

extremely short. Full epithelization of the donor site is obtained on day 8. We experienced no complications when we started using a collagen dressing (Suprasorb C) over the donor area, covered with a rectangle of vaseline gauze, which is sutured to the scalp with 4-0 nylon at its edges. Regarding color match, at first the graft looks lighter due to lack of exposure to sunlight, and it takes a while for it to gain the same color as the surrounding tissue.

Another factor to consider is that any attempt to create a retroauricular sulcus at this stage is pointless. It will obliterate due to retraction (Fig. 21). This phenomenon was also found in our secondary cases as well. This experience is shared by other authors.² Lesson 10: Attempts to reconstruct the sulcus with a TPF and a skin graft at the time of the reconstruction is doomed to failure.

CONCLUSIONS

One of the most important factors in microtia reconstruction is to establish the correct location of the new ear. As the auricle is in the cranium and not in the face, its position is not altered by the usual displacement of facial features present in hemifacial microsomia, and timing of auricular reconstruction is independent from other reconstructive procedures. Even when there seems to be an area in the face suitable for the reconstruction, when adequate measurements are taken, this space is usually anteriorly and inferiorly displaced, and the position of the new ear ends up in the scalp. The surgeon does not have to feel tempted to use this space to avoid a more complex procedure, which should be done to ensure an adequate surgical result.

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Abstract: Microtia reconstruction using autologous costal cartilage is one of the most challenging procedures in plastic surgery, offering long-term durability and biocompatibility. The Nagata 2-stage autologous technique involves creation of a soft tissue pocket and auricular framework from costal cartilage in the first stage, then projection of the framework in the second stage using a temporoparietal fascial flap and skin graft. However, the second stage compromises the aesthetic result due to skin graft color mismatch, edema, and contracture, while also eliminating the TPF flap as a future salvage option. Consequently, the authors present a single-stage autologous technique for microtia reconstruction with several modifications to the Nagata technique: (1) elevating the framework using a projecting block within a single stage, (2) performing wider undermining of the soft tissue pocket to accommodate this elevation, (3) adding a cranial extension to the tragus for stability, and (4) refining the contour of the inferior crus. In a series of 40 consecutive cases using the single-stage technique, our surgical complication rate was 15%, comparable to rates reported for autologous reconstruction. The single-stage approach yields reliable aesthetic and functional outcomes and maintains future revision options, making it an effective alternative for microtia reconstruction.

Key Words: Autologous reconstruction, microtia reconstruction, single-stage

Microtia reconstruction using autologous costal cartilage remains one of the most technically demanding procedures in plastic and reconstructive surgery.^{1–3} Although the use of alloplastic frameworks is increasing,⁴ autologous rib cartilage continues to be regarded as the gold standard⁵ due to its long-term durability⁶ and biocompatibility.

The Nagata technique⁷ is among the most widely accepted methods for autologous reconstruction,⁸ using a 2-stage approach. The first stage entails skin flap elevation, cartilage harvest, and framework fabrication, whereas in the second stage, the posterior sulcus is created by placing a piece of rib

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Single-Stage Autologous Microtia Reconstruction

cartilage behind the construct and covering with a temporoparietal fascia flap (TPF) and skin graft. The first stage involves a series of complex, interdependent surgical steps: (1) creation of a well-vascularized soft tissue pocket with meticulous elevation of thin skin flaps while maintaining a subcutaneous pedicle; (2) harvest of an adequate volume of costal cartilage; (3) precise carving and 3-dimensional assembly of multiple cartilage components to replicate the auricular framework; (4) stable placement and fixation of the framework within the prepared pocket; and (5) transposition and closure of the skin flaps over the construct. Each step presents significant technical challenges in isolation, and their combination within a single operative stage magnifies the risk of complications and contributes to variability in aesthetic outcomes.

On the basis of our initial experience of 40 patients using the Nagata 2-stage approach, we found that the second stage can diminish the overall aesthetic outcome. The skin graft often contrasts noticeably with the surrounding native skin color and quality, which brings unwanted attention to the ear. There can be chronic edema of the anterior skin, which downgrades the appearance of the construct. In the long term, the contractile forces of healing can lead to the loss of sulcus depth. Moreover, using the TPF flap at this stage removes it as a potential salvage option should postoperative complications arise at some point in the future.

