Fascia Lata Free Flap Anastomosed to the Superior Trochlear System for Reconstruction of the Anterior Skull Base

Camilo Reyes[1] C. Arturo Solares[2] Michael A. Fritz[3] Michael Groves[1] Heather Bentley[1]

[1] Department of Otolaryngology–Head and Neck Surgery and Center for Skull Base Surgery, Augusta University, Augusta, Georgia, United States
[2] Department of Otolaryngology–Head and Neck Surgery and Center for Skull Base Surgery, Emory University, Atlanta, Georgia
[3] Department of Otolaryngology–Head and Neck Surgery, Cleveland Clinic, Cleveland, Ohio, United States

Address for correspondence C. Arturo Solares, MD, Department of Otolaryngology–Head and Neck Surgery, Endoscopic Skull Base Surgery, Emory University, Medical Office Tower (MOT), 9th Floor, 550 Peachtree Street NE, Atlanta, GA 30308, United States (e-mail: solarec2@gmail.com; clementino.arturo.solares@emory.edu).

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Abstract

Objectives This study aims to introduce a novel technique for the reconstruction of the anterior skull base using a free vascularized anterolateral thigh fascia lata free flap (FLFF) anastomosed to the superior trochlear artery (STA).

Methods The diameter of the STA was measured in 38 (76 sides) computed tomography angiographies (CTAs). Independently, six cadaver heads were used to measure the diameter of the supratrochlear system, and the model was applied to one of them.

Results In women, the average diameter of the STA was 2.5 and 2.8 mm^2 for the right and left sides, respectively; for men, it was 3.0 and 3.2 mm^2, respectively. In cadavers, the average diameter of both STA was 2.5 mm^2. There was no statistical difference when comparing the right and left STA diameters between the CTA from women and men ($p < 0.208$ and < 0.492, respectively). An FLFF advanced through the nose was anastomosed to the STA to reconstruct the anterior skull base.

Conclusion The STA is a constant vessel with a 2.5 to 3.0 mm^2 diameter in men and women that can be used as a recipient free flap vessel. The FLFF can cover the entire skull base. This is a novel method to reconstruct the anterior skull base when local flaps are not available.

Keywords
- ► the superior trochlear system
- ► anterior skull base
- ► anterolateral thigh fascia lata
- ► free flap

Introduction

Indications for endoscopic resection of skull base lesions have advanced considerably during the past decade. With these innovations, open and endoscopic closure techniques for large skull base defects have been broadly studied; as the reconstruction of these defects is an important part of any expanded endoscopic endonasal approach (EEA). Exposure of bone, neurovascular structures, dura, and intracranial structures to the upper aerodigestive tract and the exterior environment must be repaired. Endoscopic reconstruction with the posteriorly pedicled nasoseptal flap (NSF) is considered the standard of care in adequately selected scenarios.[1] Although uncommon, availability of the NSF can be compromised by a prior surgical resection, radiotherapy, lesions that involve the flap, and/or septal spurs[2]; hence, the skull base surgeon must be prepared for these special situations. A vascularized flap contributes to faster healing, prevents infections at the surgical site, and is strong enough to withstand postoperative radiotherapy. Microvascular

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reconstructive techniques are an excellent option in cases where extensive reconstruction is needed. Free flaps have been used for several years as a highly trustworthy procedure of reconstruction of large skull base defects, among these; the fascia lata free flap (FLFF) has been successfully used for the reconstruction of head and neck defects. Our main objective is to use the FLFF as a new alternative for endoscopic reconstruction of the anterior skull base using a cadaveric model. Also, we measured the diameter of the superior trochlear artery (STA) in a male and female computed tomography angiography (CTA) scan to establish its viability as a recipient's vessel.

Methods

With approval by the institutional review board at Augusta University, 62 anonymized normal adults CTA scans were analyzed. A total of 24 studies were excluded due to poor quality or studies where cuts not included the forehead. The CTA scans (1.25 mm slice cuts) were then loaded into Osirix (Pixmeo, Geneva, Switzerland) for analysis and rendering. The diameter measuring tool was used for the right and left STA in both male and female populations. The mean diameter of the left and right STA, when feasible, was done at the level of the superior orbital rim. Further analysis using the three- dimensional (3D) rendering functions in Osirix was performed to provide a 3D image that would aid the surgeon in the localization of the STA.

