The Application of 3D Scanning Technique in the Congenital Microtia Reconstruction with Tissue Expander: A Preliminary Report

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Abstract

Objective: Tissue expansion technique plays an important role in microtia reconstruction surgery by creating an abundant skin envelop which is one of the most two critical factors besides the frame structure. Currently there is no precise and objective way to evaluate how large is the surface area of the expanded remnant ear and how much skin will be needed in microtia reconstruction with tissue expansion technique. This study aimed to present our preliminary results by using 3D surface scanning technique to evaluate the surface area of the normal ear and the expanded remnant ear and help the surgeons during the decision-maker process in three microtia patients reconstructed with tissue expander and autologous cartilage.

Methods: Using the two stage procedures, three microtia patients were reconstructed by tissue expander and autologous cartilages. During the expansion, the surface area of normal ear and expanded remnant ear were measured by DH-H30 3D scanning machine. The plastic surgeons preceded the second stage procedure of autologous cartilage frame placement based on these 3D scanning measurement and other related factors such as the texture of the skin and total volume of expansion accordingly.

Results: Three congenital microtia patients were enrolled in the study. The patients’ age ranged from 8 to 28 years old. The expanders applied were 100 ml kidney-shaped. The expansion time ranged from 121 to 176 days. The total volume of expansion was 174 ml, 190 ml and 176 ml respectively. After the expansion, the 3D scanning showed the expanded surface area of remnant ear was 7119.70 mm², 8310.93 mm² and 8042.76 mm², the surface area of normal ear was 3852.94 mm², 4351.08 mm² and 3591.27 mm². By subtracting the base area of the expander which was 3093.16 mm², 3094.28 mm² and 1847.78 mm², all the measurement indicated there was extra skin for the next stage procedure. All cases were successfully reconstructed by two-stage procedures with tissue expander and autologous cartilage without complications. After 2 years follow up, the reconstruct ear showed stable and favorable contour.

Conclusion: Tissue expansion is an effective way to obtain excess skin envelop for microtia reconstruction. 3D scanning technique helps the surgeons in decision making process by providing precise and objective information of the surface area of both the normal ear and the expanded remnant ear.

Introduction

Congenital microtia is a type of ear abnormality with small and malformed auricle. The prevalence varies significantly from 0.83 to 17.4 per 10,000 births among different ethnic groups. Asian population has a higher prevalence [1]. Microtia reconstruction procedure consists of two critical components by creating a sufficient skin envelope and carving a vivid three-dimensional auricular framework. Tanzer introduce the multistage autologous rib cartilage technique in 1959 [2]. Since then, the framework carved from autologous rib cartilage has gained wide acceptance. Several surgeons including Nagata, Brent and Firm in made their own modifications to improve the aesthetic results and decrease the complications [3-5]. To solve the problems of the color, texture mismatch and lack of sensory after skin graft, Brent applied tissue expansion technique in microtia reconstruction surgery.
reconstruction in 1980 [6]. More recently several groups from China, South Korean reported their successful experiences of tissue expansion in microtia reconstruction with excellent results and low complication rate [7-11]. One of the critical questions need to answer during the tissue expansion is whether there is enough skin or not. Unfortunately, this question may only be answered by the empirical judgment of the experienced surgeons. Three-dimensional surface scanning is a noninvasive, non-contact technique to assess facial morphology and symmetry. In this article, the author’s introduced the preliminary results of anew objective and quantitative measuring system by using 3D surface scanning technique that could potentially help the surgeons in microtia reconstruction with tissue expansion technique and autologous cartilage.

Patients and Methods

Three congenital microtia patients underwent auricular reconstruction using two stage procedures combined tissue expansion technique with the autologous cartilage carved framework. All three patients are male. Patient’s age range from 8 to 28 years old. Based on Nagata’s classification [3], there are two concha-type and one lobule-type patient with no hemic facial macro somia or facial nerve defect (Table 1).