Consequently, we have adopted a single-stage autologous reconstruction⁹ approach based on the Nagata method, with several key modifications: (1) elevating the framework using a projecting block within a single stage, (2) performing wider undermining of the soft tissue pocket to accommodate this elevation, (3) adding a cranial extension to the tragus for stability, and (4) refining the contour of the inferior crus. In our experience, the use of a single-stage approach better maintains the aesthetic result of the reconstruction and achieves good projection while retaining the TPF flap as a salvage option if necessary. The following describes our technique of single-stage autologous ear reconstruction.

METHODS

History and Physical Examination

A targeted hearing evaluation should be performed alongside a comprehensive medical history. Prior interventions involving the inner or middle ear—such as atresia repair or insertion of a bone-anchored hearing aid (BAHA) (eg, the Osia System)¹⁰—should be identified. Any previous surgery in the planned reconstruction area should be recognized, as it may influence treatment options. Syndromic associations with microtia, such as Treacher Collins syndrome (TCS) and craniofacial microsomia (CFM), should be clearly identified, as the timing of auricular reconstruction may require coordination with concurrent craniofacial procedures.

Perform a thorough physical examination and document the type of microtia using the Nagata¹¹ or Firmin¹² classification as they are treatment-based. Assess the anlage by comparing it to the contralateral ear and noting any scars that could affect reconstruction. It is important to document any embryologic remnants, including skin tags and pits, that may require intervention during surgery. The position of the hairline is critical in relation to the planned reconstruction as a low hairline may necessitate use of a TPF flap with a skin graft or preoperative laser hair removal. This is commonly seen in patients with TCS^{13,14} or CFM,¹⁵ in addition to an abnormal vestige

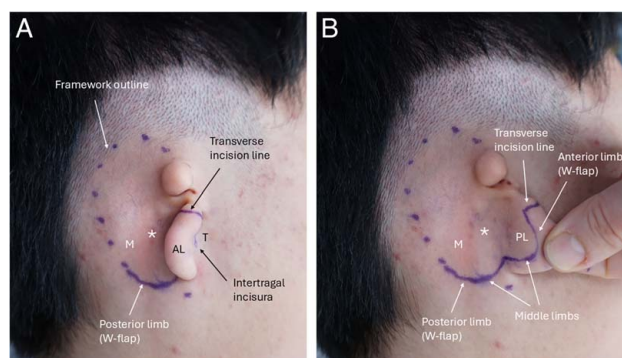


FIGURE 1. Lobule-type microtia illustrating the markings for the auricular reconstruction. (A) The markings for the perimeter of the framework, posterior limb of the W-flap, location of the pedicle (*), a 2-mm circle at the anteroinferior end of the curvilinear marking representing the intertragal incisura, tragal flap (T) and transverse marking placed on the anlage at a vertical level where it curves inward. (B) The anlage is reflected illustrating the middle limbs of the W as well as the posterior lobule (PL) flap. The anterior limb of the W joins the transverse incision marking. AL indicates anterior lobule; M, mastoid flap; PL, posterior lobule; T, tragal flap.

position,^{13,15} which further complicates the placement of the auricular reconstruction.

Investigations

Otolaryngology and audiology evaluation is necessary to ensure maintenance of hearing in the contralateral ear, and to provide options for binaural hearing. A computed tomography scan may be necessary to assess candidacy for middle ear surgery.

Surgical Planning

Reconstruction is reserved for patients over 10 years of age with a chest circumference of at least 60 cm at the xiphoid level. This criterion ensures an adequate volume of donor costal cartilage to fabricate a framework comparable in size to the contralateral ear, which by this stage is generally at or near its stable adult dimensions.

Surgical Approach

The patient is placed under general anesthesia through orotracheal intubation. Preoperative antibiotics are administered to cover both Gram-positive and Gram-negative organisms. The costal cartilage graft is harvested from the right chest to preserve the perichondrium over the heart. Markings are performed on the right chest donor site and at the site of the auricular reconstruction.

Markings Costal Cartilage

The ribs are identified beginning at the second rib beneath the clavicle and continuing to the ninth rib. A 5 cm transverse incision is placed between ribs 7 and 8 medial to the nipple-areola complex. The vertical position of this marking is selected to provide access to the costal cartilage of ribs 6, 7, and 8, with the option to reach the costal cartilage of rib 9 if required.

