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A Temporoparietal Fascia Pocket Method in Elevation of Reconstructed Auricle for Microtia

Authors:

Takashi Kurabayashi, MD

Hirotaka Asato, MD

Yasutoshi Suzuki, MD

Nobuyuki Kaji, MD

Yoko Mitoma, MD

Mibu and Koshigaya, Japan

Department of Plastic and Reconstructive Surgery, Dokkyo Medical University; Department of Plastic and Reconstructive Surgery, Dokkyo Medical University Koshigaya Hospital.

Corresponding Author:

Takashi Kurabayashi, MD

Department of Plastic and Reconstructive Surgery, Dokkyo Medical University

880 Kitakobayashi, Mibu, Shimotsuga, Tochigi, 321-0293, Japan.

E-mail: m-kura@dokkyomed.ac.jp

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A Temporoparietal Fascia Pocket Method for Elevation of a Reconstructed Auricle for Microtia

The two-stage procedures (Nagata[1-5], Firmin[6]) for the reconstruction of microtia have recently been increasingly used. In the first stage, the lobule is transposed, and the complete auricle framework, including the tragus, is inserted into a skin pocket. In the second stage, the elevation of the framework, an additional cartilage block (or blocks) is placed behind the framework for distinct projection. The axial flap of temporoparietal fascia (TPF) with skin graft is widely used to cover the added cartilage block(s). A TPF flap is reliable with its rich vascularity, but its use is associated with some morbidity, including long scars on the temporal region and alopecia. Moreover, harvesting of a TPF flap deprives a surgeon of the option for significant traumatic and secondary reconstruction.

Given these concerns, minimum invasion to the TPF is required for refinement of the procedure. Firmin[6] and Brent[7, 8] have proposed a postauricular turnover fascial flap to wrap the added cartilage block.

Furthermore, in the context of preserving an axial TPF flap, the authors devised a technically simplified covering procedure by creating a pocket in the TPF, and named the procedure the “TPF pocket method”.

PATIENTS AND METHODS

Patient selection

Microtia patients who do not wish or have an indication for middle ear surgery are the candidates for the method described here. We routinely collaborate with otorhinolaryngology (ENT) surgeons in the second stage of reconstruction and perform both middle ear surgery and framework elevation. The middle ear surgery needs elevation of a TPF flap.

Additionally, it is preferable that microtia patients do not have other combined severe hypoplastic disease, such as Treacher Collins syndrome, because the TPF pocket method requires sufficient TPF volume. However, we can still perform the TPF method by switching to an axial TPF in cases where the TPF volume is inadequate for the pocket method flap.

Surgical Technique

The surgical technique is outlined in Fig. 1. An incision is made peripheral to the border of the helix, and the constructed auricle is elevated from the head, dissecting superficially to the TPF for the posterior margin of the concha. Then, an incision is made in the TPF and the capsule to create a slit perpendicular to the temporal head plane. A pocket is created with dissection between the capsule and the cartilage laterally, and between the TPF and the pericranium medially. The pillars of rib cartilage are inserted into the pocket and fixed to the base of the auricular cartilage and to the pericranium on the temporal bone with absorbable sutures. After the slit is closed, the TPF and the capsule on the cartilage are covered with a 0.010-0.016-inch split-thickness skin graft harvested from the temporal scalp. The sutures on the skin graft are left long so as to be tied over a bolster to tamponade the graft to the recipient bed. Before skin grafting, the retroauricular skin is advanced toward the ear to reduce the skin graft requirement.

Fig. 1.

Estimation of Projection Angles and Statistical Analyses

The angles of the temporoauricular sulci were estimated by calculating inverse trigonometric functions of the preoperative and postoperative widths of the auricles on profile pictures. The landmarks and the lines in the profile pictures were defined as follows: the point para-tragion (*pT*) is the superiormost point of the tragus or the clearly identifiable point around it when the contours of the tragus are obscure; the line *M* is the line from *pT* to exocanthion; and the point para-nasion (*pN*) is the intersecting point on the line *M* and the curve of the dorsum of the nose. For comparisons among pictures of different sizes, the unit distance was measured as the length of the long axis of the reconstructed auricle if it was not clearly distorted, or the distance between two identifiable points such as nevi or two ends of a hairpin. The width of the auricle (defined as W) was measured as the distance from *pT* to the intersecting point on the line *M* and the posterior curve of the helix of the auricle. The angle of the temporoauricular sulcus was then calculated as $\cos^{-1}(W_{pre}/W_{post})$, where W_{pre} and W_{post} are the preoperative and postoperative widths of the auricle, respectively (Fig. 2).

Fig. 2.

Because profile pictures taken in daily outpatient follow-up are not standardized, like a cephalogram, parallax distortion due to shifting from the true profile picture must be managed. For management of the differences in several angles of cranial rotation on the cephalocaudal axis, measurements of the distance from *pT* to *pN* were obtained, and the difference in the cranial rotation angle between two pictures taken at a distinct period of time in the same patient was estimated. The angle differences were calculated by the approximation formula that is shown as (*Δ*) in Fig. 3, which graphically demonstrates the cranial rotation in a top-down view, where α and β are the angles from the anterior part of the midsagittal plane and are positive values when they rotate clockwise. Additionally, α and β are relatively small angles, because side view-intended pictures do not deviate markedly from the true profile (i.e. 0 degrees). A cranial shape is approximated as an ellipse with a ratio of the major semi-axis to the minor semi-axis of 1 to 0.8, adopting the mesocephalic cranial index.

