



Head and neck microsurgical reconstruction using the superficial temporal vein for antegrade and retrograde drainage: A clinical case series

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Abstract

Background In head and neck microsurgical reconstruction, previous surgery and past radiation exposure to the neck may adversely affect recipient vessel access in the neck. The superficial temporal vessels can be used to overcome these challenges. The purpose of this article is to demonstrate the viability of using the superficial temporal vein (STV) for a double venous anastomosis, for antegrade and retrograde drainage, in head and neck microvascular free flap transfers.

Methods An 11-year retrospective chart review was performed of clinical cases of head and neck reconstruction by free tissue transfer, in which the recipient vessels used were the superficial temporal artery (STA) and vein, with the latter providing for dual antegrade and retrograde drainage.

Results The case series comprised of six patients who underwent free flap reconstruction of craniofacial defects following resection of malignant tumours in five, and due to noma in one. Compromising factors were scarring, radiotherapy, previous surgery and the recipient superficial temporal vein being less than 1 mm in diameter above the parotid. The recipient vessels used were the superficial temporal artery and veins in all cases.

Conclusions The use of the superficial temporal blood supply for a single arterial supply and a dual antegrade and retrograde venous drainage is a reliable technique for free flaps to the upper two thirds of the head. A double venous anastomosis adds to its dependability.

Level of Evidence: Level IV, therapeutic study.

Keywords Retrograde and antegrade superficial temporal venous drainage · Double venous anastomosis · Scalp and cheek microsurgical reconstruction · Large scalp defect · Vessel-depleted neck · Previous radiotherapy to neck

Introduction

Our microsurgical Head and Neck unit performs about 40 reconstructions per year. The neck is a privileged site in terms of providing an abundance of recipient vessels for microsurgical reconstruction. However, scalp reconstruction by a free flap is handicapped by the relative long distance from the neck

recipient vessels. The superficial temporal vessels provide easy alternative access on the other hand, but some concerns have been raised about their reliability. In the last decade, these vessels have found a place not only for free flaps to the scalp, but also for challenges presented by the neck from previous surgery and past radiation exposure.

These vessels were our first choice in several cases. We performed a double venous anastomosis to the superficial temporal vein (STV), creating both antegrade and retrograde venous flow patterns. The aim of this article is to demonstrate, through a review of the clinical cases, the feasibility of using the superficial temporal vein (STV) as recipient for both antegrade and retrograde venous drainage. A further objective was to review the literature on the anatomy of the STV, to determine if reverse flow could occur and if a double venous anastomosis carried benefits over a single venous anastomosis.

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Patients and methods

A retrospective chart review was performed of clinical cases of head and neck reconstruction by free tissue transfer in which the recipient vessels used were the superficial temporal artery (STA) and vein (V), with the latter providing for dual antegrade and retrograde drainage. These cases were subjects operated on by the senior author during the period 2007 to March 2018. Data collected and analysed included demographic profile, tumour and related management profile, surgical reconstructive characteristics, recipient vein morphology and flap outcome.

Results

For the period of assessment, six patients were identified (the cases are summarised in Table 1). The age range was from 14 to 75 years, and there were 2 females and 4 male patients. There were four cases of cutaneous squamous cell carcinoma (SCC), one case of intraoral SCC and one case of cancrum oris. In their past history, three patients had previous radiotherapy at the site reconstruction, and two patients had previous bilateral neck dissections and radiotherapy. A free flap was the first choice for reconstruction. The superficial temporal artery and vein were in the proximity of the reconstruction and were used as recipient vessels. The STV calibre immediately above the parotid gland was less than 1 mm in four cases, and 1 to 1.5 mm in two cases. A single venous anastomosis using a relatively small calibre STV carried a risk of insufficient antegrade venous drainage for the flap. A double venous anastomosis was therefore preferred to the divided ends of the STV to drain it retrograde into the scalp and antegrade through the parotid into the neck.

Case 2 is depicted as a sample case of scalp reconstruction (Figs. 1, 2 and 3), and case 4, a sample case of cheek reconstruction (Figs. 4, 5 and 6) in a patient with previous neck dissection and radiotherapy to the neck. In case 5, a more recent case in which the neck was not compromised, the STA and V were used because the pedicle could not reach the neck without the use of vein grafts. In all cases, there were no postoperative complications, and healing was uneventful.