Independently, six cadaver heads were used to identify and measure the diameter of the superior trochlear system (artery and vein) using a double-ended vessel-measuring gauge. A complete endoscopic exposure of the anterior skull base of a freshly injected cadaver head was done. An FLFF was harvested from a cadaver's leg, and inset was then performed to determine the feasibility of the technique.

Results

A total of 38 studies (16 females and 22 males) were included. The average diameter of the female's right and left STA was 2.5 and 2.8 mm^2, respectively; for men, the left and right diameters were 3.0 and 3.1 mm^2, respectively. There were two and three absent STA on the right and left female scans, respectively (31.2%); and there were six and one absent STA, respectively (32%) for men. There was no statistically significant difference between the left and right STA for both female and male studies ($p < 0.5$ and < 0.7, respectively) (►**Table 1**). On the six cadaver heads (one female and five males), the average diameter for both left and right STA was of 2.5 mm^2 (►**Table 2**). There was no statistically significant difference when comparing the right and left STA diameters between the CTA scans and the cadaver heads.

Operative Technique

A patient CTA scan was used as a guide to identify the course of the STA. An endoscopic anterior skull base dissection was achieved in a cadaver's head, exposing the skull base from the posterior table of the frontal sinus to the clivus in the sagittal plane, and from orbit to orbit in the coronal plane.

Table 1 CTA measurements for STA

Variable	Sample size	Mean	Standard deviation	Variance
Female STA diameter				
Right STA diameter mm^2	14	2.54	1.12	1.26
Left STA diameter mm^2	13	2.79	0.65	0.42
Male STA diameter				
Right STA diameter mm^2	16	2.97	0.66	0.44
Left STA diameter mm^2	21	3.12	1.62	2.63

Abbreviations: CTA, computed tomography angiography; STA, superior trochlear artery.

Table 2 Cadavers' superior trochlear system measurements

	Diameter in mm^2			
Gender	Left artery	Right artery	Left vein	Right vein
Female	2.5	2.5	3	3
Male	2.5	2.5	3	3
Male	3	2	0	4
Male	2.5	3	3	3
Male	2	2.5	3	4
Male	2.5	2.5	3	4
Mean	2.5	2.5	2.5	3

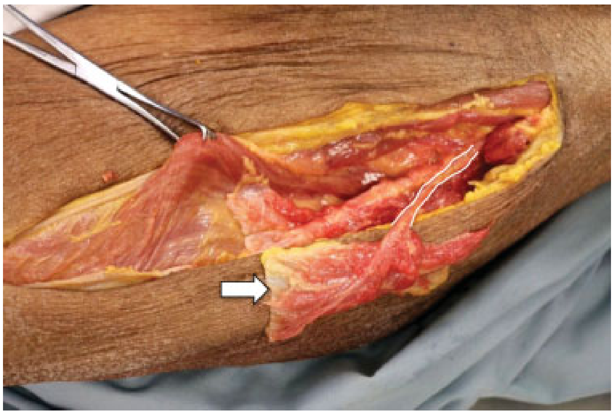

Fig. 1 A cadaver left leg was used for the fascia lata free flap harvest. White arrow shows the flap and the white line shows its pedicle.

On a cadaver's leg, drawing a line between the anterior superior iliac spine and the superolateral border of the patella marked the intermuscular septum between the rectus femoris and the vastus lateralis muscle. The perforators were identified around the midpoint of the line representing the intermuscular septum within a circle of 3 to 5 cm radius. The harvested anterolateral thigh flap (ALT) included fascia lata as well as overlying muscle and fat that were later debulked, leaving only the pedicled FLFF (►**Fig. 1**).

The superior trochlear artery and vein (recipient's vessels) were isolated via a minimal access by a Lynch incision (►**Fig. 2**). An osteotomy with a 5 mm coarse diamond burr was done at the level of the radix. A 2–0 silk suture was passed through the osteotomy to the nasal cavity and then exteriorized through the nose where it was sutured to the flaps pedicle. The FLFF was introduced through the nose (►**Fig. 3**) and used to cover the previously exposed skull base (►**Fig. 4**). The silk suture was then pulled from the osteotomy thus exteriorizing the flaps pedicle for anastomosis to the STA (►**Figs. 5** and **6**).

