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ORIGINAL ARTICLE
Craniofacial/Pediatric

Temporoparietal Fascia Flaps in Children Under 15 Years of Age: An Anatomic Investigation and Its Clinical Implications in Auricular Reconstruction

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Background: The temporoparietal fascia (TPF) flap has been successfully used in the treatment of microtia with primary or secondary cases. The literature contains numerous studies about its structure and vascular anatomy in adults. However, it is rare to study its vasculature and characteristics in children.

Methods: From September of 2013 to May of 2020, 188 patients with average age of 9.8 years (range, 5–14 years) underwent total ear reconstruction with costal cartilage in 67 patients (68 ears) or porous polyethylene framework in 121 patients (128 ears) using 196 TPF flaps. The TPF flap was most commonly used in second-stage operations to elevate the reconstructed auricle in the costal cartilage group. Contrastingly, the TPF flap was routinely used in the porous polyethylene framework group. The vascular pattern and characteristics of the TPF flap were evaluated during flap elevation.

Results: Only 140/196 cases (71.4%) showed a typical pattern with the superficial temporal artery and the superficial temporal vein in this study; others (28.6%) were supplied by combinations of the posterior auricular artery or vein, occipital vein, diploic vein, and superficial artery or vein. Meanwhile, there are variants of the STA and posterior origin-superficial temporal artery, which originates posterior to the lobule beneath the cartilage remnant (3/196, 1.5%).

Conclusion: Surgeons should inspect the pattern of the TPF flap thoroughly before elevation in children, because of the variety of the vessels and anatomic patterns of TPF. *(Plast Reconstr Surg Glob Open 2021;9:e3573; doi: 10.1097/GOX.0000000000003573; Published online 18 May 2021.)*

INTRODUCTION

The temporoparietal fascia (TPF) flap is useful for head and neck reconstruction, especially auricular reconstruction. Many surgeons use the TPF flap in difficult primary or secondary auricular reconstruction[1–5] and the fascial flap should also be applied in ear reconstruction, using a porous polyethylene framework to minimize complications.[6] Numerous studies about its structure and vascular anatomy have been discussed in the literature in adults.[7–9] Dr. Chul Park reported an analysis of 123 TPF flaps in 119 patients.[10] However, it is rare to study TPF flap's vasculature and characteristics in children.

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Received for publication December 9, 2020; accepted March 4, 2021.

DOI: 10.1097/GOX.0000000000003573

This study aimed to evaluate the vascular patterns and clinical implications of 196 consecutive TPF flaps for auricular reconstruction in 188 patients under 15 years old.

PATIENTS AND METHODS

Between September 2013 and May 2020, 188 consecutive patients underwent total auricular reconstruction, with costal cartilage used in 67 patients (68 cases) or porous polyethylene framework in 121 patients (128 cases), using 196 TPF flaps (Table 1). The types of microtia were summarized in Table 2. The TPF flap was most commonly used in second-stage operations for elevation of the reconstructed auricle in the costal cartilage framework group. In addition to ear elevation, other indications for surgery are framework exposure (2 cases), atypical type microtia with lower hair line (3 cases), and previous canaloplasty (3 cases). The TPF flap was routinely used in the porous polyethylene

Disclosure: *The author has no financial interest to declare in relation to the content of this article.*

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Table 1. Patient Demographic Characteristics

Characteristics	Cartilage Framework Group	Porous Polyethylene Framework Group
No. (cases)	67(68)	121 (128)
Gender		
Men	49	71
Women	18	50
Mean age at surgery (y)	11–14 (13.3)	5–12 (6.2)
Affected ear		
Right	45	84
Left	21	30
Bilateral	1	7

Table 2. Types of Microtia

Types	No. Cases
Lobule	153 (76*)
Atypical	18 (1*)
Small concha	17 (5*)
Concha	6 (2*)
Anotia	2
Total	196

* Number in parentheses means the cases of patients with previous canaloplasty.

framework group to minimize complications. Vascular pattern and characteristics of TPF flap were evaluated during the flap elevation. All parents or guardians gave written informed consent for participations in scientific investigations and all procedures performed in studies were in accordance with the principles outlined in the 1964 Declaration of Helsinki and its later amendments.

