A Novel Algorithm for Autologous Ear Reconstruction

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ABSTRACT

Sculpting a tridimensional autologous rib cartilage framework is essential to restore a natural ear shape and becomes routine with preoperative training, but management of the skin is the key to minimizing complications. Here the authors provide a classification scheme to manage auricular skin: Type 1 is a Z-plasty with transposition of the lobule; type 2 is a transfixion incision of the microtic ear; type 3 exposes the cartilage remnants through a cutaneous incision. They also explain how to choose between the three types, depending upon the auricular skin potential. With training and method, results in ear reconstruction using autologous rib cartilage are excellent and reproducible.

KEYWORDS: Ear reconstruction, microtia, cartilage, autologous, classification

My (F. Firmin) experience derives from the treatment of ~250 microtia and/or traumatic ear deformities annually as well as over 1600 ear reconstructions in total. I initially learned ear reconstruction from Burt Brent, M.D., in 1984 and followed his four-stage technique for several years.¹⁻³ After a visit to Japan in 1994, I adopted Dr. Satoru Nagata's two-stage approach.⁴⁻⁶ In this article, Dr. Marchac and I describe a novel algorithm for autologous ear reconstruction and provide several technical pearls.

FIRST STAGE

Sculpting the Autologous Cartilage Framework

Synthetic materials such as solid silicone or Medpor[®] (Porex Surgical, College Park, GA) are used to avoid carving rib cartilage, a step considered difficult. Nevertheless, knowledge derived from other areas of plastic surgery indicates that placing an acellular scaffold under the thin retroauricular skin exposes the patient to a high

risk of long-term complications. Autologous cartilage is a cellular structure; therefore, it is able to heal secondarily if exposed. Costal cartilage harvesting and the subsequent thoracic scar and deformity are a necessary trade-off to obtain life-long stability of the reconstructed ear. With proper training, carving the framework becomes one of the easiest steps in this surgery.

Training before Surgery

We developed a device (Firmin's Trainer; Karl Storz, Tuttlingen, Germany) to practice framework carving. Sculpting in synthetic foam and following a systematic instruction course, the surgeon can practice creating a tridimensional framework, reproducing all the contours of a normal ear. The sculpture is then placed on a platform and covered by a rubber cap. Suction is applied, forcing the rubber cap to mold to the contours of the framework, simulating the draping of the skin on top of the ear. Critical analysis of the carved framework will foster improvement after each training session, until the

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tridimensional structure of the ear is perfectly memorized (Fig. 1).

Harvesting the Costal Cartilage

Sufficient cartilage for total ear reconstruction is usually present around the age of 10 years old. Rib cartilage is harvested from the ipsilateral side, leaving the posterior perichondrium intact. The incision is oblique, measuring

5 to 8 cm and allowing access to the fifth to ninth ribs. Several segments of rib cartilage are needed to carve a complete framework. The number of ribs to be harvested depends directly on the normal contralateral ear, which determines the size and shape of the framework segments (Fig. 2).

Following harvest and before muscular closure, a bupivacaine intercostal block at the inferior border of the fifth to ninth ribs minimizes immediate postoperative

Figure 1 Preoperative training. The trainer is designed to accelerate the learning curve of sculpting. (A) The pieces are carved in foam. (B) They are glued together. (C) The framework is placed on the device, covered by a cap, and suction is applied. (D) This simulates the draping of the skin over the cartilage.

Figure 2 Harvesting the costal cartilage. (A) The oblique incision provides access to the ribs #9 to 5. (B) The template of the base, cut in radiologic film, usually fits across the synchondrosis between the sixth and fifth ribs.

pain. The anterior and posterior aponeuroses of the rectus abdominis muscle are carefully reapproximated to minimize thoracic deformity. Our experience is that the resulting deformity is mild and well accepted by patients.

Selecting the Pieces of Cartilage

To create a complete framework, we isolate at least six different pieces from the ribs: (1) the base, (2) the antihelix, (3) the helix, (4) the tragus and antitragus, (5) the projection piece, and (6) a spare piece stored under the thoracic skin to reconstruct the posterior wall of the concha during the second stage. Both the shape of the normal ear and the shape of the ribs determine how the future pieces are drawn on the ribs. Nevertheless, some findings are recurrent, such as the base, which generally includes two adjacent ribs united by a synchondrosis. The eighth rib is often found to be long enough to form the helix (10 cm). If too short, the helix will be split in two segments (7 cm and 3 cm). The complex tragus-antitragus is often found on the medial portion of the seventh or sixth rib, where it is the thickest (Fig. 3).

