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Rating the aesthetic results after auricular reconstructive surgery for congenital aural atresia with microtia

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Abstract

Objective: This retrospective study aimed to establish a robust rating system for assessing postoperative outcomes in congenital aural atresia (CAA) patients undergoing auricular reconstruction. The newly introduced «EAR Scale», a weighted grading system, not only considers anatomical landmarks but also factors like ear alignment. In addition, «Outer Ear Cartilage (OEC) Scale» and the visual analogue scale (VAS) were introduced. These scales were compared among themselves and against two established scales.

Methods: Nine raters assessed 17 eligible patients who underwent auricular reconstruction between 2001 and 2020.

Results: The study compared interrater agreement among scales, with the «EAR Scale» proving the most reliable (Krippendorff's α: 0.45), outperforming existing measures. The «OEC Scale» and VAS exhibited lower interrater agreement, indicating inferiority in assessing aesthetic outcomes.

Conclusion: The «EAR Scale» emerges as an effective tool for evaluating postoperative outcomes in CAA auricular reconstruction.

Keywords (MeSH Unique ID)

congenital microtia (D065817), ear (D004423), esthetics (D004954), Surgery, Plastic (D013518), Outcome Assessment, Health Care (D017063)

Introduction

Background

Microtia is a congenital hypoplastic malformation of the pinna with a worldwide prevalence of 0.83 to 4.34 per 10,000 births[1–5]. Males are more than twice as likely to be affected and the condition is usually unilateral (77% to 93%)[6]. The severity of the malformation may range from slightly smaller subunits of an otherwise completely developed auricle to a completely missing pinna, also called anotia. Microtia is often associated with partial or total atresia of the external auditory canal, as well as malformations of the middle ear. We hereafter refer to the combination of microtia and atresia as congenital aural atresia (CAA).

A widely used classification to describe congenital deformities of the auricle has been published by Weerda and proposes three different grades of dysplasia[7]. Depending on the severity of dysplasia, congenital ear deformities are challenging regarding both aesthetic and functional reconstructive surgery. The aim of auricular reconstructive surgery of CAA is to achieve an aesthetically pleasing ear with restoration of well recognizable anatomical landmarks.

At our centre, the reconstruction of CAA is a threefold procedure involving the insertion of a rib cartilage framework. It can be combined with functional reconstruction of the acoustic meatus and eardrum in the event of a favourable middle-ear anatomy, or in combination with the implantation of an acoustic implant. In the first session, the auricular rudiments are removed and a rib cartilage framework is placed under the skin. After at least three months, the healed ear framework is lifted off the back of the head and the earlobe is correctly positioned with a skin graft to cover the exposed wound area behind the reconstructed auricle. Fine-tuning of the reconstructed pinna can be performed subsequently. It involves scar correction, removal of excess skin, or modelling of an eventual depression of the auditory canal.

Several reconstructive surgical techniques are available, but few attempts have been made so far to develop an easy-to-use reliable tool to compare postoperative outcomes. Skarzynski et al.[8] proposed a weighted 10-point scoring system based on anatomical landmarks. Outcomes are

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classified into four categories (I: perfect reconstruction, II: complete functional and aesthetic reconstruction, III: satisfactory functional reconstruction, IV: unsatisfactory functional and aesthetic reconstruction). Another grading system by Sharma et al.[9] uses a weighted 13-point scoring system also based on anatomical landmarks and using a classification into four categories (poor, average, good, excellent). The helix is the highest weighted anatomical landmark in both scoring systems. While Sharma et al.[9] use anatomical landmarks exclusively, Skarzynski et al.[8] also consider the complete elevation of the helix from the surface of the skin. Others have used a 12-point scoring system to compare aesthetic outcomes after different types of skin coverage methods considering skin colour, thin coverage (convolution), ear size and bilaterally balanced projections[10]. Constantine et al.[11] compared the reconstruction technique with rib cartilage vs. a porous polyethylene implant, using a five-point scale with the rating of six categories: protrusion, definition, shape, size, location and colour match.

