Auricular Reconstruction for Microtia: Part II. Surgical Techniques

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Learning Objectives: After studying this article, the participant should be able to: 1. Describe the Brent and Nagata techniques for auricular reconstruction and discuss the advantages, disadvantages, and complications of each technique. 2. Describe the general approach for one-stage microtia repair. 3. Discuss the common problems encountered in microtia reconstruction and how these are currently addressed. 4. Be familiar with current research endeavors in tissue engineering as this technology applies to auricular reconstruction. (Plast. Reconstr. Surg. 110: 234, 2002.)

OPERATIVE PROTOCOLS FOR AURICULAR RECONSTRUCTION

A variety of surgical strategies have been devised for the reconstruction of the external ear, with each composed of several stages. The stages depend largely on the severity of the patient’s deformity; the size, position, and quality of the microtic elements; and the surgeon’s preference.

Tanzer advocated a four-stage reconstruction.1 In the first stage, the lobular remnant was transposed transversely to its correct anatomic position. In the second stage, costal cartilage, harvested sub-perichondrially from the sixth, seventh, and eighth contralateral ribs, was implanted beneath the mastoid skin, using a V-shaped postlobule incision. The sixth and seventh costal cartilages were used for the base and antihelix, and the eighth costal cartilage became the helical rim. The carved cartilage elements were coapted with fine-gauge wire. In the third stage, the construct was elevated from the head by advancement of postauricular skin and placement of a retroauricular, full-thickness skin graft. The concha and tragus were subsequently created with composite contralateral ear and skin/cartilage grafts. Tanzer later modified this sequence by combining the lobular transposition and placement of the cartilage framework into one stage, prefacing this modification with the admonition that if extensive mobilization or surgical manipulation of the lobule is necessary, it is best to use four separate stages to avoid vascular compromise of the lobular element.2

Numerous modifications of Tanzer’s technique have been championed over the past 20 years, but two particular techniques for total ear reconstruction have enjoyed considerable acceptance by the plastic surgery community for both their quality and reproducibility.3–14 As such, these techniques by Brent and Nagata will be examined in detail.

BRENT TECHNIQUE

Brent uses a three-stage or four-stage technique, similar to that of Tanzer, although with a slightly varied sequence:

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**First Stage**

In the first stage, a pattern for the construct is made by placing a piece of x-ray film against the normal ear and tracing its anatomic landmarks (Fig. 1). The template is then reversed and made several millimeters smaller throughout to accommodate for the thickness of the skin cover. The lobular component is altered depending on the quality and amount of residual lobular tissue. In patients with a very low hairline, Brent suggests creating slightly smaller ears to minimize problems with hirsute helices. This approach is less problematic with bilateral microtia, but it may require resection of a scapha crescent of the contralateral ear in unilateral cases to create symmetry between the normal and reconstructed ears. Once configured, the template is aligned symmetrically with the contralateral ear using the ear’s relationship to the nose, lateral canthus, and position of the lobule. In patients with hemifacial microsomia, this may be somewhat problematic because facial asymmetry always requires a compromise of the position of the reconstructed ear. In these situations, Brent recommends positioning the ear relative to the superior pole of the contralateral ear, because the lateral canthus is a less dependable landmark for positioning the auricle. Brent also cautions that the lobular remnant may be positioned
too close to the eye, and a compromise between the measured distance and the lobule may be the most appropriate solution for positioning in these cases.

The contralateral sixth, seventh, and eighth costal cartilages are usually harvested. The construct base is formed by the synchondrosis of the sixth and seventh cartilages, whereas the “floating” eighth rib is used to fabricate the helical element, which is then attached to the base. Brent carves the cartilage base with “exaggerated details” to compensate for the dampening that the overlying thickened skin produces on the final three-dimensional relief. Fixation of the cartilage pieces is achieved with clear nylon suture. The construct is placed into a subcutaneous pocket through an incision located at the posterior inferior border of the vestige. Dissection of the auricular pocket preserves the subdermal plexus, and the field of dissection is wide enough to afford adequate drape of the skin flaps over the framework without undue tension. The lobule is not repositioned in the first stage. By placing the framework in the first stage under a virgin skin envelope and using a high-profile construct, this technique will maximize definition of the reconstruction while minimizing the risk of vascular compromise of the skin flap. It is this advantage that sets Brent’s technique apart from Tanzer’s, which transposes the lobule in the first stage.

Suction drains beneath and adjacent to the framework are used to occlude the overlying skin flap to the construct and thus achieve the defining relief of the ear form. Brent finds that this technique minimizes the number of complications related to pressure and bolster dressings, which in his first 15 cases resulted in a 33 percent rate of skin loss and infection. Since using suction drains, these complications have been re-

Fig. 2. Brent technique, second stage. Managing the earlobe in microtia. (Above) Lobe transposition secondary to cartilage framework stage. (Below) The lobe transposition combined with elevation procedure, which was safe because the skin-bridge above the short lobule carries circulation across to the auricle. (Courtesy Dr. Burt Brent.)
duced to less than 1 percent. The risk of injury to the construct from pressure dressings has led Brent to suggest that parents should be prevented from changing any of the ear dressings.