Flap Elevation

Preoperative Doppler tracing was conducted in all patients to identify the course of the main vessels supplying the temporoparietal fascia. Flap dimensions were drawn on the scalp at 12–13 cm from imaginary upper helix (length) and 9–10 cm from anterior margin near the frontal hair line (width). The scalp incision should not penetrate below the deep dermis because of thin scalp skin and the superficially located the vessels in young children. After a lazy-S beveled incision in the direction of the hair follicles, the TPF was exposed by separating the wound using metzenbaum scissors, following which the scalp flap was elevated from underlying TPF. Surgeons should ensure they avoid injuring hair follicles and vessels during all procedures. Dissection from proximal to distal direction assists in minimizing vessel injury, especially to the superficial veins in the distal half of the flap, and meticulous bleeding control was performed under loupe magnification. After the scalp flap was elevated, the vascular pattern of the TPF was thoroughly inspected. The anterior margin of the TPF was incised within the hairline level to avoid injuring the frontal branch of the facial nerve, especially in atypical type microtia with malposition of the remnant ear. After the TPF flap was elevated, it was turned inferiorly and draped on the framework or the exposed portion of the framework. The fascia was covered with skin flaps[11] or grafted with the thin split-thickness scalp skin. Representative cases are shown Figures 1 and 2.

Analysis of Vascular Pattern and Characteristics of Temporoparietal Fascia

The vascular anatomy and characteristics of the fascia were inspected during the flap elevation. The distributions of the main artery and vein supplying the fascia were assessed, and their diameters were measured using sliding calipers. Anatomical variants of the superficial temporal artery (STA) were found, including the posterior origin STA (p-STA) (as opposed to the typical preauricular origin). The characteristics of the fascia, such as the presence of supra-auricular muscles and of the innominate and deep fascia, were evaluated and compared with those of adult described in the literature.

RESULTS

A total of 196 TPF flaps have been used for auricular reconstructions in 188 patients from September 2013 to May 2020. The mean dimension of the flap, measuring the length of the flap from the upper margin of the planned reconstructed ear and the average width, was 9 × 12 cm, and the elevated TPF flaps were draped onto partial or entire frameworks, the posterior surface of the elevated reconstructed ear (costal cartilage framework) and defect portions (framework exposure in the cartilage group).

Vascular Patterns of the Temporoparietal Fascia

The patterns of the artery and vein supplying the fascia were inspected and depicted in Figure 3. In the STA type, the main artery supplying the TPF flap is the superficial temporal artery (STA). Various combinations of the STA with the superficial temporal vein (STV), postauricular vein (PAV), occipital vein (OV), and diploic vein (DV) exist. In the STA type (191/196 cases, 97.4%), the typical combination of the STA and STV occurs in 140/196 cases (71.4%). The remainder is a combination of STA-PAV (45/196 cases, 22.9%), STA-OV (2/196 cases, 1.02%), and STA-DV (4/196 cases, 2.04%). In contrast, 5/196 cases (2.6%) are of the posterior auricular artery (PAA) type. The venous drainages are the posterior auricular vein (3/196, 1.5%), the superficial temporal vein (1/196, 0.5%), and the occipital vein (1/196, 0.5%) (Table 3). The occipital artery (OA) type described in the literature was not observed.[10] The diameters of the vessels were measured at the level of the upper margin of the planned reconstructed ear (Table 4). The mean diameters of the arteries and veins were 1.08 mm and 1.20 mm, respectively. Those arteries and veins with tiny caliber under 1 mm were excluded in the calculation of the mean values. The numbers of STA, STV, and PAV were 39, 18, and 3, respectively.

Anatomic Variants of the Superficial Temporal Artery

Besides a variety of the arteries and veins supplying temporoparietal fascia, there are variants of the STA (Fig. 4). The classic pattern of the STA bifurcating into frontal and parietal branches was present in 129/196 cases (66%). An additional branch from the frontal branch supplies the TPF flap in 53/196 cases (27%). The parietal branch originated from the frontal branch in 5/196 cases (2.5%). A single parietal or frontal branch occurred in 3/196 cases (1,5%) and 6/196 cases (6.3%), respectively. The STA runs