Choosing the Framework

Microtia includes a large spectrum of anomalies and we have found that it is not always necessary to carve a complete framework. We have come to distinguish three

types of anomalies: (1) microtia without tragus; (2) microtia with a tragus, but without antitragus; and (3) microtia with a good tragus-antitragus complex. Out of this derives logically three types of frameworks (Fig. 4) (Table 1).

Adding Projection to the Framework during the First Stage

For 4 years now, when sculpting a complete framework, we have been adding a piece of cartilage deep to the root of the helix and the tragus, bridging the two. This projection piece not only ensures their stability, but also improves the three-dimensional contour. This concept can also be used deep to the antihelix, to increase the height of the posterior wall of the concha, or deep to the lobule. We distinguish three types of projection pieces: P1, P2, and P3 (Table 2). P1 is used routinely (Fig. 5). When an auditory canal is present, P1 will not reach the tragus and will be placed behind the root of the helix only. P2 is used during the first stage if there is enough skin laxity in the middle third of the ear. This deepens the concha, and in some cases, will result in such a high projection that the second stage will be a simple elevation without the need for a temporal fascial flap. P3 is added to the framework to compensate for a hypotrophic mastoid, such as in craniofacial microsomia. Nevertheless, one should not compromise flap vascularization to add extra projection during the first stage, and if it is felt that the flaps will be placed under tension because of the

Figure 3 The costal puzzle. Because each costal cartilage is different, one must select with care the location of the pieces (left). Frameworks carved from the costal cartilage (right).

height of the framework, it is safer to renounce and to add them during the second stage.

Classification of the Skin Approaches

Although sculpting may seem a daunting task, we actually believe that the biggest challenge for a surgeon interested in ear reconstruction is learning to best use the skin remnants. The main goal is to plan a skin approach

Figure 4 Framework classification. (A1) Absence of tragus and/or antitragus. (A2) Complete framework (type I). (B1) The tragus is nice and complete, but the rest is atrophic. (B2) Framework type II. (C1) The complex tragus-antitragus is nicely developed. (C2) Framework type III.

that covers the framework with vascularized tension-free cutaneous flaps. We devised an algorithm to manage the skin remnants, based on a three-stage classification. This surgical classification does not depend on the shape of the fibrocartilaginous remnants, but instead on the skin potential. Type 1 is a Z-plasty with transposition of the lobule. Type 2 is a transfixion incision of the microtic ear. Type 3 exposes the cartilage remnants through a cutaneous incision (Table 3). An identical skin approach

Table 1 Framework Classification

Type I	Complete framework including the base, helix, antihelix, and complex antitragus–tragus
Type II	Framework including the base, helix, antihelix, and the antitragus
Type III	Framework including the base, helix, and antihelix

Table 2 Different Types of Projection Pieces Added to the Undersurface of the Base during the First Stage

P1	Positioned during the first stage under the root of the helix and the tragus
P2	Positioned during the first stage, under the antihelix, if there is enough skin laxity
P3	Positioned during the first stage, to compensate for a hypotrophic mastoid

Table 3 Surgical Classification of the Skin Approaches for Microtia

Type 1	Z-plasty, in which one of the flaps incorporates the lobule		
Type 2	Transverse transfixion incision (transfixes the skin and the fibrocartilage horizontally, splitting the remnants in two halves)		
Type 3	Vertical cutaneous incision	Type 3a	Accessing the deformed fibrocartilage through a direct incision and replacing it with a framework. One-stage procedure
		Type 3b	There is not enough skin to include a part of the framework into the remnants. The entire framework is buried and elevated in a second stage.

can be selected for microtia with very different shapes but similar skin potential (Fig. 6).

Choosing the Optimal Skin Approach

Observing the shape of the skin remnants is not sufficient to choose the most appropriate type of skin approach. It can only be done after drawing the ideal position of the ear on the abnormal side. The distances (root of the helix to orbit and lobule to oral commissure) and the angle (axis of the ear–nasal dorsum) serve as landmarks to place the future ear (Fig. 7). These land-

marks from the normal side are drawn on the abnormal side and remain visible during surgery. In craniofacial microsomia, due to the asymmetry of the face, these distances cannot always be respected. It is possible to accept a compromise in the anteroposterior plane because the two profiles are never seen at the same time. It remains essential, however, to avoid any compromise in the vertical plane; this would result in visible asymmetry from the frontal view.

Once the ideal position of the new ear has been determined and drawn on the skin, one must look at the position of the lobule. If the lobule is perfectly

Figure 5 Projection piece P1. (A) Preoperative picture. (B) Framework type I, with P1 uniting the root of the helix to the tragus, providing stability and projection, avoiding tilting of the tragus and sinking of the root in the concha when skin redrapes on top of them. (C) Result at 6 months before the second stage.

