# Transverse Cervical Artery: Consistent Anatomical Landmarks and Clinical Experience with Its Use as a Recipient Artery in Complex Head and Neck Reconstruction



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**Background:** Many head and neck reconstructions occur in patients with extensive history of surgery or radiation treatment. This leads to complicated free flap reconstructions, especially in choosing recipient vessels in a "frozen neck." The transverse cervical artery is an optimal second-line recipient artery in head and neck reconstruction.
**Methods:** Seventy-two neck sides in 36 cadavers were dissected, looking for the transverse cervical artery and transverse cervical vein. Anatomical location of these vessels, their diameter, and length were documented. A retrospective analysis on 19 patients who had head and neck reconstruction using the transverse cervical artery as a recipient artery was undertaken as well with regard to outcome of procedures, reason for surgery, previous operations, and use of vein grafts during surgery.
**Results:** The transverse cervical artery was present in 72 of 72 of cadaveric specimens, and was infraclavicular in two of 72 specimens. Transverse cervical artery length ranged from 4.0 to 7.0 cm, and the mean diameter was 2.65 mm. The transverse cervical vein was present in 61 of 72 cadaveric specimens, the length ranged from 4.0 to 7.0 cm, and the mean diameter was 2.90 mm. The transverse cervical artery averaged 33 mm from midline, and branched off the thyrocervical trunk at an average 17 mm superior to the clavicle. Transverse cervical artery stenosis was markedly less in comparison with external carotid artery stenosis. In a 20-year clinical follow-up study, the transverse cervical artery was the recipient artery in 19 patients. A vein graft was used in one patient, and no flap loss occurred in any of the 19 patients.
**Conclusion:** The transverse cervical artery is a reliable and robust option as a recipient artery in free flap head and neck reconstruction. (*Plast. Reconstr. Surg.* 139: 745e, 2017.)

Many patients seeking surgical repair for head and neck defects require extensive tissue coverage that necessitates the use of free flap transfers. A surgeon's plan for these repairs is commonly obfuscated by the patient's history of previous surgery and/or radiation treatment before tumor excision, leading to a neck that is devoid of appropriate recipient sites for vascular anastomoses.[1] The surgical complications that arise from scarring because of previous dissections and radiation fibrosis are so commonplace that the colloquialism "frozen neck" has been applied to these situations.[2] This problem requires that a surgeon has a reliable and easily executed plan for a successful free flap transfer when initial recipient vessel choices are unavailable. Vein grafting is often used in these situations; however, in delicate head and neck cases in already fragile patients, this technique prolongs operative time and increases the number of microanastomoses in the highest risk patients. Therefore, the need for a reliable and easily identifiable recipient site is clear.

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When planning a free flap reconstruction, the selection of the recipient vessels hinges on several factors: health and availability of the vessels ideally outside the zone of injury, matching diameters of donor and recipient vessels, ease and safety of dissection, proven reliability, and distance from the defect intended to be repaired to avoid vein grafting.[3] The gold standard recipient arteries traditionally have been branches of the external carotid artery system. The most commonly used have been the facial artery and superior thyroid artery, with the lingual artery commonly used as well. If these vessels are unavailable in the ipsilateral side of the defect, vein grafting is commonly used to access the external carotid artery branches of the contralateral neck; even vein grafts to access arteries outside of the neck have been used.[3–6] We believe that the transverse cervical artery and vein are optimal second-line recipient vessels that are reliable and robust, and can reduce the need for vein grafts in difficult head and neck free flap reconstructions, minimizing the risks incurred by using vein grafts (i.e., thrombosis, partial flap loss, and total flap loss).[4,7,8] The transverse cervical artery and transverse cervical vein can be routinely dissected by a surgeon in difficult head and neck cases, guided along by stout anatomical landmarks leading to these recipient vessels.[9]

There has never been a cadaveric study on the transverse cervical vessels to investigate reliability and consistency for use as a recipient vessel in free flap surgery. The purpose of our study is two-fold. First, demonstrate the vessel topography and anatomical characteristics of the transverse cervical vessels with exact measurements. To do this, we outlined the first cadaveric study of these vessels for this purpose coupled with precise measurements from stable anatomical landmarks. Second, we wanted to demonstrate the clinical use of these vessels as recipient sites and the outcome of these procedures. To do this, we report on our 20-year clinical experience with the use of the transverse cervical artery and vein as recipient vessels in difficult head and neck microsurgical reconstructions.

