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ORIGINAL RESEARCH

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Versatility of the supraclavicular artery island flap for head and neck reconstruction

Yiyu Ru MS[1] | Fan Ye MS[1] | Xiaojing Chen MS[1] | Jianying Ye MS[2] | Rongrong Liu MS[2] | Renyu Lin MS[1] | Jianfu Chen MS[1] | Peng Wu MS[1] | He Li MD[1]

[1]Department of Otolaryngology, First Affiliated Hospital of Wenzhou Medical University, Wenzhou City, China

[2]Department of Otolaryngology, The People's Hospital of Yuhuan, Taizhou City, China

Correspondence
Peng Wu and He Li, Department of Otolaryngology, The First Affiliated Hospital of Wenzhou Medical University, Village ShangCai, Ouhai District, Wenzhou City, Zhejiang Province 325000, China.
Email: wupeng3620@126.com; lihe@wzhospital.cn

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Abstract

Objective: To present our experience using the supraclavicular artery island flap (SCAIF) for head and neck reconstruction.

Methods: We performed a retrospective chart review to identify patients who underwent head and neck reconstruction with SCAIF at our institution. The following data were collected: age, sex, surgical indications, flap harvest time, flap dimensions, length of hospital stay, complications, and clinical outcomes.

Results: Thirty-three patients underwent SCAIF reconstruction, of whom four underwent pectoralis major myocutaneous flap reconstruction simultaneously. Twenty flaps were used to repair pharyngeal or esophageal defects following resection for tonsillar, hypopharyngeal, laryngeal, and cervical esophageal cancers. Five flaps were used for tracheal reconstruction following resection for tracheal or thyroid gland cancer. Seven flaps were used for reconstruction of cervical skin defects or fistulas related to a previous treatment. One flap for tracheal stenosis following tracheotomy. The mean age of the patients was 60.69 ± 11.47 years. The mean flap harvest time was 32.00 ± 4.44 min. The mean flap size was 10.16 ± 3.91 × 5.78 ± 0.68 cm. The mean length of hospital stay is 24.84 ± 13.78 days. Three patients had partial necrosis of the distal portion of the flap, which resolved with anti-infection therapy and local wound care. One patient developed a fistula that was resolved with wound care and further surgical intervention. Complete flap loss or major complications were not observed. No donor site complication or compromised shoulder function was observed.

Conclusion: The SCAIF can be successfully used to reconstruct head and neck defects with good outcomes and limited morbidity.

Level of Evidence: 4.

Yiyu Ru and Fan Ye contributed equally to this work and should be considered co-first authors.

KEYWORDS
head and neck carcinoma, reconstruction surgery, supraclavicular artery island flap

1 | INTRODUCTION

The head and neck are complex anatomical structures that play important roles in function and appearance. Thus, the reconstruction of head and neck defects is a huge challenge for surgeons. Free tissue transfer (FTT) is the primary reconstruction method. However, this requires proficiency in performing the microvascular anastomoses and is time-consuming and expensive. Other flaps such as the internal mammary artery perforator, pectoralis major, and deltopectoral flaps tend to be too bulky after folding, potentially leading to strictures in pharyngeal reconstructions and difficulty swallowing postoperatively.[1] Therefore, it is necessary to develop safer and more cost-effective methods. In recent years, the supraclavicular artery island flap (SCAIF), which provides a better skin-color match than other flaps and is advantageous in terms of reliability and versatility, has emerged as a dependable source of reconstruction. We successfully performed more than 30 SCAIF reconstructions for head and neck defects at our institution. Herein, we share our experience and discuss key surgical techniques, aiming to improve the efficiency of reconstruction.

2 | PATIENTS AND METHODS

We retrospectively evaluated 33 patients who underwent SCAIF reconstruction for head and neck defects at our institution between October 2017 and June 2023. Once identified, the following data were collected: age, sex, primary disease, surgical indication, flap harvest time, flap dimensions, length of hospital stay, complications at both the reconstruction and donor sites, and clinical outcomes. The total follow-up duration was at least 3 months.

The reporting method we used is retrospective medical chart review.

