Egypt, J. Plast. Reconstr. Surg., Vol. 46, No. 4, October: 389-395, 2022

Comparative Study between Patients' Satisfaction after Reconstructed Auricle Using 2D and 3D Models

MOHAMED M. ABDELHALIM, M.D.; FADY REZK SHAFIK, M.B.B.Ch.; AHMED ELSHAHAT, M.D. and AHMED M. GAD, M.D.

The Department of Plastic, Burn and Maxillofacial Surgery, Faculty of Medicine, Ain Shams University

ABSTRACT

Background: Microtia is a rare and severe craniofacial abnormality that impairs newborns' appearance. The most favored treatment for microtia is autologous ear reconstruction. It is essential for the reconstruction process that surgeons provide templates of their patients' normal auricles to be shaped. Traditionally, 2D models have been utilized everywhere. The rising use of 3D printing in the medical field has led to several improvements, especially the development of patient-specific models based on actual imaging data.

Objectives: This study compared the satisfaction of patients regarding the aesthetic outcomes between 2D & 3D modelling.

Patients and Methods: In this cross-sectional study, 44 patients; with unilateral microtia underwent autologous ear reconstruction using costal cartilage graft were selected. Bilateral cases and Anotia types were excluded. Costal cartilages of 6th to 8th ribs were harvested in the 1st stage to shape the framework, 32 patients underwent 3D model planning while 12 patients were managed by 2D template. Elevation of the framework was done in the 2nd stage after 3-6 months. Satisfaction was recorded using a questionnaire form 4 months postoperatively.

Results: Scores of 3D in specific items were significantly better than those in 2D. It was highly significant difference in satisfaction regarding concha subunit and separation of the auricle.

Conclusion: After autogenous ear reconstruction, 3D modelling is more effective than 2D modelling at improving patient satisfaction, particularly with regard to the concha's form and separation from the scalp.

Key Words: *3D modeling – Autologous ear reconstruction – Patient satisfaction – Microtia management.*

Disclosure: No conflict of interest.

Ethical Committee Approval: Study approved by local ethical committee of faculty of medicine, Ain Shams University.

INTRODUCTION

Microtia is a severe craniofacial abnormality that can exist solely in an infant or as a feature of a syndrome. Social dysfunction and lowered self-esteem are typical outcomes. Using autologous cartilage for ear reconstruction surgery is now the most efficient strategy of restoration **[1]**.

Numerous studies have demonstrated that cosmetic and psychological improvements can both be achieved through surgery. Improvement in behavioral state, physical health, and lifestyle quality are strongly correlated with patients' satisfaction with surgical results in microtia **[2]**.

Autologous ear repair for congenital microtia is a multi-stage reconstructive treatment that is performed on both children and adults. The process can be technically difficult and needs knowledge of the ear's three-dimensional architecture. However, the success of ear reconstruction is heavily dependent on patient views of the surgery's outcomes and their entire experience with the treatment. While a surgeon's assessment of the procedure's success is vital, patient reported outcome measures (PROMs) are critical for advancing surgical procedures and enhancing the patient experience **[3]**.

Patients with unilateral microtia usually have a normal contralateral ear. The success of the surgery is dependent on precise rebuilding of the auricle framework, accurate implantation of the framework, and adequate covering of the framework by soft tissues **[4]**.

Templates are typically created in unilateral microtia instances utilizing a two-dimensional (2D) trace of the normal ear on a transparent film **[5]**. In order to cut, model, and carve the costal cartilage, the surgeon uses a 2D template (Fig. 1) as a visual aid. This method, however, has a number of drawbacks. First of all, the pressure applied to the ear during the silhouette's tracing causes an error in the X-ray film-based acquisition. Basically, such pressure deforms the external ear, which results in an incorrect depiction of the structure **[6]**.

Correspondence to: Dr. Fady Rezk Shafik
E-Mail: fadynaguib94@gmail.com

Additionally, the 2D template lacks the crucial details regarding the ear's three-dimensional geometry, such as the height, thickness, and depth characteristics of its anatomical components (helix, antihelix, tragus-antitragus, scapha and concha) **[7]**.

More specifically, only 6 to 8 of the over 14 three-dimensional structures that make up the ear can be captured using the 2D template, and systematic mistakes originate when actual 3D anatomical structure of ear is changed into an abridged 2D form. As a result, doctor must find missing information directly on patient while performing the procedure. He must switch forward and back between surgical table, at which ear's structure is being reshaped, and operating table. He also closely examines the contralateral sound auricle, document its 3D shape and cognitively mirror it to attain the three-dimensional architecture of the auricle needing rebuilt. As a conclusion, procedures take much time, medical expenses rise, and patient is at an increased risk of infection **[8]**.