## MATERIALS AND METHODS

An anatomical study was performed in cadavers to assess several characteristics of the transverse cervical vessels. A total of 72 neck sides were dissected in 36 separate cadavers. The cadaveric specimens were analyzed for the presence of the transverse cervical artery and vein, the diameter of these vessels, their exact length, and their exact location using digital calipers. Furthermore, the course of the transverse cervical artery was obtained, documenting consistent anatomical relationships along their path.

To isolate the transverse cervical arteries in our cadaveric studies, we dissected toward the subclavian arteries until the thyrocervical trunks were reached, as described by Mizerny et al.[9] A cannula was positioned in the proximal transverse cervical artery after puncture into the thyrocervical trunk, which was then ligated with suture. We then infused methylene blue dye through the cannula at a rate of 10 $cm^3$/minute until a volume of nearly 200 $cm^3$ was used. Dissection of the transverse cervical artery and vein from here guided by the methylene blue infusion was performed.[9] Also, histologic specimens of the transverse cervical artery and the external carotid artery were obtained to compare luminal quality and presence of radiation-induced changes between these two arteries.

For our clinical series, we performed a retrospective analysis on 19 patients who had head and neck reconstructions by means of free flap transfer using the transverse cervical artery as a recipient artery performed by various surgeons. We documented these patients' demographic information and indications for surgery, previous treatment history (e.g., previous neck dissections, previous radiation treatment), flaps used, and neck dissection performed. We then subsequently collected data on the outcome of these patients: instance of flap loss, complications, and need for vein grafting (Table 1).

## RESULTS

### Cadaveric Anatomical Study

In our cadaveric study, we discovered a consistent topographic location for the transverse cervical vessels. The transverse cervical artery was present in 72 of 72 cadaveric specimens (100 percent). It was found to be infraclavicular in two of our 72 specimens (3 percent). The length ranged from 4.0 to 7.0 cm and the mean diameter of the transverse cervical artery was 2.65 mm. The transverse cervical vein was present in 61 of 72 cadaveric specimens (85 percent). The length of the vein ranged from 4.0 to 7.0 cm and the mean diameter of the transverse cervical vein was 2.90 mm.

The technique we used to dissect the transverse cervical vessels was similar to the one described by Yu in 2005.[2] A perpendicular incision can be made from the previous neck dissection toward the mid clavicle; alternatively, a transverse incision 2 cm above and parallel to the clavicle can be

**Table 1. Summary of Transverse Cervical Artery Patients**

| Patient | Reason for Surgery | Previous Operations | Previous Radiation Treatment | Neck Dissection | Recipient | Flap | Vein Graft Needed |
|---|---|---|---|---|---|---|---|
| 1 | Recurrent SCC in FOM | Laryngectomy for SCC | Yes | L RND | TCA/TCV | RFFF | No |
| 2 | Persistent orocutaneous fistula | Radial maxillectomy for SCC | Yes | R MRND | TCA/EJV | TRAM | No |
| 3 | Persistent orocutaneous fistula | Laryngopharyngectomy, PM flap | Yes | L + R FND | TCA/TCV | RFFF | No |
| 4 | Recurrent SCC of L tongue and FOM | Partial glossectomy, PM flap | Yes | L + R RND | TCA/TCV | TRAM | No |
| 5 | Pharyngocutaneous fistula | Pharyngolaryngectomy, PM flap | No | L + R RND | TCA/TCV | RFFF | No |
| 6 | Recurrent adenocarcinoma of palate | No | Yes | L + R RND | TCA/TCV | TRAM | No |
| 7 | Recurrent SCC in FOM | Resection with RFFF | Yes | L + R MRND | TCA/TCV | TRAM | No |
| 8 | Recurrent SCC in hypopharynx | Previous laryngectomy, RFFF | Yes | R FND | TCA/AJV | Free jejunum | No |
| 9 | Recurrent SCC in FOM | Commando, PM flap | Yes | L + R MRND | TCA/EJV | TRAM | No |
| 10 | Pharyngocutaneous fistula | Laryngectomy, thyroidectomy | Yes | L + R MRND | TCA/TCV | RFFF | No |
| 11 | Recurrent SCC in FOM | FOM resection | Yes | L + R MRND | TCA/EJV | Rectus abdominis | No |
| 12 | Salvage surgery for BOT SCC | No | Yes | L + R MRND | TCA/TCV | RFFF | No |
| 13 | Recurrent SCC in oral cavity | Commando, RFFF | Yes | L + R MRND | TCA/TCV | TRAM | No |
| 14 | Pharyngocutaneous fistula | Laryngectomy, bilateral PM flaps | Yes | L + R RND | TCA/TCV | Rectus abdominis | No |
| 15 | Recurrent SCC in FOM | FOM resection, PM flap | Yes | L + R MRND | TCA/EJV | Latissimus dorsi | No |
| 16 | Recurrent SCC in FOM | Total laryngectomy, glossectomy, RFFF | Yes | L + R MRND | TCA/EJV | Rectus abdominis | No |
| 17 | Recurrent SCC in oral cavity | Partial maxillectomy | Yes | L + R MRND | TCA/TCV | Rectus abdominis | No |
| 18 | SCC in lip with mandibular extension and orocutaneous fistula | Total lower lip resection and segmental anterior mandibulectomy | No | L + R MRND | TCA/TCV | ALT | Yes |
| 19 | Recurrent SCC in oral cavity | FOM resection, segmental mandibulectomy | No | L + R MRND | TCA/TCV | ALT | No |

