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CLINICAL ARTICLE

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The retrograde transverse cervical artery as a recipient vessel for free tissue transfer in complex head and neck reconstruction with a vessel-depleted neck

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Background: Reconstruction in a vessel-depleted neck is challenging. The success rates can be markedly decreased because of unavailability of suitable recipient vessels. In order to obtain a reliable flow, recipient vessels away from the zone of fibrosis, radiation, or infection need to be explored. The aim of this report is to present our experience and clinical outcomes using the retrograde flow coming from the distal transverse cervical artery (TCA) as a source for arterial inflow for complex head and neck reconstruction in patients with a vessel-depleted neck.

Methods: Between July 2010 and June 2016, nine patients with a vessel-depleted neck underwent secondary head and neck reconstruction using the retrograde TCA as recipient vessel for microanastomosis. The mean age was 49.6 years (range, 36 to 68 years). All patients had previous bilateral neck dissections and all, except one, had also received radiotherapy. Indications included neck contracture release ($n = 3$), oral ($n = 1$), mandibular ($n = 3$) and pharyngoesophageal ($n = 2$) reconstruction necessitating free anterolateral thigh ($n = 3$) and medial sural artery ($n = 1$) perforator flaps, fibula ($n = 3$) and ileocolon ($n = 2$) flaps respectively.

Results: There was 100% flap survival rate with no re-exploration or any partial flap loss. One case of intra-operative arterial vasospasm at the anastomotic suture line was managed intraoperatively with vein graft interposition. There were no other complications or donor site morbidity during the follow-up period.

Conclusions: In a vessel-depleted neck, the reverse flow of the TCA may be a reliable option for complex secondary head and neck reconstruction in selected patients.

1 | INTRODUCTION

The head and neck is one of the most highly vascularized regions in the body. The two major vascular sources in the head and neck regions are the branches of the external carotid system (superior thyroid, facial, occipital, posterior auricular, superficial temporal artery, and maxillary arteries) and those of the thyrocervical trunk (inferior thyroid, suprascapular, dorsal scapular, and transverse cervical artery). Out of these, the commonly preferred neck recipient vessels are facial, superior thyroid, and transverse cervical vessels.

For successful free tissue transfer, proper selection of recipient vessels is one of the most critical factors. Because of the availability of multiple options, identification of suitable vessels is not an issue in cases of initial reconstruction. However, in patients with history of prior irradiation and/or neck dissection and need for secondary reconstruction because of cancer recurrence or flap failure, recipient vessel identification and dissection is an arduous task (Head et al., 2002;

Jacobson, Eloy, & Park, 2008; Takamatsu, Harashina, & Inoue, 1996; Wei, Demirkan, Chen, & Chen, 1999; Yazar et al., 2005; Yazar, 2007). A vessel depleted neck, where the standard recipient vessels are unavailable or unsuitable, can prove to be a major stumbling block to successful microsurgical reconstruction.

In our unit, the transverse cervical artery (TCA) is one of the preferred recipient artery options for microvascular tissue transfer in secondary head and neck reconstruction. The TCA is located at the base of the neck and provides the dominant blood supply to the trapezius muscle. Before supplying the trapezius muscle, the TCA divides into a superficial (STCA) and a deep (DTCA) branch (Cordova et al., 2008). However, in certain situations the antegrade flow is affected by fibrosis and radiation making the vessel small, scarred, and therefore unsuitable for microanastomosis. Even in patients who have had a neck dissection, the distal TCA is commonly preserved and can prove to be a useful recipient artery.

Herein, we report our experience with the use of the retrograde flow coming from the bifurcation of TCA, STCA, or DTCA for complex microsurgical head and neck reconstruction in nine patients with a vessel-depleted neck.

2 | PATIENTS AND METHODS

A total of nine patients with a vessel-depleted neck, who underwent secondary head and neck reconstruction using the reverse flow of the transverse cervical artery between July 2010 and June 2016, were included in this report (Table 1). The mean age of patients was 49.6 years (range, 36 to 68 years). All patients had underwent bilateral neck dissections prior to the reconstruction and an overwhelming majority (8 out of 9 patients) also had previous radiotherapy. In all patients, external carotid branches and the proximal TCA were not readily available or were found to be unsuitable for anastomosis. The decision to use the reverse transverse cervical artery (rTCA) was made intraoperatively after observation of an adequate diameter for microanastomosis and confirmation of adequate flow. Indications included neck contracture release ($n = 3$), oral ($n = 1$), mandibular ($n = 3$), and pharyngoesophageal ($n = 2$) reconstruction necessitating free anterolateral thigh ($n = 3$) and medial sural artery ($n = 1$) perforator flaps, fibula ($n = 3$) and ileocolon ($n = 2$) flaps respectively. Active smokers, cases of primary reconstruction and those with medical contraindications did not qualify as candidates for this technique. The chart review was undertaken in accordance with the standards of the Declaration of Helsinki after informed consent was taken from all the patients.