**Second Stage**

Lobule transposition is the second stage in Brent’s technique (Fig. 2). He believes it is safer and easier to position the lobular remnant around an established construct. This stage is performed several months after the initial cartilage grafting. The lobule is rotated and often filleted to receive the end of the framework.

**Third Stage**

The construct is elevated in the third stage to achieve projection of the helical rim (Fig. 2). An incision is made several millimeters from the margin of the rim, and dissection is carried over the capsule of the posterior surface of the construct until the correct amount of projection is achieved. The ear position is stabilized by placing a piece of banked costal cartilage posteriorly beneath the framework in a fascial pocket. The retroauricular scalp is then advanced to minimize visible scarring. The remaining postauricu-

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**Fig. 3.** Brent technique. Tragal reconstruction, concha excavation, and canal mimicry in the unilateral microtia patient. (Above, left) Chondrocutaneous graft harvested from the contralateral ear. To avoid setting this particular ear too close to the head by the usual direct closure of the defect, the concha is repaired with a small skin graft harvested just anterior to the hairline. (Above, center and below, left) A composite conchal cartilage/skin graft from the opposite ear is applied beneath the “tragal flap,” developed by a J-shaped incision placed at the proposed location of the tragal margin and intertragic notch. (Above, right) Excision of excess soft tissues accentuates the conchal depth. (Below, center) A composite graft is pulled under the tragal flap with a bolster suture; the conchal floor is resurfaced with a full-thickness skin graft harvested from the posterior contralateral ear lobe. (Below, right) Result 2 years postoperatively. The shadow cast beneath the constructed tragus mimics the external auditory meatus. (Courtesy of Dr. Burt Brent.)
lar defect is closed with a “medium-thick” split-thickness skin graft from the hip.

**Fourth Stage**

Tragus construction, conchal excavation, and symmetry adjustment are performed in the fourth stage (Fig. 3). By reconstructing the tragus last, the final healing of the elevation has occurred, allowing precise adjustment of the opposite ear to ensure symmetry on the frontal view. The tragus is formed using a composite skin/cartilage graft from the contralateral conchal vault through an anterior approach. A J-shaped incision is fashioned along the posterior tragal margin, and the composite graft is inserted and positioned so that it produces both projection of the neotragus and cavitation of the retrotragal hollow. The subcutaneous tissues are then excavated to deepen the conchal bowl. In patients with bilateral microtia, Brent recommends the use of an anteriorly based conchal flap, similar to the technique described by Kirkham, but adds a cartilage strut for support.8,15 Recently, Brent devised a new method for tragus reconstruction as an alternative to this technique (Fig. 4).16

The most recent modifications of Brent’s technique include incorporating a small cartilage addition to the framework, as noted above, to create a tragus, and laser hair removal of the scalp flaps before commencement of the ear reconstruction. Brent has experience with over 1200 cases of ear reconstruction spanning a 25-year period. Long-term follow-up to 18 years attests to the safety and durability of this method over time (Fig. 5).3

A major criticism of Brent’s technique is the number of stages required to achieve the final

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**Fig. 4. Brent technique. Ear framework fabrication with integral tragal strut.**

(Above) Construction of the frame. The floating cartilage creates the helix, and second strut is arched around to form the antitragus, intertragic notch, and tragus. This arch is completed when the tip of the strut is affixed to the crus helix of the main frame with a horizontal mattress suture of clear nylon. (Below) Actual framework fabrication with patient’s rib cartilage. (Courtesy Dr. Burt Brent.)
result. This has particular relevance when one considers the operative morbidity and costs. For most microtia reconstructions, four stages are used; however, Brent will occasionally combine the earlobe transposition and elevation stages if the local vascular anatomy allows for the safe manipulation of the tissues (Fig. 2). Proponents of the Nagata technique have emphasized dissatisfaction with the appearance of Brent’s tragal reconstructions.17 In less experienced hands, the composite skin/cartilage grafts may contract, diminishing the retrotragal hollow and, sometimes, everting the tragus itself.

Brent’s technique has also been criticized for its lack of definition of the conchal bowl, the intertragic notch, and the contour of the antitragus. This criticism is underscored by the need for an additional step for conchal excavation to achieve the desired definition of ear anatomy. Without the construction of a complete crus helicis, the conchal cavity is not separated into its major components, the cymba and cavum conchae. In addition, skin grafts applied to the conchal bowl, if not taken from the opposite ear or adjacent scalp, may hyperpigment and thereby compromise the final appearance. Effacement of the postauricular sulcus is a common sequela following elevation of the construct that can result in decreased projection of the reconstructed ear. This is largely due to contraction of the skin grafts.16,17 This problem may be minimized by the application of thicker skin grafts (preferably full-thickness) or by advancing the postauricular skin to the depth of the sulcus and grafting only the posterior ear.