Operative technique

The superficial temporal artery and vein are exposed and dissected over their course above the level of the parotid gland where they traverse over the zygomatic arch and the lower temporal region of the head (Figs. 3a and 6a). In the event that the dissection needs to be extended, care must be taken not to harm the tributaries of the superficial temporal vein, i.e. the frontal and parietal branches. The vessels are generally not dissected more proximally into the parotid gland itself where

the vessels are expected to be deep in the gland. The superficial temporal vein is divided at an optimum point between the confluence of its tributaries and its entry into the parotid gland—to suit the lie of the donor veins of the free flap (Fig. 3b). The two ends of each vein are anastomosed to two draining veins of the free flap (Figs. 3c and 6b). The recipient vein drainage pattern created is that of normal antegrade flow to the neck through the parotid, and retrograde flow into the scalp. The divided STA is connected end to end to the donor artery of the flap.

Discussion

In microsurgical reconstruction of the scalp and upper lateral two thirds of the face, the superficial temporal vessels provide recipient vessel proximity. [1] Chia et al., in their retrospective analysis of 88 free flaps in head and neck microsurgical reconstruction, said the STA and STV were their first choice recipient vessels for the upper third of the face. [2] Their superficial anatomical position in their course above the superior border of the parotid enables minimal access dissection. However, they may be smaller in calibre than vessels in the neck, and may also vary in anatomy. [3, 4] Dissection of the superficial temporal vessels inferiorly into the parotid gland improves the calibre of the vessels, but this places the facial nerve branches at risk. [5]

The reliability of the superficial temporal as recipient vessels, because of poor quality, calibre, and predisposition to spasm, may be of concern. O'Connell et al. did not use the superficial temporal vessels in any of their case series of 68 free flap reconstructions of the scalp and lateral temporal bone defects; however, no reason for this was given. [6] On the contrary, elsewhere in the literature, there is significant support for the use of the superficial temporal vessels in head and neck reconstructions.

Halvorson et al. demonstrated in their cohort study of head and neck free tissue transfers that with sure knowledge of the anatomy, and proper technique, the STA and V were as reliable in 28 patients as other neck vessels were in 282 patients. [7] Nahabedian et al. in their retrospective analysis of 102 cases for microsurgical reconstruction of the head and neck, used the STA and V in 22 cases. They found that the choice of the recipient vessels did not influence free flap survival. [8] These findings should not take away from the fact that the STA and STV are known to be one of the smaller calibre recipient vessels in the head and neck region. [3, 4] Moreover, the workhorse free flaps of microsurgery like radial forearm flaps, anterolateral thigh flaps, latissimus dorsi and rectus muscle flaps have significantly larger calibre donor vessels, and are likely to generate a mismatch in size for microvascular anastomoses. If required, the smaller size of the STA is easily overcome by the use of a sleeve anastomosis.

Table 1 Case summaries

Number	Age	Diagnosis	Region	Past surgery	Past radiotherapy	Defect size (cm)	Flap cover	Antegrade vein size	Outcome
1	14	Marjolin's ulcer	Scalp	Nil	Nil	16 × 14	Latissimus dorsi	< 1 mm	Uneventful healing
2	66	Recurrent Scc	Scalp	Excision and Ssg	Scalp	11 × 15	Latissimus dorsi	< 1 mm	Uneventful healing
3	72	Recurrent Scc	Scalp	Excision and Ssg	Scalp	10 × 18	Free rectus	< 1 mm	Uneventful healing
4	70	Recurrent Scc	Cheek	Bilateral neck dissection	Radiotherapy to cheek and neck	10 × 9	Free radial forearm	> 1 to 1.5 mm	Uneventful healing
5	16	Cancrum oris	Mid-face–naso-antral–cutaneous fistula	Previous failed free flap, previous neck access for recipient vessels	No	4 × 5	Free radial forearm	> 1 to 1.5 mm	Uneventful healing
6	75	Scc mandible	Oral lining	Previous floor of mouth Scc excised and free radial forearm flap and bilateral neck dissection	Radiotherapy to both sides of the neck	6 × 5	Free radial forearm flap	< 1 mm	Uneventful healing

Scc squamous cell carcinoma, Ssg split skin graft

Venous mismatch also can be overcome by using the smaller of the vena comitans of the donor free flap to anastomose to the STV, but not without potential risk of venous insufficiency when the flap is large. Oh et al. found that in their series, in 4 out of their 19 free flaps to the scalp, the superficial temporal veins were not suitable and they had to exercise other options. [9] Suitability of the superficial temporal as recipient vessels is therefore not a given in all situations.