In order to overcome these restrictions, a 3D template (Fig. 2) that gives detailed 3D information and features of the ear's structure must be created. This need can be satisfied by generating a three-dimensional template using computer aided design (CAD) modelling, and additive manufacturing (AM) technologies, which overcome the challenging and inaccurate process of 2D line sketching on ear **[8]**.

The use of 3D template has various benefits, including reduced time, less waste, and the ability to mimic auricles with intricate designs that are geometrically challenging to make using conventional methods **[9]**.

Patients were polled by Cui et al., **[10]**. The tool contained questions about patient satisfaction with auricle substructures, and their general satisfaction. This research might lead to a better understanding of patients' quality of life and reconstructive surgery experiences.

This study's objective is to assess the patients' satisfaction with the finished result following ear reconstruction using two dimensional (2D) and three dimensional (3D) template models.

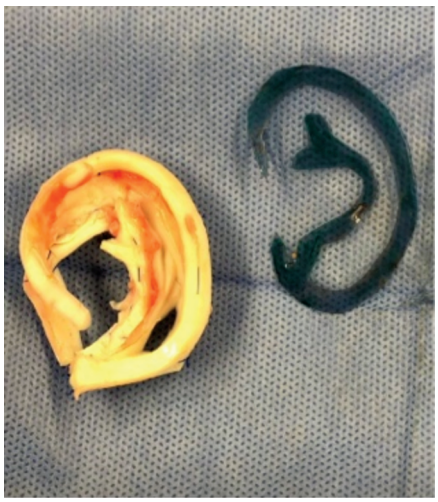

Fig. (1): 2D template.

Fig. (2): 3D template.

PATIENTS AND METHODS

After approval of Local Ethical Committee of Faculty of Medicine, Ain Shams University, this cross-sectional study targeted the patients with unilateral microtia who underwent first and second stage of auricular reconstruction 4 months at least postoperative. Forty-four cases of unilateral microtia from 1st of June 2021 to 31st of May 2022 in Plastic, Burn and Maxillofacial Surgery Department were included in this study. All patient operated by the senior author (Prof A. ElShahat). Written informed consent explaining the whole procedure in this research has been obtained from all patients or their parents and absolute confidentiality as regard the patients' names and addresses was given special care and attention.

Inclusion criteria:

Patient related criteria: Both males and females from 6-15 years old, patients are cooperative and fit for surgery with no contraindications, capable of reading, writing and willing to take part in face-to-face interviews.

Auricular related criteria: Unilateral congenital type.

Exclusion criteria:

Patient related criteria: Non co-operative patients or parents or not fit for surgery, severely impaired vision.

Auricular related criteria: Bilateral type of microtia, less than 4 months' post-operative, post traumatic auricular loss needing reconstruction, anotia type of microtia and previous application of hearing aids before surgery or external auditory canal surgeries.

All participants had auricular repair using the modified Nagata procedure. In first stage, surgeon harvested contralateral sixth, seventh, eighth costal cartilages to build the structure. Twelve patients underwent the classic 2D planning by tracing the contralateral normal ear on a transparent film. Thirty-two patients were planned using 3D template. Patient is scanned with Multi-slice or cone beam CT. Scanned Cuts are transformed to DICOM files then these files are segmented to show the soft tissue of patient's face, including the healthy auricle and the microtic one. The healthy auricle is separated from the rest of soft tissues. It is then downsized to be 2mm in all directions. The auricle is mirrored using the midsagittal plane to lie in the position of the microtic ear. The mirrored auricle is trimmed to separate helix, antihelix and concha. Then this mirror image is printed using 3D printer.

Patient underwent 2nd stage of reconstruction, three to six months after wards, that involved separation and elevation of the framework and application of skin graft. At least 4 months afterwards, Patient is interviewed to participate in the questionnaire to asses satisfaction regarding the reconstructed auricle.

The questionnaire was divided into three sections. Part one comprised 5 questions about how satisfied people were with the general appearance of their ears. The second section comprised questions about the ear's four distinct cosmetic parts (helix, antihelix, concha and lobule). The third section evaluated the auricle's separation from the scalp. Parents provided assessments on a five-point Likert-type scale ranging from 1 (very dissatisfied) to 5) (very satisfied).

Each interview lasted around 15 minutes. A sub-group study was undertaken to see if there were any variations in satisfaction with the rebuilt ear based on the intraoperative used model. The interview and questionnaire were conducted in the patient's native language, which allowed them to be understood and recorded. Patients filled out the questionnaire by themselves, and if they found some difficulties or unable to interact, their parents could provide them guidance.