NAGATA TECHNIQUE

Nagata’s technique involves two stages. It was first introduced in 1993 and has undergone several possible technical refinements, depending on the type of microtia present (i.e., lobular, small concha, conchal, anotia, low hairline).9–14 In addition to the helix, crura, antihelix, and conchal elements, this technique provides for the incisura intertragica and the tragus as key elements in the reconstruction.

First Stage

In the first stage, the rib cartilage framework, which incorporates a tragal component, is placed in a subcutaneous pocket and the lobe is transposed. This first stage thus roughly corresponds to the first three stages in Brent’s sequence. In contrast to the three contralateral costal cartilage segments used in the Brent technique, Nagata harvests the ipsilateral costal cartilages of the sixth, seventh, eighth, and ninth ribs. The total perichondrium is left in situ except for the junctional region of the sixth and seventh costal cartilages. Nagata constructs the framework base into three “floors,” with each floor representing different elevations: the cymba and cavum conchae form the base; the crus helicis, the fossa triangularis, and the scapha form the second level; and the helix, antihelix, tragus, and antitragus the top
level. The base frame is constructed from the sixth and seventh costal cartilages (Fig. 6). The helix and crus helicis are constructed from the eighth costal cartilage. The ninth costal cartilage is used to construct the superior crus, inferior crus, and antihelix. The remaining structures are carved from residual cartilage pieces. The cartilage construct is assembled using fine-gauge wire sutures (Fig. 7).

Nagata uses the skin of the posterior lobule and mastoid to cover the conchal aspect of the construct. By converting the V-shaped posterior lobule incision used by Tanzer into a “W,” he also increases the surface area of skin available to cover the framework (Fig. 8). This also permits lobule transposition, obviating the need for a conchal skin graft or a switchback procedure for lobular transposition as necessitated in Tanzer’s technique. The skin incision separates the lobule into three skin flaps: the posteroanterior lobular skin flaps and an anterior tragal skin flap. A 2-mm circular portion of skin is removed from the inferior portion of the anterior lobule/tragal incision. A subcutaneous pocket is dissected through the access provided by the posterior lobule incision. Vestigial cartilage remnants are removed carefully so as to not damage the subdermal plexus of the flaps. In lobule-type microtia, the central portion of the posterior skin flap remains attached by means of a subcutaneous pedicle to augment its blood supply. After creation and placement of the cartilage framework, the posterior flap is advanced and sutured to the tragal flap. The small circular skin defect that was created at the inferior point of this juncture is sutured, forming a closure cone (inverted dog-
ear), which represents the incisura intertragica. In small concha-type microtia, the anterior incision is varied only slightly and the area directly posterior to the indentation is excised. The lobule is transposed by reassembling the flaps in the fashion of a Z-plasty (Fig. 9). Bolsters affixed with mattress sutures are used to approximate the skin flaps to the framework. These are left in place for 2 weeks.

**Second Stage**

Six months after the first stage, the construct is elevated using a crescent-shaped piece of cartilage harvested from the fifth rib through the previous chest wall incision (Fig. 10). The skin around the construct is incised 5 mm posterior to the construct. The framework is elevated and held in this position by wedging the carved, crescent-shaped cartilage graft into a position that substitutes for a posterior conchal wall. A temporoparietal fascia flap is then elevated and tunneled subcutaneously to cover the posterior surface of the cartilage graft and reconstructed auricle and the mastoid surface. The retroauricular skin is advanced toward the ear to minimize visible scarring, and the posterior aspect of the construct is closed with a skin graft, which is secured with a tie-over bolster in a manner similar to that of Brent. Nagata prefers a split-thickness graft harvested freehand from the occipital scalp for this purpose (ultra-delicate split-thickness skin graft).

Nagata emphasized the need for a deep, high-definition framework to create a good

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**Fig. 8. Nagata technique. Incision planning, creation of skin flaps, placement of framework.** *(Above, left)* Incision line for the anterior surface of the auricle. Note that the terminus of the anterior incision is circular (arrow). *(Above, center)* Incision line for the posterior surface of the auricle; note the W-shaped flap. The shaded area (S) depicts the area of subcutaneous tissue that will be left intact so as to optimize blood supply to the flaps. *(Above, right)* The skin flaps are undermined, and the wings of the W-shaped flap have been approximated to form the cup of the intertragic notch (C). *(Below, left and center)* Insertion and positioning of framework. *(Below, right)* Transposition of lobule and closure of incisions. Excessive skin shown at (D) is inverted to construct the pseudoacoustic meatus. The skin flaps are then approximated to the underlying framework with cotton cylinder compresses secured by bolster sutures. *(Courtesy Dr. S. Nagata.)*
tragus, which he believes is the weak link in most contemporary ear reconstructions. In addition, he reasons that carving the crus helicis into the base frame ensures a more realistic and smooth curve of the helix as it joins the lobule. By eliminating the need for conchal excavation, his technique results in a more natural and deeper conchal bowl.\(^9\)–\(^{14}\)