2.1 | Techniques

The SCAIF flap is designed to extend from the supraclavicular fossa, formed by the sternocleidomastoid (SCM), external jugular vein and clavicle, toward the acromioclavicular joint and deltoid. The flap is elevated from distal to proximal part in a subfascial plane. Electrocautery can be performed on the distal part of the flap. During flap harvesting, the vascular pedicle must be carefully protected. Therefore, we do not recommend skeletonization of the pedicle. When approaching the vascular pedicle, sharp dissection or an ultrasonic scalpel can be used to prevent vascular injury. The proximal portion of the flap can be deepithelialized to provide good rotation. Preservation of the superficial fascial system and related platysma around the vascular pedicle is particularly useful, as it can protect the flap vasculature by preventing kinking, partial compression, and undue tension.[2] If necessary, the distal tip can be trimmed until adequate bleeding is noted to prevent distal flap necrosis. The flap is then rotated or tunneled into the defect.

2.2 | Data analysis

Statistical analysis was performed using SPSS 22.0. Data were expressed as the mean ± standard deviation.

None of the work involved the use of animal or human participants. This was a retrospective medical chart review, and the patients were not identified.

3 | RESULTS

A total of 33 patients underwent SCAIF reconstruction for head and neck defects, of whom four underwent pectoralis major myocutaneous flap reconstruction simultaneously. Among these patients, 32 were men and 1 patient was a woman. The average age of the patients was 60.69 ± 11.47 (range: 30–80) years. In 20 patients, the SCAIF were used to repair pharyngeal or pharyngoesophageal defects following oncological resection, including tonsillar, hypopharyngeal, laryngeal, and cervical esophageal carcinomas. In five patients, it was used for tracheal reconstruction following resection of tracheal or thyroid gland carcinoma. In seven patients, it was used to repair the anterior cervical skin defects or fistulas associated with a previous treatment or oncological resection. In one patient, it was used to treat the tracheal stenosis following tracheotomy. The average flap harvest time is 32.00 ± 4.44 (range: 25–40) min. The flap size ranged from 5 to 7 cm in width and 7 to 16 cm in length, with an average size of 10.16 ± 3.91 × 5.78 ± 0.68 cm. Three patients exhibited partial necrosis of the distal portion of the flap, which resolved with anti-infection therapy and local wound care. One patient developed a fistula that was subsequently resolved with wound care and further surgical debridement. No complete flap loss was observed during the hospital stay. Donor sites were primarily closed with adjacent tissue advancement and skin grafting was not performed. Only one patient developed a sensation of neck tightness after surgery, which was resolved by physical rehabilitation. A widened scar was noted, but no significant donor-site complication or compromised shoulder function was observed. The average length of hospital stay was 24.84 ± 13.78 (range: 9–78) days. No in-hospital death was noted, and all patients were discharged with good outcomes. The patients started oral feeding until at least 14 days after surgery. Stenosis in the neopharynx or esophagus was not observed in any patient. Typical cases are illustrated in Figures 1–4.