SCC, squamous cell carcinoma; RND, radical neck dissection; MRND, modified radical neck dissection; RFFF, radial forearm free flap; BOT, base of tongue; FOM, floor of mouth; L, left; R, right; TCA, transverse cervical artery; TCV, transverse cervical vein; EJV, external jugular vein; AJV, anterior jugular vein; PM, pectoralis major; TRAM, transverse rectus abdominis myocutaneous.

made. If the external jugular vein is encountered, it is dissected away and preserved. The sternocleidomastoid muscle was then located and retracted medially. The omohyoid muscle was located traveling transversely, with fibrofatty tissue just cephalad to this point. Within this adipose tissue, the transverse cervical vein is dissected and the transverse cervical artery lies just posterior and cephalad to the vein. Distal dissection can be performed to gain vessel diameter and length.

In our measurements, we were able to establish consistent measurements to outline exact locations of the transverse cervical artery and vein, going one step further than merely identifying topographic landmarks to aid with surgical dissection. The transverse cervical artery was found to be an average of 33 mm from the midline. The takeoff of the transverse cervical artery from the thyrocervical trunk was located approximately 17 mm superior to the clavicle at the anterior border of the sternocleidomastoid muscle and rising to a mean of 20 mm above the clavicle at the muscle's lateral border. Furthermore, the transverse cervical vessels were found on average 12 mm posterior to the clavicle (Figs. 1 through 3). On histologic examination of luminal cross-sections by means of light microscopy, it was noted that the degree of luminal stenosis caused by atherosclerotic deposits in the transverse cervical artery was markedly less compared with the degree of stenosis of the external carotid artery. Furthermore, it was also noted that when comparing irradiated subjects, the degree of luminal stenosis in the transverse cervical artery again was markedly less compared to the degree of stenosis of the external carotid artery (Table 2).