Fig. 3.

The accuracy of the approximation formula was evaluated using 3D-CT head images of ten individuals without congenital craniofacial conditions at several angles in profile rotated in 5-degree increments from –20 to 20 degrees, and measurements were obtained for angle difference estimation. The one-sample Student's *t*-test was used for statistical comparisons between the actual differences and calculated differences in each rotation angle combination of α and β.

The mean discrepancies and 95% confidence intervals are shown in Table 1. The difference was not significant (df = 9, p > 0.05; one-sample Student's *t*-test) in many combinations of α and β. Even in other combinations of α and β where the difference was significant, the gaps from the actual angle differences of rotation were small. Therefore, our rotation difference estimation formula is acceptable for practical use, especially in small angle combinations of α and β.

Table 1.

Collectively, the angles of the temporoauricular sulci, the projection angles, were calculated by the change in width of the auricles, adding the correction angles to address parallax distortion. Even though there is the risk of deviation from the true angle, the accuracy of our evaluation was much better than subjective evaluation, such as "excellent, good, and fair". Additionally, the estimation system can evaluate the projection of the auricle by the pictures, no matter how old they are.

To evaluate the long-term stability of the method, two-way analysis of variance ($p < 0.05$) using SPSS version 23 software (SPSS Inc., Chicago, IL) was carried out to analyze the influence on the projection angles of the method (an axial TPF flap method versus a TPF pocket method) over short-term and long-term follow-up.

RESULTS

A total of 38 reconstructed ears in 38 patients with microtia ranging in age from 9 to 19 years were elevated using the authors' method from 2002 to 2014 and followed-up for at least 5 months. The average age at operation was 11 years. The patients included 31 male patients and 7 female patients. The mean follow-up period was 47 months.

For estimation of projection angles and statistical analyses, 27 auricles of 26 patients elevated with use of the standard axial TPF flap method, 25 auricles elevated along with middle ear surgery, and 27 auricles of 27 patients elevated with the TPF pocket method without complications that had appropriate follow-up photographs for measurement were enrolled. The projections of the auricle of both methods were assessed in short-term and long-term follow-up (Table 2). The projection of the auricle was retained in long-term follow-up (23 ± 8 degrees with the standard TPF method and 28 ± 11 degrees with the TPF pocket method, which is considered to be comparable to the average cephaloauricular angles reported by da Silva Freitas et al.[9] as 31 ± 6 degrees). They defined the cephaloauricular angle as the intersection of a straight line running through the tragus insertion and the lateral portion of the mastoid region with a straight line running through the tragus and the middle of the helix. Since the present measurement point of the helix is posterior to theirs, the present calculation of the cephaloauricular angle is smaller by several degrees than theirs.

Table 2.

Two-way analysis of variance demonstrated that the elevation method and follow-up time did not significantly affect the projection angle of the auricle (method: P = 0.06; time: P = 0.46; method*time: P = 0.55; two-way analysis of variance). Accordingly, the TPF pocket method appears to have long-term stability and equal efficacy to the standard TPF flap method. Furthermore, taking into account that the long-term follow-up time of the TPF pocket method was longer than that of the standard TPF flap method (df = 52, P = 0.03; unpaired Student's *t*-test), it may be concluded that our method has superior stability to the standard TPF flap. Furthermore, the mean difference of the projection angle between the axial TPF flap method and the TPF pocket method was -4.4 degrees (95% confidence interval; -9.1-0.23 degrees; Bonferroni post hoc test). Thus, despite the difference not being significant, there could be a tendency that the projection angle of the TPF pocket method is larger than that of the axial TPF flap method. This tendency can be explained by the position where the pillars of the rib cartilage are placed. In cases of elevation with middle ear surgery, the pillars are placed posterior to the reconstructed auditory meatus. Therefore, the projection angle of elevation with middle ear surgery is smaller than that of elevation without middle ear surgery, if the height of the cartilage pillars is the same.

Collectively, good projection of the auricles was achieved after elevation by the TPF pocket method in cases with no complications. Furthermore, the projection of the auricles showed little tendency to become effaced over long-term observation, and it showed equal efficacy to the standard TPF flap method.

The overall complication rate related to ear reconstruction, including infection and skin graft failure, was 13.2%. Cartilage exposure caused by infection was observed in one case (2.6%). Local debridement of the framework, a part of the helix, was needed in that case, and the resultant auricular deformity was later modified. Partial skin graft failure was observed in three cases (7.9%), but the ulcers healed with conservative management. However, in all of the three cases, contracture resulted in shallow sulci, which needed further surgeries for depth; in each of the cases, a postauricular flap, an axial TPF flap with skin graft, and a Y-V advancement flap of the superior end of the sulcus were used, respectively. The infection rate and skin graft necrosis rate were higher than the rates reported by Long[10]et al., who reviewed 60 articles on autologous cartilage microtia reconstruction, as 0.9% and 0.41%, respectively, which may not fully mirror the complication rate.

The cartilage pillars collapsed in one case (2.6%) and were corrected to an upright position and covered with a postauricular flap.

CASE REPORTS

Case 1

The patient in case 1 was a 10-year-old boy with left lobule-type microtia (Fig. 6). Six months after cartilage framework grafting, the ear was elevated with the TPF pocket method. The 6 pillars of costal cartilage were bundled together and inserted into the TPF pocket. The retroauricular skin was advanced toward the ear to reduce the skin graft requirement, and the sulcus was covered with a 0.010-inch split-thickness graft harvested from the temporal region.

