Three-dimensional scanning technique in the congenital microtia reconstruction with tissue expander

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To solve the problems of the color, texture mismatch and lack of sensory after skin graft, Brent applied tissue expansion technique in microtia reconstruction in 1980. More recently, several groups from China and Korea reported their successful experiences of soft tissue expansion technique in microtia reconstruction with excellent results and low complication rate.[1] One of the critical questions is whether there is enough skin or not after the expansion. Unfortunately, this question may only be answered by an empirical judgment from the experienced surgeons. In this article, the authors introduced the preliminary results of a new objective and quantitative measuring system by using three-dimensional (3D) surface scanning technique to help the surgeons in microtia reconstruction with tissue expansion technique.

Three congenital microtia patients underwent auricular reconstruction using two-stage procedures combined with tissue expansion technique and autologous cartilage-carved framework. All three patients are male. Patient’s age ranges from 8 to 28 years. On the basis of Nagata’s classification, there are two concha-type and one lobule-type patient with no hemifacial macrosomia or facial nerve defect.

With the patients in sitting position, the surface area of patient’s normal ear and expanded remnant ear was measured by DH-H30 3D scanning machine (Guangzhou Dimenstar Intelligent Technology, Guangzhou, China). The data collected were processed by Geomagic Studio 2014 software (Morrisville, NC, USA). In each patient, we calculate the whole surface area of the normal ear [Figure 1A, purple area], the expanded remnant ear [Figure 1A, pink area], and the shaded area vertically down from the edge of expander to the mastoid region, which represents the base area of the expander [Figure 1A, 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.

The surgery was performed in two stages. The first stage was the insertion of tissue expander 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. We started the expansion at 10 days after the surgery when the sutures were removed. Usually, 6 to 12 mL of normal saline was injected during the once-a-week expansion process initially. Thereafter, the 3D surface scanning results suggested that there was enough skin to proceed with the second-stage procedure, the infusion then switched to 4 to 6 mL every 2 weeks for 2 to 3 months. The second stage was the insertion of ear framework carved from autologous rib cartilage and translocation of ear lobe. The seventh, eighth, and lower portion of the sixth costal cartilage were harvested through a subcostal incision. The posterior aspect of the perichondrium connected 6th and 7th costal cartilage was preserved. This allowed the sixth and seventh costal cartilage stay together and makes the base of the frame. The eighth costal cartilage was harvested as free piece. The 3D framework was carved following the Brent technique. The muscle and connective tissue were removed. The minor revision procedures may add as required.

Three congenital microtia patients were reconstructed with tissue expander and autologous cartilage. The expansion process ranged from 121 to 176 days. The total volume of expansion was 174, 190, and 176 mL, respectively. After the expansion, the 3D scanning showed the expanded surface area of remnant ear was 7119.70, 8310.93, and 8042.76 mm², and the surface area of normal ear was 3852.94, 4351.08, and 3591.27 mm², respectively. By subtracting the base area of the expander which was 3093.16, 3094.28, and 1847.78 mm², respectively, all the
measurements indicated there was an extra skin for the next stage procedure. All cases were successfully reconstructed by two-stage procedures without complications. After 2 years of follow-up, the reconstruct ear showed stable and favorable results [Figure 1B–1E].

Congenital microtia reconstruction remains as the most challenging reconstructive procedure in plastic surgery. A successful ear reconstruction surgery includes two fundamental parts: creating a soft tissue pocket coverage and fabricating a bio-durable 3D framework. As for the skin pocket, traditional techniques need a skin graft for the frame elevation procedure to cover the defects on the posterior aspect of the frame and the mastoid region. However, the color and texture mismatch problems after skin grafting are more obvious in Asian population than Caucasian population. Moreover, the graft does not carry skin sensation to protect the reconstructed ear.

By applying tissue expansion technique, the surgeons may get extra skin with the same color and texture as the adjoining tissue. However, considering high rate of complications in tissue expansion procedures, especially in pediatric patients,[2] the application of tissue expansion technique in microtia reconstruction did not gain popularity in plastic surgery for a long period of time. Recently, several groups from China and South Korea presented their excellent results by using tissue expander in large case series of microtia reconstruction.[1] These successful results were not achieved by chance. First, careful selection of good candidates for the tissue expansion technique. Second, the authors have tremendous experience with tissue expander in microtia reconstruction. For example, to obtain an accurate assessment of volume expansion for each patient is critical. Obviously, under expansion is not good, and over expansion may not be good either, because with over expansion, the expander exposure rate increases sharply in pediatric populations.[3] In microtia reconstruction, these mean do we have enough expanded skin to cover the 3D framework? To answer this question, we need to know the surface area of the normal ear and the expanded remnant ear. Unfortunately, there is no objective way to quantitatively evaluate it by far. All the judgments were based on the experience of the physician.[4]

As a non-invasive and noncontact technique, 3D surface scanning has gained enormous popularity in plastic surgery recently.[4] The technique provides the surgeon with invaluable information by demonstrating true surface dimensions during preoperative consultation, surgical

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 (A). Case 3 lobule-type microtia reconstruction. Preoperation (B); after expansion (C); 2-year follow-up (D–E).
planning, and postoperative follow-up. Latest research showed that 3D surface scanning technique may help the surgeons with microtia reconstruction by providing the morphology information of normal ear and fabricating a 3D framework template.[5]

In this article, the authors introduce the 3D scanning system to evaluate the surface area of the normal ear and expanded remnant ear. By calculating and comparing the surface area of the normal ear and expanded remnant ear, the surgeons have a better idea about whether there is enough skin to proceed to the next procedure. The authors believe it is the first reported application of non-invasive and non-contact technique to measure the surface area of expanded tissue. On the basis of our preliminary results, this technique can provide the plastic surgeons with critical information of expansion, which may potentially lower the complication rate of tissue expansion technique in microtia reconstruction.

In this preliminary study, we focus on the post expansion surface measurement. We did not collect the data before the placement of tissue expander, at each inflation session and at the post-operation follow-up. We are planning to collect all those data in the future study. With more data available, we could potentially establish a formula to predict the expansion process, which may help the surgeons in microtia reconstruction with tissue expansion technique. We do see there is an advantage to apply this non-invasive and non-contact surface scanning technique to all types of tissue expansion procedures, including tissue expander plus implant-based breast reconstruction and giant nevus resection with tissue expander reconstruction.

We did not measure different portions of the ear separately. For example, the scanning only confirmed there was enough skin available, but we did not have the data for the upper third, middle third, and lower third portion of the ear individually. As we know, the upper third of the ear has the largest surface area compared with the middle and lower third of the ear and need more skin to reconstruct, while the upper part may be the least expanded area. Due to the gravity, the heavy-filled expander tends to shift downward causing more tension on lower portion of the expanded skin. Although we noticed that we had extra skin on the basis of the scanning result in case 3, but it was found out the upper third of the skin was not well stretched out during the second-stage procedure. In our recent cases, we modified the inflation with air injection only instead of sterile normal saline and started to measure three portions of the ear separately. These may help significantly to reduce the expander shifting and get more precise information about the expansion.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s)/patient’s guardians has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the article. The patients/patient’s guardians understand that their names and initials will not be published and due efforts will be made to conceal the identity of the patient, although anonymity cannot be guaranteed.

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Conflicts of interest

None.

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