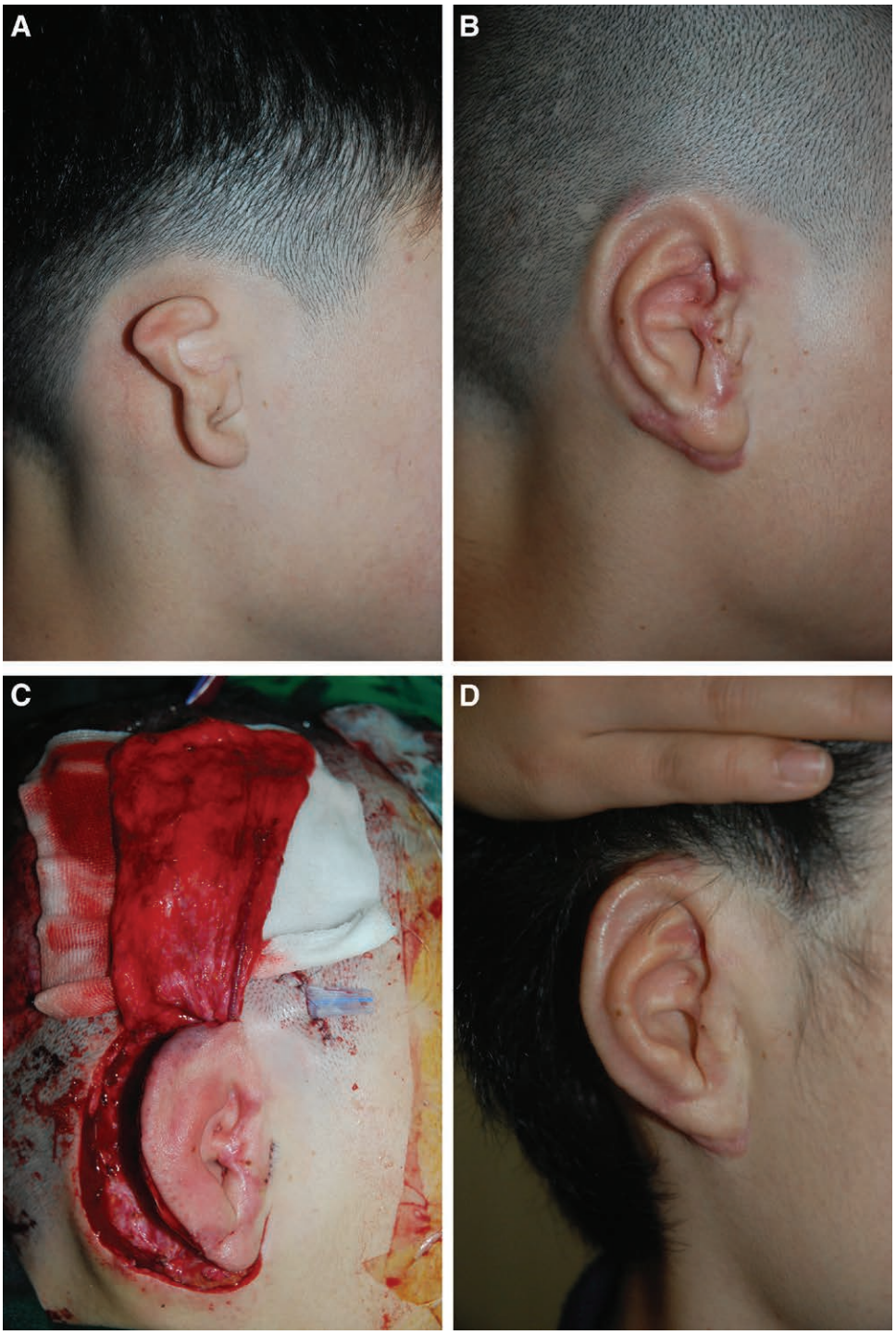

Fig. 1. Clinical case 1 (cartilage framework). A 14-year-old boy with small concha-type microtia. The patient underwent total auricular reconstruction using a costal cartilage framework. A, Preoperatively. B, Six months after the first-stage operation, C, Elevated TPF flap during the second stage operation, D, 1 year and 1 month, postoperatively.

anteriorly to the ear and courses superiorly on the surface of the TPF. However, a clinically important variation of the STA originating posterior to the lobule beneath the cartilage remnant occurred in 3/196 cases (1.5%) (**See Video [online],** which demonstrates the posterior origin of the STA). The p-STA is prone to injury during removal of remnant cartilage and in canaloplasty. Therefore, it is important to confirm the course of the STA preoperatively using a Doppler ultrasound device, and surgeons must take care not to injure the artery during removal of cartilage remnant.

