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ORIGINAL ARTICLE FACIAL SURGERY

Total Auricular Reconstruction Using a Single Extended Postauricular Flap Without Skin Grafting in Two Stages: Experiences of 106 Cases

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Abstract

Background Postauricular fascial flap with skin grafting is popular as a solution in total auricular reconstruction, which might result in visible scars and mismatched color, especially in Asian people. Other methods using an expanded postauricular flap to avoid skin grafting often require three or more operations, which increases suffering for patients. This work aims to introduce a modified technique for auricular reconstruction using a single expanded postauricular flap without skin grafting in a two-stage operation.

Methods An 80-ml kidney-shaped expander was implanted in the mastoid area as the first-stage operation after preoperative evaluation. After a gradual expansion period and a 2-month rest time, the flap achieved the appropriate size and thickness. In the second stage, a three-layer cartilage framework was fabricated and inserted into the pocket through an incision at the remnant ear, and the earlobe and tragus were rebuilt simultaneously.

Results From September 2013 to October 2017, 106 microtia patients were selected for auricular reconstruction applying this method in our hospital. Patients were followed up to 6 months to 4 years. Most of them (93.4%) were satisfied with the reconstructed ears, especially with respect to suitable color and invisible scars. Complications of expander exposure or framework exposure happened in three cases, and all of them finally got a satisfactory result.

Conclusion A single large expanded postauricular flap without a skin graft is an effective and efficient technique for auricular reconstruction with satisfying results. It can reconstruct an exquisite ear without a skin graft and can be finished in only two stages of operations.

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Keywords Microtia · Auricular reconstruction · Tissue expansion · Skin grafting · Cartilage · Flap

Background

Total auricular reconstruction is the best treatment for congenital microtia till now. Two basic factors are always essential for satisfying results: an exquisite three-dimensional ear framework, sufficient and qualified skin for coverage [1]. Autogenous costal cartilage is the consensus best choice for the auricular framework [1]. However, as constructing a delicate and lifelike 3D ear framework with cartilage has become the most routine part of the surgery, many clinical efforts are now focused on soft tissue coverage techniques to obtain satisfying results with few

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complications. The majority of current techniques require additional skin grafting combining postauricular or temporoparietal fascial flaps [2–6], which lead to visible scarring and mismatched color, especially in Asian people. We reported a technique of using a single expanded postauricular flap without skin grafting before, but it requires three or more stages of operations [7], which increases the economic and psychological burdens on patients and their families. In this study, we will introduce a modified technique of using a single expanded postauricular flap without skin grafting with only two stages of operations for a total ear reconstruction.

Patients and Methods

Patients Selection

From September of 2013 to October of 2017, 106 microtia patients (111 ears) in outpatient in Szechwan Bravou Medical Plastic Surgery Hospital were selected for auricular reconstruction applying this modified technique after assessing the qualification of the retroauricular skin and the amounts of patients' costal cartilage. The ages of the patients ranged from 6 to 41 years, 32 (30.2%) were between 6 and 10, 51 (48.1%) were between 11 and 15, 18 (17.0%) were between 16 and 20, and five (4.7%) were older than 20. Among the patients, 66 cases (62.3%) involved the right ear, 35 cases (33.0%) involved the left, and five patients (4.7%) were bilateral. There were 1.86 times more males than females. According to Nagata's definition, 86 cases (81.1%) were typical lobule-type microtia and 19 cases (17.9%) were concha-type microtia, and one case (0.9%) was anotia.

Surgical Procedure

First Stage: Tissue Expander Insertion and Inflation

(1) *Tissue expander insertion* An 80-ml kidney-shaped tissue expander was implanted in the mastoid area through an incision on the scalp, which is 3–4 cm long and 0.5 cm distant from the expander insertion pocket. We suggest the upper pole of the expander should be 3 cm higher than the contralateral ear's upper pole and stay in the layer close to the hair follicle, in order to provide enough thin skin for the protrusion of the upper part of the reconstructed ear and a clear outline of the cranioauricular angle and crus helix. The pocket started from the subcutaneous layer close to the hair follicle, and the layer gradually went deeper as the level further decreased even the lower third of the flap included part of the retroauricular fascia to reduce expander exposure. The front edge of the pocket should lie on the remnant ear, and part of the remnant auricular cartilage will be dissected when necessary. After accurate hemostasis, the tissue expander was implanted into the pocket, and a negative-pressure drainage tube was placed subcutaneously (refer to Fig. 1a which shows the incision design, the position of expansion port, and the dissecting scope of the expander pocket). Another significant consideration is incision tense relief in order to reduce the danger of undesirable incision healing. Three hitching stitches were performed using 0 suture to fix the derma of scalp on the deep fascia layer along the pocket side of the incision. Then, the incision was closed by simple sutures. The drainage was removed in the 3rd day after the operation, and then, the patient can leave the hospital and come back