2.1 | Surgical technique

After confirmation of adequate retrograde flow from the distal end by performing a spurt test (Video 1), microanastomosis was done in an end-to-end fashion in all the cases. Direct anastomosis to the retrograde limb of STCA, DTCA, or TCA bifurcation (Figure 1) was possible in all cases except one, in which we had to use a short interposition vein graft. Venous anastomoses were performed in end-to-end fashion to either a transposed cephalic vein or a internal jugular vein (IJV) branch. After microanastomosis and confirmation of perfusion, the skin bearing flaps were de-epithelialized to match the skin requirements of the defect. Intestinal flaps were covered by a deltopectoral flap and split thickness skin graft. A penrose drain was inserted to avoid any fluid collection. Flap monitoring was done in the microsurgical intensive care unit for the first 72 hours and subsequently in the ward. Postoperative follow-up was performed every 2 weeks during the first 3 months and subsequently every 3 months for the first year.

3 | RESULTS

The mean time for exploration and preparation of the recipient artery was 36.1 minutes (range, 25 to 60 minutes). The average length of the rTCA pedicle was 3.7 cm (range, 3 to 5 cm). The recipient vein was a branch of IJV in 3 cases, while in the remaining 6 cases, cephalic vein transposition was used for venous drainage. Intraoperative vasospasm of the artery after microanastomosis, most likely because of tension on the suture line, was observed in one patient. This patient was successfully managed by interposing a short (5 cm) lesser saphenous vein graft. All flaps survived completely without any partial flap loss or need for reexploration. There were no instances of delayed wound healing or any other donor site morbidity. The average length of hospital stay was 21.1 days (range 19 to 24 days) and the mean follow-up time was 12 months (range, 8 to 20 months).

4 | CASE REPORTS

4.1 | Case 1

A 43-year-old male with a history of oral cancer and multiple prior reconstructions (including two free fibulae, a free latissimus dorsi and a free radial forearm flap) presented with microstomia, plate exposure and severe neck contracture (Figure 2A,B). The patient had also underwent bilateral neck dissections and radiotherapy. Release of extensive contractures and coverage with a large anterolateral thigh flap (ALT) was planned. The commonly used recipient neck vessels were unavaible. The right TCA had been previously used. Therefore, we explored the TCA at the base of the left neck, and found its proximal segment scarred and of inadequate caliber. Since neither the thoracoacromial nor the internal mammary vessels would reach the flap pedicle without a long vein graft, meticulous dissection was continued distally on the TCA to a segment with a healthy vessel wall. After extensive adventitiectomy and lidocaine irrigation, the artery—STCA—appeared of adequate caliber to match the ALT pedicle. Upon division of the vessel, the flow from the proximal end was insufficient. There was, however, pulsatile flow from the distal end with a spurt of 6 cm confirming its suitability for microvascular anastomosis. End-to-end anastomosis was performed to the donor artery, while an IJV branch was used for venous drainage. Postoperatively, the flap survived completely and the patient had an uneventful recovery. At 20 months of follow-up, the patient was satisfied with mouth opening and range of motion of the neck, and he refused further interventions (Figure 2C,D).

TABLE 1 Demographic data, clinical information, intraoperative details and outcomes

