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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 mm^2, 8310.93 mm^2 and 8042.76 mm^2, the surface area of normal ear was 3852.94 mm^2, 4351.08 mm^2 and 3591.27 mm^2. By subtracting the base area of the expander which was 3093.16 mm^2, 3094.28 mm^2 and 1847.78 mm^2, 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.

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Introduction

Congenital micortia 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 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 hemi 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 plan and then proceeds to the same plan 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 7^{th}, 8^{th} and lower portion of the 6^{th} costal cartilage was harvested through a sub costal incision. The posterior aspect of the perichondrium connected 6^{th} and 7^{th} costal cartilage was preserved. This allowed the 6^{th} and 7^{th} costal cartilage stay together and makes the base of the frame. The 8^{th} 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 6^{th} and 7^{th} costal cartilage was carved to form the base of the ear, the helix was created by shaping the 8^{th} costal cartilage and the anti helix was enhanced by a small splitting piece from the 8^{th} costal cartilage. The carved piece from the 6^{th} 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.

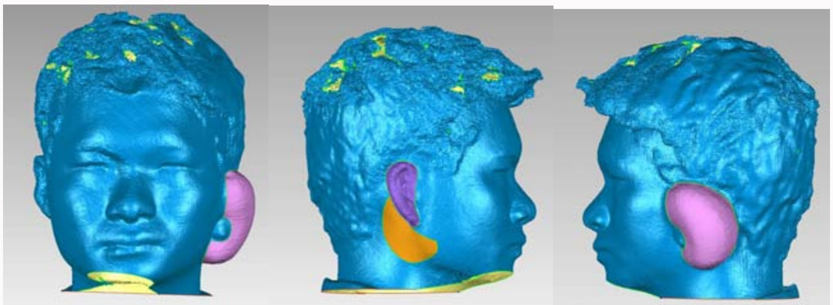

Figure 1: Three-dimensional surface scanning.
Purple area: the whole surface area of the normal ear
Pink area: the surface area of the expanded remnant ear
Yellow area: mirror image of the base area of the expander on the normal side

Table 1: Case Information.

	Age (year)	Gender	Nagata Classification	Expander Type and Size (ml)	Total Volume of Expansion (ml)	Duration of Expansion (day)
Case 1	26	Male	Small Concha	Kidney–Shape/100	174	109
Case 2	8	Male	Small Concha	Kidney–Shape/100	190	176
Case 3	28	Male	Lobule	Kidney–Shape/100	176	121

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 mm^2, 8310.93 mm^2 and 8042.76 mm^2, the surface area of normal ear was 3852.94 mm^2, 4351.08 mm^2 and 3591.27 mm^2. By subtracting the base area of the expander which was 3093.16 mm^2, 3094.28 mm^2 and 1847.78 mm^2, 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 cartilageis 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].

Figure 2: Case 3 lobule type microtia reconstruction.
Top left: Pre-operation
Top Right: After expansion
Bottom: Two year follow up

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 2: Three Dimension Scanning Measurement (mm²).

	Normal Ear	Expanded Remnant Ear	Base of Expander
Case 1	7119.7	3852.94	3093.16
Case 2	8310.93	4351.08	3094.28
Case 3	8042.76	3591.27	1847.78

graft was needed and the results are excellent with low complication rate [7-11]. These successful results were not achieved by chance. First, carefully 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, over expansion may not be good either, because with over expansion the expander exposure rate increases sharply in pediatric populations [20,21]. In microtia reconstruction these mean do we have enough expanded skin to cover the three-dimensional framework? To address this question, we should know how large is the surface area of the normal ear and how large is the surface area of the expanded remnant ear. Unfortunately, there is no objective way to quantitatively evaluate it by far. All the judgment was based on the experience of the physician [7].

As a noninvasive, non-contact technique, three-dimensional surface scanning has gained enormous popularity in plastic surgery recently [22-27]. The technique provides the surgeon with invaluable information by demonstrating true surface dimensions during preoperative consultation, surgical planning, and post-operative follow-up [26]. Latest research showed three-dimensional surface scanning technique may help the surgeons with microtia reconstruction by providing the morphology information of normal ear and fabricating a 3D framework template [28-31].