Three-dimensional surface scanning system and measurement of surface area

With the patients in sitting position, the surface area of patient’s normal ear and expanded remnant ear were measured by DH-H30 3D scanning machine (Guangzhou Dimen star Intelligent Technology, Guangzhou, China). The data collected was processed by Geomagic Studio 2014 software (Morrisville, North Carolina, USA). In each patient, we calculate the whole surface area of the normal ear (Figure 1, purple area), the expanded remnant ear (Figure 1, pink area) and the shaded area vertically down from the edge of expander to the mastoid region which representing the base area of the expander (Figure 1, yellow area). By subtracting the whole surface area of the normal ear and the base area of the expander from the area of expanded ear, we can estimate if there is extra skin to use for the second stage procedure.

Surgical procedures

The surgery was performed in two stages. First stage was the insertion of tissue expander and inflation; second stage was the insertion of carved ear framework from autologous rib cartilage and translocation of ear lobe. Minor revision procedures may add as required.

Stage I: Tissue expander insertion and inflation

A 100 ml kidney-shaped silicone gel tissue expander (Wanhe Plastic Materials, Guangzhou, China) was placed under the subcutaneous plane of the mastoid region through a 4 cm incision inside the temporal hairline. The dissection was initiated under the subcutaneous plane and then proceeds to the same plane at mastoid region until the 1 cm extra size pocket larger than the expander was created. For concha-type patients the dissection did not pass the remnant ear, while for lobule-type patient we did pass the remnant ear to recruit extra skin for the second stage. One 100 ml kidney-shapes expander passed anti-leak test was inserted into the pocket and #10 Jackson-Pratt drains was placed underneath. Before two-layer closure of the incision, a row of 3-0 silk sutures were placed to close the connection between the expander pocket and the incision, this will prevent future expansion of hairline and lower the risk of incision breakdown during the expansion. The expander’s port was placed under the skin within the temporal hairline. Twenty milliliter of normal saline was injected to confirm proper function of the expander intra-operatively. We started the expansion at 10 days after the surgery when the sutures were removed. Usually 6 ml to 12 ml of normal saline was injected during the once-a-week expansion process initially. After the 3D surface scanning result proved that there was enough skin to precede the second stage procedure, the infusion then switched to 4 ml to 6 ml every two weeks for 2-3 months.

Stage II: Autologous cartilage framework fabrication, insertion and ear lobe translocation

Removal of tissue expander and the remnant cartilage: The expander was removing distinctly through the same incision. We applied hydro-dissection technique to resect the anterior aspect and the thickening edge of the expander capsule. The posterior aspect and the base of expander capsule were preserved. After the removal of the expander, the total liquid volume inside the expander was measured for further research purpose. The upper portion of the remnant cartilages and the restricted concha cartilage were removed through an on top incision in two concha-type patients.

Translocation of ear lobe: We adopted Nagata’s method to translocate the earlobe [12]. Briefly, a W-shape incision for the posterior surface and a curve incision for the anterior surface of lobule were applied. The curve incision anteriorly was connected to the incision used for remnant cartilage resection. An extra skin incision was made near the lower portion of the expanded flap to facilitate the translocation of the earlobe posteriorly and insertion the flap anteriorly.

Autologous cartilage harvest and three-dimensional framework fabrication and insertion: The 7th, 8th and lower portion of the 6th costal cartilage was harvested through a sub costal incision. The posterior aspect of the perichondrium connected 6th and 7th costal cartilage was preserved. This allowed the 6th and 7th costal cartilage stay together and makes the base of the frame. The 8th costal cartilage was harvested as free piece. The three-dimensional framework was carved following Brent’s technique [13]. The muscle and connective tissue were removed. The 6th and 7th costal cartilage was carved to form the base of the ear, the helix was created by shaping the 8th costal cartilage and the anti helix was enhanced by a small splitting piece from the 8th costal cartilage. The carved piece from the 6th costal cartilage fit well for the base block to enhance the ear projection. All the pieces were attached together by 5-0 prolene sutures and all the nodes were place on the back of the frame. The cartilages were irrigated with normal saline intermittently to prevent desiccation.