Sex	Age	History	Pathology	Procedure	Prior neck dissection	Free flap	Size of skin paddle (cm)	Pedicle rTCA length (cm)	rTCA-recipient artery	Recipient vein	Vein graft (cm)	Flap survival	Complications	Follow-up (months)	Functional outcomes achieved
M	43	SR + RT	Neck contracture	Contracture Release	Bilateral	ALT	20 x 11	4	Left rSTCA	IJV-b	NO	YES	None	20	Supple Neck
M	63	SR +RT + PFF	Buccal cancer with recurrence	Mandibulectomy	Bilateral	Fibula	8 x 24	3	Right rDTCA	IJV-b	NO	YES	None	12	Stable mandibular continuity with good form
M	51	SR + RT	Neck contracture	Contracture Release	Bilateral	ALT	28 x 10	4	Left rDTCA	CVT	NO	YES	None	9	Supple Neck
M	49	SR + RT	Neck contracture	Contracture Release	Bilateral	MSAP	16 x 7	5	Right rDTCA	CVT	NO	YES	Intraoperative vasospasm	15	Supple Neck
M	51	SR + RT + PFF	Hypopharyngeal cancer	Pharyngoesophageal reconstruction	Bilateral	Ileocolon	–	4	Right rSTCA/DTCA	CVT	YES (5 cm)	YES	None	8	Resumption of oral diet/Progressing succesfully through speech therapy
F	47	SR + RT + PFF	Pharyngocutaneous fistula	Pharyngoesophageal reconstruction	Bilateral	Ileocolon	–	3	Left rSTCA/DTCA	CVT	NO	YES	None	16	Resumption of oral diet/Intelligible speech
M	68	SR + RT	Oral floor cancer with recurrence	Intraoral and lip reconstruction	Bilateral	ALT	22 x 12	3	Right rSTCA	CVT	NO	YES	None	12	Oral competence/ Normal tongue excursion
M	39	SR + RT	Osteoradionecrosis	Mandible reconstruction	Bilateral	Fibula	16 x 8	4	Right rDTCA	CVT	NO	YES	None	18	Stable mandibular continuity with good form
M	36	SR	Osteoradionecrosis	Mandible reconstruction	Bilateral	Fibula	22 x 9	4	Left rSTCA/DTCA	IJV-b	NO	YES	None	10	Stable mandibular continuity with good form

ALT, anterolateral thigh; CVT, cephalic vein transposition; IJV-b, internal jugular vein branch; MSAP, medial sural artery perforator; PFF, previous flap fail; rDTCA, retrograde deep transverse cervical artery; rSTCA/DTCA, bifurcation rSTCA/DTCA; rSTCA, retrograde superficial transverse cervical artery; RT, radiotherapy; rTCA, retrograde transverse cervical artery; SR, secondary reconstruction.

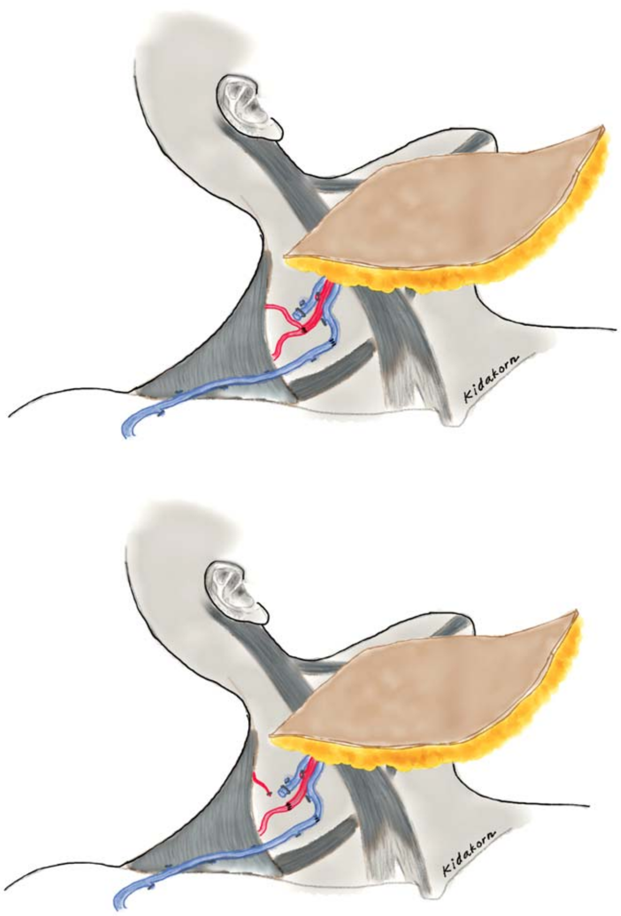

FIGURE 1 Illustration of recipient arterial anastomotic options. A, Microsurgical anastomosis between bifurcation of the retrograde TCA and the flap pedicle. B, Deep branch of retrograde TCA anastomosed to the flap artery. Cephalic vein transposition used as recipient vein in both cases