Statistical analysis: For data analysis, SPSS version 23 was employed. To assess patients' satisfaction with different substructures, calculating the average scores for each item was done, and a one-way ANOVA with a Tukey post hoc test was run. Satisfaction rate was measured as how frequently utilizing "extremely satisfied" and "satisfied" evaluations was. The association between satisfaction with particular substructures and total auricle was investigated using a Spearman bi variable correlation. Overall satisfaction was computed using the total scores of all structures. Ratings were classified as satisfied (equal or above median score) or unhappy (median score below). Fisher's exact test and a Chi-square test were employed for the univariate analysis, and results that were significant (p0.1) were incorporated into the logistic regression.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: p-value >0.05: Non significant (NS). p-value <0.05: Significant (S). p-value <0.01: Highly Significant (HS).

RESULTS

As explained in the Table (1), 44 patients with unilateral microtia were included in the study distributed as 32 patients were operated upon using prefabricated 3D model, while 2D model was used in the other 12 patients. Regarding results; All patients were satisfied with the reconstructed auricle as a whole and ear fitting with face.

Regarding auricular subunits, helix and lobule were the parts that patients liked the most. The least subunits pleased patients were concha and antihelix. Most People were satisfied with the separation of the auricle (35/44) (79.5%).

Regarding comparison between 2D and 3D modelling in aesthetic outcomes and patients' satisfaction as shown in Table (1) Scores of 3D in specific items were higher than those in 2D. It was highly significant difference in satisfaction regarding concha subunit and separation of the auricle.

Table (1): Outcome of each questionnaire components in 2D and 3D planning.

	Type		Test value	*p*-value	Sig.
	2D No. = 12	3D No. = 32			
Ear in general:					
Median (IQR)	4 (4-5)	5 (4-5)	–1.170≠	0.242	NS
Range	3-5	3-5			
Unsatisfied	0 (0.0%)	0 (0.0%)	–	–	–
Satisfied	12 (100.0%)	32 (100.0%)			
Ear fitting with face:					
Median (IQR)	5 (5-5)	4 (4-5)	–2.322≠	0.020	S
Range	4-5	4-5			
Unsatisfied	0 (0.0%)	0 (0.0%)	–	–	–
Satisfied	12 (100.0%)	32 (100.0%)			
Helix:					
Median (IQR)	5 (5-5)	5 (4-5)	–2.014≠	0.044	S
Range	4-5	3-5			
Unsatisfied	0 (0.0%)	0 (0.0%)	–	–	–
Satisfied	12 (100.0%)	32 (100.0%)			
Concha:					
Median (IQR)	2 (1-2)	3 (2-4)	–3.055≠	0.002	HS
Range	1-3	1-5			
Unsatisfied	10 (83.3%)	12 (37.5%)	7.333*	0.007	HS
Satisfied	2 (16.7%)	20 (62.5%)			
Antihelix:					
Median (IQR)	2 (1-2)	2 (2-4)	–1.543≠	0.123	NS
Range	1-4	1-5			
Unsatisfied	10 (83.3%)	18 (56.2%)	2.766*	.096b	NS
Satisfied	2 (16.7%)	14 (43.8%)			
Lobule:					
Median (IQR)	5 (5-5)	5 (3-5)	–1.688≠	0.091	NS
Range	3-5	2-5			
Unsatisfied	0 (0.0%)	2 (6.2%)	0.786*	0.375	NS
Satisfied	12 (100.0%)	30 (93.8%)			
Separation:					
Median (IQR)	2 (2-4)	5 (4-5)	–4.053≠	0.000	HS
Range	2-5	2-5			
Unsatisfied	7 (58.3%)	2 (6.2%)	14.550*	0.000	HS
Satisfied	5 (41.7%)	30 (93.8%)			

p-value >0.05: Non significant. *p*-value <0.05: Significant. *p*-value <0.01: Highly significant.

Fig. (3): Post-operative photos of right microtia underwent reconstruction using 2D template.

Fig. (4): Right microtia case underwent reconstruction using 3D template.

DISCUSSION

Majority of patients want their ears to at least return to normal, with great duplicated substructure. However, there are no measurable standards for a successful surgical net result and patient and physician opinions frequently diverge. Patient satisfaction is a major predictor of future quality of life and, as such, is the primary surgical objective **[11]**.

In earlier research, the ear structures were assessed, but the judgments of the medical personnel were given more weight. There is little information available concerning patients' impressions of the novel auricular subunits. Particularly, it is unclear which portion of the auricle is most tightly linked to patient contentment **[12]**. The purpose of this study was to compare between 2D and 3D modelling and its influence in surgical outcomes and patient perceptions.