Figure 6 Surgical classification of skin approach. (A) Type 1 is a Z-plasty where one of the flaps includes the lobule. (B) Type 2 is a transfixion incision of the microtic ear, creating a pocket for the framework. (C, D) Type 3 exposes the cartilaginous remnants by a cutaneous incision.

positioned and broad, one may use a type 1 (Z-plasty with transposition of the lobule) approach. In our practice, this is a very rare situation. If the lobule is narrow, we prefer to use a type 2 (the transfixion incision will then be very low) or a type 3b. In type 2, we must appreciate the ideal level of the transfixion skin incision. This level can be precisely located by pulling the remnants posteriorly and marking the point where they reach the drawing of the contour of the ear. This will mark the level of the transfixion incision and back cut. If the dimensions of the

abnormal ear are approximately those of the normal ear, we can use a type 3a, in a single stage. If the upper pole is too small, we can use a type 2 (the transfixion incision will then be high) and perform the reconstruction in two stages. We prefer type 2 or 3 to type 1, which puts the tip of the posterior flap at risk for skin necrosis. Furthermore, it can be used only if the insertion of the lobule is in its ideal position. Type 3a requires the upper part of the ear to be large enough to fit in the framework, which is an infrequent situation. Overall, type 2 and type 3b approaches are most common.

Figure 7 Placing the ear in its ideal position. The distances (H–O = root of the helix–orbit) and (L–C = lobule–oral commissure) and the angle (axis of the ear–nasal dorsum) are measured on the normal side and serve as landmarks to place the future ear.

SECOND STAGE

The retroauricular sulcus is created during the second stage, which is performed at least 6 months after the first. Depending upon the degree of projection required, we will choose alternatively between the following techniques.

Brent's Technique

When a small amount of projection is needed, the periphery of the ear is incised and the framework is elevated, preserving a layer of soft tissue covering the cartilage. The retroauricular skin is then advanced to the level of the sulcus, anticipating the formation of a dog ear by a triangular skin excision. The soft tissue covering the posterior surface of the base is skin grafted. Instead of full thickness skin grafts taken from the groin or from the inner side of the upper arm, we prefer to use split thickness skin grafts (STSG) from the scalp as advocated by Satoru Nagata, which, in our experience, have an excellent color match and do not retract if placed on a well-vascularized bed. The caudal portion of the retroauricular skin creates a non-hair-bearing flap, but the

cranial skin flap brings hair into the sulcus. Therefore, we cover the upper portion of the retroauricular area with a separate skin graft.

Tunnel Technique

When it is necessary to add moderate projection to the framework to match the contralateral ear, after elevation of the ear following Brent's technique, we 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.

Modified Nagata's Technique

When, to match the contralateral ear, it becomes necessary to reconstruct the entire posterior wall of the concha, we use a modification of Nagata's technique.⁶

Like him, we add a piece of cartilage behind the base and cover it by a superficial temporal fascial flap. The flap is then skin grafted (STSG harvested from the scalp) (Fig. 8). Nagata described raising the framework along with a layer of soft tissue. We prefer to expose the posterior surface of the base. Doing so, we can mobilize the entire base all the way to the level of the concha, which provides more space to place the additional piece of cartilage (banked under the thoracic skin during the first stage). This piece is sculpted to reproduce the posterior wall of the concha. This thin curved piece is secured directly to the posterior surface of the framework, behind the antihelix, providing stability to the reconstructed posterior wall of the concha. This modification of Nagata's technique has several advantages: (1) the framework can be mobilized extensively and some adjustments to the axis or the position of the reconstructed ear are made possible, (2) direct coverage of the posterior surface of the framework without interposition of soft tissue results in a thinner ear as seen from

Figure 8 Second stage with cartilage graft, superficial temporal fascial flap, and scalp split thickness skin grafts (STSG). (A) Elevation of the framework exposing the cartilage. (B) The piece of cartilage banked under the thoracic skin is fixed to the base. (C) Creation of the posterior wall of the concha. (D) The superficial temporal fascial flap is rotated downward. (E) 1-Year postoperative result with scalp STSG and temporal parietal fascia (TPF). (F) 1-Year postoperative result.

behind, and (3) removal of wire sutures and thinning of the posterior edge of the framework can be done if necessary.

The modified Nagata technique is the one used most frequently in our practice.

CONCLUSION

Ear reconstruction is a challenging surgery, but with training and method, results can become excellent and reproducible.^{7–11} Sculpting autologous rib cartilage, often thought to be a daunting task, becomes the most-routine part of the procedure. Appropriate use of the auricular skin is in fact the challenge, and mastering this step is the real key to good results and few complications. We hope that the classifications provided here will help surgeons interested in ear reconstruction to choose the optimal skin approach and ultimately provide their patients with a normal-looking ear for the rest of their lives.

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