Auricular Soft Tissue Pocket

Transparent 2-dimensional templates, sized according to the contralateral ear, are used to guide positioning and orientation of the framework markings at the site of the auricular reconstruction. The framework perimeter is outlined in reference

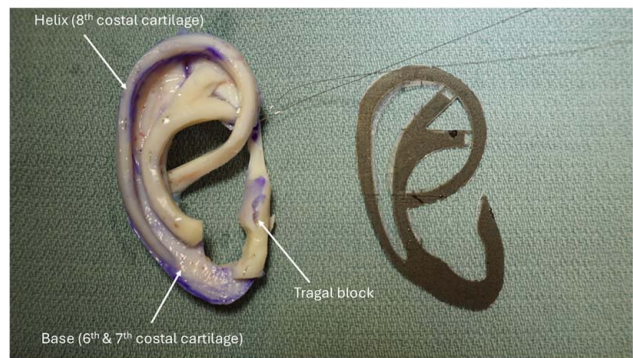


FIGURE 2. The final framework after assembly with the adjacent template highlighting the base carved from the sixth and seventh costal cartilage, the helix carved from the eighth costal cartilage, and the tragal block carved from remaining cartilage.

to the ear anlage, and soft tissue flap markings are made following the method described by Nagata. Markings are tailored to the microtia subtype as per Nagata's classification: (1) lobule, (2) small conchal, (3) conchal, and (4) anotia.¹¹

For the most common lobule type, a rounded W-flap is designed, beginning on the posterior surface of the remnant lobule and extending retroauricular onto the mastoid skin. The posterior limb of the W is placed 5 mm posterior to the framework outline to recruit mastoid skin. A transverse incision line is marked on the anlage at a vertical level where it curves inward connecting with the anterior limb of the W on the posterior surface of the lobule. Anteriorly, the transverse marking continues into a curvilinear line that defines the posterior border of the tragus. At the anteroinferior end of this tragal marking, a 2 mm circular marking is placed for excision, creating the intertragal incisura. The middle 2 limbs of the W-flap define the conchal bowl just below the intertragal incisura. This marking pattern defines 4 distinct flaps for reconstruction: (1) mastoid flap, (2) posterior lobule flap, (3) anterior lobule flap, and (4) tragal flap (Fig. 1).

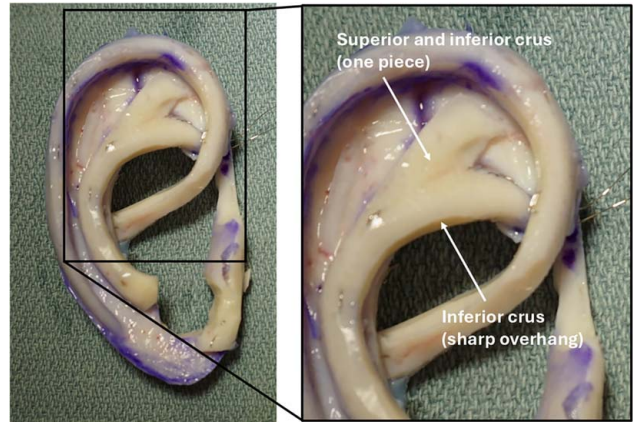


FIGURE 3. The framework with a close-up illustration of the superior and inferior crus. Our method forms an inferior crus with a distinct overhang above the symba concha. In this case, the antihelix, superior and inferior crus were created using a single piece of cartilage. These three structures can also be formed from two pieces of cartilage (antihelix and superior crus as a separate piece from the inferior crus) if an insufficiently large piece of cartilage is available.

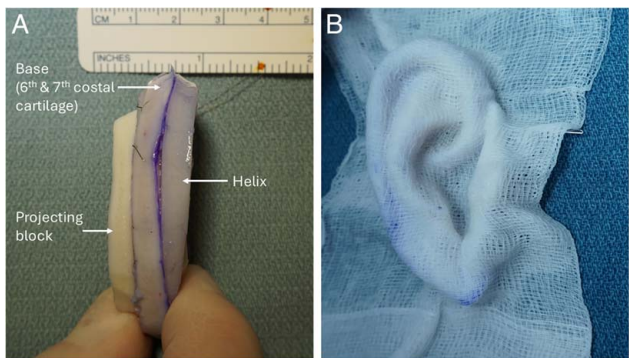


FIGURE 4. (A) The complete framework with the projecting block secured to its base. (B) The anticipated soft tissue coverage and final contour is simulated by draping a moist gauze over the construct.

For small conchal microtia, the curvilinear incision behind the conchal bowl depression defines the posterior tragal margin; the depressed skin is then everted to drape over the tragus. For large conchal-type microtia, a cephalad, flattened W-shaped incision above the lobule follows the helical rim and extends into the conchal bowl, preserving the lower auricular cartilage (tragus and antitragus).