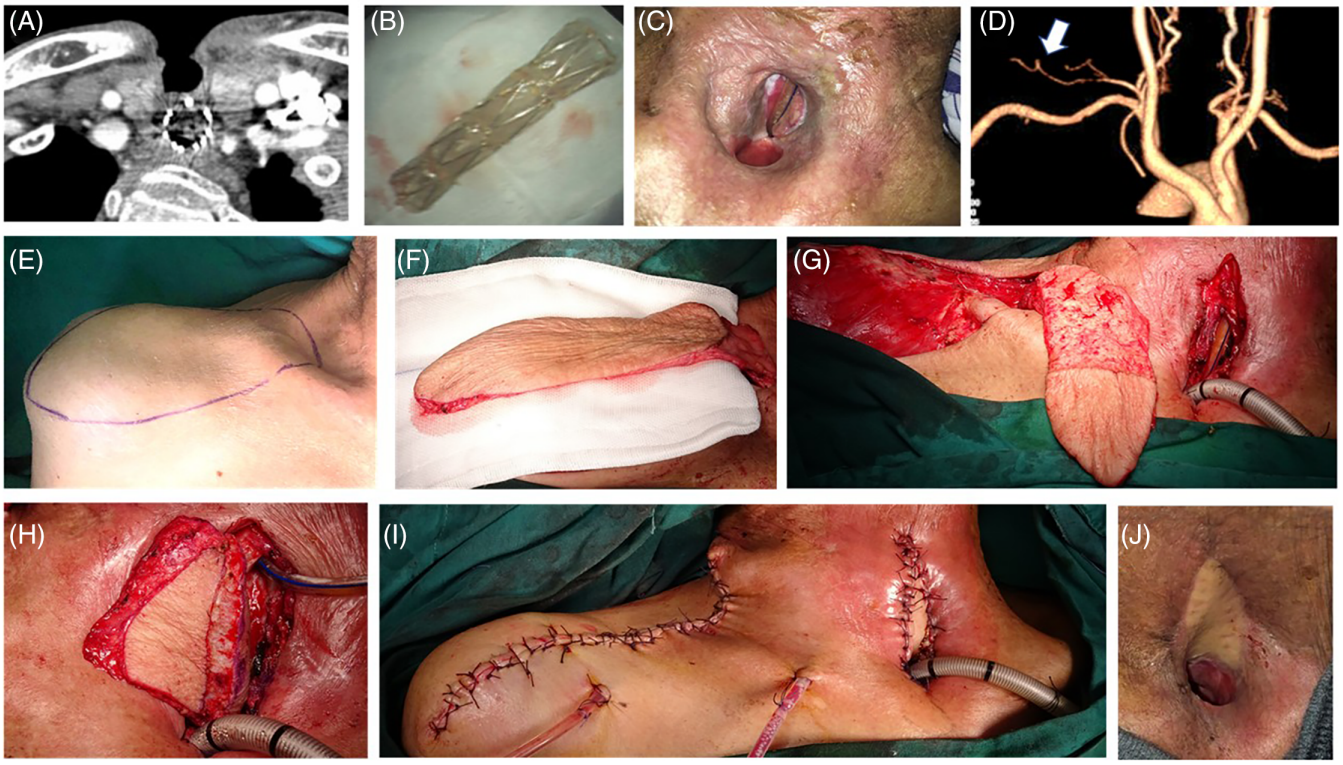
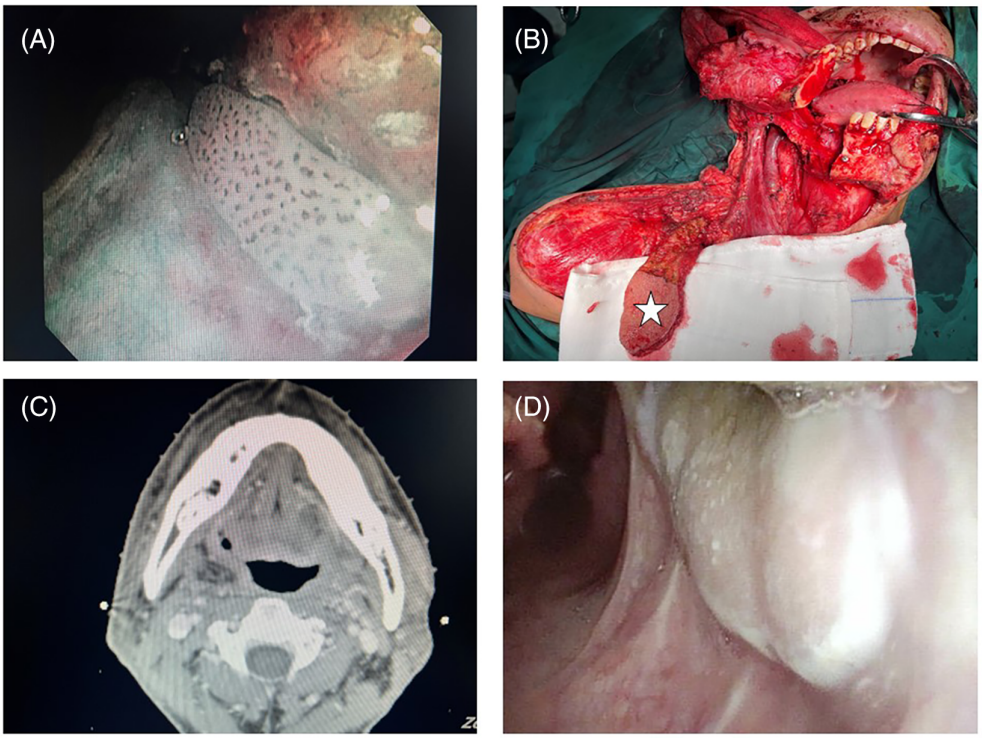


FIGURE 1 A 72-year-old man with skin defect and fistula in the neck underwent esophageal stent implantation for esophageal stricture following total laryngectomy thyroid gland carcinoma. (A, B) Esophageal stent. (C) Neck skin defects and fistulas. (D) Computed tomography angiography scan shows the transverse cervical artery (white arrow). (E) Design of the flap. (F) Flap harvesting. (G) The skin proximal to the flap was removed. (H) The flap was double-folded to form two skin paddles, one for the anterior esophageal wall and the other for the posterior tracheal wall, achieving a two-layer closure. (I) Appearance after reconstruction. (J) Five months after reconstruction, the skin defect healed well, and the patient resumed oral feeding.