Regarding results of satisfaction of the surgical outcomes in current study, most of the people were satisfied with the entire auricle and distributed as (45.5%) were satisfied and (45.5%) were very satisfied while (9.1%) were acceptable results. However, all people were satisfied with the ear fitting with face as (54.5%) were very satisfied and (45.6%) were satisfied.

Widodo et al., 2021 **[13]**, concluded that around 67.7% of the patients expressed satisfaction, 19.4% stated extreme satisfaction, and 12.9% said they could accept the results of their surgeries, implying that no one regretted having the surgery, similar to present study with the difference in percentage distribution that favors in the present study in overall satisfaction.

In terms of patient expectations, 71% were happy with their helix, while 74% were extremely delighted with their lobules. Since they fell short of their predictions, patients were disappointed or extremely dissatisfied with concha and antihelix.

These findings are very comparable to this study findings, which confirmed that the helix and lobule were the most satisfied auricle components. As (59.1%) were extremely pleased with helix, (36.4%) were satisfied and (4.5%) reported acceptable results. Regarding the lobule, 63.6 percent of patients were extremely happy. On the other hand, the concha and antihelix were the least pleased components in studied cases. As regards concha, although 27.3 percent of patients were dissatisfied, 22.7 percent were extremely dissatisfied. In terms of antihelix, 40.9 percent were dissatisfied, with 22.7 percent extremely dissatisfied.

Regarding Akter et al., 2017 **[14]** findings, the lobule received the greatest score, whereas tragus/antitragus received the lowest. This surgery would be recommended by 90% of all youngsters. 88% of all male patients (23/26) and 91.6% of female patients (22/24) said they would undergo the surgery again.

As regards correlation between age difference and scores attained in questionnaire, although there was a wide range of ages with median 8 years old, there was no significant difference in satisfaction results concerning any subunit of the auricle or the whole ear either. However, some previous studies reported that children gave higher ratings for surgical results than adult patients **[15,16]**. Being a cross sectional study, age could not have been standardized, however, to overcome this fallacy in further studies, it is recommended to calibrate age group and their interaction for each subgroup. Results from children to be reported by their caregivers, and scores from the adults to be recorded by themselves.

In the present research, it was also noted that 3D scores were higher than 2D. Specifically involving concha subunit of the auricle and the separation of the framework, thus patients who underwent auricular reconstruction by the aid of 3D template were more satisfied with the aesthetic outcomes than their colleagues with whom 2D model was used. This may be clarified for the architecture of 3D model which is formed separated into three tiers (helix, antihelix, concha) (Fig. 5) rather than one whole unit. Making a multi-level model help to deepen of the concha and enhance inclination of auricle in the second stage during separation from scalp which subsequently given more satisfaction from patients' prospective.

Fig. (5): Three tiers of 3D model.

Byoungjun et al., 2016 **[7]** conducted a research comprising seven microtia kids, age ranges from 11 to 16, in order to analyze and enhance the aesthetic outcomes of autologous ear reconstruction

by providing surgeon with 3D representations of patients' ears. Youngsters often struggle to stay motionless for the lengthy period of time needed for scanning; as a result, Researchers used a casting-based technology to construct an exact representation of sound auricle. The accuracy of conventional 2D blueprint and 3D design of auricle with molded ear sculptures were compared, and it was found that the mean percentage variations were distinguishable; notably, the 2D pattern and the molded ear had an average difference of 16.03 percent, whereas the 3D prototype and the molded ear had an average difference of 2.3 percent. Thus, throughout both surgery simulation and the actual procedure, the 3D model provided surgeons with a considerably more accurate point of reference.

Zhou et al., 2016 **[6]** compared surgical results with those attained using ordinary X-ray film on 20 individuals and 20 other cases who used 3D model. Comparative analysis revealed that the novel templates (3D) produced the outcomes with the highest degree of accuracy concerning size, homogeneity, cranio-auricular inclination, and reconstructed substructures. Additionally, in contrast to the procedure supported by an X-ray radiograph, surgery times were cut by roughly 15 minutes.

The advantages of utilizing a prototype in three dimensions were further supported by randomized controlled study contrasting the cosmetic outcomes from autologous ear reconstruction carried out using classic 2D blueprint with those acquired utilizing three-dimensional forms **[17]**. When data from two groups was compared, the physician and patient satisfaction levels differed significantly. Physician and patient feedback ratings for the group using 3D objects were statistically greater than for the 2D model group.