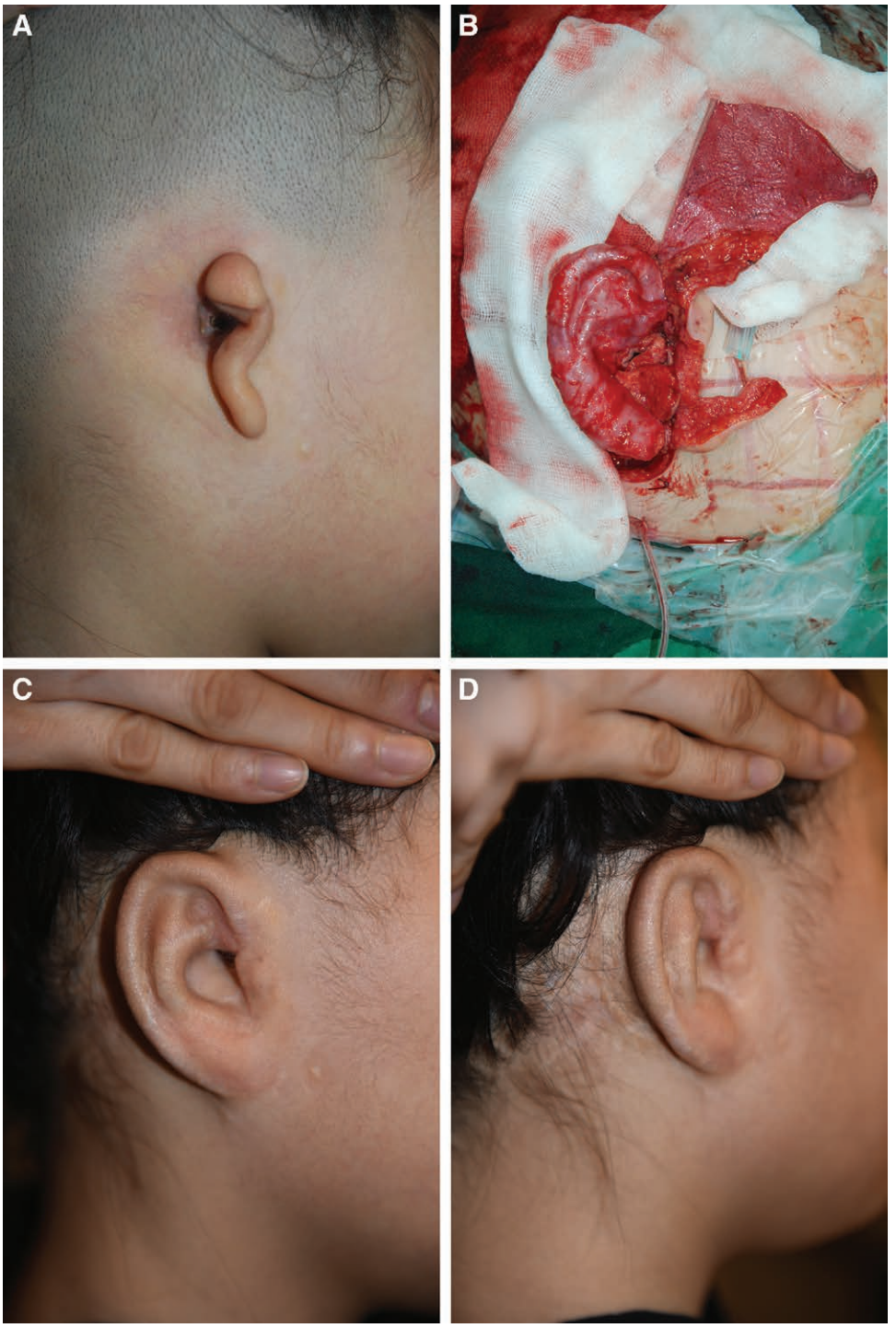

Fig. 2. Clinical case 2. (porous polyethylene framework). A 6-year-old girl with lobule-type microtia. She underwent canaloplasty before ear reconstruction and subsequent total auricular reconstruction using a polyethylene framework, temporoparietal fascia flap, and skin flaps. A, Preoperatively. B, The framework was covered with temporoparietal fascia flap and noted elevated skin flaps. C, Lateral view, 3 years and 2 months, postoperatively. D, Posterior view, 3 years and 2 months, postoperatively.