The reconstructed sulcus was well defined one year postoperatively.

Fig. 4 (a,b,c,d,e,f,g,h,i).

Case 2

The patient in case 2 was a 10-year-old boy with right lobule-type microtia (Fig. 7). Five months after cartilage framework grafting, the ear was elevated with the TPF pocket method. The 4 pillars of costal cartilage were bundled together and inserted into the TPF pocket. The retroauricular skin was advanced toward the ear to reduce the skin graft requirement, and the sulcus was covered with a 0.012-inch split-thickness graft harvested from the temporal region.

The reconstructed sulcus was well defined even in the relatively long period after ear elevation at 4 years and 10 months.

Fig. 5 (a,b,c,d,e,f).

DISCUSSION

The authors devised a less invasive method for cartilage covering by creating a pocket in the postauricular TPF. The TPF pocket method requires a minimal incision to the TPF and no additional incision to the temporal region. Although the method is straightforward, excellent results in ear reconstruction have been achieved with it.

Auricular separation solely with skin grafting leads to gradual postoperative fading of projection. In order to counteract the considerably strong shrinking force of the skin graft, an additional cartilage block is placed behind the framework for distinct and durable projection. The added bare cartilage block must be covered with tissue to provide nourishment for skin grafting. A TPF flap with its rich vascularity is reliable. Thus, Nagata[5] uses the fascia as an axial flap to cover a cartilage block.

An axial TPF flap, however, is also an appropriate option for significant traumatic and secondary reconstruction cases. Therefore, sparing an axial TPF is desirable. Firmin[6] and Brent[7, 8] proposed a retroauricular turnover fascial flap to wrap the added cartilage block.

We addressed this issue by decreasing the invasion to the TPF, creating a slit and a pocket in the TPF. Our method is simple, but it does not impair the vascularity of the TPF, and it keeps the fascia in the anatomically original place. Firmin et al.[11] reported a tunnel technique, which adds moderate projection to the framework. They create a tunnel behind the framework to bury a piece of cartilage under the retroauricular soft tissue. This tunnel can be dissected behind the antihelix to achieve maximal projection of the upper portion of the ear or behind the antitragus to project the lobule, or occasionally behind both. Since they did not describe the details of the tunnel technique and their results, it appears that they prefer a modified Nagata's technique to achieve appropriate projection. On the other hand, our technique can mobilize the framework to achieve appropriate projection and fix the cartilage to the framework and the temporal region. Although it can be speculated that their tunnel has a common space with our pocket, our dissected extent must be larger than their tunnel. Moreover, our incision is located at the center of the space. Therefore, we think a pocket is an appropriate name for the created space. Walton et al.[12] suggested that Brent performed the following in the third stage of his microtia reconstruction repairs: "The ear position is stabilized by placing a piece of banked costal cartilage posteriorly beneath the framework in a "fascial" pocket." In this context, a fascial pocket means a turned over occipitalis fascia flap from behind the ear with a long curved fascial incision posteriorly. Brent[7] covers a scalp-banked rib cartilage graft with a retroauricular turnover fascial flap. Beheiry et al.[13] reported that "The TPF was found to be part of the subcutaneous fascial system, being mobile and continuous in all directions with other structures of that system: the galea superiorly, the frontalis muscle anteriorly, the occipitalis posteriorly, and the auricularis muscles and the superficial musculoaponeurotic system of the face inferiorly." In addition, Park et al.[14] reported that "On the upper portion of the retroauricular surface, between the skin and the temporal bone, there are three discrete fascial layers: the superficial temporal fascia, the deep temporal fascia, and between them the innominate fascia.” Regarding the lower portion of the retroauricular surface, they described the superficial mastoid fascia and the deep mastoid fascia that could be elevated from the underlying thin fascia investing the sternocleidomastoid musculoaponeurotic portion. The superficial mastoid fascia corresponds to the superficial temporal fascia cephalad, and the deep mastoid fascia corresponds to the innominate fascia. We minimally incise the TPF directly under the reconstructed auricle and create a pocket. Because the superficial temporal artery, the posterior auricular artery, and the occipital artery remain intact, it is feasible to use an axial TPF flap, a mastoid fascia flap, and an occipital fascia flap after our approach.

Moreover, our method has the advantage of ear projection durability and shows equal efficacy to the standard axial TPF flap. The temporoauricular sulci have a tendency to hold their steep profile over a long period of time.

Projection durability also demonstrated that the pillars of the cartilage are less likely to be resorbed, which in turn suggests that the cartilage of the framework is less likely to be resorbed, because the framework is close to the skin and has the same or richer vascularity than the pillars of cartilage.

Additionally, even though the thickness of skin graft was in the realm of ultrathin (0.010-0.016-inch), the present study suggested that the thinness of the skin graft does not affect the projection durability. However, shrinkage of the skin graft always occurs, which is seemingly inconsistent with projection durability. To address this issue, there are two possible explanations: contraction of the TPF is less likely because of less damage to vascularity; and the shrinking force of the skin graft is directed anteriorly to push the pillars of the rib cartilage orderly encapsulated by a nearly intact TPF, thereby sustaining the projection of the auricle as a buffering function.