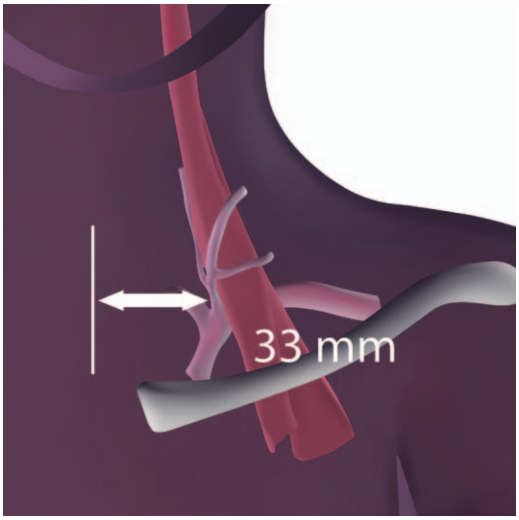


**Fig. 1.** Distance of the transverse cervical artery origin lateral to the midline.

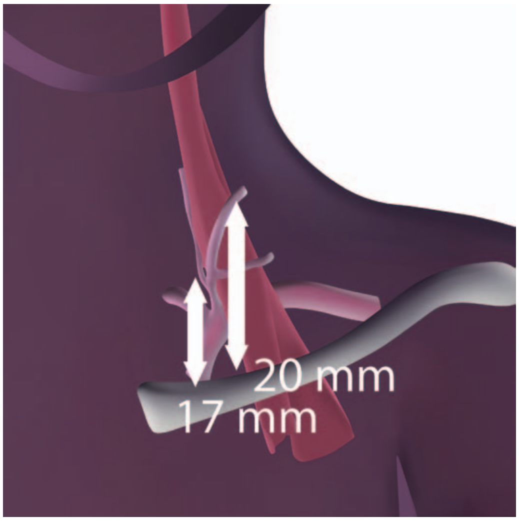


**Fig. 2.** Distance of the transverse cervical artery origin superior to the clavicle.

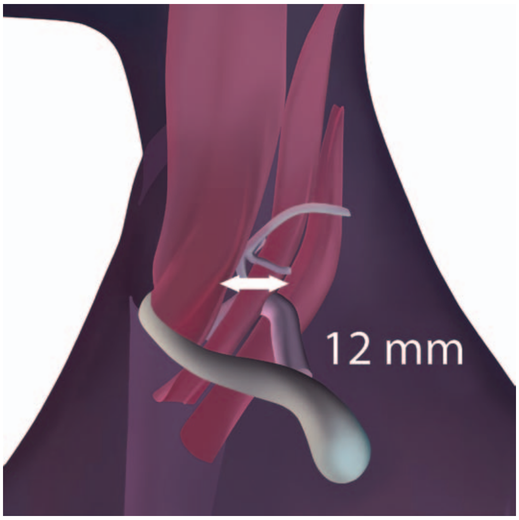


**Fig. 3.** Anteroposterior location of the transverse cervical artery vessels using the clavicle as an anatomical landmark.

## Clinical Study

Our clinical patient group consisted of 19 different patients over the course of nearly 20 years in need of free flap transfer to the head and neck for large defects caused by tumor excision. Seventeen of our patients (89 percent) had undergone previous neck dissections, and 12 patients (63 percent) had undergone surgery because of recurrent cancer. Eleven patients were diagnosed with squamous cell carcinoma, one patient presented with adenocarcinoma, and five patients (26 percent) underwent surgery for persistent orocutaneous or pharyngocutaneous fistulae. Sixteen patients (84 percent) received radiation treatments before this surgery.

**Table 2. Comparison of Luminal Stenosis of the External Carotid and Transverse Cervical Arteries**

| Percentage of Lumen Stenosed | ECA (%) | TCA (%) |
|---|---|---|
| None | 53 (74) | 70 (97) |
| 0–25 | 12 (17) | 2 (3) |
| 26–50 | 7 (10) | 0 |
| 51–75 | 0 | 0 |
| 76–100 | 0 | 0 |
| Total | 72 | 72 |

ECA, external carotid artery; TCA, transverse cervical artery.

The transverse cervical artery was identified and used as the recipient artery in 19 of our microsurgical flap transfers (100 percent). The transverse cervical vein was identified in 14 of our patients (74 percent) and used as the recipient vein in 13 of our flap transfers (68 percent). A vein graft was used in one of our patients (5 percent). After the time course of our investigation, there was no flap loss in any of our patients.

## DISCUSSION

Difficult head and neck reconstructions frequently occur in patients with previous tumor extirpation, previous neck dissection, and/or radiation therapy. Adjuvant therapy in head and neck cancer has a well-demonstrated effect on prognosis in these patients, yet can negatively affect the vasculature in this irradiated area. The reconstructive surgeon is often challenged by limited recipient vessel options for free flap microsurgical reconstruction in these cases. This problem is so common that even stepwise algorithms for selecting appropriate recipient vessels have been suggested.[6] The current paradigm for head and neck reconstruction with free flap transfer focuses on several well-analyzed recipient blood vessels. The most prominent recipient blood vessels include the facial artery, superior thyroid artery, and superficial temporal artery. These recipient vessels are usually chosen because of well-established reliability, ease of dissection, vessel diameter, and proximity to the pertinent defect area to be repaired.[3,6] However, many drawbacks to the use of these vessels have been elucidated. The most commonly used vessels are all branches of the external carotid artery system, which has a prominent location in the neck, leaving it vulnerable to damage from previous neck dissections, tumor encroachment, and adjuvant radiation damage. Also, the external carotid system has a higher affinity for endovascular damage secondary to atherosclerosis; thus, these vessels may not even be suitable to begin with.[10,11] Furthermore, when these external carotid artery branches are too distant from the defect site, vein grafting is commonly used to extend the reach of these flaps.[5,12]