FIGURE 2 A 51-year-old man with right tonsillar carcinoma. (A) Preoperative laryngoscopy image shows carcinoma invading the right lateral pharyngeal wall. (B) Flap harvesting and intraoperative status post-resection. The supraclavicular artery island flap was prepared to repair lateral oropharyngeal defect (skin paddle marked with a star). (C) Postoperative computed tomography scan shows excellent healing of the flap. (D) Nine months postoperative laryngoscopy image shows excellent coverage and healing.



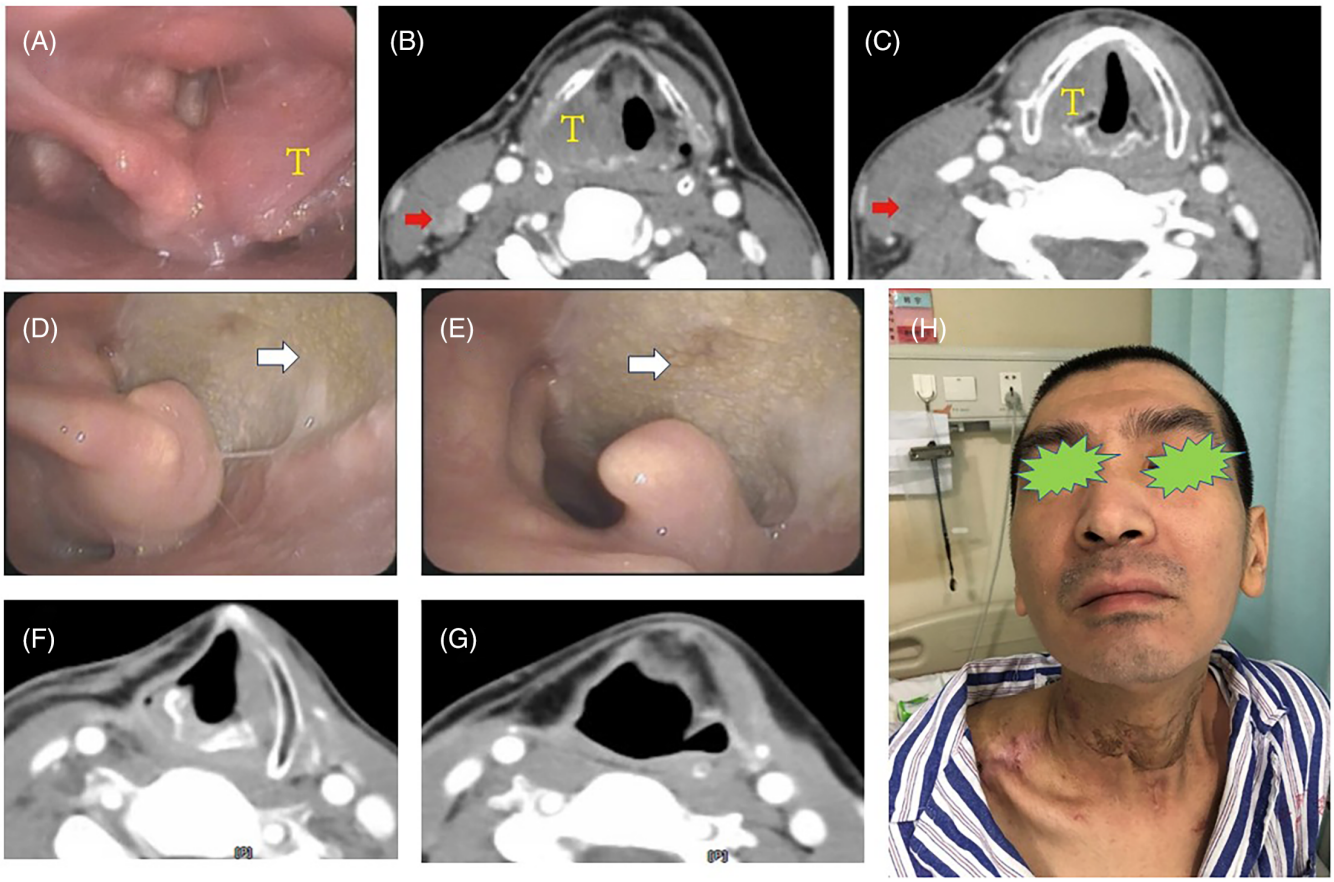


FIGURE 3 A 40-year-old man with hypopharyngeal carcinoma. (A–C) Preoperative laryngoscopy and computed tomography (CT) images reveal hypopharyngeal carcinoma (marked with the letter T). (D, E) Six months postoperative laryngoscopy image. The supraclavicular artery island flap was used to repair the lateral hypopharyngeal defect with excellent coverage and healing (marked with an arrow). (F, G) Postoperative CT scan shows excellent healing of the flap. (H) Six months postoperative outcomes.

4 | DISCUSSION

Head and neck oncologic resections often result in complex reconstructive challenges that require a reliable flap option to restore both the function and aesthetic appearance. The SCAIF, has become a dependable and versatile source for complex head and neck reconstruction due to its foldability, thin skin paddle, arc of rotation, and its length allowing for tension-free sutures in the facial, cervical, pharyngeal, and parotid regions. The SCAIF was first described by Lamberty[3] in 1979 but had been criticized for its high incidence of distal flap necrosis. In 1997, Pallua's[4] detailed anatomical studies on SCAIF's vascularity popularized its use for reconstruction. DiBenedetto further demonstrated its utility in reconstructing various chest and facial defects.[2,5] In 2009, Chiu was the first to describe the use of the SCAIF in head and neck oncologic reconstruction.