After the final refinement, the framework was inserted into the pocket and adjusts in place according the pre-surgical makings. All the incisions were closed in two layers. Two negative-pressure drains were placed in the pocket. One butterfly needle drain trimmed with side hole was placed along the scapha to the concha anteriorly; one #8 JP drain was placed beneath the framework. The negative pressure drain system was removed on day 5 for the anterior drain and day 7 for the posterior drain.

Revision surgery of the reconstructed ear: For the lobule-type microtia patient, the remnant lobule was resected one year after the reconstruction surgery due to its significant malposition comparing to the normal side.
Results

Three congenital microtia patients were reconstructed by tissue expander and autologous cartilage with the assistance of 3-D surface scanning technique. The expansion process ranged from 121 to 176 days. The total volume of expansion was 174 ml, 190 ml and 176 ml respectively. After the expansion, the 3D scanning showed the expanded surface area of remnant ear was 7119.70 mm², 8310.93 mm² and 8042.76 mm², the surface area of normal ear was 3852.94 mm², 4351.08 mm² and 3591.27 mm². By subtracting the base area of the expander which was 3093.16 mm², 3094.28 mm² and 1847.78 mm², all the measurement indicated there was extra skin for the next stage procedure (Table 2). All cases were successfully reconstructed by two-stage procedures without complications. After 2 years follow up, the reconstruct ear showed stable and favorable results (Figure 2).

Discussion

Congenital microtia reconstruction remains as the most challenging reconstructive procedure in plastic surgery. A successful ear reconstruction surgery includes two critical factors: creating sufficient skin pocket coverage and fabricating a bio-durable 3-D framework. Tanzer first present his excellent results of 4 stages ear reconstruction by using autologous costal cartilages 1959 [2]. Nagata introduces his modified 2 stages ear reconstruction techniques in 1993 [3] and gradually gained popularity in reconstructive surgery. Later, Firm in and Brent introduced their tremendous experience of microtia reconstruction with autologous cartilages [4,14]. All these data supported the fact that autologous cartilage is the most reliable framework material with favorable results and least complications. As for the skin pocket, these techniques described above all needed skin graft for the frame elevation procedure to cover the defects on the posterior aspect of the frame and the mastoid region. The color and texture mismatch problems are more obvious in Asian population who tend to have hypertrophic scar and hyper pigmentation after skin graft procedure comparing to Caucasian population. Moreover, the graft does not carry skin sensation that is critical for the protection of reconstructed ear [15].

By applying tissue expansion technique, the surgeons may get extra skin that has the same color and texture as the adjoining tissue. Neumann implanted a subcutaneous balloon for the reconstruction of external ear deformity in 1957 [16]. Hata described the technique using tissue expander to correct the congenital microtia in 1988 [17]. Considering high rate of complications in tissue expansion procedures [18], especially in pediatric patients [19,20], the application of tissue expansion technique in microtia reconstruction did not gain popularity in plastic surgery as autologous cartilage did for a long period time. Recently several groups from China and South Korean presented their successful experience using tissue expander in large case series of microtia reconstruction, in these cases no skin

Table 1: Case Information.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (year)</th>
<th>Gender</th>
<th>Nagata Classification</th>
<th>Expander Type and Size (ml)</th>
<th>Total Volume of Expansion (ml)</th>
<th>Duration of Expansion (day)</th>
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Figure 1: Three-dimensional surface scanning. Purple area: the whole surface area of the normal ear; Pink area: the surface area of the expanded remnant ear; Yellow area: mirror image of the base area of the expander on the normal side.

Figure 2: Case 3 lobule type microtia reconstruction. Top left: Pre-operation; Top Right: After expansion; Bottom: Two year follow up.
Table 2: Three Dimension Scanning Measurement (mm²).

<table>
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<th>Expanded Remnant Ear</th>
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