Although our method has technical advantages of simplicity and lesser invasiveness, there are occasions when sufficient volume of the TPF is not available to create an appropriate pocket. These circumstances could arise as a result of an associated facial deformity, such as hemifacial microsomia, Goldenhar syndrome, and Treacher Collins syndrome, in each of which the temporal muscle is often hypoplastic. In such cases, we switch to a procedure with an axial TPF flap.

Even though projection of the auricles was sustained in the long term, the form of the auricle changed consistently after operation, as is the case in any other reconstruction method for microtia. Remodeling and resorption of cartilage as a result of limited repair capabilities play some role in decay of the auricle. However, in view of the fact that cartilage demands a lesser oxygen supply than skin, contraction of skin appears to be the main force collapsing the auricle.

Our system for estimation of the projection angle has a risk of deviation from the true projection angle by several degrees. When an auricle before elevation surgery is tilted along the line that extends anterolateral to posteromedial (medially projected), especially in a patient with a small cranium, estimation of the projection angle can be underestimated. However, the ability of humans to recognize parallax is not so poor. It contributes to risk reduction by discarding inappropriate pictures that are apparently deviated from the profile view and have medially projected auricles. Furthermore, besides rotation on the axial plane, rotation on the coronal plane can occur, though parallax on the coronal plane affects the length for the observer minimally because it is multiplied by the cosine function, which is nearly 1 when the rotation angle is small.

Additionally, growth of the face may affect the measurement. However, because cranial growth reaches 96% of adult size at the age of 10 years, the age group that commonly undergoes auricular reconstruction, there is a negligibly small change in the distance from *pT* to *pN* after surgery.

Despite the limitations in its use, the technical advantages of our TPF pocket method, its simplicity and lesser invasiveness, are clear. Furthermore, our method creates excellent and long-lasting projection of the reconstructed ear. We think that the TPF pocket method can be a standard choice for elevation of a reconstructed auricle.

CONCLUSIONS

The TPF pocket method is simple and maintains distinct projection of the constructed auricles for a long period. Moreover, it is less invasive and has the benefit of sparing TPF flap elevation.

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LEGENDS

Fig.1. TPF Pocket Method. Diagrams in posterolateral view (1st and 2nd columns) and horizontal sectional view (3rd column). (red: TPF, orange: capsule on the cartilage, yellow: cartilage, violet: pericranium on the temporal bone, green: TPF pocket). 1st row: Blue line peripheral to the border of the helix shows an incision line. The constructed auricle is elevated from the head, dissecting superficially to the TPF for the posterior margin of the concha (blue arrows show the direction of elevation).; 2nd row: An incision (blue line) in the TPF and the capsule is made to create a slit perpendicular to the temporal head plane. A pocket (green area) is created with dissection between the capsule and the cartilage laterally and between the TPF and the pericranium medially (blue and light blue arrows show the direction of dissection).; 3rd row: The pillars of rib cartilage are inserted into the pocket and fixed to the base of the auricular cartilage and to the pericranium (blue arrow shows the insertion of the pillars).; 4th row: The slit is closed, and then the TPF and the capsule on the cartilage are covered with a split-thickness skin graft harvested from the temporal region (red dots area shows the donor site). The sutures on the skin graft are left long so as to be tied over a bolster to tamponade the graft to the recipient bed. Before skin grafting, the retroauricular skin is advanced toward the ear (blue arrows suggest the direction of advancement) to reduce the skin graft requirement.

Fig. 2. Landmarks and lines in the profile pictures (above). *pT*: para-tragion, the superiormost point of the tragus or the clearly identifiable point around it when the contours of the tragus are obscure; *Ex*: exocanthion; *M* (yellow line): the line from *pT* to *Ex*; *pN*: para-nasion, the intersecting point on the extended line *M* and the curve of the dorsum of the nose; W: obliquely measured width of the auricle as the distance from *pT*

to the intersecting point on the extended line *M* and the posterior curve of the helix of the auricle. Projection of auricle in the horizontal sectional view (below). W_{pre}, W_{post}: W obtained on preoperative and postoperative pictures, respectively; θ, projection angle of the auricle.

Fig. 3. Illustration of cranial rotation in top-down view. α and β: the angles from the anterior part of the midsagittal plane; pT_0, pT_α, pT_β: points of the paratragion, when the rotation angles are 0, α, and β degrees, respectively; pN_0, pN_α, pN_β: points of the paratragion, when the rotation angle are 0, α, and β degrees, respectively; D_0, D_α, D_β: projected distance from the paratragion to the paranasion on the observer's plane, when the rotation angle are 0, α, and β degrees, respectively; R: length of the major semi-axis.

$$
\begin{aligned}
&D_\beta\text{-}D_\alpha \\
&= (R\cdot\cos\beta + 0.8\cdot R\cdot\sin\beta) - (R\cdot\cos\alpha + 0.8\cdot R\cdot\sin\alpha) \\
&\approx 0.8\cdot R\cdot(\sin\beta - \sin\alpha) \qquad\qquad \because \cos\alpha \approx 1, \cos\beta \approx 1 \\
&= 0.8\cdot 2\cdot R\cdot\cos\frac{\alpha+\beta}{2}\cdot\sin\frac{\beta-\alpha}{2} \\
&\approx 0.8\cdot 2\cdot R\cdot\sin\frac{\beta-\alpha}{2} \qquad\qquad \because \cos\frac{\alpha+\beta}{2} \approx 1 \\
&\Leftrightarrow \beta-\alpha \approx 2\cdot\sin^{-1}\frac{D_\beta\text{-}D_\alpha}{0.8\cdot 2\cdot R}
\end{aligned}
$$