Jeon generated 3D-computer-aided design models for each patient's ear by performing 3D laser scanning for a mirror-transformed cast of their normal ear. The models were consistent and accurately represented the thickness, depth, and height of the normal ear which helped the surgeon to reduce the amount of unnecessary work during surgery [30].

In this article the authors introduce the 3-D 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. Based on 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 surgeon 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.

Another short-come of the study was we did not separate the measurement of different portion of the ear. For example, the scanning only confirmed there was enough skin available, but we did not have the number 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 comparing to the middle and lower third of the ear and need more skin to reconstruct, while the upper part may be the lest expanded area. Due to the gravity, the heavy filled expander tends to shift downward causing more tension on lower portion of the expanded skin. In case 3 we noticed although we had extra skin according to the scanning result, but we 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 helped significantly to reduce the expander shifting and get more precise information about the expansion.

Conclusion

This is the first reported application of 3D surface scanning technique for surface area measurement in microtia reconstruction with tissue expansion. Our preliminary study show this non-invasive, non-contact technique is an accurate and objective way to evaluate the surface area of normal ear and the expanded remnant ear during the ear reconstruction. More data are needed to test its potential role in decreasing the complication rate of microtia reconstruction with tissue expansion technique and its potential application on other tissue expander based procedures.

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References

1. Luquetti DV, Heike CL, Hing AV, Cunningham ML, Cox TC. Microtia: epidemiology and genetics. Am J Med Genet A. 2012;158A(1):124-39.
2. Tanzer RC. Total reconstruction of the external ear. Plast Reconstr Surg Transplant Bull. 1959;23(1):1-15.
3. Nagata S. A new method of total reconstruction of the auricle for microtia. Plast Reconstr Surg. 1993;92(2):187-201.
4. Brent B. Technical advances in ear reconstruction with autogenous rib cartilage grafts: personal experience with 1200 cases. Plast Reconstr Surg. 1999;104(2):319-34.
5. Firmin F, Marchac A. A novel algorithm for autologous ear reconstruction. Semin Plast Surg. 2011;25(4):257-64.
6. Brent B. The correction of microtia with autogenous cartilage grafts: II Atypical and complex deformities. Plast Reconstr Surg. 1980;66(1):13-21.
7. Xing W, Kang C, Wang Y, Zhang Q. Reconstruction of Microtia Using a Single Expanded Postauricular Flap without Skin Grafting: Experience of 683 Cases. Plast Reconstr Surg. 2018;142(1):170-9.
8. Qian J, Li Z, Liu T, Zhou X, Zhang Q. Auricular Reconstruction in Hemifacial Microsomia with an Expanded Two-Flap Method. Plast Reconstr Surg. 2017;139(5):1200-9.
9. Li C, Jiang H, Huang C, Chen J, Wu R, Bi Y, et al. A new strategy for total auricular reconstruction using prelamination of an extended retroauricular flap with tissue expansion. J Plast Reconstr Aesthet Surg. 2016;69(6):819-26.

10. Jiafeng L, Jiaming S, Xiaodan L. Auricular reconstruction using a novel three-flap technique improves the auriculocephalic angle. J Plast Reconstr Aesthet Surg. 2016;69(10):1430-5.

11. Park BY, Im JT, Lim SY, Pyon JK, Bang SI, Mun GH, et al. Microtia reconstruction using tissue expanders without skin grafts from groin region. J Plast Reconstr Aesthet Surg. 2014;67(11):1481-7.

12. Nagata S. Modification of the stages in total reconstruction of the auricle: Part I. Grafting the three-dimensional costal cartilage framework for lobule-type microtia. Plast Reconstr Surg. 1994;93(2):221-30.

13. Brent B. Microtia repair with rib cartilage grafts: a review of personal experience with 1000 cases. Clin Plast Surg. 2002;29(2):257-71.