4.2 | Case 2

A 51-year-old male with a hypopharyngeal cancer initially underwent total pharyngolaryngectomy followed by radiation. He was referred to our clinic after a failed attempt at reconstruction with ALT (Figure 3A). In accordance with the patient's desires, a simultaneous phrayngoesophageal and voice reconstruction with a free ileocolon flap was offered. Because of the positioning of the flap and therefore direction and length of the ileocolic pedicle, a recipient artery in the right lower neck was required. The proximal segment of the right TCA was compromised by scarring and deemed unsuitable for anastomosis. Anastomosis to the internal mammary and thoracoacromial vessels required a relatively long vein graft. Also, the vein grafts were at risk of kinking and compression by the ileocolon flap itself because of edema, especially in the early postoperative period. Therefore, further distal dissection on the TCA was undertaken to identify a healthy segment. The vessel was divided at the junction of the compromised proximal and healthier distal parts. Antegrade flow from the proximal end was meager, whereas retrograde arterial flow from the distal end was robust. To match the relatively large ileocolic artery, the TCA bifucation site was used for end-to-end anastomosis. A cephalic vein transposition was used for venous drainage (Figure 3B). The flap survived completely (Figure 3C) and at 8 months follow-up the patient was able to swallow and was successfully progressing through the speech training program (Figure 3D).

5 | DISCUSSION

The head and neck regions have an extensive bilateral vascular network offering multiple options for revascularization of flaps in primary cancer reconstruction. This holds true even in the setting of secondary reconstruction after primary flap failure or cancer recurrence (Demirkan, Wei, Chen, Chen, & Liao, 1999; Takamatsu et al., 1996). However, scarring from previous surgery or radiotherapy may lead to fibrosis and render potential recipient vessels unreliable for microanastomosis. It has been reported that fibrosis of recipient vessels can be the greatest adverse predictive factor in head and neck free tissue transfer (Head et al., 2002). Thus, for optimum outcomes it is of paramount importance to choose recipient vessels that are located in unviolated areas and are free from fibrosis.

The development of microsurgical techniques for identification and exposure of optimal vessels has facilitated management of extensive head and neck defects (Hanasono, Barnea, & Skoracki, 2009). The ipsilateral external carotid artery sytem is usually preferred for arterial inflow. If this is unavailable, the TCA is a reliable alternative and has… as the "best recipient vessel" for head and neck reconstruction by Urken, Vickery, Weinberg, Buchbinder, and Biller (1989). Alternative recipient sites that have been suggested when ipislateral TCA is unsuitable include: ipsilateral superficial temporal artery (STA), ipsilateral thoracoacromial branches, ipsilateral internal mammary artery, contralateral neck vessels, and even branches of a previous or simultaneous flap (Hanasono et al., 2009; Miller, Schusterman, Reece, & Kroll, 1993). While all these sources can provide a reliable arterial inflow, they often require additional incisions and sometimes long interposition venous graft to brigde the arterial gap (Biemer, 1977; Furr, Cannady, & Wax, 2011). Use of interposition vein grafts (IVG) in head and neck reconstruction remains controversial (Kruse, Luebbers, Gratz, & Obwegeser, 2010). Furr et al. (2011) reported 95% free flap survival rate with the use of IVGs in head and neck reconstruction. On the other hand, other authors have reported up to 24% free flap loss when IVGs are used, especially in salvage cases (Nelson et al., 2015). In a review article examining the literature on prevention and treatment of thrombosis in microvascular surgery, Hanasono and Butler (2008) considered vein graft use an unfavorable condition and suggested use of antithrombotic agents prophylactically after risk stratification. In addition, to the risk of thrombosis, other disadvantages of IVG use include donor site scarring and increase in operative time because of vein graft harvest and additional microanastomosis.

During recipient vessel exploration in a hostile neck with prior radiation, neck dissection, failed reconstruction, or cancer recurrence, we methodically search for reliable vessels as suggested in the literature (Urken et al., 1989). In this setting, pristine vessels outside the