Operative Technique

The chest is prepped with chlorhexidine solution. The face and both ears are prepped with povidone-iodine, followed by sterile draping of both regions. A sterile transparent adhesive dressing (Tegaderm, 3M) is applied over the nose and mouth to maintain the sterile field. Two surgical teams are used—one for cartilage harvest and framework fabrication, and the other for soft tissue pocket dissection—to minimize surgeon fatigue and reduce operative time.

Auricular Pocket Incisions and Dissection

A 15-blade scalpel is used to create the incisions. The anterior limb of the W is incised first to split the lobule, ensuring equal thickness of the anterior and posterior lobule flaps. The incision is then extended posteriorly along the remaining limbs of the W onto the mastoid skin. The pocket is dissected ~10 mm beyond the planned auricular outline, maintaining skin and subcutaneous tissue thickness at 1.5 to 2 mm. A subcutaneous pedicle is preserved and positioned at the site of the future conchal bowl, near

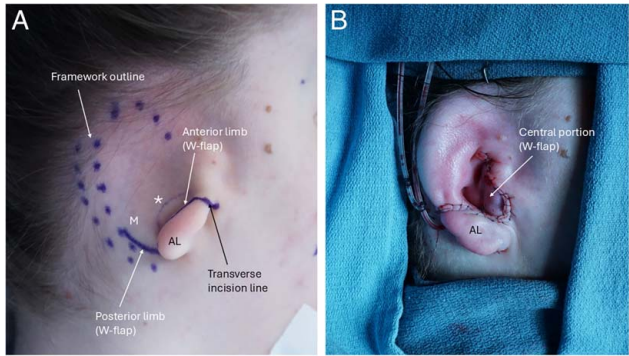


FIGURE 5. Illustration of a (A) preoperative and (B) immediate postoperative result using the single-stage autologous technique. Suction is applied to the drains to contour the skin over the framework. AL, anterior lobule; M, mastoid flap. *Location of the subcutaneous pedicle.



FIGURE 6. Postoperative result for the patient in Figure 5 illustrating the outcome of the single-stage autologous reconstruction of the right ear from a (A) perspective view and (B) worms eye view with symmetric projection compared to the contralateral ear.

the central aspect of the W-flap, to provide vascular supply to the mastoid skin and anchor it to the bowl's depth (Fig. 1).

Costal Cartilage Harvest

A 10-blade is used to incise through skin down towards subcutaneous tissue. Monopolar cautery is used to dissect deeper towards the rectus fascia followed by wide undermining in the plane immediately above the fascia. Manual palpation identifies the insertion of the rectus and serratus muscles. The fascia is incised vertically just medial to the lateral border of the rectus muscle continuing through until the vertical rectus fibers are visualized. The fascia is elevated laterally off the rectus muscle until the transition between the rectus and serratus muscles is identified. Dissection is performed at this junction to avoid traversing muscle fibers. Each muscle is then reflected to expose the costal cartilage of ribs 6, 7, and 8. The perichondrium is incised with a 15-blade, taking care not to penetrate the underlying cartilage. Costal cartilage is harvested circumferentially in a subperichondreal plane. The perichondrium of rib 8 is first elevated, and the cartilage is removed from medial to lateral, separating it laterally at the cartilage-bone junction. Ribs 6 and 7 are harvested en bloc in a similar subperichondreal manner, but from lateral to medial—beginning with separation at the cartilage-bone junction laterally, followed by release from the sternum medially. If required, the ninth cartilage is harvested in the same manner as rib 8. Pleural integrity is assessed by instilling saline into the pocket under positive airway pressure. After framework carving and



FIGURE 7. (A) Preoperative sagittal view of a patient with lobule type microtia. (B) Postoperative sagittal view of the reconstruction.

fabrication, any remnant cartilage is returned to the subperichondreal pocket followed by closure of the perichondrium over the remnants. Closure then proceeds with the rectus sheath, followed by layered closure of the subcutaneous tissue and skin.

Framework Carving and Fabrication

Framework assembly is optimally performed with 40-gauge wire sutures. Knots are positioned on the deep surface of the framework and the anterior loop of wire is countersunk on the superficial surface of the framework. A transparent template is used to outline and define the cartilage components. These components are cut with 11-blade and 15-blade scalpels, whereas concavities are sculpted using Nagata blades. Both convexities and concavities are exaggerated by 1.5 mm to account for the thickness of the overlying soft tissue envelope.