The transverse cervical artery is a vessel that we believe is chronically underused in head and neck free flap reconstructions. The transverse cervical artery—like the branches of the external carotid arteries—has well-documented anatomical relationships and dissection guidelines, and has been demonstrated to possess vessel diameter and reliability comparable to those of the vessels of the external carotid artery.[2] The transverse cervical vessels are found in a well-defined anatomical triangle: the dorsal edge of the sternocleidomastoid muscle forming the medial border, the superior edge of the clavicle forming the inferior border, and the external jugular vein forming the lateral border.[13] The transverse cervical artery originates from the thyrocervical trunk in approximately 80 percent of subjects, yet can be found originating from the subclavian artery in a minority of cases.[14,15] The artery then runs posterolaterally toward the trapezius muscle, lying transverse and anterior to the anterior and middle scalene muscles and the levator scapula, and deep to the inferior belly of the omohyoid muscle. The transverse cervical artery also lies anterior to the brachial plexus.[16,17] The transverse cervical vein follows a similar course to the transverse cervical artery, being superficial to the omohyoid muscle in 75 percent of instances, and deep to it in the other 25 percent.[2] In our cadaveric study, we were able to map out consistent actual measurements to precisely locate the transverse cervical artery and vein based on easy-to-identify anatomical landmarks. We believe this will increase the ease of dissection in locating the transverse cervical vessels for head and neck microsurgeons.

Focus on the transverse cervical artery and vein as appropriate recipient vessels for free flap head and neck reconstruction has seen a modern resurgence. In 1989, Urken et al. documented their use of the transverse cervical artery as their primary and utmost preferred recipient artery for head and neck free flap reconstruction; however, the current landscape of free flap reconstruction of the head and neck does not reflect their enthusiasm for this vessel, with branches of the external carotid artery being touted as the gold standard candidates in much of the literature.[3,6,10] We believe there are many qualities the transverse cervical vessels possess that could categorize them as primary options for free flap recipient sites in head and neck reconstruction. The transverse cervical artery has been demonstrated to have comparable diameter, blood flow, and integrity when contrasted with branches of the external carotid artery.[18] Furthermore, dissection of this particular recipient site precludes dissection of the carotid area, which poses an increased risk of vascular damage. The recipient vessels of the transverse cervical artery and vein have also been noted to have a more vertical position than carotid branches, which remain in a more neutral position after flap placement, reducing the risk of vessel kinking.[18] The dissection of the transverse cervical artery is fairly straightforward; however, it is not devoid of all risk. Once appropriate vessel diameter is reached within the transverse cervical artery itself, we discourage further proximal dissection, as this brings the dissection closer to the thyrocervical trunk, subclavian artery, and other areas of major risk. The phrenic nerve lies on the anterior surface of the anterior scalene muscle in the region of the transverse cervical artery branching from the thyrocervical trunk; this warrants conservative dissection of the transverse cervical artery proximally, but as stated above this is discouraged and rarely necessary to perform to find a vessel of appropriate caliber. Furthermore, on the left, the transverse cervical artery has an intimate relationship with the thoracic duct. The thoracic duct passes posterior to the jugular vein yet courses anterior to the transverse cervical artery near its branching point from the thyrocervical trunk, and the thoracic duct approaches the confluence of the subclavian vein and carotid artery. The thoracic duct is a thin-walled, fragile structure in proximity to the thyrocervical trunk. However, once again, dissection of the transverse cervical artery proximally to such a degree is rarely necessary.

Our 20-year retrospective clinical study of 19 head and neck free flap reconstructions in which the transverse cervical artery was used as the recipient artery further supports the utility of these vessels in complex head and neck reconstruction. After 10 years, all 19 flaps using the transverse cervical artery as the recipient artery—with a majority having venous anastomosis to the transverse cervical vein as well—had no flap loss. Furthermore, the claim that using the transverse cervical vessels as recipient sites would require vein grafting to be feasible was not the case in this study, as only one of the 19 patients required vein grafting in the process of anastomosis of the flap vasculature, which further establishes the transverse cervical artery as a recipient artery just as capable as any branch of the external carotid artery system.[1]

## CONCLUSIONS

Various branches of the external carotid artery have been used as recipient sites because of their well-studied and documented anatomical course and exact location within the body. It has been previously thought that using alternatives involved either vein grafting or end-to-side anastomosis into the external carotid directly. In this study, we demonstrate through cadaveric study and retrospective clinical study that these premonitions are false. We believe the transverse cervical artery and vein are reliable and accessible recipient vessels based on their anatomical consistency, ease of dissection, vessel quality, length, ability to avoid vein grafts, and ability to avoid end-to-side anastomoses into the external carotid and jugular system directly.

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