One of the options for dealing with an unsuitable STV is to use a vein graft from the flap directly to the neck. Erk, in 10 cases of scalp reconstructions with free flaps, used the superficial temporal vessels, but in 2 of them the STV was not suitable, and a vein graft to the neck was required. [10] An interposition vein graft to the neck, bypassing a suitable STV, should also be used when the flap vascular pedicle cannot directly reach the STV. The vein graft should be tunnelled

subcutaneously and drained directly into veins of the neck which are of better quality and calibre. This strategy is not known to adversely affect free flap survival, unless the neck has been compromised.

Compromise can come from previous neck dissections and radiotherapy. Under these conditions, the use of the neck for recipient blood vessels is associated with higher complication rates. [11] The strategy of using the superficial temporal vessels was described by Chia et al. as part of their algorithm for recipient vessel selection in head and neck microsurgical reconstruction. [2] Tan et al. also supported their use from their analysis of 853 head and neck free flap surgery cases. [12] They used the STA and V in 60 of these cases. Shimuzu also demonstrated the reliability of the superficial temporal vessels as a reserve recipient site in vessel-depleted necks in 15 cases. [13] By using the

Fig. 1 a, b A 66-year-old male with a large squamous cell carcinoma of the scalp





Fig. 2 Post-reconstruction view of the lateral aspect of the head is shown

STA and V when free flap vascular pedicles can reach them, vein grafts can be avoided.

However, to make the STV for free flap venous drainage more reliable, the shortcomings of a small calibre vein needs to be overcome—to avoid the risk of venous insufficiency. This study proposes a technique of antegrade and retrograde superficial temporal venous drainage using one vein to establish dual drainage by performing a double venous anastomosis to the transferred free flap.

Does performing a double venous anastomosis as opposed to a single one in head and neck microsurgery offer any advantages? The literature was reviewed to find an answer to this question, and to determine if there were theoretical benefits to the technique of performing a dual venous drainage using the STV.

Futran et al. in a comparative study in 1996 of 47 free radial forearm flaps and a meta-analysis of small number ($n = 218$) of patients, demonstrated no difference in single versus double venous anastomoses. [14] Chen et al., in a large retrospective comparative study in 2014 of 315 patients undergoing an



Fig. 4 A 70-year-old male subject demonstrating the post-excision defect of the cheek

anterolateral thigh flap in head and neck reconstruction, showed a higher revision rate after single anastomoses. [15] Since 2014, there have been three large systematic reviews addressing the controversy of single versus double venous anastomosis in head and neck free flap outcomes. [16–18] All of them demonstrated that a double venous anastomosis improves flap outcome in terms of reduced venous thrombosis, flap revision rates and free flap failure. All three authors recommended performing a double venous anastomosis whenever possible.

The argument against performing a double venous anastomosis for free flap drainage has been anecdotal, thinking that a single venous anastomosis offers better protection against venous thrombosis because of the higher flow rate achieved in