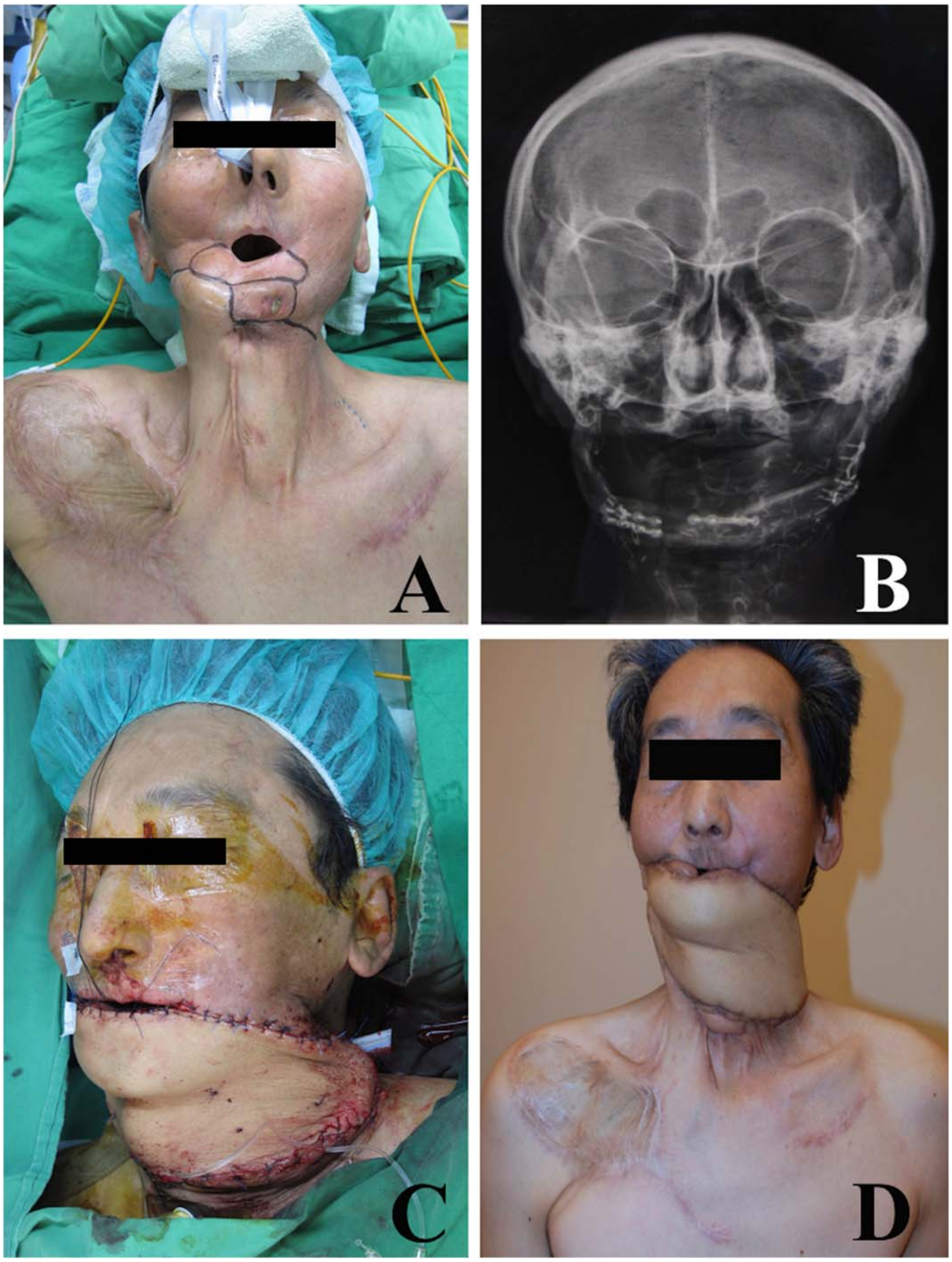

FIGURE 2 A, The preoperative image showed microstomia, plate exposure and severe neck contracture. B, Radiogram showed previous two fibular reconstructions. C, Inmediate postoperative picture showed reconstruction with a large anterolateral flap anastomosed to the left rTCA. D Post-operative picture at twenty months of follow-up

area of fibrosis and scarring are a prerequisite for successful secondary reconstruction. If the pedicle of the flap is long enough to reach ipsilateral thoracoacromial/internal mammary vessels or contralateral recipient sites, either directly or through a small IVG, then no further exploration is required. However, if instead a long IVG is required to reach these vessels or when these vessels are not available, the proposed technique presents that avoids the risk of kinking or compression incurred by the vein graft. Also, it obviates the need for additional scars often required for IVG harvest and exposure of distant recipient sites.

When the proximal TCA was found to be compromised or unsuitable for anastomosis, we continued our exploration distally along the vessel. The segment of TCA outside the zone of "injury" was commonly noted to not only be of larger caliber, but also with stronger pulse. When the vessel was divided at this level, the flow from the proximal segment was tenuous, whereas a pulsatile flow from the distal segment

FIGURE 3 A, Voice reconstruction with free ileocolon flap was planned. B, Ileocolon flap transferred to the hypopharynx and perfused by the right rTCA artery. C, At ten days, post-operative picture showed a viable flap with complete take of overlying skin graft. D, At eight months of follow-up, picture showed the patient adjusting pressure on the voice tube as part of the speech training program

(rTCA) was detected. The rTCA was deemed reliable for microanastomosis, only if there was a good size match with the donor pedicle and the spurt test was adequate (at least 5 cm).