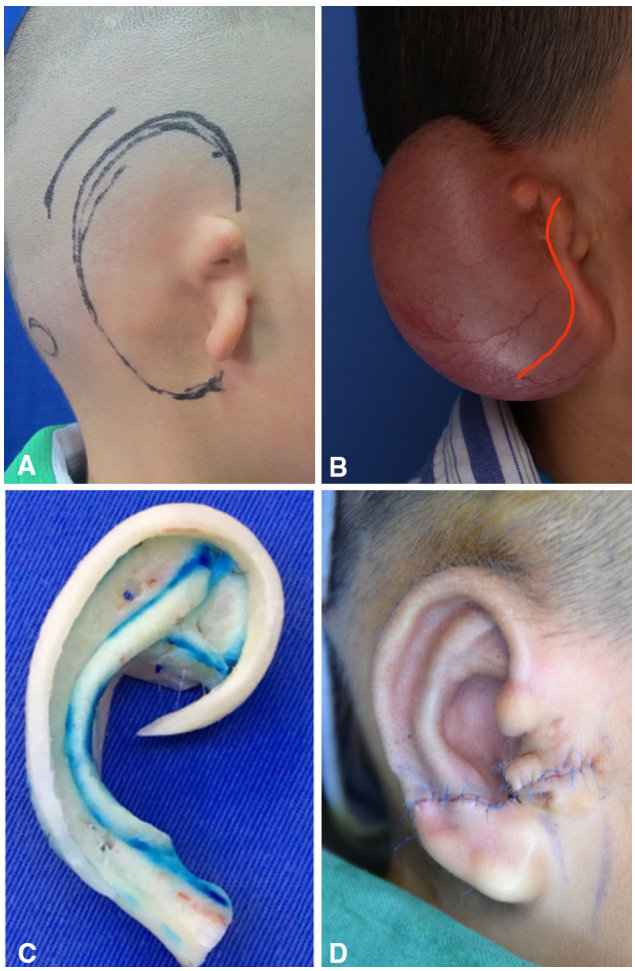

Fig. 1 **a** Incision design, the position of jug, and the dissecting scope of the expander pocket in the first stage. **b** The incision design of the second stage. Dissect the earlobe as the traditional method firstly. Next, mark the proper transposed position of the earlobe as the incision of the expanded flap. **c** A three-dimensional framework with three-layer projection was fabricated using a splicing and attachment method. **d** Immediate result of a typical case after the second stage using this method

to the hospital for suture removal and regular expander inflation.

(2) *Tissue expander inflation* Expander inflation begins on the 7th day after surgery. Four to 7 ml of 0.9% sterile saline solution was injected into each expander each time every 3–4 days. The sutures were removed safely after the 3D saline injection was finished. Usually, approximately 120–160 ml of total injection volume is necessary for the operation. During the inflation period, the plastic surgeon should always pay attention to the thickness and softness of the expanded flap and adjust the single quantity and interval time of saline injection according to the condition of the expanded flap when necessary, until the flap reaches a satisfied thickness. The whole inflation period usually lasts about 3 months. Patients receiving a tissue expander need a rest of 2 months without any treatment before the second-stage surgery to reduce potential expanded flap retraction. Laser epilation should be conducted during the expansion period or the rest time for low-hairline patients; usually 2–3 treatments were enough. An intense pulsed light hair removal system with a 695- to 1200-nm wavelength (Lumenis One, Lumenis, USA) was used. The patients were treated using 17 J/cm^2, decreasing to 15 J/cm^2 with the expander in place. All epilation procedures should be conducted by laser physicians as we reported before [7].

Second Stage: Auricular Reconstruction and Management of the Remnant Ear

The second-stage operation should be performed when the expanded flaps achieve a stable area, volume, and softness. This is the most challenging work during the whole treatment which includes four main procedures at this stage.