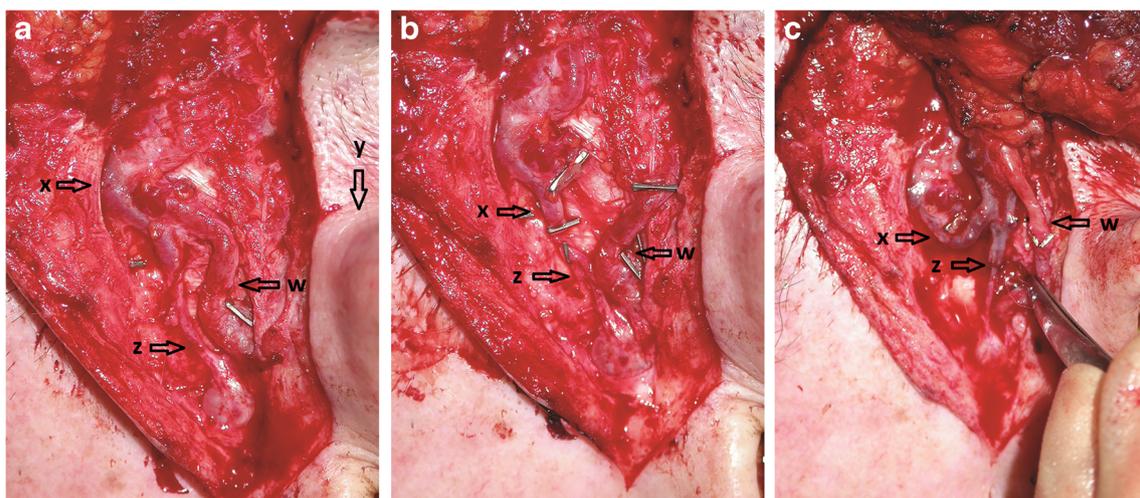


Fig. 3 **a** The STA (w) and STV (x) are dissected anterior to the root of the helix (y) of the ear. Note the very small calibre of the STV (z) just above the parotid gland. **b** The STA (w) and STV are shown divided as (x and z). The STV is divided such that it shows a larger calibre vessel (x) superiorly

and a < 1-mm calibre vessel (z) inferiorly. **c** The anastomosed donor artery to STA (w). Each of the two venae comitantes of the latissimus dorsi flap is drained end to end superiorly (x) (retrograde flow) and inferiorly (z) (antegrade flow)



Fig. 5 Post-reconstruction of the cheek with free radial forearm flap

the single vein. [19] Hanasono et al. demonstrated with the use of intraoperative Doppler that the mean blood velocity in flaps in which one venous anastomosis was performed was greater than the mean blood velocity in either vein, when two venous anastomoses were performed. [20] Flap outcomes were not assessed, and velocity on its own is not an indication of flow rate. Their proposed advantage of a single venous anastomosis can therefore only be a theoretical one. [21]

So, if the superficial temporal vessels are to be used as recipients, using the STV for antegrade venous drainage only, a double venous anastomosis would require adding an interposition vein graft to the neck. An alternative option, as this study is recommending, is to establish an additional retrograde STV flow, thereby serving to augment the classical antegrade superficial venous drainage. The retrograde and antegrade STV flow venous drainage will be in keeping with

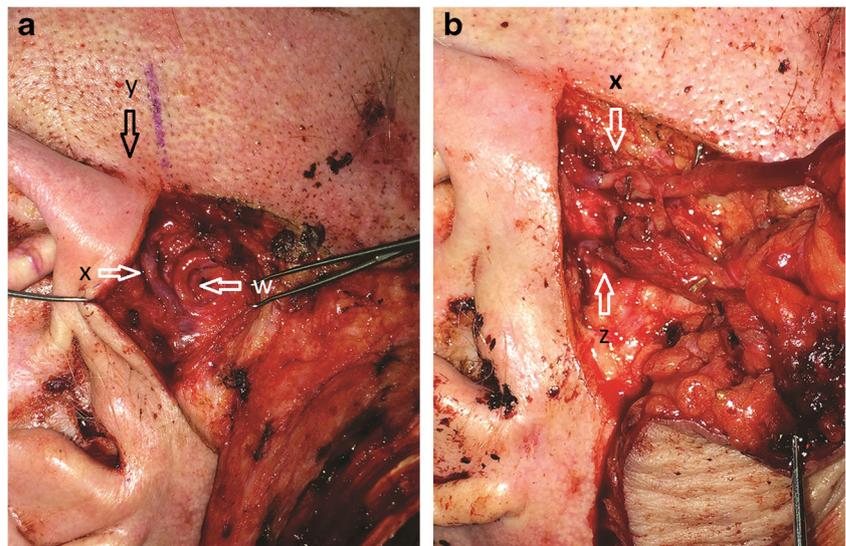
recommendations by recent meta-analyses that promote a double venous anastomosis, offering a significant safety margin without the need for a vein graft to the neck. [16–18] This will also serve as a good solution for vessel-depleted necks as well.

The use of dual drainage for free flaps anastomosed to the STV in this series of cases was born out of necessity. Microsurgical reconstructions of the scalp were the first three cases in the series. In them, the STV segment just above the superior border of the parotid was less than 1 mm in calibre, but more superiorly into the scalp the STV was greater than 2 mm. Donor flap pedicle length was not favourable for a more inferior dissection into the parotid gland to reach a larger calibre section of the vein. A single venous anastomosis at the superior larger section of the STV with a > 2-mm calibre was easily achievable. But, the flow rate limiting inferior portion with a calibre of < 1 mm was going to be the ultimate determinant of venous drainage of the flap. Free flaps invariably provide more than 1 outlet for venous drainage, but the calibre of the veins may vary. Avoiding a vein graft and providing dual drainage as described earlier made theoretical sense, and were therefore used.