[6] Subsequently, multiple studies have highlighted the use of the flap in reconstructing various head and neck oncologic ablative defects, posterolateral skull base defects, oropharyngeal defects, mandibular or parotid gland defects, neck skin defects or fistulas after radiation, and tracheostomal defects, as well as for the establishment of digestive tract continuity.[7–10]

The SCAIF is based on the supraclavicular artery, a branch of the transverse cervical artery in 93% of the patients, and the suprascapular artery in the remaining cases.[3] Venous drainage usually occurs via the accompanying transverse cervical or external jugular vein.[11,12]

The thickness, color, and texture match make the SCAIF suitable for reconstructing cervical cutaneous defects and fistula.[13] We performed seven SCAIF reconstructions to repair fistula defects related to previous therapy or oncologic resection. In four patients, the small cutaneous defects or fistulas were repaired by double folding the island of SCAIF. In the remaining three patients, large defects or fistulas were repaired using SCAIF combined with a pectoralis major flap. A typical case is shown in Figure 1.

In our study, the most common surgical indications were pharyngeal and esophageal reconstruction following oncological resection ($n = 20$). The flap was not too bloated after folding, which made it possible to repair nearly complete circumferential defects of the hypopharyngeal and esophageal walls, leading to fewer strictures than that with the pectoralis major myocutaneous flap.[14] All patients were able to resume swallowing postoperatively. Stenosis was not observed in any case. The characteristics of the reconstruction are summarized in Table 1. Two typical pharyngeal reconstructions are shown in Figures 2 and 3, respectively.

The mediastinum is a narrow space; therefore, the repair of tracheal defects can be particularly difficult. While a free flap