(1) *Dissection of the expanded flap* Firstly, a short incision at the lower part of the expanded flap and the remnant ear was designed: approximately 3 cm long at the lower part of the expanded flap linked to the incision of the remnant earlobe (Fig. 1B). Then, the expander was exposed and dissected through the incision, and removed after clearing away the inside saline by suction apparatus. A negative-pressure drainage tube was placed into the pocket through a small incision on the scalp which was used to remove the jar of the expander.

(2) *Autogenous rib cartilage harvest and framework reconstruction* The seventh cartilage, eighth cartilage, and part of the sixth rib cartilage were harvested from a 3-cm-long incision by Nagata's method [8, 9]. All the perichondrium was left in situ, and the incision was sutured layer by layer. A three-dimensional framework with three-layer projection was fabricated using a splicing and attachment method following an ear template [7] (see Fig. 1c). The seventh cartilage and part of the sixth cartilage were used to make the base block. The triangular fossa and scaphoid fossa were formed by sculpture on the base block, and the antihelices were enhanced with the piece cut from scaphoid fossa. The eighth cartilage was used for the helices. Lastly, the rest of the cartilages were knotted together to form the support part. To withstand the retraction of the flap, the framework should be formed more stable and with an enhanced projection.

(3) *Insertion of the framework* After flushing the envelope with iodine and saline repeatedly, the fabricated cartilage framework was grafted into the envelope through the incision. According to the marking lines, the position of the framework was adjusted. When suction was applied, the outline of the reconstructed ear was immediately apparent. During this period, additional dissection might be needed on the capsule to get a clearer outline if necessary, but over-dissection of the capsule should be avoid.

(4) *Disposure of the remnant ear* It includes earlobe transposition, tragus reconstruction, and redundant tissue removal. The lobular transposition usually included rotation of the vertical lobular posteriorly and inferiorly, but it could also be performed in a retrograde transposition when the location of the vestigial ear is lower than that of the normal ear [10]. The tragus was reconstructed by the remnant ear cartilage and local tissue flaps. Other remnant tissue was dissected in the premise of leaving no incision tension. After the envelope was repeatedly flushed with saline, the incision was stitched by interrupted vertical mattress sutures with 7–0 Prolene (Fig. 1d). The level of negative pressure for the suction should be regulated according to both the blood supply of the flap and the outline of the reconstructed ear. Finally, erythromycin ointment and simple gauze coverage are applied to protect the wound. The suction system could be removed on the 5th day after surgery, and sutures could be removed fractionally 10 days and 14 days after the surgery.

Results

A total of 106 microtia patients (111 ears) were treated with this total auricular reconstruction technique without skin grafting in two stages (for typical cases refer to Figs. 2, 3, 4, and 5) in this study and followed up for 6 months to 4 years by outpatient appointments and telephone calls. Patients were scored according to the results from a questionnaire. Ninety-nine patients and their families (93.4%) responded as being satisfied with the outcome, especially with respect to suitable color of flaps, invisible scars, and relatively brief treatment cycle. The applied evaluation criteria for the ear reconstruction outcome are given in Table 1. No severe complications, such as

Fig. 2 Case 1 A 7-year-old boy who presented with microtia on the right side. **a** Preoperative front view of concha-type microtia. **b** Postoperative view after the first stage with full expansion. **c** Seven-month postoperative front view of the reconstructed ear. **d** Preoperative back view before treatment. **e** Seven-month postoperative back view of the projection of the reconstructed ear and the symmetry of bilateral ears. **f** Minimal scar on the donor site

Fig. 3 Case 2 A 12-year-old boy who presented with microtia on the left side. **a** Preoperative front view of lobule-type microtia. **b** Postoperative view after the first stage with full expansion. **c** Six-month postoperative front view of the reconstructed ear. **d** Preoperative back view before treatment. **e** Six-month postoperative back view of the projection of the reconstructed ear and the symmetry of bilateral ears. **f** Minimal scar in the donor site

Fig. 4 Case 3 A 19-year-old girl who presented with microtia on the right side. **a** Preoperative front view of concha-type microtia. **b** Postoperative view after the first stage with full expansion. **c** Front view of the reconstructed ear 1 year and 7 months after the second operation. **d** Preoperative back view before treatment. **e** Back view of the projection of the reconstructed ear and the symmetry of bilateral ears 1 year and 7 months after the second operation. **f** Minimal scar on the donor site