Despite the excellent appearance of Nagata’s ear reconstructions, a number of criticisms have arisen from others who have attempted to adopt his techniques. These stem from the vascular compromise of the peri-lobular flaps, most especially, the posterior flap. In his original description of 36 cases, Nagata described no complications, but in the hands of others, flap necrosis has approached 14 percent.\(^{17}\) The stresses inflicted on the skin envelope during the first stage of the Nagata technique would seem to be greater than with the Brent technique, because of the relatively higher framework relief and the incisional compromise of skin circulation attendant to the lobule transposition. Nagata suggests preserving a subcutaneous pedicle to the posterior skin flap to avert this complication, but others doubt that this effectively increases the flap’s blood supply.\(^{17}\) Some think that the sacrifice of posterior ear lobe skin to provide additional lining for the tragus reconstruction also compromises the natural shape and contour of the lobule, thereby diminishing the natural appearance of the reconstruction.\(^{16}\) Brent has argued that the refinement of Nagata’s tragal reconstruction is less than that of a composite skin/cartilage graft, yet Brent has recently begun incorporating a tragal component into his framework for bilateral microtia cases.\(^3\),\(^7\)

Although all techniques using autologous costal cartilage produce a permanent anterior chest wall deformity, the amount of costal cartilage harvested by Nagata (the sixth through ninth costal cartilages) is considerable and may result in a significant chest wall deformity. Nagata emphasizes that the degree of chest wall deformity can be minimized if the perichondrium is left intact at the site of harvest to allow for cartilage regeneration.\(^{18}\) This, however, would seem to have a greater likelihood of success in children than in adults.

Some have argued that the relatively greater amount of cartilage used by Nagata to achieve the high relief in his reconstructions produces unnaturally thick ears. Nagata believes that natural-appearing reconstructed auricles are attained by carving the posterior margin of the base frame of the fabricated framework, resulting in the attainment of a thin and normal reconstructed auricle.\(^{19}\) Partial resorption of the piecemeal components of the frameworks may also lead to the late development of contour irregularities, although the relatively short follow-up on patients in Nagata’s published series is insufficient to derive any definitive

![Fig. 9. Nagata technique, first stage. Clinical case. (Left) A 29-year-old woman with lobule type microtia. (Center) Immediate result after placement of framework and skin closure. (Right) Six months after the first-stage operation. (Courtesy Dr. S. Nagata.)](image-url)
conclusions as to long-term stability. Nevertheless, using his current two-stage method, which now exceeds 600 cases with a maximum follow-up of 14 years, Nagata reports no untoward problems or complications with cartilage resorption or framework distortion. Nagata’s use of wire sutures to assemble his cartilage framework has been criticized because of the high (8 percent) extrusion rate observed by others using this technique. Nagata argues that this problem does not occur if the subcutaneous pedicle of the posterior flap is properly constructed and the loop portion of the wire suture is embedded into the substance of the anterior surface of the framework, as he describes in his original article. Finally, the use of a temporal fascial flap in every case seems somewhat excessive, with its attendant risks of scalp scarring, temporal hair thinning, and the sullying of a potential reconstructive lifeboat. Even though the temporoparietal fascia flap is used during the second-stage auricular reconstruction (auricular projection) in all cases, Nagata counters that the deep temporal fascia is preserved and remains a potential source of vascularized soft tissue for use in salvage operations.

Although Nagata’s two-stage technique holds a certain advantage over Brent’s three-stage or four-stage technique in the number of operations used, as in most abbreviated approaches used in reconstructive surgery, some

Fig. 10. Nagata technique, second stage. Clinical case. (Above, left) The design for incision lines and harvesting of the ultra-delicatthick scalp graft and temporoparietal fascia. (Above, center) A crescent-shaped costal cartilage block is fabricated from the harvested fifth costal cartilage. (Above, right) The constructed cartilage is undermined and elevated. The cartilage graft is wedged in the postauricular sulcus to create the posterior conchal wall. A temporal parietal fascial flap is then transposed to provide soft-tissue coverage over the postauricular surface. The wound is closed with an ultra-delicatthick scalp skin graft. (Below, left) Lateral view shown 2 years after the second-stage operation. (Below, center) Frontal view shown 2 years after the second-stage operation. (Below, right) Posterior view shown 2 years after the second-stage operation. (Courtesy Dr. S. Nagata.)
vulnerability may exist in the ability to achieve precise, consistent results by all users. Brent argues that Nagata has not specifically addressed the issue of frontal symmetry in his reconstructions, and were he to do so a third stage would likely be required. Nagata contends that favorable and desired results are consistently attained using his two-stage technique. He believes that failure to achieve the desired endpoint is the result of compromise of the surgical technique or the omission of certain procedures during the reconstruction. In the case example, the ear projection achieved by the Nagata technique on frontal inspection appears remarkably symmetrical to the normal side (Fig. 10).