Recall that $R \approx \frac{D_\beta+D_\alpha}{2}$ (mean of D_α and D_β). Hence,

$$\beta-\alpha \approx 2\cdot\sin^{-1}\frac{D_\beta\text{-}D_\alpha}{0.8\cdot(D_\beta+D_\alpha)}$$

This approximation is relatively good. But when $|\beta-\alpha|$ is large, $R \not\approx \frac{D_\beta+D_\alpha}{2}$.
In that case, α or β can be assumed to be 0.
So, suppose $\alpha \approx 0$,

$$\frac{D_\beta+D_\alpha}{2} = \frac{\{R + 0.8\cdot R\cdot\sin(\beta-\alpha)\} + R}{2} = R\cdot\{1 + 0.4\cdot\sin(\beta-\alpha)\}$$

Then, the corrected R estimation is defined by the following equation.

$$R \approx \frac{D_\beta+D_\alpha}{2}\cdot\frac{1}{1+0.4\cdot\sin(\beta-\alpha)} \approx \frac{D_\beta+D_\alpha}{2}\cdot\frac{1}{1+0.4\cdot\sin\left\{2\cdot\sin^{-1}\frac{D_\beta\text{-}D_\alpha}{0.8\cdot(D_\beta+D_\alpha)}\right\}}$$

Therefore,

$$\beta-\alpha \approx 2\cdot\sin^{-1}\frac{(D_\beta\text{-}D_\alpha)\cdot\langle 1+0.4\cdot\sin\left\{2\cdot\sin^{-1}\frac{D_\beta\text{-}D_\alpha}{0.8\cdot(D_\beta+D_\alpha)}\right\}\rangle}{0.8\cdot(D_\beta+D_\alpha)} \qquad \cdots\cdots\cdots\cdots(\varDelta)$$

Fig. 4. Case 1. a) A 10-year-old boy with left lobule-type microtia, shown preoperatively. b) The line of the periauricular incision in the second stage of reconstruction. c) The TPF pocket is created after the auricle is elevated. Note the slit in the TPF and the capsule (blue arrow). The dashed line depicts the border of the pocket. d) The inserted pillars of rib cartilage in the pocket. e) Closing the slit. f) Superior view of the projection of the auricle from the temporal head. g) Applying a split-skin graft. Note the retroauricular skin is advanced toward the ear to reduce the skin graft requirement. h), i) Lateral and posterolateral views, respectively, 1 year postoperatively. The projection angle was estimated to be 18 degrees.

Fig. 5. Case 2. a) A 10-year-old boy with right lobule-type microtia. The line of periauricular incision in the second stage reconstruction. b) Elevating the ear; creating the TPF pocket; advancing retroauricular skin. c) Posterolateral view after inserting the pillars into the TPF pocket and closing the slit. d), e), f) Lateral, posterolateral, and posterior views, respectively, 4 years and 10 months postoperatively. The projection angle was estimated to be 50 degrees, which is relatively large, even though symmetry was attained.

Table 1

Table 1. Discrepancies between the actual differences and the calculated differences on 3D-CT images

	α (degrees)																										
	-20			-15			-10			-5			0			5			10			15			20		
β (degrees)	Mean	±	95%CI	Mean	±	95%CI	Mean	±	95%CI	Mean	±	95%CI	Mean	±	95%CI	Mean	±	95%CI	Mean	±	95%CI	Mean	±	95%CI	Mean	±	95%CI
-20				-1.3	±	1.5	-0.5	±	1.8	0.2	±	1.8	1.4	±	1.8	3.5	±	1.8*	6.2	±	1.4*	9.3	±	1.3*	-4.6	±	3.0*
-15	1.3	±	1.5				0.4	±	1.5	0.6	±	1.5	1.3	±	1.7	3.0	±	1.7*	5.4	±	1.5*	8.3	±	1.4*	-0.2	±	3.2
-10	0.5	±	1.8	-0.4	±	1.5				-0.2	±	0.8	0.2	±	1.0	1.6	±	1.1*	3.8	±	1.0*	-0.2	±	2.2	1.4	±	2.3
-5	-0.2	±	1.8	-0.6	±	1.5	0.2	±	0.8				0.0	±	0.7	1.1	±	0.8*	0.5	±	1.1	1.7	±	1.6*	3.4	±	1.8*
0	-1.4	±	1.8	-1.3	±	1.7	-0.2	±	1.0	0.0	±	0.7				0.5	±	0.5*	1.5	±	0.6*	2.9	±	1.1*	4.8	±	1.4*
5	-3.5	±	1.8 *	-3.0	±	1.7*	-1.6	±	1.1*	-1.1	±	0.8*	-0.5	±	0.5*				1.2	±	0.7**	2.7	±	1.2*	4.8	±	1.3*
10	-6.2	±	1.4*	-5.4	±	1.5*	-3.8	±	1.0*	-0.5	±	1.1	-1.5	±	0.6*	-1.2	±	0.7*				1.7	±	0.6*	3.9	±	0.8*
15	-9.3	±	1.3*	-8.3	±	1.4*	0.2	±	2.2	-1.7	±	1.6*	-2.9	±	1.1*	-2.7	±	1.2*	-1.7	±	0.6*				2.3	±	0.6*
20	4.6	±	3.0*	0.2	±	3.2	-1.4	±	2.3	-3.4	±	1.8*	-4.8	±	1.4*	-4.8	±	1.3*	-3.9	±	0.8*	-2.3	±	0.6*			