14. Firmin F. Ear reconstruction in cases of typical microtia. Personal experience based on 352 microtic ear corrections. Scand J Plast Reconstr Surg Hand Surg. 1998;32(1):35-47.

15. Hata Y. Do not forget the fundamental merits of microtia repair using a tissue expander. Plast Reconstr Surg. 2002;109(2):819-22.

16. Neumann CG. The expansion of an area of skin by progressive distention of a subcutaneous balloon; use of the method for securing skin for subtotal reconstruction of the ear. Plast Reconstr Surg (1946). 1957;19(2):124-30.

17. Hata Y, Hosokawa K, Yano K, Matsuka K, Ito O. Correction of congenital microtia using the tissue expander. Plast Reconstr Surg. 1989;84(5):741-51.

18. Wang J, Huang X, Liu K, Gu B, Li Q. Complications in tissue expansion: an updated retrospective analysis of risk factors. Handchir Mikrochir Plast Chir. 2014;46(2):74-9.

19. Patel PA, Elhadi HM, Kitzmiller WJ, Billmire DA, Yakuboff KP. Tissue expander complications in the pediatric burn patient: a 10-year follow-up. Ann Plast Surg. 2014;72(2):150-4.

20. LoGiudice J, Gosain AK. Pediatric tissue expansion: indications and complications. J Craniofac Surg. 2003;14(6):866-72.

21. Marks M, Argenta L. Princeples and applications of tissue expansion. In: Neligan P, editor. Plastic Surgery. 2017;473-97.

22. Largo RD, Wettstein R, Fulco I, Tremp M, Schaefer DJ, Gubisch W, et al. Three-dimensional laser surface scanning in rhinosurgery. Facial Plast Surg. 2013;29(2):116-20.

23. Patete P, Eder M, Raith S, Volf A, Kovacs L, Baroni G. Comparative assessment of 3D surface scanning systems in breast plastic and reconstructive surgery. Surg Innov. 2013;20(5):509-15.

24. Chai G, Tan A, Yao CA, Magee WP 3rd, Junjun P, Zhu M, et al. Treating Parry-Romberg Syndrome Using Three-Dimensional Scanning and Printing and the Anterolateral Thigh Dermal Adipofascial Flap. J Craniofac Surg. 2015;26(6):1826-9.

25. Rashaan ZM, Stekelenburg CM, van der Wal MB, Euser AM, Hagendoorn BJ, van Zuijlen PP, et al. Three-dimensional imaging: a novel, valid, and reliable technique for measuring wound surface area. Skin Res Technol. 2016;22(4):443-50.

26. Weissler JM, Stern CS, Schreiber JE, Amirlak B, Tepper OM. The Evolution of Photography and Three-Dimensional Imaging in Plastic Surgery. Plast Reconstr Surg. 2017;139(3):761-9.

27. Liu C, Luan J, Mu L, Ji K. The role of three-dimensional scanning technique in evaluation of breast asymmetry in breast augmentation: a 100-case study. Plast Reconstr Surg. 2010;126(6):2125-32.

28. Modabber A, Galster H, Peters F, Möhlhenrich SC, Kniha K, Knobe M, et al. Three-Dimensional Analysis of the Ear Morphology. Aesthetic Plast Surg. 2018;42(3):766-73.

29. Kaneko T. A system for three-dimensional shape measurement and its application in microtia ear reconstruction. Keio J Med. 1993;42(1):22-40.

30. Jeon B, Lee C, Kim M, Choi TH, Kim S, Kim S. Fabrication of three-dimensional scan-to-print ear model for microtia reconstruction. J Surg Res. 2016;206(2):490-97.

31. Zhou J, Pan B, Yang Q, Zhao Y, He L, Lin L, et al. Three-dimensional autologous cartilage framework fabrication assisted by new additive manufactured ear-shaped templates for microtia reconstruction. J Plast Reconstr Aesthet Surg. 2016;69(10):1436-44.