Fig. 5 Case 4 A 20-year-old girl who presented with microtia on the right side. **a** Preoperative front view of concha-type microtia. **b** Postoperative view after the first stage with full expansion. **c** Six-month postoperative front view of the reconstructed ear. **d** Preoperative back view before treatment. **e** Six-month postoperative back view of the projection of the reconstructed ear and the symmetry of bilateral ears. **f** Minimal scar on the donor site

Table 1 A satisfactory outcome defining as a total score of 10 to 15, a partially satisfactory outcome as 6 to 9, and an unsatisfactory outcome as 0 to 5.13

Scoring system of auricular reconstruction				
	Score			
	3	2	1	0
Helix	Symmetric size and location	Slightly smaller, symmetric location	Slightly larger, symmetric location Indistinct hollow	Significantly different size, or asymmetric location Flat
Scapha	Distinct hollow, proper width	Distinct hollow, inappropriate width	Indistinct	Flat
Triangular fossa	Distinct	Shallow	Less distinct hollow, some scar	Flat, much scar
Cavity of concha		Distinct hollow, little scar	Slightly different size, symmetric location, indistinct antitragus	Different size, asymmetric location, without antitragus Disappeared
Tragus and antitragus		Symmetric size and location, distinct antitragus	Smaller	
Cranioauricular angle		Symmetric		

hematoma, dehiscence of incision, or infection, occurred in the whole procedure and follow-up visiting.

Tissue expander exposure and skin loss (due to trauma during the rest time) occurred on two cases, which were reconstituted by using the retroauricular fascial flap and skin graft technique. Flap necrosis and local infection happened on one adult patient after ear reconstruction, which was repaired by using the temporal fascial flap and free skin grafts method. All the final outcomes were acceptable.

Discussion

Total auricular reconstruction is still regarded as a challenge for plastic surgeons. Satisfied ear reconstruction depends on two factors: an exquisite three-dimensional ear framework, sufficient and qualified skin for coverage. Nagata's [5, 6] and Firmin's [3] two-stage procedures are more popular but require additional skin grafting combined with a postauricular or temporoparietal fascial flap, which might result in visible scarring and mismatched color. Because the skin and scalp in the mastoid region are thicker and much more prone to scar hypertrophy in most Asian populations compared with Caucasians, more attention was paid to the problem of insufficiency of the skin envelope.

To resolve the shortage of skin coverage in ear reconstruction, Neumann firstly introduced the concept of tissue expansion into this field in 1957 [11]. Many doctors have made potential improvements in tissue expansion for ear reconstruction to provide adequate qualified skin with a better blood supply [12–15]. In the recent studies of Pan et al. [16] and Qian et al. [17], kidney-shaped expanders were adopted to extend the retroauricular skin. In their method, the expanded skin could only cover the anterior portion of the framework; free skin grafts were still needed to assist the posterior framework coverage. At the same time, the operation required no less than three stages to ensure the blood supply for the flap. Liu et al. [18] reported a method of total auricular reconstruction using two tissue expanders without skin grafts in which more than three stages were still needed to ensure the blood supply of the flap. Furthermore, there might be more scars because of the splicing of the two extended flaps. Xing et al. [7] reported an easily repeatable method of using a single expanded retroauricular flap to reconstruct an ear without skin grafts in 2018, but it still required three or more stages of operations.

To reduce the visible scar, mismatched color and suffering for the patients at the same time, a single extended postauricular flap without skin grafting in two stages was introduced in this study. An 80-ml kidney-shaped tissue expander with approximately 120–160 ml expansion volume in total was adopted to provide a flap sufficient to afford complete coverage of the framework. In this way, no free skin graft was needed, which will significantly improve the skin color of the reconstructed ear and reduce injure at the donor site. Simultaneously, a 2-month-long rest time guaranteed a low extended flap retraction rate which also contributed to long-term stability. Removing the tissue expander and inserting the framework through an incision on the remnant ear could reserve a reliable pedicle for the flap and make the handling of the remnant ear convenient at the same time. Thus, the number of operation stages was reduced.