Characteristics of Temporoparietal Fascia

The TPF in children was thinner than in adults, especially in patients with facial palsy and hemifacial microsomia. The diameters of the vessels supplying the TPF were small, even the arteries, which appear similar to capillaries in some patients. Vascular spasm was severe during dissection, and dissecting the fascia from proximal to distal along the vessels prevented vascular injury. Therefore, the elevation of the TPF flap was difficult in children because of the thin-caliber vessels, severe vascular spasm and anatomic variations of TPF.

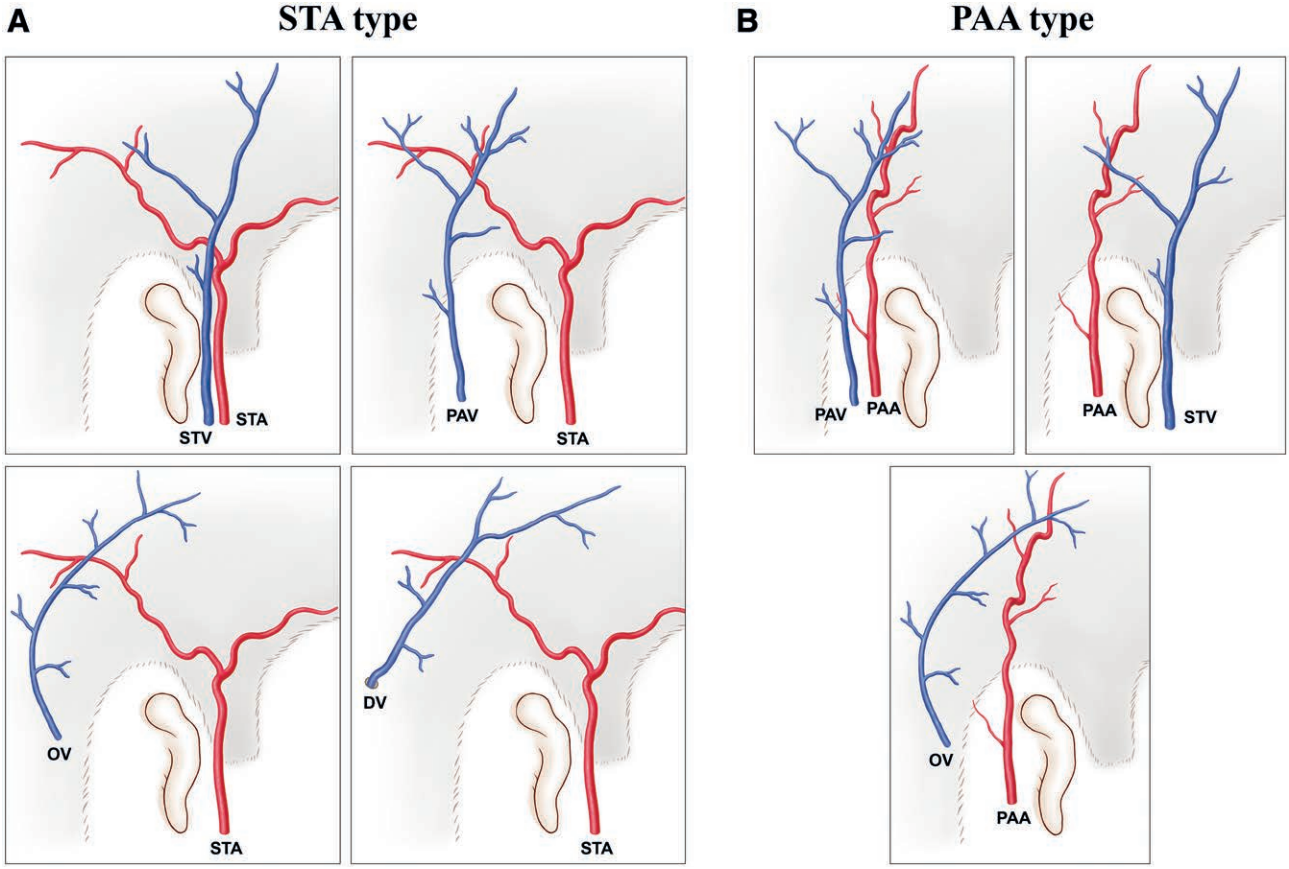

Fig. 3. Vascular patterns of temporoparietal fascia flaps. A, In the STA type, the primary arterial supply to the temporoparietal fascia flap via the STA. B, In the PAA type, the supply is via the posterior auricular artery. In the STA type (191/196, 97.4%), the classical pattern of supply via the STA and STV occurs in 140 of 196 cases (71.4%). The remainder is a combination of STA-PAV (45/196 cases, 22.9%), STA-OV (2/196 cases, 1.02%) and STA-DV (4/196 cases, 2.04%). 5/196 cases (2.6%) were of the PAA type. The venous drainages are the PAV (3/196, 1.5%), the STV (1/196, 0.5%) and the OV (1/196, 0.5%). The occipital artery type described in the literature was not observed.

Table 3. Vascular Patterns of the Temporoparietal Fascia in Children

STA Type	STA-STV	STA-PAV	STA-OV	STA-DV	
