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ORIGINAL ARTICLE
Reconstructive

Facial Defect Repair Using a Flap Based on the Superficial Temporal Artery

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Background: Although a local flap repair is optimal for facial defects, an extra flap or split-thickness skin graft may be needed if a sufficient local flap area is not available. In this study, we developed a distant axial pedicle flap procedure based on the inner transverse perforator of the ascending frontal branch of the superficial temporal artery to repair facial defects while meeting patients' requirements for a like-for-like tissue reconstructive outcome.

Methods: For defect repair after facial tumor removal, we designed upper frontal facial pedicle flaps based on the inner transverse perforator of the ascending frontal branch of the superficial temporal artery. Facelift procedures were applied concomitantly for donor site repair.

Results: We applied the procedure to 12 patients who underwent curative lesion resection. Notably, all flaps survived. Venous congestion developed in only 1 case, in which the wound was covered with heparin sodium gauze to inhibit wound coagulation until the congestion gradually resolved. In all cases, the frontal donor site scars were adjacent to the hairline and were concealed very well by hair growth. During postoperative follow-ups of 8–43 months, the patients experienced only minor complications.

Conclusions: The flap based on the inner transverse perforator of the ascending frontal branch of the superficial temporal artery is a useful alternative for facial defect repair surgery. The low incidence of complications and easy concealment of the donor site underscore the safe and aesthetically acceptable nature of the procedure. *(Plast Reconstr Surg Glob Open 2021;9:e3541; doi: 10.1097/GOX.0000000000003541; Published online 23 April 2021.)*

INTRODUCTION

The superficial temporal vessel and its branches serve as the main blood supply to the lateral face and frontal and parietal territories. The anatomically consistent nature of this vessel has led to its popularity as a clinically advantageous feature for axial skin flap design in the field of plastic surgery. Currently, the generation of a flap raised on the superficial temporal vessel or its divisions remains a primary method for the repair of scalp or facial soft tissue defects.[1–6] A flap based on the temporal artery as a source vessel may be particularly flexible.[7,8] This method is the primary treatment option for large eyebrow, mustache, beard, or sideburn defects,[9–13] as a flap can be designed from the scalp to create a hairy strip. A flap that contains cranial bone can also be designed for a bone defect repair.[14,15]

During a forehead rhytidectomy procedure for facial rejuvenation in an aged person, tissue is removed from the scalp or upper frontal skin and discarded. This wasted tissue inspired us to consider the design of a distant axial pedicle flap below the front hairline that would take advantage of this upper frontal wrinkled skin and soft tissue. Particularly, we intended the use of this new flap for the repair of midfacial defects when the dimension of a local advanced flap was not sufficiently large. We determined that a distant pedicle flap based on the inner transverse perforator of the ascending frontal branch of the superficial temporal artery (STA) would not only reduce the midfacial advanced flap incision but would also reduce the risk of complications such as hemorrhaging and pain at the wound site, which are increased by the chewing motions performed while eating.[16]

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In our technique, the new donor site was adjacent to the upper frontal hairline, and the donor incision was closed after a facelift procedure to smooth the wrinkled lower frontal skin. The donor incision site coincided with the hairline and was thus inconspicuous (ie, covered by hair growth), yielding an aesthetically acceptable appearance. The patients willingly accepted the procedure and expressed satisfaction with the results. Here, we report the details of the procedure and the outcomes of 12 cases.

PATIENTS AND METHODS

Clinical Cases

Between December 2015 and January 2018, 12 patients in whom local advanced flaps could not sufficiently repair midface defects underwent reconstruction with flaps based on the inner transverse perforator of the ascending frontal branch of the STA (Table 1). The patients' ages ranged from 64 to 79 years, with a mean age of 73 years. Three patients had hypertension, and 2 had a history of cerebral infarction. Additionally, 2 patients had diabetes mellitus and 1 was a smoker. The tissue defects involved the left and right sides in 5 and 7 cases, respectively, and all were secondary defects after the curative ablation of facial tumors. These lesions were malignant in 4 cases (2 cases each of squamous cell carcinoma and basal cell carcinoma), and benign in 8 cases. Eight lesions were ulcerated with surface secretion, and five were infected. The facial defects ranged in size and shape from an ellipse measuring 1.5 cm × 2.0 cm to a semilune measuring 2.0 cm × 6.0 cm. All were reconstructed using flaps based on the inner transverse perforator of the ascending frontal branch of the STA. The study was conducted in accordance with the World Medical Association Declaration of Helsinki.