Discussion

The principles of the reconstruction of skull base defects are to separate the cranial cavity from the sinonasal tract to prevent complications derived from this exposure such as tension pneumocephalus, seizures, cerebrospinal fluid (CSF) leaks, and meningitis. The success of reconstructive techniques should be individualized to every patient needs. Low flow CSF leaks or small defects (< 1 cm) are consistently repaired using multilayered free grafts, reconstructive allografts, and dural sealants with success rates $> 90\%$.[3–5] High-flow CSF leaks, defects > 3 cm, obese and Cushing disease patients profit from vascularized flaps.[6] The NSF, along with other local mucosal flaps,[7–9] as part of skull base reconstruction, have historically changed the reconstructive outcomes after skull base surgery having a postoperative CSF leak risk close to 5%[1,6]; however, prior septoplasty, septal perforation, posterior septectomy, sphenoidotomy or tumoral compromise of the septum can compromise the use of the NSF. For this reason, alternative reconstructive techniques have been studied such as the facial buccinator flap,[10] palatal flap, pericranial flap, and temporoparietal fascial flap.[11]

For complex head and neck cases, free flaps are preferred in patients with a history of surgery, irradiation, or chemotherapy[12] as these can render a pedicled flap unreliable.

Song et al[13] first introduced the ALT-FLFF in 1984 and Wei et al[14] were the first to describe a large series of head and neck reconstruction in 475 patients. Although used to reconstruct large skull base defects, the FLFF can accommodate to the patient-specific needs. Its blood supply is dependent on the descending branch of the lateral femoral circumflex artery. It can measure 8×25 cm, or larger depending on the donor area, and its artery diameter can be between 1.5 and 2.5 mm.[2,15] Another free flap commonly used in anterior

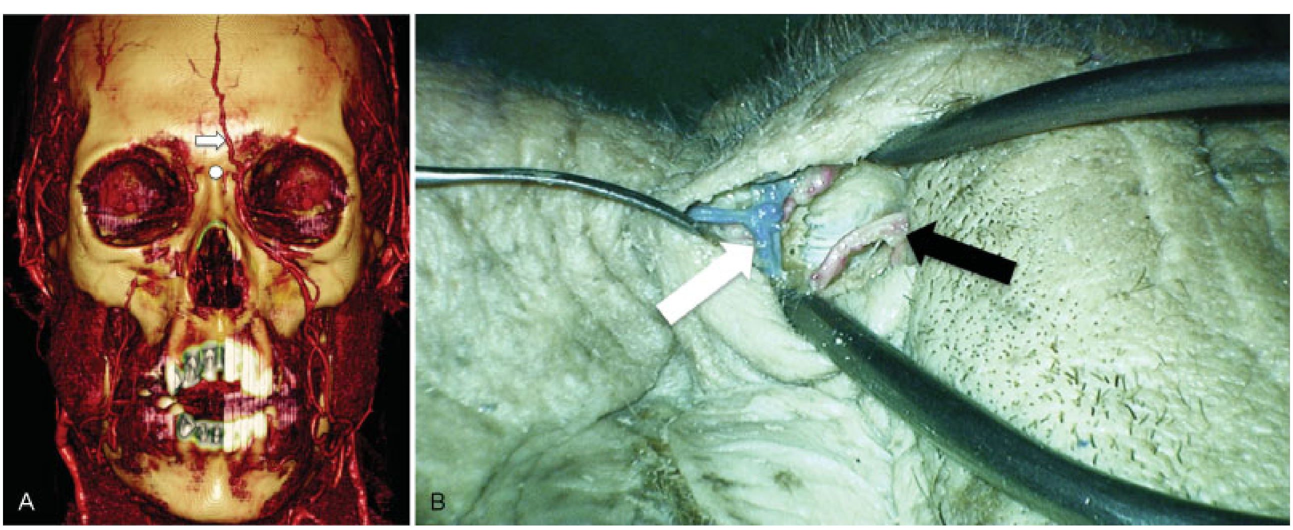

Fig. 2 (**A**) 3D rendering of a patient CTA scan, white arrow indicates the course of the left STA, white circle marks the area of the osteotomy. (**B**) Left Lynch incision exposing the superior trochlear artery and vein, black and white arrows respectively.