	140 (71.4%)	45 (22.9%)	2 (1.02%)	4 (2.04)	191 (97.4%)
PAA Type	**PAA-PAV**	**PAA-STV**	**PAA-OV**		
	3 (1.5)	1 (0.5%)	1 (0.5%)		5 (2.6%)
OA Type					0

The STA type means that the main artery supplying the temporoparietal fascia flap is a superficial temporal artery and the main artery is a posterior auricular artery in the PAA type. For STA, PAA, OA, STV, PAV, OV, and DV, see Fig. 3.

Table 4. The Diameters of the Vessels Supplying Temporoparietal Fascia Flaps

Vessel	Mean Diameter (mm)
STA (152*)	1.03
STV (123*)	1.14
PAA (5)	1.12
PAV (43*)	1.23
DV (4)	1.26
OV (3)	1.2

*The vessels with thin caliber under 1 mm were excluded in the calculation of the mean value (STA: 39 cases, STV: 18 cases, PAV: 3 cases).
The number in parentheses means the cases of subtracting that from total cases. For STA, STV, PAA, PAV, DV, and OV, see Fig. 3.

Because the supra-auricular muscle was not observed in the most cases, it does not affect the thickness of the elevated TPF flap. Innominate fascia shows fiber-like characteristics, not definite fascia or membrane. In cases of total ear reconstruction using porous polyethylene framework, the innominate fascia was included in the elevated TPF flap as much as possible to provide the gliding surface between the TPF flap and covered skin. In some patients, the deep temporal fascia shows abortive or not definite fascia, compared with the dense, tough and uniform fascia of adults.