**SINGLE-STAGE TOTAL EAR RECONSTRUCTION**

Single-stage ear reconstructions have been used primarily for the reconstruction of partial defects such as the superior helix or lobule. Current techniques for single-stage total ear reconstruction involve the fabrication of a cartilage framework, followed by coverage using a combination of local skin flaps, fascial flaps, and skin grafts. External stents are commonly used to maintain contour. Unfortunately, early results have fallen short in duplicating the precision and refinement achieved through the use of established, staged techniques. This is underscored by the experience of Park, who modified his two-flap, single-stage reconstruction into an expanded, two-flap, three-stage reconstruction with significant improvement in the results. The concept of single-stage auricular reconstruction, nevertheless, remains promising and will likely grow in applicability as further experience is gained.

**PROBLEMS ENCOUNTERED IN EAR RECONSTRUCTION**

**Hair**

The low hairline in many microtic patients necessitates placement of a portion of the cartilage framework beneath hair-bearing scalp. This results in hair growth on the construct, which substantially detracts from the final result. Moreover, the hair-bearing scalp is thicker and contours less well to the underlying framework, thereby compromising the fine definitions that might otherwise have been achieved through the use of a thinner flap. Use of the scalp in ear reconstruction may also lead to inflammation/infection complications from ingrown hair, keratin accumulation, maceration, and difficulties with hygiene. To address these problems, many surgeons recommend manual depilation, although this technique has been shown to induce circulatory problems in the flaps, leading to necrosis and increased scarring. Brent has recommended electrolysis or resurfacing the area with a skin graft. Recent attempts at preoperative laser depilation are promising but have not withstood the rigors of critical, long-term analysis. Using the temporoparietal fascia, a three-dimensional framework, a cartilage block, and an ultra-delicate split-thickness scalp graft to precisely position the reconstructed ear and reposition the hairline, Nagata believes that the problems associated with low hairline have been solved.

**Soft-Tissue Cover**

An adequate skin envelope of good quality is critical for a successful ear reconstruction. The skin must be supple, thin, and well vascularized to drape over the numerous convolutions of the framework to render an adequate definition. Skin quality may be compromised by the presence of hair, previous trauma, or attempted microtia repair. Certain patients may present with very taut, inelastic skin that resists conformation. These patients constitute a special group that often defies the traditional approaches to ear reconstruction.

First introduced by Fox and Edgerton in 1976 and popularized by Tegtmeier in 1977, the temporoparietal fascial flap has become a workhorse flap for external ear reconstruction. This flap is primarily used in secondary procedures or in ear salvage. It has also been used in primary procedures to supplement inadequate soft-tissue cover. Nagata advocates the use of the temporoparietal fascia flap in combination with an ultra-delicate split-thickness scalp graft for complicated auricular reconstructions and for secondary reconstructions. Brent uses a Y-shaped scalp incision, although a curvilinear incision beginning in the preauricular region is usually adequate for most operative exposures. The temporoparietal fascia flap is based on the superficial temporal artery and vein. The vessels are mapped out with a Doppler and are carefully dissected in a plane just deep to the hair follicles. It is a tedious dissection; care must be taken to avoid injury to the hair follicles, axial vessels, and frontal branch of the facial nerve. The flap is elevated from the deep temporal fascia and then draped over the framework as needed. Complications of
the flap include alopecia (28.6 percent), scalp numbness (17.4 percent), and objection to the visible scar (25 percent in male patients). The anatomy and course of the superficial temporal system vary considerably in microtic patients and can complicate the surgical planning. The use of fascia combined with a skin graft may also result in less definition in the reconstructed ear compared with that using a supple skin flap. To overcome this shortcoming, the cartilage construct can be carved to a higher relief and the conchal vault expanded to accommodate for the additional thickness of the composite soft-tissue envelope and for the anticipated skin contraction. Having used the ultra-delicate split-thickness scalp graft with temporoparietal fascia in the majority of his microtia reconstructions, however, Nagata reports that the ears have excellent definition and that steps to create frameworks with higher relief and an expanded conchal vault are unnecessary.14,22,35

Tissue expansion could theoretically net additional soft tissue for coverage. The use of this technique in auricular reconstruction, however, is quite controversial. Opponents argue that the thick fibrous capsule formed adjacent to a previously implanted tissue expander prevents adequate skin draping over the cartilage framework, thereby obscuring its detail and negatively affecting the quality of the reconstruction.37 Although current thinking does not favor the use of tissue expansion in auricular reconstruction, expanded skin and fascia has been successfully used in over 146 microtia reconstructions by Park with excellent results and relatively few complications, thus giving new cause for reconsideration of this technique.31 Brent has advocated “intraoperative” tissue expansion, using a large Foley catheter to relieve “marginal” skin tension, but this technique has limited application.8

COMPLICATIONS

Regardless of the method used, complications arising from surgical efforts to reconstruct the external ear may occur both at the ear reconstructive site and at the donor sites for tissue harvest.