Surgical Technique

Before the operation, we marked the course of the inner transverse perforator of the ascending frontal branch of the STA in the upper frontal and zygomatic area, which was determined by palpation or ultrasound probe assistant localization. We also designed an approximate preliminary flap dimension immediately under the anterior hairline in the upper frontal area (Fig. 1A, Fig. 2B).

After removing the lesion, we dissected the border of the defect backward to the pretragus and forward to the nasolabial groove on the underside of the superficial musculoaponeurotic system (SMAS). This created 2 opposite local SMAS flaps on the medial and lateral sides of the defect. The dimension of the defect was reduced by advancing these local SMAS flaps to the center. The remaining defect was covered by saline gauze, and a paper template was made.

The flap design was then modified in the frontal area. While preserving 0.5–1.0 cm of fascial tissue on the bilateral vascular verge, the flap was elevated meticulously along the artery to pretragus until the pedicle length was sufficient. A subcutaneous tunnel was then dissected from the root of the pedicle to the remaining defect, and the flap was drawn through this tunnel. After the flap was trimmed, a drainage tube was placed into the incision. The incision was cauterized carefully with a bipolar cautery, and the flap was sutured with the defect intermittently. In the upper frontal area, we sutured the incision using a layer-by-layer technique by raising the middle and lower frontal tissues to the anterior hairline with the facelift procedure.

RESULTS

All 12 repair procedures were successful in terms of flap survival. For right-sided defects, the maximum and minimum defect sizes were 2.0 cm × 6.0 cm and 1.5 cm × 2.0 cm, respectively, and the maximum and minimum flap sizes were 2.5 cm × 7.0 cm and 1.5 cm × 2.0 cm, respectively. For left-sided defects, the maximum and minimum defect sizes were 2.0 cm × 4.0 cm and 2.0-cm diameter (round), respectively, while the maximum and minimum flap sizes were 2.5 cm × 4.0 cm and 2.0 cm diameter (round), respectively. Postoperatively, venous congestion occurred in only 1 case. To manage this complication, we removed the stitches from the flap and covered the wound with heparin sodium gauze to inhibit wound coagulation. The congestion resolved gradually, and the flap survived. In all cases, the donor incisional scar on the upper frontal facial surface was concealed by the hairline. In some patients, the concomitant facelift procedure noticeably reduced or almost completely resolved any upper frontal facial wrinkling. The patients were followed postoperatively for 8–43 months and expressed satisfaction with the outcomes of the repair procedure. Below, we discuss the details and outcomes of 2 representative cases.

Table 1. Clinical Patients Subjected to Facial Defect Repair Using a Flap Based on the Inner Transverse Perforator of the Ascending Frontal Branch of the STA

Patient No.	Gender	Age (y)	Site	Dimension of the Remaining Defects	Dimension of the Flaps	Preoperative Complications	Follow-up (mo)
1	Woman	77	Right	2.0 cm × 3.0 cm	2.0 cm × 3.0 cm	Ulcer, infection	28
2	Man	78	Left	2.0 cm × 2.5 cm	2.0 cm × 2.5 cm	Ulcer	23
3	Man	79	Left	2.5 cm × 2.0 cm	2.5 cm × 2.0 cm	Ulcer	23
4	Man	64	Right	1.5 cm × 2.5 cm	2.0 cm × 2.5 cm	No	22
5	Woman	74	Left	2.0 cm × 4.0 cm	2.5 cm × 4.0 cm	Ulcer, infection	20
6	Man	76	Right	2.0 cm × 1.5 cm	1.5 cm × 2.0 cm	No	43
7	Man	70	Right	Diameter of 2.0 cm	Diameter of 2.0 cm	Ulcer	40
8	Woman	72	Right	1.5 cm × 2.5 cm	1.5 cm × 2.5 cm	No	18
9	Woman	79	Right	Diameter of 2.0 cm	Diameter of 2.0 cm	No	8
10	Man	70	Left	Diameter of 2.0 cm	Diameter of 2.0 cm	Ulcer, infection	21
11	Woman	71	Left	2.0 cm × 2.5 cm	2.0 cm × 2.5 cm	Ulcer, infection	15
12	Man	77	Right	2.0 cm × 6.0 cm	2.5 cm × 7.0 cm	Ulcer, infection	13

Fig. 1. Photographs from a representative case (Case 1). A, Preoperative view. The lesion was located on the lateral surface of the left canthus and zygomatic bone. The tumor excision margins were mapped, and a flap based on the inner transverse perforator of the ascending frontal branch of the STA was designed on the upper frontal. B, Intraoperative view. The defect and flap were raised. C, The flap was transferred to the defect through a subcutaneous tunnel. D, Postoperative view. The flap survived well, and the donor incision site was sutured directly by lifting the lower frontal flap along the hair line. E, Front view obtained 15 months postoperatively. The patient's eyebrows are symmetrical, and wrinkling on the left upper frontal is reduced. F, Profile view. The flap matched the defect site perfectly.