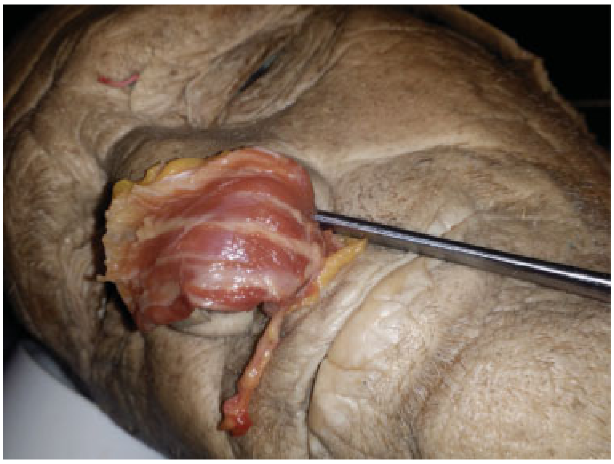

Fig. 3 The FLFF was successfully advanced through the cadavers left nostril without any damage to the flap or its pedicle. FLFF, fascia lata free flap.

skull base reconstruction is the rectus abdominis myocutaneous flap,[12] however, we decided not to use this flap owing to its bulkiness due to the width of the subcutaneous tissue of the abdominal wall. Also, the radial forearm fascicocutaneous flap has been commonly used for anterior skull base reconstruction. Nevertheless, we decided not to use this flap because more permanent movement impairment is seen with this flap compared with the ALT flap.[16]

The STA travels under the orbicularis oculi muscle and over the corrugator muscle, and it gives multiple cutaneous branches as it travels toward the vertex. It has been described as the feeding vessel for the local pericranial flap and forehead skin flaps in nasal reconstruction,[17,18] however, to date, it has not been used as a recipient's vessel for free flap inset.

We analyzed the presence and variability of the STA in both patients CTA scans and cadavers' heads. We found no statistically significant difference between the diameter of