Chest Wall Donor-Site Complications

The complications associated with costal cartilage harvest include the immediate problems of the pneumothorax and atelectasis and the delayed issues of chest wall deformity and scarring.18,38 The precise frequency of the incidence of pneumothorax during rib harvest is unclear, because most authors suggest the placement of a temporary catheter to evacuate the air leak. Brent notes no need for prolonged chest tube drainage in his initial experience with over 600 costal cartilage graft harvests.8 Anterior chest wall deformity occurs in most patients, and it is considered by most to be an inevitable consequence of the harvest that is well justified by the improvement gained in facial appearance resulting from the reconstruction. In evaluating a series of 32 donor sites used in 18 patients undergoing microtia reconstruction, Ohara et al. observed chest wall deformities in over 64 percent of children under the age of 10 years compared with a 20 percent rate in older children, leading them to recommend delaying costal cartilage harvest as long as possible.38 Many surgeons have adopted this policy, which seems to be more accepted in Eastern cultures than in the West. The psychological stigmata of impaired socialization in unreconstructed patients, however, remain to be addressed. The trend to leave the posterior perichondrium intact when harvesting the costal cartilage, as recommended by Nagata, is sound and may help to stifle the deformity that would otherwise result from excision of all of the perichondrium.19

The age group that most commonly undergoes auricular reconstruction is also prone to the development of hypertrophic scars that may prove to be rather unsightly. These scars usually atrophy over time. Careful placement of the surgical incision in the medial inframammary fold, especially in female patients, is a useful adjunct that will be especially appreciated as the child grows into adolescence.

Costal cartilage harvest evokes considerable pain and discomfort and easily constitutes the most immediately problematic postoperative event. To minimize pain in the chest wall, it is helpful to place a small-diameter infusion catheter in the wound bed at the time of graft harvest for use as a conduit for the administration of bupivacaine or other local anesthetics during the postoperative period.

Complications at the Ear Reconstruction Site

Exposure of the cartilage framework due to overlying skin flap necrosis can be devastating to the reconstruction and may necessitate the complete removal of the framework. In cases of flap compromise, early intervention is manda-
tory for salvage of the reconstruction. This is usually achieved with a combination of local skin and fascial flaps. A point to be emphasized is the importance of placing the initial drain access sites remote to the superficial temporal system so as to avoid injury to a potential salvage resource, the temporal fascia. More commonly, small areas of skin loss (<1 cm) may be dealt with conservatively with topical and systemic antimicrobial therapy, allowing the area to granulate and heal by secondary intent. Even a small area of skin loss or compromise may have a negative affect on the resulting ear reconstruction, and every effort must be made to avoid this problem.

Careful intraoperative dissection with preservation of the subdermal plexus, and approximation of the skin flaps to the underlying cartilage framework, are imperative for an uncomplicated, successful outcome. Pressure dressings should be avoided. Infection is not a common complication (0.5 percent), but it may stem from either construct exposure or pathogens in the vestigial external ear canal. As such, careful assessment of any pathologic findings in the middle ear, such as otitis or cholesteatoma, and preoperative cleaning of the canal are imperative. Similarly, although hematoma is an infrequent complication (0.3 percent), its occurrence could have devastating consequences. Meticulous hemostasis is therefore imperative.

Long-term complications in the reconstructed ear primarily relate to extrusion of suture material and resorption of the cartilage framework, which may alter the shape and form of the auricular components. Usually, these complications are minor in nature and can be easily managed in the office setting. Significant resorption of the framework, however, may require additional cartilage grafting to restore a satisfactory ear contour. The cause of cartilage resorption must be carefully determined or the problem may repeat itself. Sutures placed too tightly or placement of the framework in a scarred, ischemic bed may predispose the cartilage to resorption. For the latter, excision of the scarred bed and replacement with healthy, vascularized tissue (temporoparietal fascial flap) may be necessary to achieve stability in the reconstruction. Finally, resorption of the cartilage at the site of the synchondrosis can sometimes lead to notching of the framework, requiring reintervention.15

**Technical Points**

A successful reconstructive effort necessarily follows a thorough evaluation of the external ear with assessment of the associated pathologic findings and establishment of the status of the middle ear. Any need for otologic intervention must be carefully orchestrated with the external ear reconstruction. The appropriate sequence and timing of each operative stage must be individualized. The minimum safe number of operative stages needed to obtain the highest quality reconstruction is the goal all surgeons must strive to achieve. A number of different surgical techniques are available, and each surgeon must consider the most appropriate for his or her skills and experience. Autologous cartilage frameworks, despite their potential for donor-site complications, remain the accepted standard for external ear reconstruction. All authors agree that maximum relief of the construct is essential for the highest quality of reconstruction. The use of fine-gauge stainless steel wire to coapt the cartilage elements of the framework has been associated with a higher incidence of construct notching and wire extrusion, although this may relate to the technical issues of wire placement and fixation.14 Suture fixation of the cartilaginous framework parts is an alternative that has been shown to result in decreased extrusion/resorption rates, but it may not provide as rigid a fixation of the various framework elements as with wire.8

Minimizing the number of operative stages and dissection over the framework will likely optimize its anatomic definition and enhance the quality of the reconstruction. It must be remembered that the vascularity of the tissue adjacent the vestigial ear remnant is limited, and overly zealous dissection may result in disaster. In certain cases, it may well be better to use an additional operative stage to avoid compromise of the skin flaps than to risk complete loss of the reconstruction.