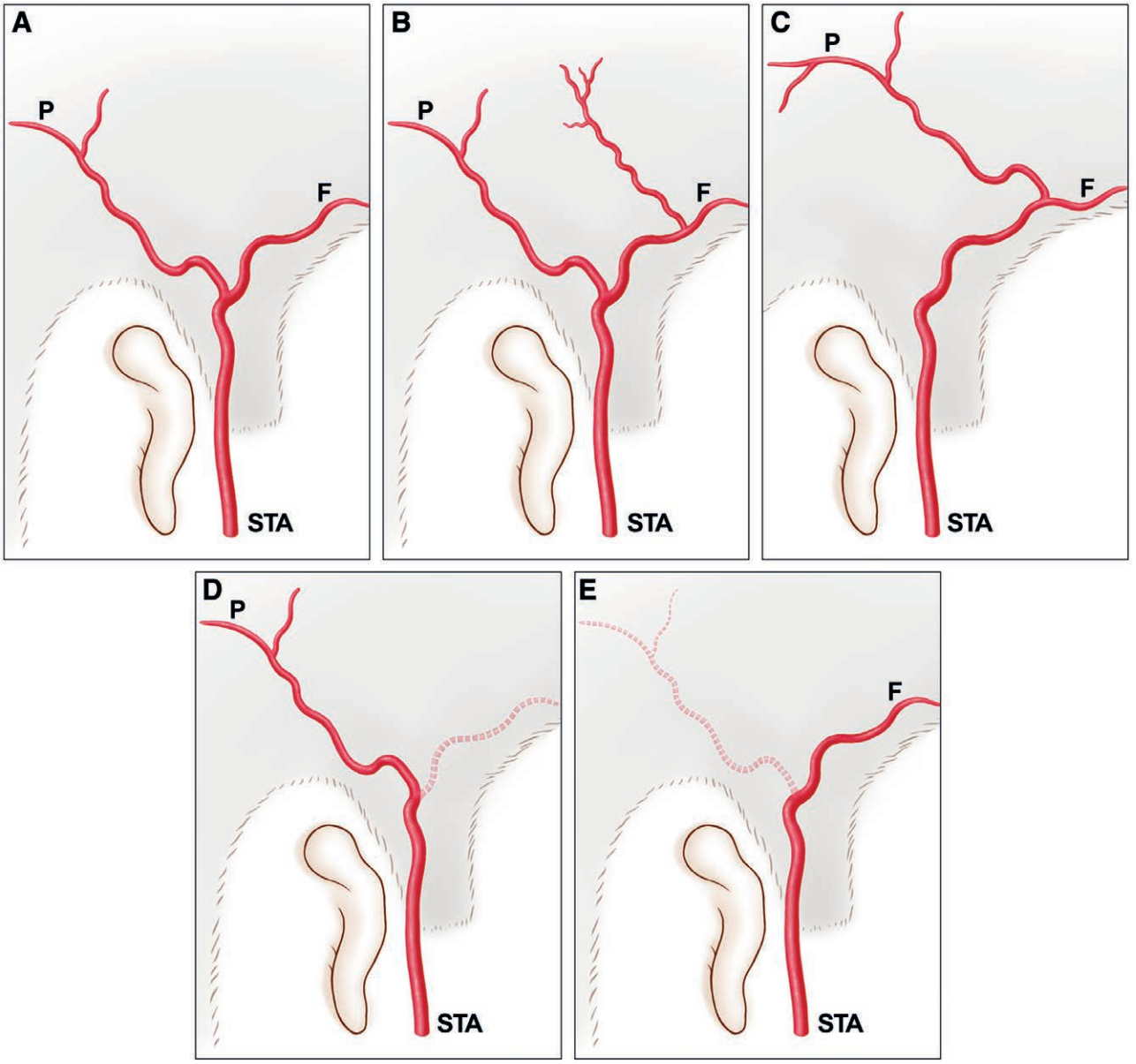

Fig. 4. STA variants. A, The classic pattern of bifurcation into the frontal and parietal branches was in 129/196 cases (66%). B, An additional branch from the frontal branch supplied the temporoparietal fascia in 53 of 196 cases (27%). C, The parietal branch originated from the frontal branch in 5/196 cases (2.5%). D, E, A single parietal or frontal branch in 3/196 cases (1.5%) and 6/196 cases (6.3%), respectively. P: Parietal branch of STA, F: Frontal branch of STA.

COMPLICATIONS

Vessel Injuries during Flap Elevation

Because of their small caliber and anatomic variations, the vessels were injured in 17 cases: 3 in arteries and 14 in veins. Of the 3 cases of arterial injury, 2 were at the incision site on the scalp, due to the thin scalp skin and superficially located artery. Consequently, surgeons took care not to penetrate below the deep dermis, and the TPF was exposed by dissecting the wound using Metzenbaum scissors after a shallow incision. Most venous injuries were in the distal half of the flap. Although the damaged arteries were repaired, venous repair was not routinely performed in the distal portion of the flap. Instead, the fascia flaps were elevated as broad-based flap at least 10-cm wide for venous drainage.

Framework Exposure May Be Related to Partial Flap Necrosis

There are no cases of partial or total flap necrosis in cartilage framework group. However, 18 cases of framework exposure developed in the polyethylene group. Multiple factors may cause polyethylene framework, including a thin skin flap, and draping the fascia flap with tension; however, partial necrosis of the TPF flap may be attributed to framework exposure. The portions with framework exposure were covered with deep temporal fascia or mastoid fascia flap and skin graft (Fig. 5). However,

Fig. 5. Clinical case of framework exposure in polyethylene group. A 7-year-old boy with lobule type microtia. The patient underwent total auricular reconstruction with a porous polyethylene framework, a temporoparietal fascia flap, and skin flaps. However, the framework exposure developed 20 days postoperatively (A). B, The wound was covered with deep temporal fascia and skin was grafted with the remnant preauricular skin. View 10 months postoperatively.

porous frameworks were removed due to repeated exposure in 2 cases.