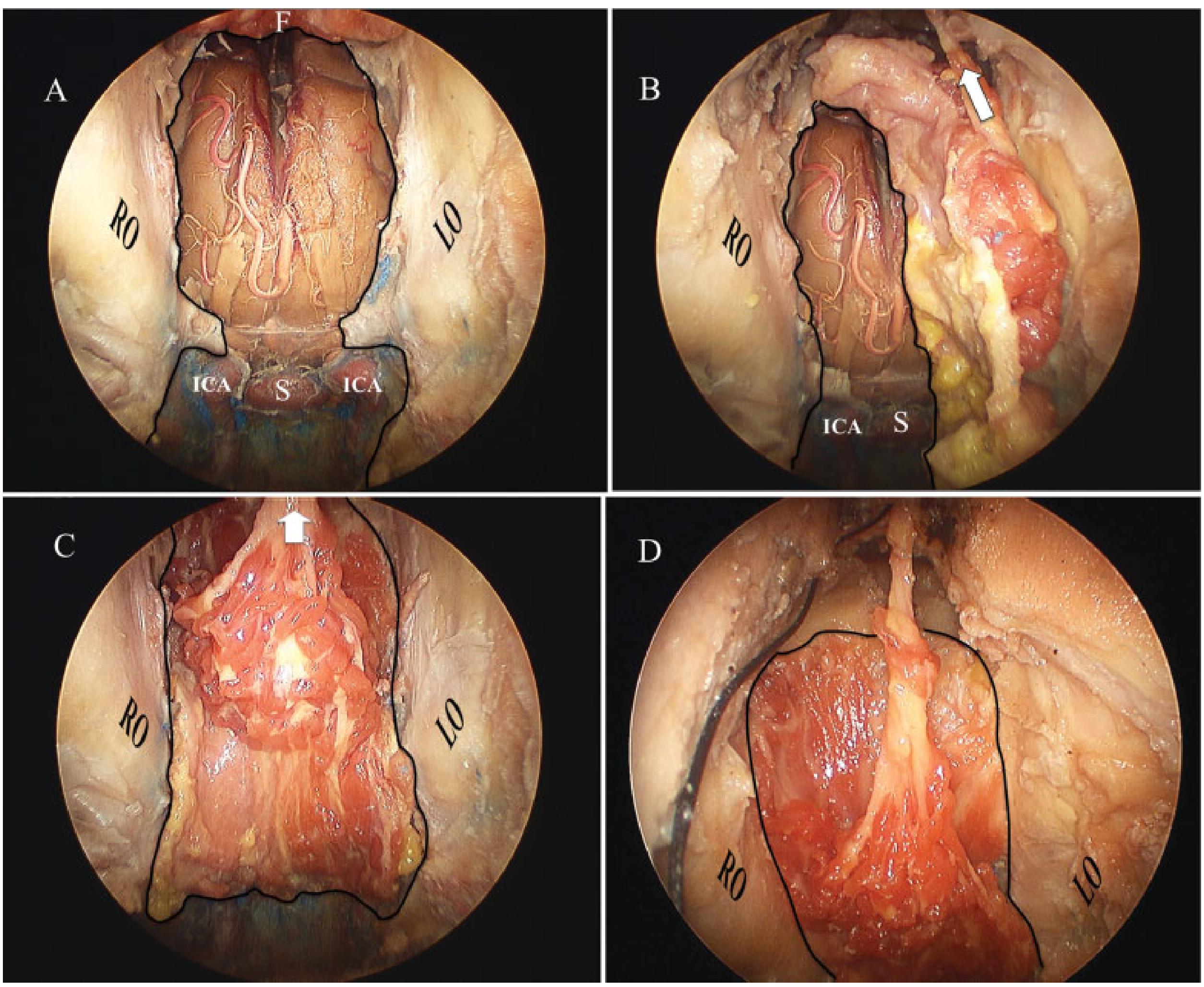

Fig. 4 (**A**) Endoscopic exposure of the anterior skull base. The cribriform plate, falx cerebri, and olfactory bulbs were removed. The sella, bilateral internal carotid artery, and clivus were also exposed. (**B**) Flap insert, half of the defect in the sagittal plane is covered. (**C**) FLFF covered the entire skull base defect successfully; white arrow shows the FLFF pedicle. (**D**) FLFF insert and its pedicle exiting the previously made osteotomy, the tension was applied to the pedicle for picture purposes. F, frontal sinus; FLFF, fascia lata free flap; RO, right orbit; LO, left orbit; ICA, internal carotid artery; S, sella.

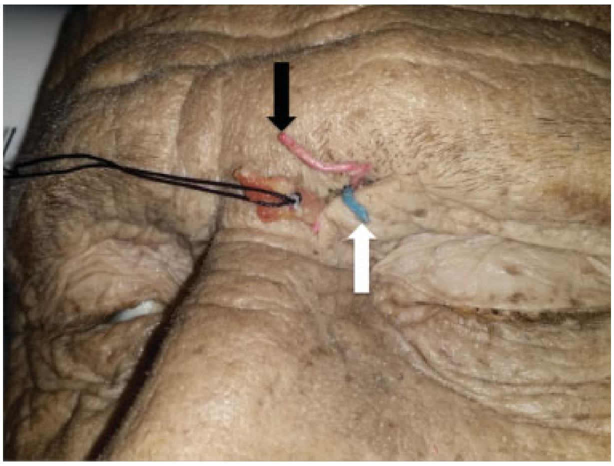

Fig. 5 A silk suture was tied to the flaps pedicle and was used to exteriorize it through the osteotomy. The superior trochlear artery and vein were used as recipient vessels, black and white arrows respectively.

the right and left STA in both, male and female, CTA scans and cadaver heads; also, there was no statistically significant difference in the diameter of the STA diameter (right and left) between men and women. We found that approximately 31% of patients have either the left or right STA absent; however, in the cadaver heads we were able to identify both STA with a Lynch incision approach. Although not included in the analysis, we found the STA length ranged from 4.4 to 5.6 cm, adding length for the anastomosis.