The framework base is constructed from the combined sixth and seventh costal cartilages (Fig. 2). If the synchondrosis between these segments is unstable, it is excised, and the cartilages are secured together with wire sutures. A Nagata blade is then used to sculpt the scaphal concavity in the base. This base serves as the structural support for the helix, antihelix, antitragus, and superior crus.

The helix is created using the eighth costal cartilage. The curved inferior portion of the eighth costal cartilage is used to replicate the external curvature of the helix. This requires incising along the length of the eighth costal cartilage to create a flat superior surface to lie flush on the base. The helix is secured to the base using the wire sutures placed at 3 mm intervals. The helical root is secured to the base on its deep surface. Additional stability can be achieved using a tongue-in-groove joint (Fig. 2).

Although Nagata originally utilized the ninth costal cartilage to construct the antihelix and crura, in most cases we find that large residual segments from ribs 6, 7, and 8 are sufficient. When an adequately sized piece is available, the antihelix, antitragus, and both superior and inferior crura can be sculpted as a single unit. If a single large segment is unavailable, the antihelix, antitragus, and inferior crus are sculpted from one piece, and the superior crus from another, with the triangular fossa carved between them. The antihelix and antitragus are typically contoured as a single unit to form a continuous posterior cavum wall. The superior and inferior crura have distinct morphologies: the superior crus is low-profile, broad, and smooth, whereas the inferior crus forms a sharp, overhanging shelf, which better defines the aesthetics of the concha cymba. This approach contrasts with Nagata's technique, in which the inferior margin of the ninth costal cartilage is split to create the superior and inferior crura and the intervening triangular fossa, often resulting in an inaccurate inferior crus contour (Fig. 3).

A separate cartilage segment is carved to form the tragus and secured to the inferior aspect of the base, just below the antitragus. This segment incorporates a closing strut extending from the superior aspect of the tragus, which can be anchored to the deep surface of the helical root to enhance stability and preserve framework shape after insertion. The strut is not attached to the helical root until the framework has been placed within the soft tissue pocket (Fig. 2).

A large remaining cartilage segment is fashioned into a projection block, ~6 to 8 mm in height, to match the contralateral ear projection. This block is secured to the deep surface of the framework (Fig. 4A).

Upon completing the framework assembly, the anticipated soft tissue coverage and final contour can be simulated by draping a moist gauze over the construct (Fig. 4B).



FIGURE 8. (A) Preoperative anterior view of the same patient in Figure 7 with lobule type microtia. (B) Postoperative anterior view of the reconstruction illustrating the symmetric projection of the ear compared to the contralateral ear.

Framework Insertion

Before framework insertion, 2 drains are placed into the pocket through small stab incisions. The framework is then positioned within the soft tissue pocket, rotated around the pedicle as needed to achieve proper alignment relative to the contralateral ear, and secured to the deep mastoid tissue with clear nylon sutures. The height of the framework is adjusted if the pocket appears excessively tight, to reduce the risk of flap necrosis. A wire is used to secure the superior edge of the tragal block to the helix for added stability.

The soft tissue flaps are subsequently transposed, draped, and fixed over the framework using 6-0 nylon sutures. The anterior lobule flap is rotated over the lobule component of the framework and anchored to the posterior mastoid skin. The central portion of the W-flap forms the conchal bowl, with its inferior skin secured to the anterior lobule and tragal flaps. Any residual pits or tags are excised, and suction is applied to the drains to contour the skin over the framework (Fig. 5).

Achieving projection in a single stage requires greater recruitment of surrounding soft tissue and skin compared with the Nagata technique, which uses a TPF flap with skin graft in a second stage. Care must be taken to avoid excessive tension on the soft tissue, which could compromise skin viability. Additional undermining of the envelope may be necessary to achieve the desired projection while minimizing risk to the overlying skin.



FIGURE 9. (A) Immediate postoperative result using the single-stage autologous technique. (B) Demonstration of the same patient with a well-defined retroauricular sulcus enabling wearing of a face mask.

Dressing Care

Antibiotic ointment is applied to the incisions, followed by petroleum gauze dressings. A thick foam ring is positioned over the reconstruction for protection, and the entire site is secured with a head dressing.

Postoperative Care

Patients are admitted and started on prophylactic antibiotics, including coverage for gram positives and *Pseudomonas*, for 2 weeks. Dressings are removed 24 hours postoperatively to assess for hematoma and evaluate skin flap viability. Incentive spirometry is provided to support respiratory function. Patients are typically discharged after drain removal on postoperative day 3.