Paralysis or Weakness of the Frontal Branch of the Facial Nerve

Complete paralysis of the frontal branch of the facial nerve was not noted. There were 2 cases of facial weakness, but all patients recovered spontaneously within 6 months

Postoperative Alopecia

The incision on the scalp for harvesting of the TPF flap causes postoperative alopecia and also decreases the density of hair, although there is a difference in degree among patients. It is more conspicuous in men than in women because of hairstyles. Despite techniques including beveled incision along the direction of hair follicles, dissection using electric cautery with a low-powered setting, and lazy-S incision rather than a Y-shaped incision, postoperative alopecia was inevitable. The revision operation for correction of alopecia will be needed after maturity.

DISCUSSION

The TPF flap is used for head and neck reconstruction as well for other body parts because it has thin, pliable, and a rich vascular supply. Since Tegtmeier and Gooding, Brent et al[1–3] have performed auricular reconstruction using the TPF flap, the TPF flap has been widely used in difficult primary or secondary auricular reconstruction.[4,5] Numerous studies regarding the TPF structure and vascular anatomy have been introduced in the literature.[7–9,12–14] However, the study of its vasculature and characteristics in children is rare. The author conducted a large anatomical investigation into the vascular patterns and characteristics of the TPF flaps in 196 cases of 188 pediatric patients. Dr. Chul Park published an article analyzing 123 temporoparietal fascia flaps in 1999,[10] where he mentioned that 63.4% of the TPF flaps were primarily supplied by the STA and STV, and that the STA was the main artery supplying the TPF flap in 88.2%, whereas 140 of 196 cases (71.4%) exhibited typical patterns of supply by the STA and STV. The STA type, where the main artery supplying the TPF flap was the STA, was 191 of 196 cases (97.4%) in this study. The PAA type was 5/196 cases (2.6%) and the OA type described in Dr. Chul Park' s report was not observed. The primary venous drainage was via the STV in 141/196 cases (71.9%), and via the PAV in 48/196 cases (24.4%). Eight patients in this study had bilateral microtias, 3 of whose TPF flaps were equally supplied by the STA and STV. In 5 patients, the flaps were supplied by the STA and STV in one side, whereas the STA and the PAV in the other side.

A variety of the STA was observed. Only 129 of 196 cases (66%) showed the typical pattern of bifurcating into frontal and parietal branch: the cases with an additional branch from the frontal branch were 53 of 196 cases (27%). The only parietal branch without the frontal branch and the frontal branch without parietal branch were noted in 3/196 cases (1.5%) and 6/196 cases (6.3%), respectively. Therefore, thorough inspection of the vascular pattern of

the TPF before flap elevation through open approach is essential, although this increases the possibility of postoperative scar and alopecia.

In addition, there is a clinically important variation of the STA, namely the posterior origin STA (p-STA), which originates from posterior to the lobule beneath the cartilage remnant, and does not run anteriorly to the ear. Reinisch and Tahiri observed the posterior origin of the STA in 18% of cases,[15] compared with 3/196 cases (1.5%) in this study. The STA runs immediately beneath the cartilage remnant, rendering arterial damage likely during removal of remnant cartilage. The p-STA is likely to occur in those patients with atypical type microtia, especially mal-positioned remnant ear and moderate to severe hemifacial microsomia. Therefore, it is important to determine the course of the STA preoperatively using a Doppler probe.

Because of the aforementioned variations and characteristics of the TPF flap in children, surgeons must confirm the position of the dominant vessels first and then dissect along the major vessels from proximal to distal.

CONCLUSIONS

The author conducted a large intraoperative anatomical study of the vascular patterns and characteristics of the TPF flaps in children under 15 years old. Typical patterns with the STA and STV supplying the TPF flaps were present in 140/196 cases (71.4%). The STA bifurcated into frontal and parietal branches in 129 of 196 cases (66%) and the p-STA, which originated posterior to the lobule beneath the cartilage remnant, not running anteriorly to the ear, in 3/196 cases (1.5%). The TPF flap displays different characteristics in children, including small caliber vessels, severe spasm, and STA variants. Although the endoscopic technique for harvesting the TPF flap can minimize postoperative alopecia, the vascular pattern of the TPF flap cannot be judged and may also be vulnerable to vessel injury, especially in distal 2 cm of the flap with 12–13 cm × 9–10 cm dimensions. Therefore, it is safe to elevate the TPF flap through open approach, not by minimal incision such as endoscopic approach, because the surgeons inspect the vascular pattern of the TPF flap thoroughly before flap elevation.

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