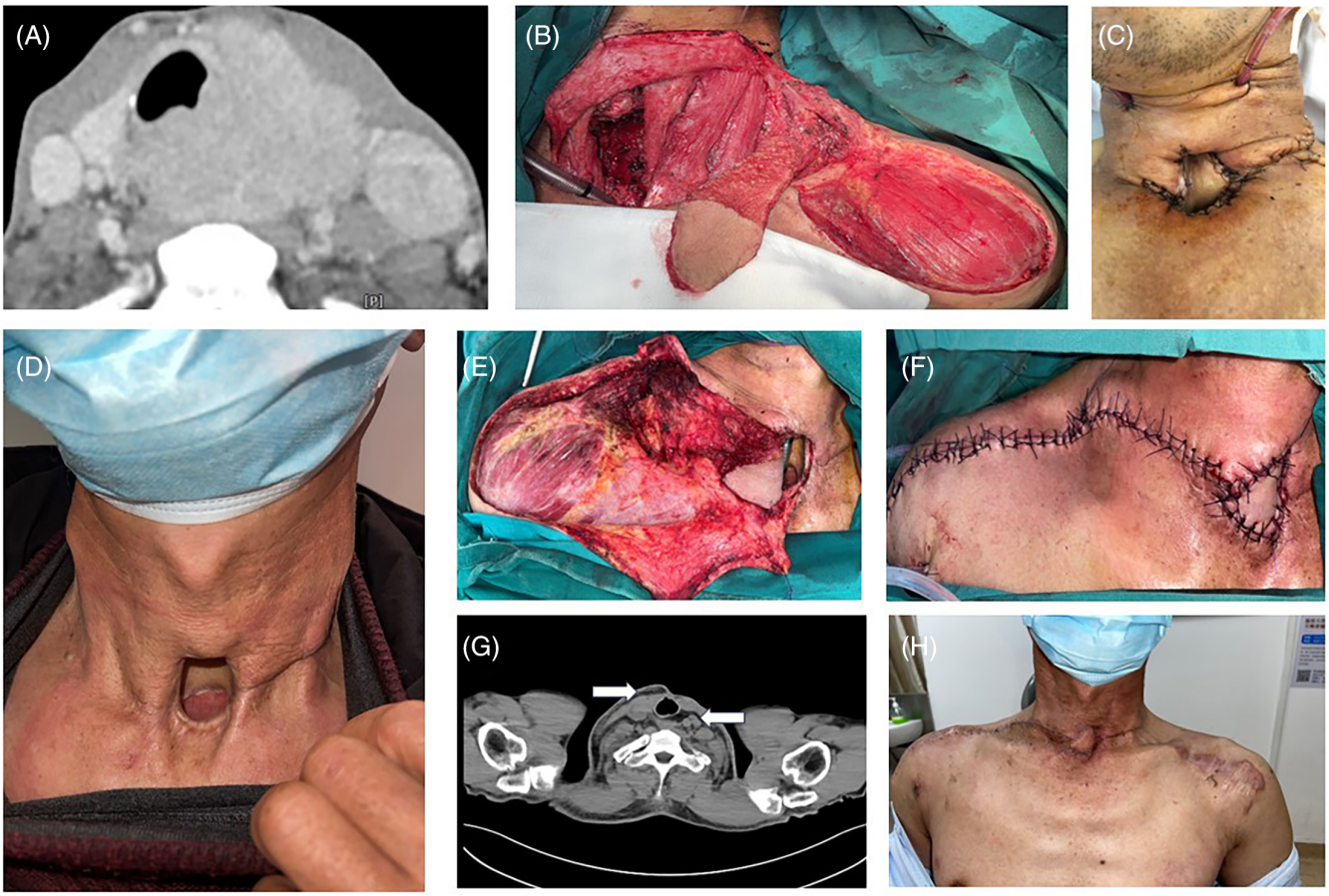


FIGURE 4 A 52-year-old man with thyroid gland carcinoma. (A) Preoperative computed tomography (CT) scan shows carcinoma invading the trachea. (B) Flap harvesting and intraoperative status post-resection. (C) Appearance after the first reconstruction. The supraclavicular artery island flap (SCAIF) was used to repair the posterior wall of trachea. (D) Eight months postoperative outcomes. (E) Flap harvesting at the time of the second surgery. (F) Appearance after reconstruction. The SCAIF was used to repair the anterior wall of trachea. (G) Postoperative CT scan shows excellent healing of the flap (marked with an arrow). (H) Six months postoperative outcomes of the second surgery, with excellent coverage and healing.

TABLE 1 Reconstructive characteristics.

Defect	No. of patients	Flap	Complication	Defect characteristics
Anterior neck skin defect	5	2 SCAIF and PMMF 3 SCAIF	No complication	N/A
Pharyngo-cutaneous fistulae	2	1 SCAIF and PMMF 1 SCAIF	1 fistula 1 partial necrosis of the flap	N/A
Hypopharyngeal and esophageal defect	19	1 SCAIF and PMMF 18 SCAIF	1 neck tightness sensation 2 partial necrosis of the flap	5 cirumferential defects 14 partial defects
Oropharyngeal defect	1	SCAIF	No complication	N/A
Tracheal defect	4	SCAIF	No complication	3 cirumferential defects 1 partial defects
Tracheostomal defect	1	SCAIF	No complication	N/A
Tracheal stenosis	1	SCAIF	No complication	Cirumferential defect

Abbreviations: PMMF, pectoralis major muscle flap; SCAIF, supraclavicular artery island flap.