If middle ear reconstruction is included, the creation of the canal and performance of the middle ear surgery is usually done in one or two stages through both conchal and postauricular/mastoid approaches. Even in the best of hands, this procedure carries a high complication rate, with frequent stenosis of the external auditory canal. To avoid this problem, Firmin et al. advocate lining the canal with vascularized subgaleal fascia.39 In
addition, it may be wise to perform the oto-
logic portions of the reconstruction before helical elevation and then to stage the eleva-
tion in two stages to avoid vascular compromise of the construct.40,41

Dressings are a key adjunct to ear reconstruc-
tion. Pressure dressings may compromise the vascularity of the already taut overlying skin envelope, resulting in skin necrosis and exposure of the framework. Pressure and bolster-
type dressings should be avoided during the framework placement stage and used only with extreme caution in secondary procedures. Some practitioners advocate the use of plica-
tion sutures for securing the skin envelope to the framework. In the hands of novices, how-
ever, this technique may pose considerable risk for producing skin necrosis and must be mon-
tored closely. Nagata emphasizes that the use of bolsters is safe provided that the overlying skin envelope is well vascularized and not taut following placement of the framework. He se-
cures the bolsters with sufficient tension such that they gently coapt the skin envelope to the framework without pressure or blanching. In this manner, he is able to avoid skin necrosis complications.12–14,24,35 Suction drains have proved to be invaluable in achieving flap coap-
tation to the framework, but they must be pre-
cisely placed for optimal effect. Success of the suction drain is improved by careful, airtight closure of the surgical incisions. This may re-
quire fine-layered closure and, occasionally, the use of an impervious elastic drape or a surgical adhesive applied over the suture line. The drains must be monitored closely for clot-
ting of the drain system so as to stifle the development of hematoma or seroma forma-
tion. Also, the vacutainer tubes must be changed every 4 hours or less, which may im-
pose some constraints on the available medical and nursing staff.23

The highly complex nature of ear recon-
struction places it in the higher echelons of reconstructive surgical procedures. The multi-
disciplinary issues surrounding congenital ear deformities, combined with the technical expert-
ise and experience necessary to satisfacto-
riely conduct the surgery, suggest that these types of reconstructions should not be per-
formed by surgeons unfamiliar with the tech-
nique. Optimal results can only be achieved through dedicated study and experience.

**Prosthetic/Osseointegrated Auricular Reconstruktion**

Recent advances in implantology and prosthetic materials have lead to excellent results using osseo-integrated anchoring devices and ear prostheses. Prosthetic reconstruction may be an excellent alternative in patients with poor local tissues resulting from radiation, cancer, or prior surgery (such as in previously unsuccessful autologous reconstructions), in elderly patients, or in those patients with high operative risk factors. Provided that good bone stock is available, the surgical procedures for implanting and exposing the osseo-integrated anchoring prostheses are relatively straightforward, and the adverse effects of the percutaneous connection are predominantly minor skin reactions. The weak link in this technology lies in the quality of the prosthesis itself, the lifelike appearance of which is wholly dependent on the artistry and skill of the anaplastologist. Patients undergoing this approach have been generally quite satisfied with the prostheses and wear them daily and for prolonged periods without difficulty.12–14 This represents a considerable improvement over the old style, “glue-
on” type of prostheses.