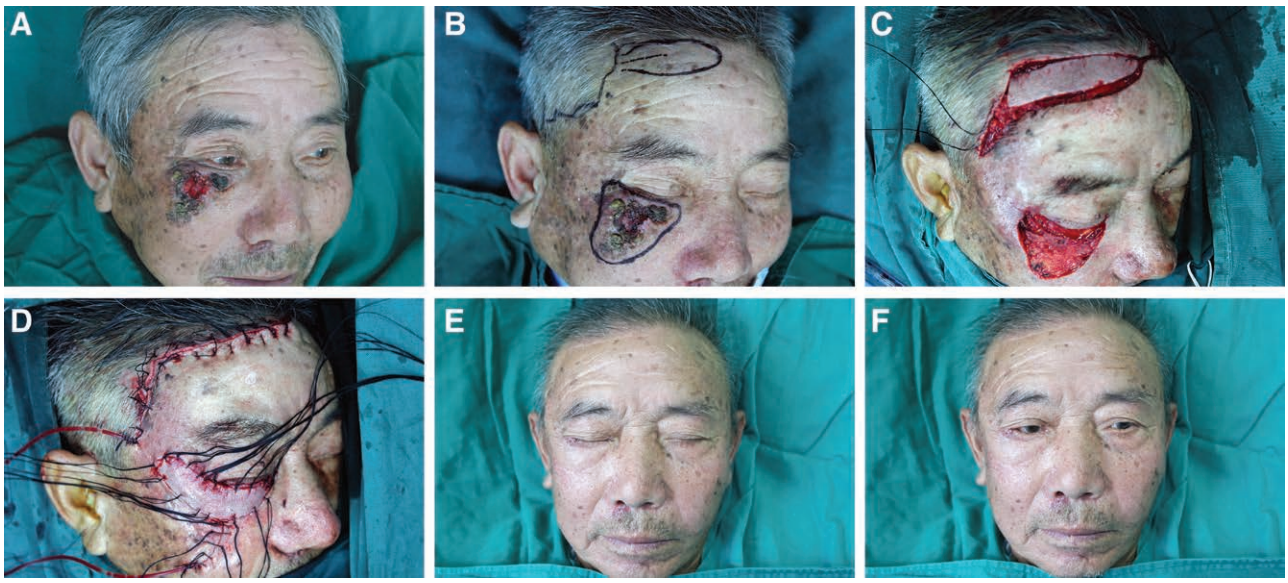

Fig. 2. Photographs from a representative case (Case 2). A, Preoperative view. The lesion was located in the lower palpebra and pars buccalis and featured a triangular configuration with a central ulcer. B, The edge of the lumpectomy was planed, and a flap was designed in the upper frontal. The course of the frontal branch of the STA at the temporal location had a zigzag shape. C, Intraoperative view. The defect included the entire lower palpebra and the lower lateral canthus and part of the cheek. The flap was elevated. D, The flap based on the inner transverse perforator of the ascending frontal branch of STA was used to repair the defect over the lower palpebra and lateral canthus. The cheek defect was repaired using advanced flaps. E, Postoperative view after 9 months. The photograph with eyes closed demonstrates good flap survival, with good color and texture matching. The patient's eyebrows are symmetrical, the donor site scar is concealed by the hairline, and the indicated wrinkles on the right frontal have flattened. F, Postoperative view with the eyes open.

Case 1

A 71-year-old woman presented with a tumor on the left lateral canthus and pars zygomatica that appeared ulcerated, with blood exudate. The tumor was dissected with a 0.5-cm margin via en bloc resection. A frozen section examination confirmed the diagnosis of basal cell carcinoma, with tumor-negative margins. After relaxing the incisional borders of the defect beneath of the superficial muscular aponeurotic system and connecting the zygomatic region, a 2.0 cm × 2.5 cm elliptical

defect remained over the left lateral canthus and pars zygomatica.