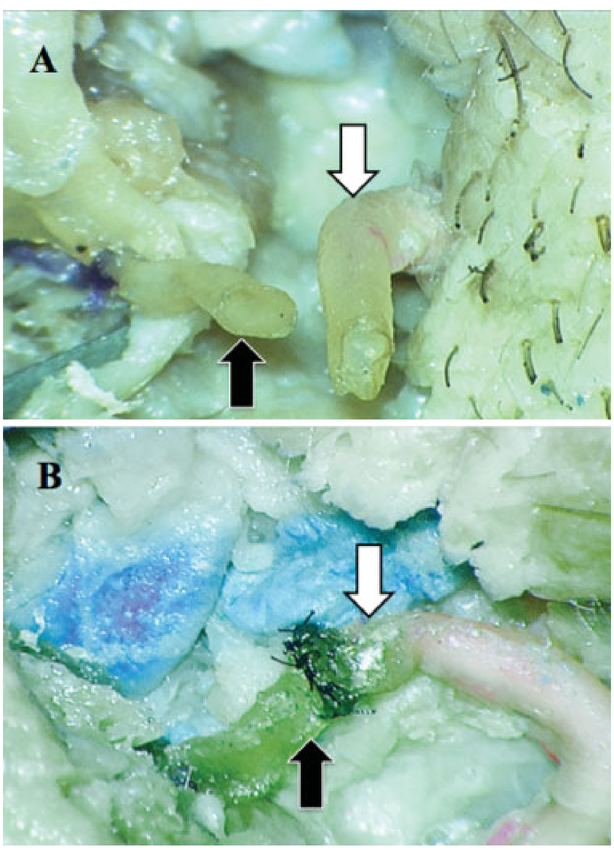

Fig. 6 (**A**) Exposed FLFF lateral femoral circumflex artery (black arrow) and recipient superior trochlear artery (white arrow). (**B**) Anastomosis between the lateral femoral circumflex arteries (black arrow) with the superior trochlear artery (white arrow).

Preferably, the same route used for tumor removal should be used to repair a skull base defect, thus avoiding the comorbidity of a second incisional approach. We evaluated the viability of the model by anastomosing the FLFF pedicle to the superior trochlear artery and vein. We decided to use a Lynch incision to expose the STA and exteriorize the FLFF pedicle through a radix osteotomy diminishing as possible external scars. The FLFF could be introduced through the nose without any resistance, it covered the anterior skull base completely, and its pedicle was successfully anastomosed to the superior trochlear artery and vein after it was exteriorized across the radix osteotomy without damage to it.

Hanasono et al[12] published a large retrospective study were they provided management guidelines for skull base reconstruction. They suggested an ALT free flap for reconstruction of extended central anterior skull defects and extended lateral defects communicating with the sinuses. Also, Schmalbach et al[19] proposed free flap reconstruction as a primary choice for large anterior skull base defects, although both studies assess patients with craniofacial approaches, with the advent of the endoscope and advancing skull base techniques, the EEA now play an important role in the management of anterior skull base neoplasms in properly selected cases.

Camaioni et al[16] retrospectively analyzed a cohort of 38 patients taken to surgery for oral and oropharyngeal carcinoma were they compared outcomes after radial forearm fasciocutaneous flap[17] versus the anterolateral thigh cutaneous flap.[31] No statistically significant difference was seen in flap survival and functional results at the receiving site; however, permanent movement impairment was seen in 35.3% of patients in the radial forearm fasciocutaneous flap group compared with the ALT flap group, where there was only transitory gait impairment in 12.9% of patients. Because there is no need for muscle or skin for endoscopic skull base reconstruction, we consider that the FLFF should be favored in this setting.

One advantage of our technique is that simultaneous resection and flap harvest can be done. The long pedicle (up to 7 cm) from the FLFF and the recipient's vessel gives these technique important degrees of freedom. As opposed to the NSF, the FLFF can be harvested after complete resection of the skull base and be custom-made to the resulting defect. The vasculature of its pedicle is strong enough to withstand postoperative radiotherapy. Furthermore, the flap is not subject to any type of tension, donor-site morbidity is very low, and early ambulation is tolerated.

Because this is a cadaveric study, many questions remain unanswered. First, the cosmetic sequelae from the radix osteotomy cannot be assessed in this model. Closure of the osteotomy with possible compromise of the flap's pedicle and proper early complications of free flaps could occur.

We consider that free flap techniques applied to minimally invasive procedures, such as the EEA, have a role in the future of reconstructive techniques.

Conclusions

The FLFF anastomosed to the STA is a feasible option for skull base reconstruction. The FLFF can cover from the posterior table of the frontal sinus to the clivus, and it holds a high potential as a new alternative for skull base reconstruction in adequately selected scenarios. It should be considered in patients with a history of surgeries which compromise blood flow to intranasal tissue and/or extensive damage to the recipient bed from infection or radiation; nonetheless, this model is still theoretical. It should be used only when other options are not viable. Further studies are needed to assess its safety and efficacy in skull base reconstruction.

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