In the first stage, the pocket starts from the subcutaneous layer in the scalp part and goes deeper as the level further decreases gradually, in order to reduce the danger of

expander exposure, even the lower third of the flap raised part of the retroauricular fascia. Therefore, not only the safety of expansion was improved, but also a large part of the postauricular fascia was reserved, which is helpful in rescuing of some unexpected complex complications (such as framework exposure). The pocket should be also 3 cm higher than the contralateral ear to avoid insufficient extension of the upper expanded skin to limit the protrusion of the upper part of the reconstructed ear and make the outline of cranioauricular angle and crus helix clearer. The incision for the expander was created 0.5 cm away from the pocket and closed with two-layer tension reduction suture which is the key to avoid dehiscence or rupture of the incision during expansion.

In the second stage, appropriate dissection of the expander capsule could adjust the thickness of the flap and loosen the flap to provide additional skin. However, over-dissection of the capsule should be also avoided to reduce complications such as framework leakage or envelope necrosis due to local ischemia. Usually, we prefer to dissect part of the thicker edge of the capsule when necessary and reserve the central and most of the pedicle part for the flap.

In this technique, a modified three-layer cartilage sculpture was designed to provide a more projected and stable framework. And for this reason, three-dimensional CT reconstruction of the costal cartilage is very important to evaluate the amount of the cartilage in each patient. In our experience, we concluded that the criteria of patients are taller than 130 cm and a chest diameter greater than 55 cm. On the other hand, patients with loose and thick skin and a well-developed mastoid process in the postauricular region were only recommended to use this technique, so that the flap could be extended easily and safely to a proper condition and the well-developed mastoid process could provide a qualified foundation for the framework.

Few complications, such as extrusion and infection of the expander, occurred in our procedure, which might result from two main reasons. Firstly, how to "choose patients." As is mentioned before, only patients taller than 130 cm and a chest diameter greater than 55 cm with loose and thick skin and well-developed mastoid were recommended for this technique. These are also the limitations of this method: When the patient did not meet the requirements, the cartilage may be insufficient or not strong enough to build an enhanced 3D framework, or the flap cannot be safely expanded large enough to cover the whole reconstructed ear. Secondly, plastic surgery principals were followed and the concept of asepsis was kept in mind strictly at every single step.

Three accident cases happened in our study; one of them required a secondary operation for remedy. There were two cases of tissue expander exposure because of trauma during the rest time back home, which were reconstituted by using the retroauricular fascial flap and skin graft technique. Reserving most of the retroauricular fascial flap endowed us with a low-cost solution for accidents. In another case, the flap suffered necrosis and infection after ear reconstruction due to over-dissection of the envelope capsule and it was then repaired by using the temporal fascial flap and free skin graft method to cover the cartilaginous framework.

From our data, this new method of ear reconstruction obtained similar results to conventional techniques with respect to rate of complications (2.8%), hospital stays (about 4 days to 1 week), recovering time (6 months to 1 year), and patient satisfaction (93.4%), but better outcomes for the reconstructed ear, especially in terms of natural and coherent color of the flaps and invisible scars in both recipient and donor sites.

Conclusions

Our auricular reconstruction technique with a single extended postauricular flap without skin grafting provides excellent results with a clear outline, better color match, and minimal scars in only two stages. This novel technique is more acceptable for patients because of its admirable results and time-conserving. At the same time, this technique is relatively easy to perform and accepted for plastic surgeon with effective and low-cost remedy plan. But there is one thing that should be always kept in mind: Preoperative evaluation is very important for each patient because this method is only suitable for patients with loose and thick mastoid skin, a well-developed mastoid process, and sufficiently strong costal cartilage.

Author Contributions QC, CK, JZ, BW and YW participated in the clinical application of thetechnique and the follow-up of the patients and analysis of data for the work. All authorsparticipated drafted the article. QZ and CK contributed the conception and design of the study andrevised it critically for important intellectual content. All the authors approved the version to besubmitted.

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Compliance with Ethical Standards

Conflict of interest The authors report no financial and personal relationships with other people or organizations that could inappropriately influence the work.

Ethical Approval All procedures involving human participants were approved by the institutional ethics committee and conformed to the ethical standards of the institutional and national research committee and the World Medical Association Declaration of Helsinki (June 1964).

Informed Consent Written consent forms were received from all individuals.

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