CI: confidence interval

* One-sample Student's *t*-test, $p < 0.05$

Table 2

Table 2. Projection angles of the axial TPF flap method and the TPF pocket method

		Short term						Long term					
		Projection (degrees)			Follow-up time (months)			Projection (degrees)			Follow-up time (months)		
Elevation method	**No.**	**mean**	**±**	**SD**	**mean**	**±**	**SD**	**mean**	**±**	**SD**	**mean**	**±**	**SD**
Axial TPF method	27	25	±	8	6.1	±	1.1	23	±	8	38.2	±	23.2
TPF pocket method	27	28	±	9	5.2	±	1.3	28	±	11	58.7	±	40.8

Figure 1

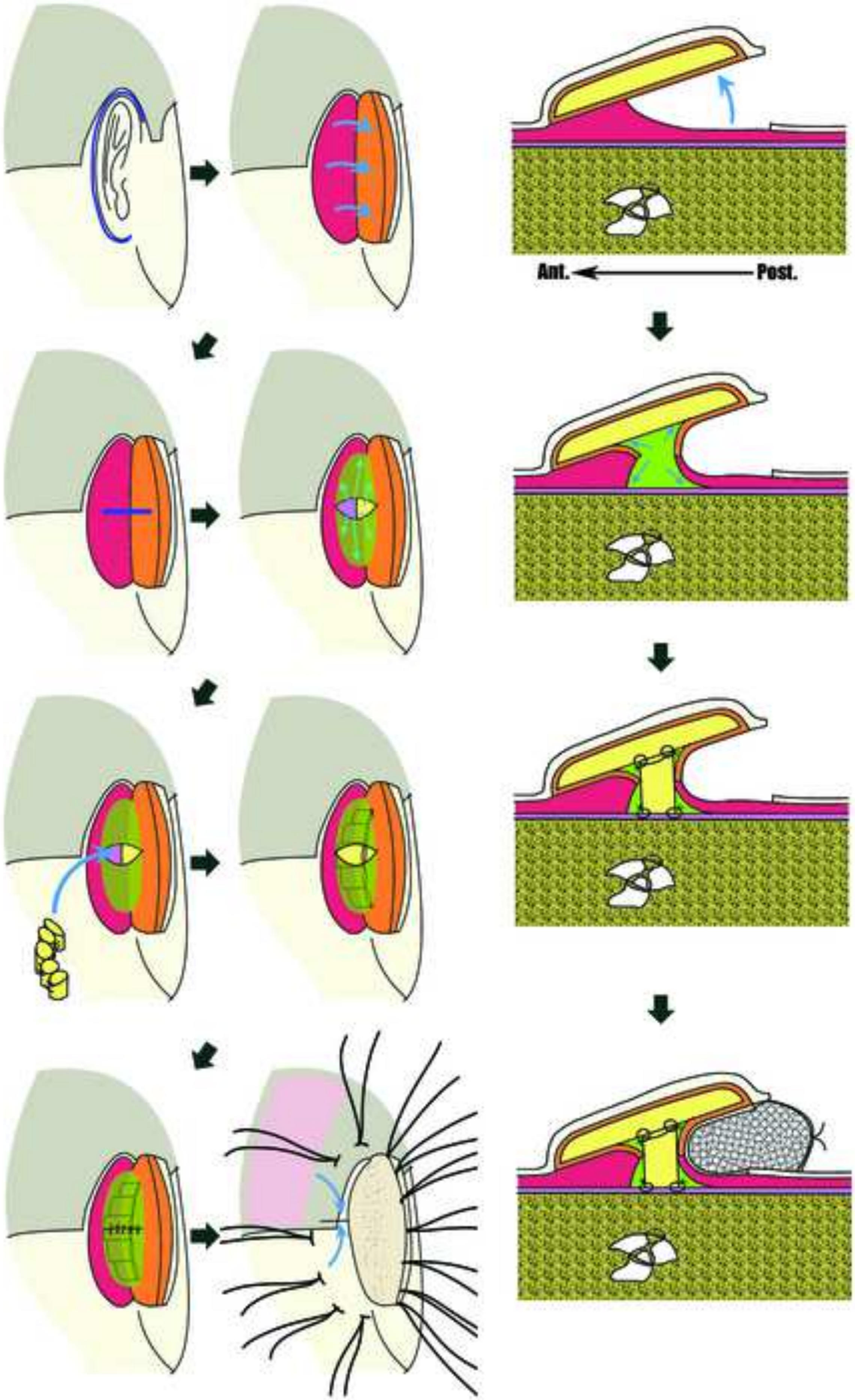
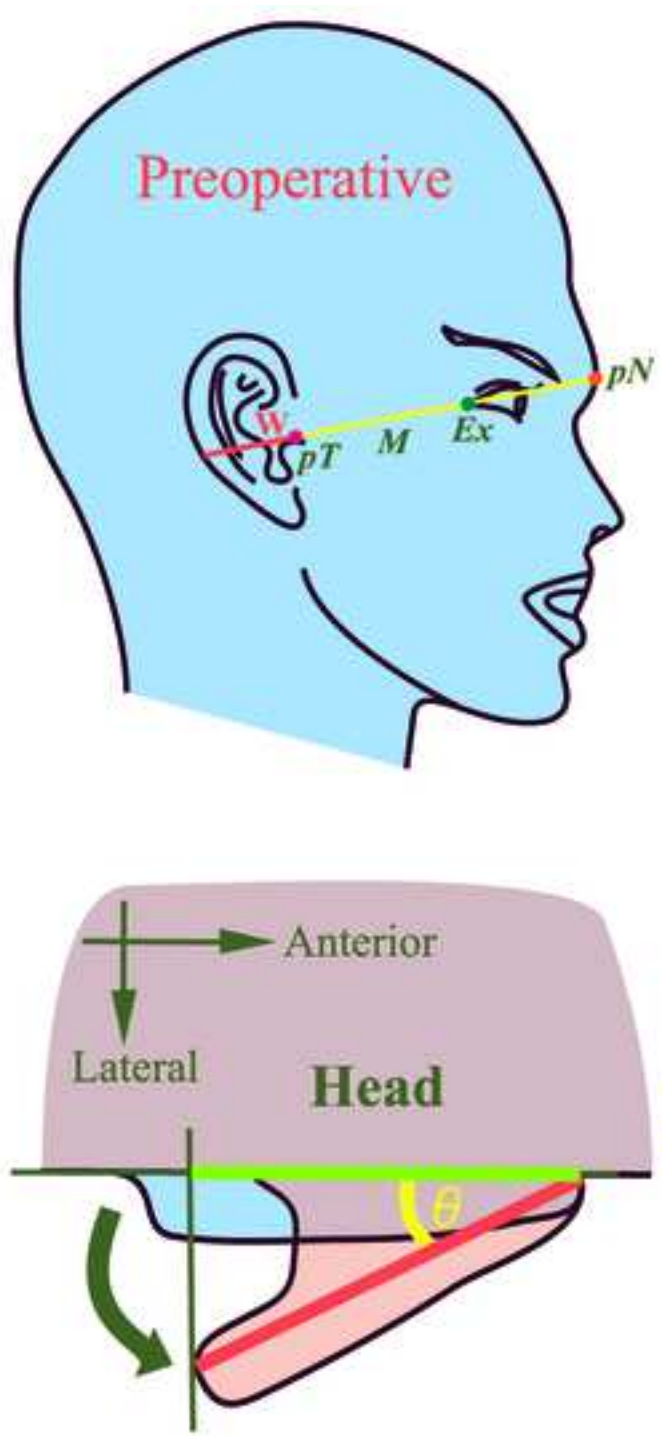