Sceptics may still argue that the current study's 100% success in a small group of patients does not prove that the retrograde flow was effective or patent. The retrograde and antegrade flow creation was based on the judgement of an experienced surgeon, that the single exit antegrade flow might not be sufficient. The question that needs answering is, what supportive evidence is there that retrograde STV drainage into the scalp works?

The strategy of using retrograde flow is supported by a study by Shih et al. [22] In a 2013 publication, they demonstrated a 100% success rate in 9 patients with a single retrograde venous drainage to the STV in patients undergoing head and neck free tissue transfer with frozen necks. [22] In their

Fig. 6 **a** The STA (w) and STV (x) are dissected anterior to the root of the helix (y) of the ear. The STV (x) shows a uniform calibre. **b** The flap is drained by the cephalic vein flowing retrograde into the superior end of the STV (x) and a venae comitantes flowing antegrade into the inferior end of the STV (z)



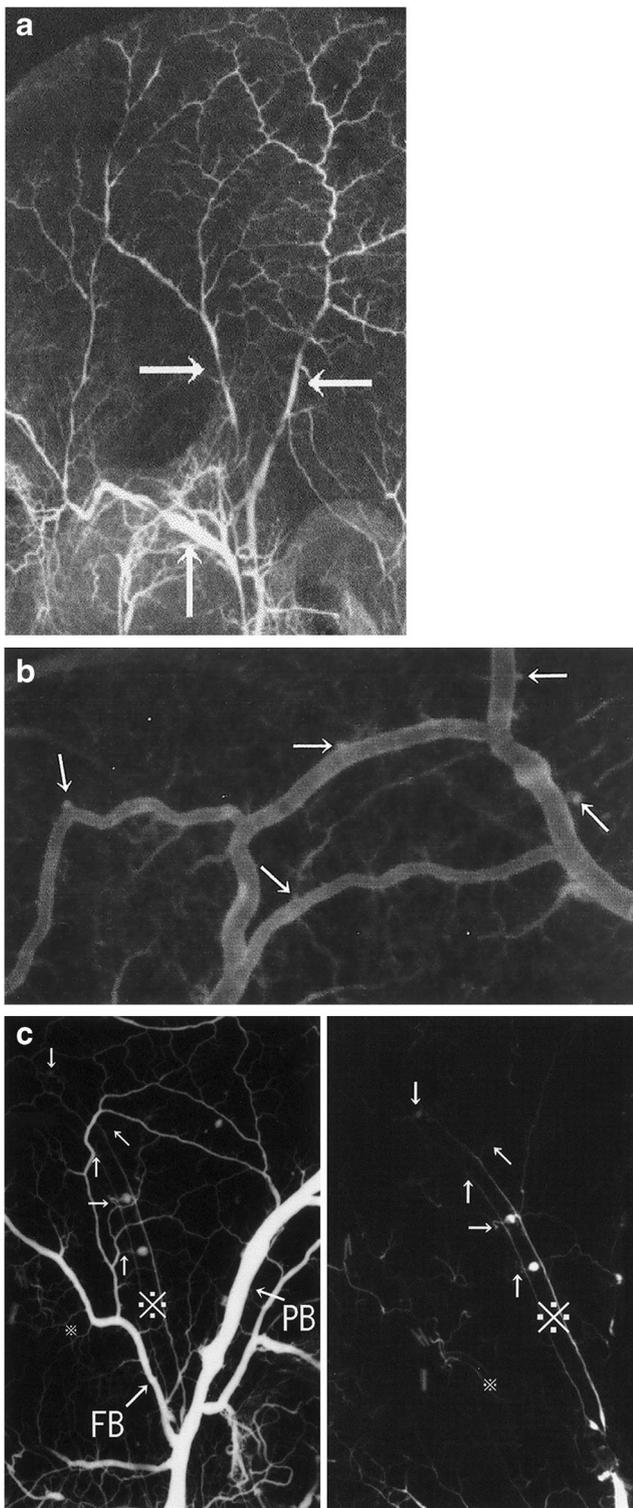


Fig. 7 **a** Venogram showing one of the branching patterns of the STV with smaller branches into polygonal venous network (arrows). **b** Venogram performed after the radiopaque area was flushed with water, showing valves. **c** Venograms of the skin and underlying soft tissue (left) and only the underlying soft tissue (right). Thin parallel veins (*) arose from the superficial temporal vein. Arrows indicate anastomoses between a venous network and thin parallel veins. *FB* frontal branch of the superficial temporal vein, *PB* parietal branch of the superficial temporal vein. All figures under Fig. 7 appeared in a previous publication of Imanishi et al. [23]

article, they promoted their preference for dual venous drainage, but were not able to because their harvested free flap pedicles presented with a single vein only. We share their philosophy in defaulting to the retrograde superficial temporal vein for a frozen neck, instead of the many other microsurgical techniques discussed here and in their article.