reconstruction is an option, it requires high microsurgical expertise and prolonged operation time. The pectoralis major muscle flap can be bulky, potentially narrowing the airway or hindering speech rehabilitation by obstructing the tracheoesophageal prostheses used for esophageal speech. Muscle flaps with skin grafts are susceptible to failure because of shear and soilage caused by upper digestive tract

secretions. The skin-pedicled design, perfect thickness, large arc of rotation, and tubularization ability make the SCAIF a reliable option for tracheal reconstruction. Michael W. Chu et al.[15] reported five patients who underwent SCAIF, suggesting it to be a safe and effective reconstruction option for tracheostomal wounds resulting from oncologic procedures. Chad A. Zender et al.[16] reported a treatment method utilizing a prefabricated composite auricular cartilage graft embedded in the SCAIF for tracheal reconstruction in patients with tracheal stenosis. The usefulness of this flap has also been demonstrated for the closure of long-term tracheostomies, even with a small bone fragment obtained from the distal clavicle.[17] In a comprehensive review,[18] 18 studies reporting 643 SCAIF cases were assessed in a "meta-analysis." The SCAIF was most commonly used in cutaneous neck reconstruction, followed by oral, tongue, and mandibular reconstruction, as well as laryngeal, pharyngeal, and esophageal reconstruction.[18] In addition, few studies have described its utility in patients with complicated circumferential or longer-segment tracheal defects following oncological resection. Zhao Jiazheng et al.[19] reported a case series of 10 patients who underwent reconstructive surgery with SCAIF for tracheal defects after the resection of cervical or thoracic tumors.

In our case series, four cases required tracheal reconstruction following oncological resection, including two cases of tracheal adenoid cystic carcinoma and two of thyroid carcinoma. We used the SCAIF to repair complete circumferential tracheal defects without the need for bone or cartilage fragments. None of the patients had tracheostomal stenosis and were able to recover their voices by covering the tracheostoma with their hands. Furthermore, tracheostomal defects can be repaired in the second surgery using another SCAIF, according to the requirements and conditions of the patients.

As shown in Figure 4, the patient had a complete circumferential tracheal defect following thyroid gland carcinoma resection. Staged bilateral SCAIFs reconstruction was performed. The first flap was used to repair the posterior tracheal wall, leaving a tracheostomal defect. The second flap was used to repair the anterior tracheal wall, 6 months after the previous surgery to achieve a staged reconstruction. The postoperative period was uneventful. The patient recovered his voice and exhibited no tracheostomal stenosis.

Its utility has been demonstrated in one case of tracheostomy closure and another case of tracheal reconstruction in patients with tracheal stenosis following tracheotomy. In our most recent case, we used the SCAIF to repair a tracheoesophageal fistula. The patient is still undergoing follow-up without any complications up to now.

The most common complications of the SCAIF are partial flap necrosis, donor site dehiscence, recipient site dehiscence, fistula formation, infection, and esophageal stenosis.[20] Minor complications occurred in three patients, which resolved with local wound care. Among these three patients, two had underwent the SCAIF combined with pectoralis major flap reconstruction. The complications may be attributed to the intricate reconstruction and poor condition of the native tissues. One patient with a pharyngocutaneous fistula related to a previous surgery developed a fistula following SCAIF reconstruction, which resolved with antiinfection therapy, wound care, and further surgical debridement. These outcomes were deemed acceptable. According to our review, necrosis of the distal part of the flap and fistula development were possibly related to a previous radical radiotherapy,[21] contaminated surgical sites, transverse cervical vessel injury, and complicated flap design. The vascular territory of the SCAIF ranges from 4 to 12 cm in width and 20 to 30 cm in length,[22,23] extending from the supraclavicular region to the shoulder cap. Kokot[24,25] demonstrated that a flap length greater than 22–24 cm was significantly associated with flap necrosis. However, other studies demonstrated survival in flaps up to 41 cm in length.[26] In our study, the flap size ranged from 5 to 7 cm in width and 7 to 16 cm in length. All flaps were designed to be within the dimensions of the angiosome and exhibited excellent viability. No unfavorable complications were observed. Only one patient developed a sensation of neck tightness, especially during swallowing, which resolved with physical rehabilitation. This was possibly attributed to the preservation of the nervi supraclaviculares. Therefore, we suggest denervation of the nervi supraclaviculares during flap harvesting. All other patients were satisfied with their functional and aesthetic outcomes.