Neligan, She-Yue, and Gullane, (1997) and Holzle et al. (2009) have previously reported that use of the reverse flow of facial artery can serve as a good alternative for microsurgical anastomosis. To the best of our knowledge, the current series is the first to report use of the rTCA as a "salvage" recipient artery for head and neck reconstruction in a vessel-depleted neck. The trapezius muscle is principally supplied by three vascular sources: the transverse cervical artery (dominant blood supply), the dorsal scapular artery, and the posterior intercostal arterial branches. Interconnections between these vascular networks provide the anatomical basis for the rTCA (Yang & Morris, 1998). The TCA is a branch of the thyrocervical trunk and in a minority of cases may arise from the subclavian artery directly. It runs posteriorly and laterally toward the trapezius muscle. Before reaching the trapezius muscle, the TCA divides into two branches: a superficial transverse cervical artery (STCA) for the upper part of the muscle and a deep transverse cervical artery (DTCA) for the lower (Cordova et al., 2008). Because the distal segment of TCA and its branches are spared the deleterious effects of irradiation and/or neck dissection, they maintain their original caliber, which is often a reasonable match with the donor pedicle. Alternatively, the increased diameter of the TCA bifurcation area can be exploited to achieve a better match.

Since this technique is employed in complex secondary reconstructions, it is not surprising that the dissection of the recipient artery is somewhat technically challenging. The deep location of the artery may sometimes add to the complexity of the dissection and microanastomosis. Careful dissection with the help of microscope is very useful in these cases. The tissue planes surrounding the distal segment of TCA are generally well defined and healthier than the proximal. Therefore, the TCA is exposed just outside the zone of fibrosis and is followed in an antegrade fashion towards the trapezius muscle. In our report, we just had a single instance of interposition of a short segment of vein graft to relieve tension on the anastomosis that had led to arterial spasm. In all other cases, direct anastomosis was perfomed with the ipsilateral rTCA without interposition of a vein graft. To this effect, attention was paid to harvesting flaps with longer pedicles and strategic placement of the flap at the time of inset.

The specific risk of thoracic duct damage with the use of antegrade TCA as a recipient artery on the left side has been reported by Yu (2005). Inadvertent injury of the thoracic duct during exploration of the proximal TCA is possible in the setting of a scarred neck because of distorted anatomy and obscured planes of dissection. As the STCA/DTCA are located much more posteriorly and closer to the trapezius muscle, avoidance of the scar tissue over the proximal TCA, in close proximity to the thoracic duct, is an advantage in this regard. In our series, we had 4 cases of left sided recipient vessels, but there was no incidence of thoracic duct injury. To avoid injury to the thoracic duct, exploration should start at the level of the supraclavicular fat pad and continue with gentle blunt dissection preferably under magnification.

This report is not without limitations. In the current series, the mean age of the patients was 49.6 years. This may give the impression that younger patients were preferentially selected for this report. However, the region from which this study has been reported has a high incidence of betel nut chewing (Adel et al., 2016; Guo et al., 2013). As a result, the head and neck cancers are diagnosed at a younger age and recurrences/second primary cancers are not uncommon. Similarly, the fact that we elected to exclude smokers may be perceived as a selection bias. While smokers are in general at increased risk for developing complications after free tissue transfer, TCA may still be a viable option in this group. We elected to limit the application of this method to nonsmokers first, as this is a small series exploring a new recipient pedicle in the unfavorable scenario of a vessel-depleted neck. Even though this series is admittedly of limited size, we believe it adds a "salvage", yet reliable, recipient vessel option to the armamentarium of the reconstructive surgeon dealing with challenging head and neck cases. The rTCA pedicle, by its location in the ipsilateral lower neck, avoids additonal scarring and vein graft use in most cases. A larger series will allow a deeper scrutiny of the rTCA pedicle characteristics and may possibly establish it as a viable option in the algorithm for recipient vessel selection in complex cases.

6 | CONCLUSION

The reverse flow TCA was found to be a reliable recipient option in a vessel-depleted neck. This technique may provide an alternative neck recipient site that obviates the need for long vein grafts to reach distant recipient vessels. We advocate its use as a salvage option when other more common alternatives are either unavailable or less favorable.

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CONFLICT OF INTEREST

None of the authors received any funds or has any financial interests to disclose.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

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