is also the most favorable. It is therefore the choice contralateral recipient vessel. Finally, insetting the flap in the most favorable position to maximize the reach of the pedicle will enable one to avoid the need for vein grafts in a majority of cases.

Several additional options noted in the literature can be used in the truly vessel-depleted neck.[2–4] The cephalic vein, either as an arteriovenous loop or simply as a recipient vein, is easily harvested from the ipsilateral upper limb and tunneled into the neck.[46–49] The thoracodorsal pedicle can also be transposed into the neck as the recipient vessel.[50] The internal mammary vessel, commonly used in breast reconstruction, can also be used.[2,51–53] The right side is preferred as the vein is more consistent. In double free flaps, the first flap can be used as a source of recipient vessel for the second free flap. This second free flap can be vascularized by either a proximal sizable muscle branch of the flap pedicle (chimeric-type flap) or by the distal runoff of the first flap (sequential chain-linked or flow-through flap).[2,54,55] However, such linking of double free flaps has been demonstrated to be associated with a higher rate of partial and complete flaps loss.[7] Recipient arteries, like the superior thyroid, facial, superficial temporal, and thoracodorsal, have been shown to sustain a flap through retrograde flow.[4,56,57] A favorable pedicle geometry and presence of pulsatile flow from distal ends of the arteries are crucial for successful retrograde anastomosis.[57]

CONCLUSION

Recipient vessel selection is crucial to the success of microsurgical procedures in the head and neck. Although several options exist in most cases, the most appropriate choice makes the entire procedure simple and enjoyable. Conversely, a wrong choice makes an already complex procedure a monumental struggle. The algorithm presented here is a simplified and systematic approach to vessel selection that will help in identifying the best option in each case.

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