A previous radical radiotherapy or functional neck dissection (level IV or V lymph nodes) is not an absolute contraindication for flap harvesting.[27] However, it is preferable to choose the contralateral shoulder to avoid unfavorable complications. Therefore, such patients should be carefully evaluated before surgery. Computed tomography (CT) angiography (CTA) or vascular ultrasonography can be performed to determine whether the transverse cervical artery is present or has been injured, but it is not always necessary. Preoperative ultrasonography and CT examination were useful in confirming the absence of lymph node metastases at levels IV and V. If both shoulder are suitable for flap harvesting, the decision should be based on the patient's handedness.

In our study, all donor sites were primary closed with adjacent tissue advancement. However, skin grafting should be performed when the defect is wider than 7–8 cm.[6,28] A shoulder drain may be unnecessary because the dead space is completely closed. No compromised shoulder function was observed in our study. Some investigators have used the Penn Shoulder Score and Constant Shoulder Scale to measure postoperative shoulder strength and flexibility.[29]

Due to the elimination of microvascular anastomosis, the average flap harvest time was 32.00 ± 4.44 min in our study. This may significantly decrease perioperative morbidity and overall care costs.

In our study, all flaps survived, with a complication rate of 15.15%, which was lower than those reported in other studies.[30,31] These results were deemed acceptable. Herein, we have summarized some key points on flap harvesting, although our series is too small to show major technical innovations on the using of the SCAIF. (1) The first critical technical aspect is the design of a skin island over the ventral surface of the deltoid. The skin island designed in a more dorsal position over the cap of the deltoid may outside the angiosome of the supraclavicular vessel. (2) Another key to success is the creation of a soft tissue pedicle around the vascular pedicle. We designed the soft tissue pedicle to be equal to the width of the skin island. Taking the fascia and a small amount of trapezius muscle tissue with the flap provides more vascular coverage. Skeletonization of the vascular pedicle

is considered unnecessary. The fat and nodal tissue may need to be meticulously mobilized as far as the origin of the pedicle is concerned, based on its length and rotational requirements. In our study, the flap size ranged from 5 to 7 cm in width and 7 to 16 cm in length. The flaps can reach defects in the oropharynx, hypopharynx, trachea, and esophagus without tension. (3) The supraclavicular artery can be reliably located within the triangle made up of the dorsal edge of the SCM, external jugular vein, and clavicle. In some of our cases, the SCAIF was safely harvested without the assistance of CTA or vascular ultrasonography. González-García JA et al.[17] were able to successfully harvest several flaps using anatomical landmarks alone. However, we suggest that color Doppler ultrasound or CTA should be performed preoperatively or intraoperatively in patients with a history of level V neck dissection and/or radiation to determine whether the transverse cervical artery is present or has been injured. Further research is needed to evaluate whether preoperative vascular analysis can help prevent flap necrosis. (4) Preservation of the supraclavicular nerves can lead to donor site dysesthesia.[32,33] Some patients report referred sensation to the shoulder while drinking or eating or when there is contact with the flap skin island.[34] In our study, the supraclavicular nerves accompanying the artery were sacrificed in 33 patients, and only 1 patient developed a sensation of neck tightness when swallowing; all other patients had no pain at the donor site. However, further clinical investigations are required to confirm the potential benefits of flap denervation.

A limitation of our study is that we did not assess the patients' perception of the surgery, especially with regard to the aesthetic outcomes of cutaneous defects or function of the donor site. While, patients were satisfied with their functional and aesthetic outcomes, quantitative measurements were not performed in this study. A detailed assessment of postoperative shoulder mobility and function is required in future studies. Further investigations are required to confirm the potential benefits of flap denervation and the necessity for vascular analysis before surgery. In addition, a larger patient series using a randomized controlled trial is valuable for determining the clinical outcome success compared to other surgical techniques.

5 | CONCLUSION

Our experience shows that the SCAIF is a thin, pliable, and versatile flap that is quickly harvested and has a good color match for head and neck oncological defects. Therefore, this flap should be viewed as an important treatment option for head and neck reconstruction.

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CONFLICT OF INTEREST STATEMENT

No conflict of interest exists regarding this manuscript.

ORCID

Fan Ye https://orcid.org/0000-0002-2523-6728
Renyu Lin https://orcid.org/0000-0002-0278-0704
Peng Wu https://orcid.org/0000-0001-8109-5694

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