Advancements in the treatment of unfavorable auricular reconstruction

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Auricular reconstruction is challenging for plastic surgeons because of its rarity and technical complications.[1,2] During development over 60 years, many surgical techniques have been explored and have produced good effects; these techniques include the Tanzer method, Brent method, Nagata's two-stage method, and tissue expansion method.[3] The key to successful auricular reconstruction is to replicate the elaborate ear framework and ensure sufficient soft tissues for coverage. However, auricular reconstruction is often associated with undesirable esthetic outcomes because of the postoperative complications, the patient's individual condition, and the surgeon's poor skills. In this report, we introduced several strategies in salvage procedures. Improvement of an unfavorably reconstructed ear usually involves correcting the position, increasing the height, remolding the contour, and blending the color tones. If the superior part of the reconstructed ear is pitched forward, the ear should be mobilized and rotated back into the correct position or a full-thickness skin graft should be added to the face anteriorly, if necessary.[2] If the position of the reconstructed lobule is higher or lower than that of the opposite ear, an incision can be made in the upper pole of the cranioauricular sulcus to adjust the framework and fix the scaffold on the cranial periosteum.[4] Patients who have previously undergone external auditory meatoplasty might exhibit an inferoposterior position deformity of the reconstructed ear with indirect separation of the auricle and canal orifice. Ji *et al*[5] and Zhang *et al*[6] described an ear-forward technique in which an inverted U-shaped purse was used to change the high anterior location of the external auditory canal orifice along with the use of rotation flaps to relocate the ear position.

In 1969, Tanzer *et al*[7] described deepening of the auriculocephalic sulcus and insertion of more split-thickness or full-thickness skin grafts for patients with an insufficient auriculocephalic angle. Retroauricular wedges of sponge rubber or rib cartilage blocks can also reportedly increase the auriculocephalic angle. If the height is inadequate, strips of concha or costal cartilage can be applied to obtain small gains; a full-thickness graft, scalp roll, and more cartilage can be used to set the superior rim of the framework back under hairless skin and thus correct larger deficiencies; and a pedicle flap can be placed along the superior rim to contain the additional cartilage and thus repair larger defects. Artificial materials, such as a microporous high-density polyethylene implant (MEDPOR; Stryker Corporation, Kalamazoo, MI, USA), have also been used in the symmetric adjustment of ear reconstruction.

To deepen the helical sulcus, the surgeon can thin the helical cartilage or the fascia on the cartilage surface to accommodate movement of the excess skin to the floor of the sulcus, or an "eave flap" can be used to exaggerate the overhang of the helical rim. Trimming can be performed to destroy the hair follicles during the adjustment if there is more hair remaining on the helix. To obtain a deepening concha cavity, the extra soft tissue and cartilage mass under the concha cavity should be fully stripped until the outer membrane of the skull is reached.[3,4] In 1998, Yotsuyanagi *et al*[8] described a quickly and easily fabricated thermoplastic splint that could be applied directly on the contours of the newly reconstructed ear by maintaining mild compression on the surface of the ear. This splint might prevent edema and scarring, resulting in a definite contour and desirable protrusion of the reconstructed ear.[2] However, this splint has not been promoted because of the limitation of materials and uncontrollable pressure.

If the overlying skin flap of the reconstructed ear cannot be placed in close contact with the scaffold, scar or granulation tissues will fill the dead space, resulting in a flattened surface, especially in the scapha, triangular fossa, and concha cavity. The use of triamcinolone acetonide in patients with suboptimal results can reportedly be used to acquire a distinct contour.[9] Because of its non-invasive

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nature, convenience, and reliability, local injection of triamcinolone acetonide could be used during the primary reconstruction or as a remedy therapy for unshaped ears after total ear reconstruction, thus avoiding complicated secondary salvage.

To obtain a good color match, full-thickness skin grafts can be dissected from the auriculocephalic sulcus or the medial surface of the contralateral ear in primary operation. If not heavily scarred, the skin overlying the previous scaffold, which usually matches the color of the lobule and adjacent cheek, can be used as a full-thickness skin graft or a skin flap. Alternatively, tissue expansion can provide additional soft tissue to cover the scaffold and a superior match of color and texture.

The secondary surgery to repair unfavorable results is considered a challenge for surgeons because of the heavy scarring, limited availability of tissues, and unfavorable blood circulation status. We herein describe surgeons' experience performing total secondary reconstruction according to the local soft tissue condition, availability of fascial flaps, and types of implant materials [Supplementary Table 1 http://links.lww.com/CM9/A687].