**Future Approaches for Auricular Reconstruktion: Tissue Engineering**

The majority of surgeons recognize the superi-
ority of autologous cartilage over the available alternatives for constructing an ear frame-
work. However, it would clearly be of great benefit if one could obviate the use of the chest wall donor site with its attendant risks and morbidity. The potential to fabricate or engi-
neer autologous parts has recently become a blooming field of scientific endeavor. The con-
cept of engineering complex body parts is not new. Proponents for creating complex parts ini-
tially sought to render three-dimensional form through the process of molding tissue.43,46 Un-
fortunately, the constructs did not maintain their engineered shape over time because of the lack of a stable substructure, or scaffolding. To address this problem, Walton et al. success-
fully engineered a fibrovascular stroma with a skin covering to various alloplast ear-shaped scaffolds.47,48 They demonstrated that three-
dimensional facsimiles of ears could be fabric-
cated by this technique and that these con-
structs could be transferred microsurgically. The alloplastic materials used in these experi-
...
ment, however, eventually extruded, resulting in deformation and loss. The scaffolding, therefore, seems to be a critical component in the engineering of a complex body part such as an ear. Biologic/autogenous materials for scaffolding intuitively should work better, given the documented clinical experience with autologous materials, for all types of reconstructions, especially ear reconstructions. Vacanti and, later, Saadeh explored this concept in the experimental setting. They demonstrated that bovine chondrocytes transplanted into mice hosts onto synthetic, biodegradable scaffolds, could, under special conditions, produce de novo cartilage. When placed into special molds, others have shown that this de novo neocartilage could be rendered into complex, three-dimensional shapes and configurations. The chondrocytes in these experiments, however, were derived from nonhuman, fetal tissues, making the clinical applicability of this exercise somewhat suspect for both human children and adults. Human chondrocytes have been extracted from a number of sources, in-duced to replicate their numbers and form immature cartilage. Although the durability of this neocartilage as a scaffold for ear reconstruc- tion remains to be demonstrated, the concept and the technology are promising.

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ACKNOWLEDGMENT

The authors thank Drs. Burt Brent and Satoru Nagata for their invaluable advice and critique in the preparation of this review and for contributing the figures.

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**Self-Assessment Examination follows on the next page.**
Auricular Reconstruction for Microtia: Part II. Surgical Techniques
by Robert L. Walton, M.D., and Elisabeth K. Beahm, M.D.

1. THE FIRST STAGE OF BRENT’S TECHNIQUE FOR MICROTIA RECONSTRUCTION INCLUDES WHICH ONE OF THE FOLLOWING SEQUENCES?
A) Lobule transposition
B) Framework placement and lobule transposition
C) Framework placement
D) Excision of remnant cartilages, laser hair removal
E) Excision of remnant cartilages and lobule transposition

2. WHICH ONE OF THE FOLLOWING STATEMENTS ABOUT BRENT’S TECHNIQUE FOR AURICULAR RECONSTRUCTION IS INCORRECT?
A) Suction drains are used to secure the skin envelope to the cartilage framework.
B) Wire sutures are used to fixate cartilage components of the framework.
C) The tragus is constructed using a composite graft from the opposite ear.
D) Lobule transposition is performed as the second stage.
E) For most microtia reconstructions, four stages are involved.

3. WHICH OF THE FOLLOWING ASPECTS OF NAGATA’S METHOD FOR AURICULAR RECONSTRUCTION DOES NOT DIFFER FROM THAT OF BRENT?
A) Reconstruction of the incisura intertragica
B) Positioning of the framework
C) Use of cotton bolsters to secure the skin envelope to the framework
D) Use of wire sutures to secure elements of the framework
E) None of the above

4. WHICH OF THE FOLLOWING IS A COMMON CRITICISM OF THE BRENT TECHNIQUE?
A) Excessive number of reconstructive stages involved
B) Frontal symmetry
C) Resorption of the cartilage framework
D) Reproducibility
E) All of the above

5. WHICH OF THE FOLLOWING IS A COMMON CRITICISM OF THE NAGATA TECHNIQUE?
A) Excessive harvest of costal cartilage
B) Cartilage resorption and splitting of wire sutures
C) Skin flap necrosis
D) Reproducibility
E) All of the above

6. WHICH ONE OF THE FOLLOWING ASPECTS OF AURICULAR RECONSTRUCTION IS COMMON TO BOTH THE BRENT AND THE NAGATA TECHNIQUES?
A) Use of ipsilateral autologous costal cartilage
B) Use of wire sutures to secure the cartilage framework
C) Use of temporal-parietal fascia to cover the posterior framework
D) Use of cotton bolsters
E) Use of costal cartilage graft to elevate helix
7. WHICH OF THE FOLLOWING INTERVENTIONS HAS NOT BEEN USED FOR AURICULAR RECONSTRUCTION IN LOW HAIRLINE PATIENTS?
   A) Temporoparietal fascial flap
   B) Laser ablation
   C) Manual depilation
   D) Electrolysis
   E) Gene therapy

8. WHICH OF THE FOLLOWING STATEMENTS REGARDING THE TEMPOROPARIETAL FASCIAL FLAP IS NOT CORRECT?
   A) Temporal scalp alopecia occurs in over 25 percent of cases.
   B) Temporal artery course is inconsistent in microtia patients.
   C) Hyperpigmentation occurs in the overlying scalp.
   D) Use results in diminished definition of the reconstructed ear.
   E) All of the above

9. WHICH OF THE FOLLOWING COMPLICATIONS DOES NOT RESULT FROM ANTERIOR CHEST WALL HARVEST OF COSTAL CARTILAGE?
   A) Hypertrophic scar
   B) Diminished respiratory reserve
   C) Chest wall deformity
   D) Pneumothorax
   E) None of the above

To complete the examination for CME credit, turn to page 387 for instructions and the response form.