We elevated an oval-shaped upper frontal flap based on the inner transverse perforator of the ascending frontal branch of the left STA. The flap was harvested along the vessel, and a subcutaneous pedicle was reserved with 1 cm of perivascular fascial tissue. The flap was tunneled to the defect through a subfascial planar incision, and drainage was placed under the flap. Next, the flap was interrupted and sutured to the defect after trimming. We applied a facelift procedure at the upper frontal donor site wherein we lifted the tissue at the lower frontal, tightened and flattened the slack skin, and directly closed the donor site incision. Both incisions healed very well. The upper frontal horizontal scar coincided with the front hairline and was parallel with the skin wrinkles, and was not obviously visible when covered by the hair flow. The patient's eyebrows remained symmetrical. Only minor complications occurred during a postoperative follow-up of 15 months (Fig. 1).

Case 2

A 77-year-old male patient presented with an ulcerative lump on the right low palpebra and pars buccalis that had persisted for 6 years. The lump was infected and contained a non-healing ulcer with bloody effusion. The shape of the lump was somewhat triangular, with irregular and unclear borders. Resection of the lump created a triangular defect on the right face, with an edge length of 6 centimeters. The lower part of the defect was located on the cheek and was sutured by sliding advanced flaps along and directly beneath the SMAS. The remaining upper part of the defect nearly coincided with the low right palpebra and low lateral canthus and measured 2.0 cm × 6.0 cm.

We designed an upper right frontal flap pedicled with the inner transverse perforator of the ascending frontal branch of the right STA, adjacent to the hairline. The flap size of 2.5 cm × 7.0 cm was slightly larger than the remaining defect. We carefully dissected the flap along the marked line to the superior of the zygomatic arch until a sufficient pedicle length was achieved. The vessel was protected by a fascial tissue reserve of 1.0 cm. A hypodermal tunnel was formed and used to draw the flap to the right low palpebra and lateral canthus. A vacuum drain was placed under the flap. Subsequently, when the defect was sutured closed, an internal stitch of the flap was made along with the incision of the low palpebra and lateral canthus defect. The donor site was sutured directly during a facelift procedure. Nine days postoperatively, the stitches were removed, and the flap survived very well. The patient's eyebrows were symmetrical, and the donor site scar on the right upper frontal coincided with the hairline and was concealed by the hair flow. The patient experienced only minor complications during a postoperative follow-up of 12 months (Fig. 2).

DISCUSSION

In this report, we have described our successful design of a distant axial pedicle flap procedure based on the inner transverse perforator of the ascending frontal branch of the STA. We further demonstrated the successful application of this procedure for the repair of large facial defects. Our procedure is associated with only minor complications, and the treated patients expressed satisfaction with the aesthetic and functional outcomes.

Although our procedure is novel, flaps based on the STA and its divisions have been used for more than 100 years. In 1892, Dunham dissected a flap containing the anterior branch of the STA to reconstruct a left facial defect secondary to a tumor resection.[17] The operation was successful and yielded satisfactory effects. Subsequently, Monks used a forehead flap based on the frontal branch of the STA to reconstruct a lower palpebra with reference to Dunham's experience, and also achieved a successful result.[18] These early results provided a very good precedent for future plastic and reconstruction surgical procedures. These successful experiences widely inspired the application of island flaps based on the STA or its divisions for the clinical reconstruction of facial and scalp defects.[19,20]

The STA, a direct terminal furcation of the external carotid, is a constant anatomical feature with an ample blood supply, as demonstrated by Pinar et al.[21] The lateral face and scalp contain many subbranches of the STA. The backward subsidiary branches contain many anastomoses with the occipital artery at the back of the head, while the forward subsidiary branches contain many anastomoses with the zygomaticotemporal facial artery and the frontal supratrochlear and supraorbital arteries. The complex terminal ramifications anastomose with the opposite terminal ramifications at the vertex of the epicranial aponeurosis or the frontal midline. Consequently, a flap pedicled with the STA or a subsidiary vessel provides a large rotation arc. This flap can be dissected proximally to the front of the ear to meet the concrete operative needs. The anastomoses support the survival of a flap that crosses the midline. They observed the frontal branch in all 27 specimens. This branch traverses forward to the forehead and runs parallel to the upper corner of the orbicularis oculi muscle. It anastomoses with the opposite frontal branch on the galea. The perforating branches then pass through the deep fascia and the frontal muscle.