In 1969, Tanzer *et al*[7] first introduced a six- or four-stage secondary ear reconstruction technique. The first stage involved revision and lobule rotation, including removal of all scar tissues, unsuitable skin grafts, and implanted materials to create a flat base while simultaneously rotating the lobule into a horizontal position. The second stage involved conventional reconstruction. The final stages consisted of elevating the ear, creating a temporary tunnel to sharpen the definition of the anti-helical roll, reconstructing the tragus, and closing the tunnel. In 1971, Gorney *et al*[10] reported a four-stage revision surgery for using the contralateral concha cartilage by cutting and splicing it. This method was more suitable for reconstructing the smaller defects rather than a total secondary reconstruction because of the limited implant materials. In 1974, Tanzer *et al*[11] also reported the use of a full-thickness supraclavicular graft in a secondary reconstruction. However, these methods had not been accepted by other scholars because of the poor elasticity of the skin grafts, inconspicuous details of the reconstructed ear, and the heavy scar tissues. In 1983, Brent and Byrd[12] reported the use of temporoparietal fascia (TPF) and rib cartilage for secondary revision of severely scarred ear. Although this method provides an adequate blood supply, it is still inadequate for patients with congenital dysplasia of the temporal vessels or severely damaged TPF. In 1990, Hirase *et al*[13] reported the use of deep temporal fascia (DTF) for secondary revision because of TPF necrosis after the primary ear reconstruction. These fascial bilobed flaps using the TPF and DTF have provided new materials for framework coverage. However, because of the need for multiple stages and unclear detailed features, these flaps have not been widely accepted. In 1994, Nagata[14] reported a two-stage secondary reconstruction method using TPF to cover the insufficient skin surface area (usually the superior third of the ear) before skin grafting and using the innominate fascial flap for the ear elevation stage. Reinisch *et al*[2] reported a one-stage outpatient salvage procedure in patients with non-intact TPF using an occipital artery fascial flap and porous polyethylene (PPE) framework combined with skin grafting for salvage surgery. Free prefabricated composite forearm flaps, free tissue transfers of contralateral TPF, omental flaps, and serratus anterior fascial flaps are also available for patients with extensive scarring and insufficient healthy tissues; however, these techniques are limited by their poor esthetic results and the need for microsurgery.[2]

Most salvage surgeries involve non-expansion methods for primary ear reconstruction. Two main reasons may explain the use of such methods. First, the non-expanded skin flaps for framework coverage may bring in an insufficient hairless region and a relatively thick skin flap, especially in patients with obesity and thick skin texture. Greater skin pulling force and lack of clarity of the structural details may occur after framework implantation. Second, although the first level of the framework (helix and antihelix) is clear, it becomes unstable and deformed after the secondary elevation surgery because of the direction of stress and stretching of the skin grafts.

The use of tissue expanders for salvage after undesirable primary reconstruction was first reported by Rueckert in 1990[15], but the contour of the reconstructed ear was far from that of primary reconstruction. Considering that TPF was usually used for primary reconstruction and could not be reused, Lee *et al*[16] reported a three-stage revision method in which the expanded adjacent tissues (tissue expansion in the temporal region) were good substitutes. This method was suitable for patients with severe scar contracture and insufficient soft tissues. In 2014, Liu *et al*[17] reported a novel two-stage skin flap expansion method for secondary total auricular reconstruction in which the reconstructed ear area was expanded. Tissue expansion can provide the thinner skin and a scar tissue envelope with a fine blood supply without the need for TPF transfer or skin grafting.

Using the tissue expansion method in primary surgery is associated with a lower rate of secondary reconstruction. Compared with the non-expansion method, this procedure can provide thinner skin flaps with clear detailed structures. Additionally, the whole framework was fabricated at one time with good stability. The retroauricular fascial flap has an abundant blood supply provided by the mastoid branches of the posterior auricular artery, which is conducive to flexible transfer and application of the fascial flap. However, once serious complications such as infection have occurred, causing the operation to fail, the repair is difficult. Only TPF or other fascial flaps can be used to solve the problem of framework coverage.

Because of the complicated process of harvesting rib cartilage and the possible associated complications, many scholars prefer to utilize PPE implants or osseointegrated prostheses in severe conditions of ear reconstruction. Reinisch *et al*[2] recently reported the use of PPE implants for secondary reconstruction with minimal morbidity and a relatively low complication rate. However, the disadvantages of artificial materials, such as skin irritation, a short implant life, persistent pain, inferior esthetic results, and vulnerability to infection and trauma, should not be ignored. Therefore, many scholars still believe that the autogenous cartilage framework is the mainstream for ear reconstruction because it is more effective than artificial materials.

A satisfactory reconstructed ear has a delicate appearance, well-demonstrated features, bilateral positional symmetry, and a normal auriculocephalic angle. Because of the complexity of the procedure, auricular reconstruction usually has poor esthetic outcomes and a relatively high incidence of complications. Two key points of the technique are the selection and sculpture of the framework and the application of the flap to coverage. Both autogenous rib cartilage and artificial materials are recommended by different plastic surgeons. In China, autogenous rib cartilage is still regarded as the preferred implant material unless the patient's costal cartilage is severely calcified; in such cases, artificial materials can be used instead. Both the flap thickness and blood supply should be considered. Scar tissues under the skin flap can be removed appropriately without affecting the blood supply to increase the flap's flexibility and ductility, thereby prefabricating the thinnest possible skin flap to make a well-demonstrated contour. The application of a fascial flap can provide a sufficient blood supply, facilitate the survival of the rib cartilage framework, and reduce the incidence of framework distortion. The retroauricular fascial flap, TPF flap, DTF flap, occipital artery-based fascial flap, and fascial free flap have been reported in salvage surgery to date, and the selection of methods should be based on the specific cases. For patients with no available fascial flap, tissue expansion should be considered to provide adequate coverage materials. In addition, the operation should ideally be performed >1 year after the primary surgery, at which time the tissue swelling has completely subsided, the blood supply of the skin flap has been sufficiently established, and the scars have softened; this can minimize the complications of secondary surgery. If the primary reconstruction was performed >3 years previously, the blood supply of the skin grafting area has been fully established and can also be used as part of the postauricular skin flap for secondary surgery.

Conflicts of interest

None.

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