DISCUSSION

In a series of 40 consecutive cases using the single-stage technique, our surgical complication rate was 15%, comparable to rates reported for autologous reconstruction. A systematic review by Long et al¹⁶ of 60 studies with 9415 patients who underwent autologous reconstruction reported an overall complication rate of 16.2%. Fu et al¹⁷ found a complication rate of 12.2% for 311 patients who underwent reconstruction using the Nagata technique.

Autologous costal cartilage reconstruction remains the gold standard for microtia repair. Multiple surgical approaches have been described, with the Nagata 2-stage technique and the method developed by Francis Firmin¹² being widely adopted. When performed by experienced surgeons, these techniques are capable of producing excellent aesthetic and functional results.

Single-stage autologous reconstruction for microtia offers excellent aesthetic outcomes (Figs. 6–9) while eliminating the need for a second-stage procedure, which may compromise the final result. Avoiding a second stage also preserves the TPF flap, thereby maintaining this valuable reconstructive option should complications occur.

In our experience, the projection achieved with single-stage reconstruction creates a well-defined retroauricular sulcus, enabling patients to comfortably wear glasses and face masks (Fig. 9B). One drawback, however, is that the hair cannot be tucked behind the sulcus, a limitation that is discussed with patients during preoperative counseling. If the patient has an over-projected ear on the opposite side, they are offered a setback otoplasty at a later date to bring more symmetry to the reconstructed side.

Patients with a low hairline require special consideration to prevent hair-bearing skin from encroaching on the reconstruction. Two strategies are available. Although the TPF flap is not part of our standard single-stage technique, in such cases the hair-bearing skin can be excised and the framework covered with a TPF flap and skin graft. More recently, however, our preferred approach has been to have patients undergo laser hair removal before reconstruction, which offers a simpler and less invasive solution.

For patients with bilateral microtia, we prefer to reconstruct each ear separately, allowing a comfortable side for sleeping from both the auricular and chest donor site perspective. Nonetheless, simultaneous bilateral reconstruction has been reported with good success.^{18,19}

CONCLUSIONS

We present a single-stage autologous technique for microtia reconstruction that achieves excellent aesthetic outcomes with reliable projection. In our experience, a single-stage approach better maintains the overall appearance of the reconstruction while preserving the TPF flap as a valuable salvage option if required.

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Abstract: Single-stage auricular reconstruction using a porous polyethylene (PPE) framework with temporoparietal fascia flap (TPFF) coverage has become increasingly popular for microtia correction. This technique reduces the number of operative stages and avoids donor-site morbidity from rib cartilage harvest. We describe our refined approach combining PPE framework implantation with endoscopic-assisted TPFF harvest via a single small incision. Preoperative planning includes 256-slice contrast-enhanced MSCT angiography and Doppler mapping to delineate the branching pattern of the superficial temporal artery (STA), guiding flap design while minimizing risk of damaging the frontal branch of the facial nerve. Intraoperative endoscopic magnification ensures clear visualization of STA branches and interconnections, preserving all small anastomoses to improve flap viability. We also propose an anatomic classification of STA branching patterns. On the basis of our experience with 113 patients, this approach improves surgical precision, reduces complications, enhances team teaching, and achieves excellent aesthetic outcomes.

Key Words: Endoscopic, microtia, porous polyethylene, single stage, superficial temporal artery

Auricular reconstruction for microtia remains a complex challenge with evolving techniques. Traditional autologous costal cartilage frameworks (eg, 2-stage approach) require rib harvest and are often delayed until age 10 to 12 years, with significant donor-site morbidity and multiple surgeries.^{1,2}

Single-stage reconstruction using a porous polyethylene (PPE) framework offers several advantages: it avoids rib harvest, reduces surgical stages, and can be performed as early as 4 to 5 years of age, supporting psychosocial development before school.^{3,4} However, achieving stable, vascularized coverage is critical to prevent exposure or infection.

The temporoparietal fascia flap (TPFF) is ideal for this purpose, but conventional harvest methods typically require longer or multiple scalp incisions. Dissection is performed under direct vision or with loupe magnification through a narrow incision, limiting light source and allowing only the primary surgeon to visualize the field. Assistants cannot clearly see the

Endoscopic-Assisted Harvest of Temporoparietal Fascia Flap Through a Single Incision for Single-Stage Auricular Reconstruction With Porous Polyethylene Framework: How I Do It

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