Shih et al. do make references to anatomical studies which help explain the reliability of the retrograde STV, but none of which were directly appropriate in describing the anatomy of the STV. The scientific basis for the use of retrograde STV drainage can be found in studies by Imanishi et al. For a better understanding, their findings are summarised below.

Imanishi et al., in a study on the anatomy of the STA and STV using 15 fresh cadavers, provided sound scientific reasoning for our dual drainage strategy using the STV. [23] It was demonstrated that the STA and STV are together at the root of the helix of the ear, but as they pass into the scalp, the branching pattern and distribution pattern may vary. The distribution of the STV is over a larger area of the scalp comparatively than the STA. The STA is instead accompanied by its own small venae comitantes.

Three types of branching patterns, varying from 1, 2 or 3 major branches of the STV, were identified. These major branches gave off further branches which anastomosed with adjacent veins, forming a polygonal venous network in the skin (Fig. 7a). From this network, further numerous smaller veins anastomosed with one another. Venous valves were noted at several anastomotic sites (Fig. 7b). In addition to the polygonal network, two parallel veins were seen branching from the proximal portion of the STV (Fig. 7c). These small parallel veins, which had their own independent branching pattern, were the accompanying venae comitantes of the STA. Importantly, these parallel veins anastomosed freely with the polygonal venous network of the STV within the skin and soft tissues of the scalp.

Imanishi et al. also studied venous drainage of the forearm and scapular region using the same experimental technique. [24, 25] It was postulated that the ease with which the valves in the small veins of the connecting networks in the scalp were demonstrated, suggested that they did not offer much resistance to reflux. On the contrary, in the scapular and forearm studies, the ascending veins connecting the deep and superficial systems offered resistance to reflux. They likened the STV and its branches to the superficial venous system and the venae comitantes of the STA, to the deep drainage system. We know today that in most regions of the body, the deep system is connected to the skin by musculocutaneous and septocutaneous perforators, although this concept per se may not be appropriate to the scalp.

The bulk of the venous drainage of the dermis of the scalp occurs into the polygonal venous network, with the venae

comitantes serving mainly as bypass reserve. In our small series where the STV was used for retrograde flow, the low resistance valves are likely to have allowed for a relatively unobstructed flow between venous networks. Although unlikely, even if we assume that venous drainage of the individual major veins of the other regions of the scalp does not connect directly to each other, the dermis with its rich vasculature itself may be adequate in dealing with shunting venous drainage into other areas of the scalp, ultimately finding its way to the superficial and deep veins of the head and neck.

So, support for the use of superficial temporal retrograde venous drainage in microsurgical reconstruction of the head and neck can be found in studies by Imanishi et al. and Shih et al. Chia et al. produced a good algorithm guide for recipient vessel selection in microsurgical head and neck reconstruction. [2] Further, the value of double venous anastomoses over a single venous anastomosis in microsurgery has been demonstrated in several systematic reviews. [16–18] It follows then that anastomoses of two draining veins of the flap, when available, can be done to the retrograde and antegrade divided ends of STV to achieve dual venous drainage, both under normal and compromised situations. There is an added advantage of ease of access, and it is a solution for a compromised neck. The anatomical territories of the head that can reach it, depending on free flap pedicle length, include defects of the upper two thirds to the lateral lower one third.

Conclusion

The use of the superficial temporal blood supply for a single arterial supply and a dual antegrade and retrograde venous drainage is a reliable technique for free flaps to the upper two thirds of the head. This strategy achieves a double venous anastomosis without the use of more elaborate techniques, and is especially valuable for necks depleted of vessels and/or previous exposure to radiotherapy.

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Compliance with ethical standards

Ethical approval Approval number BE 291/13 was obtained from the university's Biomedical Research Ethics committee.

Conflict of interest M. Daya and T. Pillay have no financial disclosures and report no conflicts of interest with any of the companies or products mentioned in this article.

Patient consent Patients provided written consent for their inclusion in this study. Additional consent was obtained for the use of patient's images.

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