Figure 2

Click here to download Figure Fig2new.tif



$$\theta = \cos^{-1}(W_{post}/W_{pre})$$

Figure 3

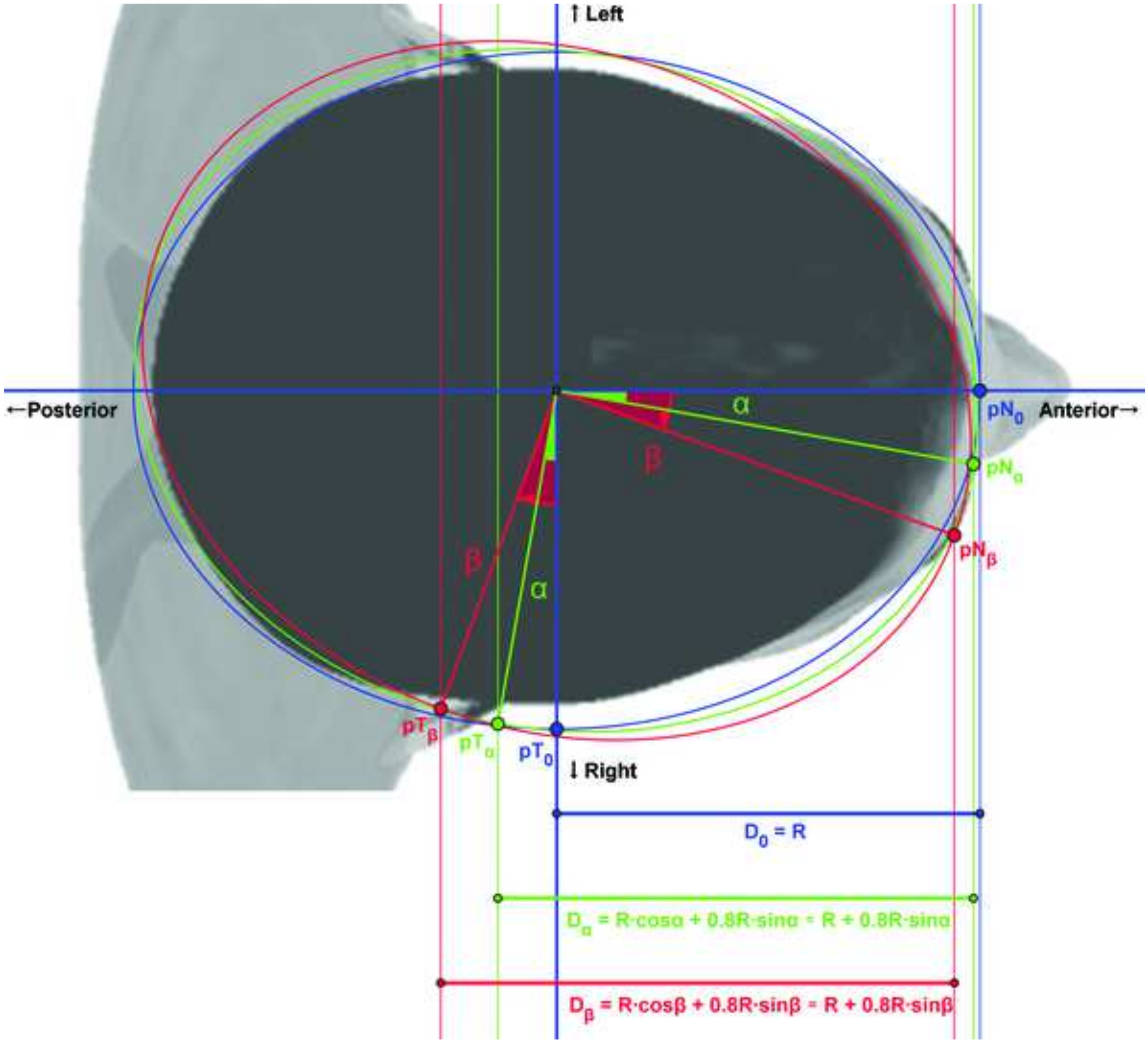

↑ Left
←Posterior
Anterior→
pN0
pNα
pNβ
α
β
β
α
pTβ
pTα
pT0
↓ Right
D0 = R