In a retrospective in vivo analysis, Medved et al observed the STA in 93 cases using digital subtraction angiography and identified only 1 case in which the frontal branch was not visible.[22] In that case, the vessel may have been very small or in a state of contraction, or may have formed a sharp oblique angle with the trunk. Those reasons might have caused reduced filling with the contrast agent relative to the larger vessels, which would have reduced the visibility of the artery on the angiographic image. This study outcome proved the generally good stability of the frontal branch. In a study of 30 head and neck cadaver specimens perfused with a radio-opaque lead oxide mixture via the femoral vessels, Houseman et al combined photographic and radiologic subtraction techniques to construct 3-dimensional angiosomal maps of the head and neck region on a computer system.[23] These maps revealed that the angiosomes normally formed communicating branches within tissues, and that the midline of the forehead was rich in arterial anastomoses.

Kleintjes reported the distribution of four subsidiary branches of the frontal branch of the STA in the frontal and anterior temporal areas: the descending temporal branch, ascending temporal branch, ascending frontal branch, and transverse frontal branch.[24] Lee et al also observed the complicated ramifications of the ascending frontal branch,[25] noting that some subsidiaries of this branch also passed through the deep fascia and occipitofrontalis muscle and reached the midline from the lateral border of the frontal occipitofrontalis muscle belly, with transverse ramifications below the frontal hairline. Notably, this transverse ramification is a distal terminal perforator of the STA. We designated the terminal ramification of the ascending frontal branches that course inward to the midline as the inner transverse perforator of the ascending frontal branch of the STA.

In a study of 15 fresh cadavers, Fissette et al demonstrated the frontal anastomoses of the 2 superficial temporal arteries,[26] which were consistently superficial. In that study, the average anastomostic territory of the frontal branch was 7.6 cm on the midline (range: 4–11 cm). These anastomoses therefore provide a great advantage for flap survival, even if the midline is crossed.

We recommend the cautious dissection of the upper frontal flap based on the inner transverse perforator of the ascending frontal branch of the STA, particularly with regard to the pedicle. It is important to avoid damaging the ascending frontal branch of the STA toward the vertex, which is normally located between the anterior border of the temporalis muscle and the lateral border of the frontalis muscle. The frontal branch, and particularly the segment that furcates from the ascending frontal branch, curves in a waved shape above the anterior part of the zygomatic arch. Kuruoglu et al illustrated this course using a 3-dimensional computed tomographic image volume rendering technique.[27] Our operative technique further confirmed this curved course. To ensure a successful operative manipulation, we recommend confirming the course of the inner transverse perforator of the ascending frontal branch of the STA preoperatively by digital palpation, or with ultrasound assistance if the artery is not easily palpable. These procedures can reduce uncertainty and the risk of accidental intraoperative injury.

We note that as we aimed not to perform a frontal split-thickness skin graft repair, our newly described flap based on the inner transverse perforator of the ascending frontal branch of the STA is only suitable for the repair of small- or medium-sized midfacial defects. In all cases, we initially used an advanced flap to repair the local defect. The newly described flap was placed when the dimension of the advanced local flap was not sufficient to complete the repair, and this combined procedure advantageously enabled us to reduce the dimension of the frontal flap.

As noted, we selected the frontal area under the hairline as the donor site for multiple reasons. Particularly, this donor site was easily closed, and the incision site was easily concealed by the hair flow. The maximal flap breadth did not exceed 2.5 cm, and most of the frontalis muscle was retained. Consequently, brow ptosis and asymmetry were avoided. The procedure also enabled an optimal match of skin color and texture with the recipient site. This alternative provided a good option for patients who stated aesthetic requirements, while reducing the incidence of complications such as postoperative hemorrhage and dehiscence. We note that the careful selection of appropriate patients was an essential component to success, as it would be for any clinical application.

CONCLUSIONS

Our results suggest that a facial defect repair procedure that combines a local flap with an upper frontal pedicle flap based on the inner transverse perforator of the ascending frontal branch of the STA is a feasible treatment option. This repair procedure was combined with a facelift procedure to ensure the adequate closure of the donor incision. The procedure maintained the symmetry of the eyebrows and did not disrupt the patient's dietary intake, and the donor site scar was easily covered by the hair flow. Moreover, this option avoided the placement of a long incisional scar on the midface. Only minor postoperative complications were observed. Consequently, the patients easily accepted this procedure and expressed satisfaction with the outcome.

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PATIENT CONSENT

The patients provided written consent for the use of their images.

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