Limitations: The low number of microtia cases (44), further studies should be conducted on larger number of cases. Second limitation was the short follow-up interval (4 months), It may be needed to reassess satisfaction of patients with autologous ear reconstruction after 3 to 5 years. Third limitation was inability to calibrate age group for patients to overcome any fallacy in recording perception and satisfaction.

Conclusion:

3D modeling is superior to 2D modeling in enhancing patient satisfaction after Autogenous Ear Reconstruction especially in the shape of concha and separation of the reconstructed ear from the scalp.

REFERENCES

1- Li D., Chin W., Wu J., Zhang Q., Xu F., Xu Z. and Zhang R.: Psychosocial outcomes among microtia patients of different ages and genders before ear reconstruction. Aesthetic Plastic Surgery, 34 (5): 570-6, 2010.

2- Soukup B., Mashhadi S.A. and Bulstrode N.W.: Health-related quality-of-life assessment and surgical outcomes for auricular reconstruction using autologous costal cartilage. Plastic and Reconstructive Surgery, 129 (3): 632-40, 2012.

3- Pertschuk M.J. and Whitáker L.A.: Social and psychological effects of craniofacial deformity and surgical reconstruction. Clinics in Plastic Surgery, 9 (3): 297-306, 1982.

4- Dreher R., Blaya C., Tenório J.L.C., Saltz R., Ely P.B. and Ferrão Y.A.: Quality of life and aesthetic plastic surgery: A systematic review and meta-analysis. Plast. Reconstr. Surg. Glob. Open., 4 (9): e862, 2016.

5- Bly R.A., Bhrany A.D., Murakami C.S. and Sie K.C.Y.: Microtia reconstruction. Facial Plast. Surg. Clin. North Am., 24 (4): 577-591, 2016.

6- Zhou J., Pan B., Yang Q., Zhao Y., He L., Lin L., Sun H., Song Y., Yu X., Sun Z. and Jiang H.: Three-dimensional autologous cartilage framework fabrication assisted by new additive manufactured ear-shaped templates for microtia reconstruction. Journal of Plastic, Reconstructive & Aesthetic Surgery, 69 (10): 1436-44, 2016.

7- Jeon B., Lee C., Kim M., Choi T.H., Kim S. and Kim S.: Fabrication of three-dimensional scan-to-print ear model for microtia reconstruction. journal of Surgical Research, 206 (2): 490-7, 2016.

8- Mussi E., Furferi R., Volpe Y., Facchini F., McGreevy K.S. and Uccheddu F.: Ear reconstruction simulation: From handcrafting to 3D printing. Bioengineering, 6 (1): 14, 2019.

9- Liaw C.Y. and Guvendiren M.: Current and emerging applications of 3D printing in medicine. Biofabrication, 9 (2): 024102, 2017.

10- Cui C., Li Y., Zhang R., Zhang Q., Xu Z., Chiu E.S., Xu F., Li D., Li T. and Chen W.: Patient perception and satisfaction questionnaire for microtia reconstruction: A new clinical tool to improve patient outcome. Journal of Craniofacial Surgery, 29 (2): e162-7, 2018.

11- Clapham P.J., Pushman A.G. and Chung K.C.: A systematic review of applying patient satisfaction outcomes in plastic surgery. Plast. Reconstr. Surg., 125: 1826-1833, 2010.

12- Honigman R.J., Phillips K.A. and Castle D.J.: A review of psychosocial outcomes for patients seeking cosmetic surgery. Plast. Reconstr. Surg., 113: 1229-1237, 2004.

13- Widodo D.W., Mars R., Suwento R., Alviandi W., Oriza I.I. and Bardosono S.: Satisfaction and health-related quality of life of patients with microtia following reconstructive surgery using the Nagata technique. PloS One, 16 (9): e0256652, 2021.

14- Akter F., Mennie J.C., Stewart K. and Bulstrode N.: Patient reported outcome measures in microtia surgery. Journal of Plastic, Reconstructive & Aesthetic Surgery, 70 (3): 416-24, 2017.

15- Horlock N., Vogelin E. and Bradbury E.T.: Psychosocial outcome of patients after ear reconstruction: A retrospective study of 62 patients. Ann. Plast. Surg., 54: 517-524, 2005.

16- Cui C., Hoon S.Y., Zhang R., Zhang Q., Xu Z., Xu F., Li D. and Li Y.: Patient satisfaction and its influencing factors of microtia reconstruction using autologous cartilage. Aesthetic Plastic Surgery, 41 (5): 1106-14, 2017.

17- Zhu P. and Chen S.: Clinical outcomes following ear reconstruction with adjuvant 3D template model. Acta. Oto-Laryngologica., 136 (12): 1236-41, 2016.