Dα = R·cosα + 0.8R·sinα = R + 0.8R·sinα
Dβ = R·cosβ + 0.8R·sinβ = R + 0.8R·sinβ

Figure 4 (a,b,c,d,e,f,g,h,i)

Click here to download Figure Fig4CMYK.tif

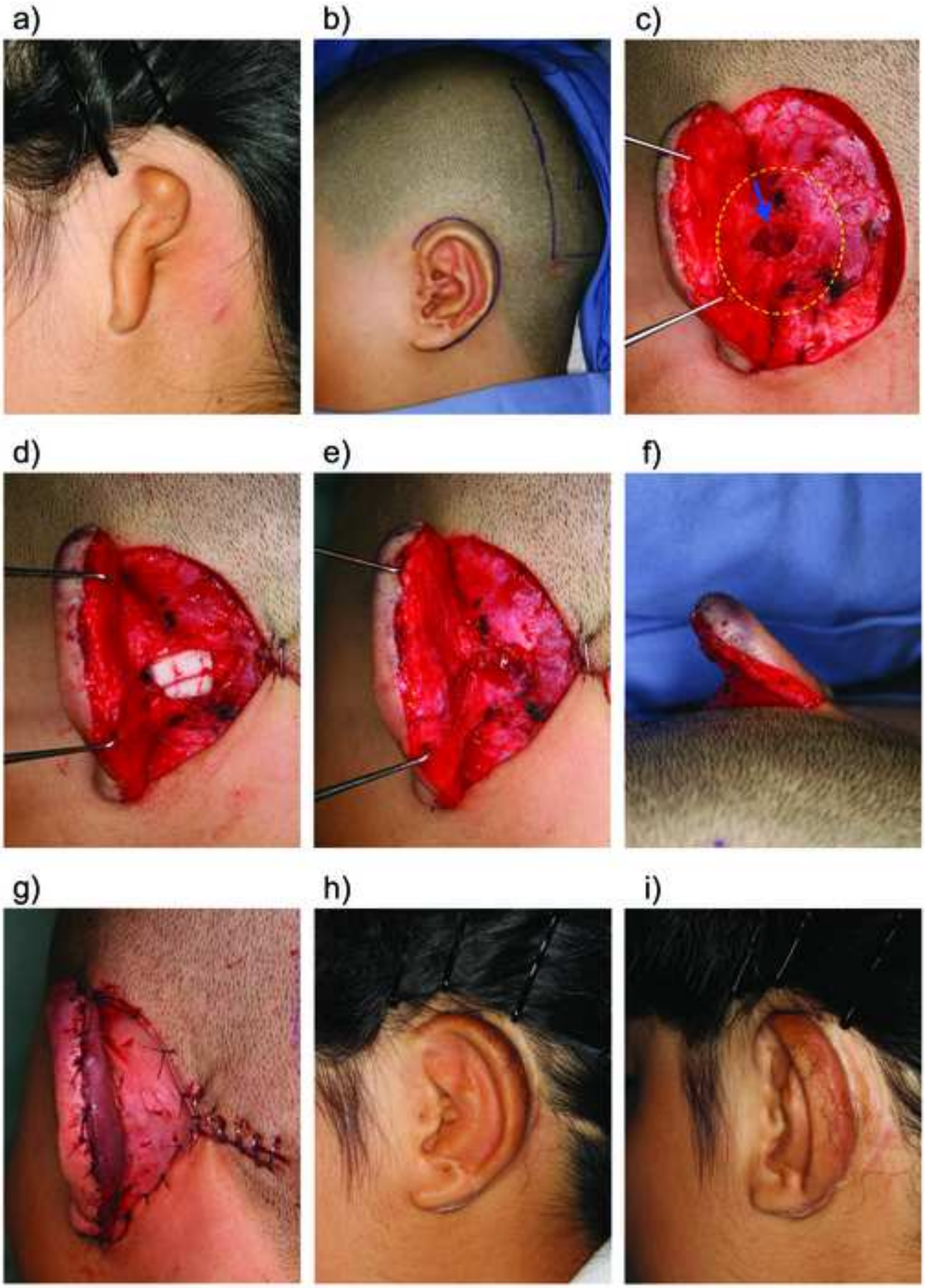


Figure 5 (a,b,c,d,e,f)