Objectives

The aim of this study was to develop a new scale for evaluating aesthetic results after auricular reconstructive surgery of CAA. Former published grading systems and the analysis of postoperative results after reconstruction surgery at our institution served as a basis for the development of the outer ear or «EAR Scale». Analyzing the appearance of the cartilage framework we also propose a slightly modified version called the «OEC Scale». The "C" stands for cartilage. Its aim is to rate the quality of the cartilage framework and to determine putative correlations between the intraoperatively constructed cartilage framework and postoperative outcomes. The overall result is assessed by means of a Visual Analogue Scale (VAS). Neither consideration of the cartilage framework nor the assessment by VAS have been included in the studies published until now.

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Materials and methods

Study design

The study was designed as a retrospective data analysis using the «EAR Scale», «OEC Scale» and the VAS grade the aesthetic postoperative outcomes of patients based on photos of auricular reconstructive surgery of CAA and of the cartilage framework (Figures 1 and 2).

Participants

All consecutive patients with CAA treated by auricular reconstructive surgery between January 2001 and December 2020 were assessed for eligibility. Their medical charts and photographs were reviewed. Patients without general consent forms, those who had not undergone all three stages, and patients with missing pre- or postoperative photographs were excluded. Out of the 81 patients identified, 22 presented bilateral CAA, thus resulting in 103 ears with CAA. In 70 cases, either no auricular reconstruction had been performed or they were still too young to undergo surgery. Thirty-three ears were thus treated with auricular reconstructive surgery. Another 16 ear atresia patients could not be evaluated owing to missing or incomplete data. Our final patient population was thus composed of 17 patients with unilateral CCA (Figure 3). The intraoperative photographs of the cartilage framework were missing in five patients, resulting in 12 patients for the assessment of the «OEC Scale». Informed consent was obtained from all patients included in the study.*Description of the scales*

The « EAR Scale»

The « EAR Scale» is a weighted rating scale with a maximum score of 13 points. The helix is weighted with a maximum of four points, the lobulus with a maximum of three points, and the anthelix with a maximum of two points. These three anatomical landmarks are thus the most heavily weighted anatomical landmarks. The tragus, cavum conchae and/ or external auditory canal, symmetrical ear alignment and symmetrical ear projection (ear-head angle) are weighted with a maximum of one point each (Table 1). Depending on the score obtained, a grading system

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divides the aesthetic result into four categories: a score of 13 points is excellent, 10 to 12 is good, 5 to 9 is average, and below 5 points is poor.

The «OEC-Scale»

The «OEC-Scale» is used to assess the constructed auricular cartilage framework intraoperatively (Table 2). It also has a maximum score of 13 points. Like the « EAR-Scale», the helix is weighted with a maximum of four points, the lobulus with a maximum of three points, and the anthelix with a maximum of two points. The tragus and cavum conchae are weighted with a maximum of one point. Unlike the « EAR Scale», the overall impression is also analysed and scored with a maximum of two points. Ear alignment and ear projection can obviously not be rated when only rating the cartilage framework. A score of 13 points is excellent, 10 to 12 points is good, 5 to 9 points is average, and 4 or below is poor.

The VAS

In the Visual Analogue Scale (VAS), the overall impression of the auricle is evaluated on a scale from 0 (indicating poor reconstruction) to 10.0 (indicating perfect reconstruction) (Figure 4). The scale was displayed on a 10 cm measuring line, where each centimeter represented 1 rating point. The overall impression was indicated by a mark along the line. The rating is read off to one decimal. A score of 9.0 to 10.0 means excellent reconstruction, 6.0 to 8.9 is good, 3.0 to 5.9 is average, and 0 to 2.9 is poor.

Measurement

The « EAR Scale», «OEC Scale», VAS and the scales of Skarzynski[8] and Sharma[9] were applied to the set of intraoperative and postoperative photographs. Nine physicians of different educational status in our ENT department conducted the rating independently: three experienced ENT surgeons who operate on CAA, four experienced ENT surgeons not involved in

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reconstructive surgery, one ENT resident and one medical student. The sequence of postoperative and intraoperative photographs was presented randomly to each rater.

Statistical methods

All statistical evaluations were completed using STATA (Version 17.0, StataCorp, College Station, Texas, USA). Categorical variables were summarized by absolute and relative frequencies. Quantitative variables were analyzed using descriptive statistics. In order to assess the consistency of agreement between scales, intraclass correlations and corresponding 95% confidence intervals were calculated, based upon a mixed effects model with a fixed effect for scale and random effects for rater and patient. The analysis of the interrater agreement was performed using Krippendorff's alpha coefficient and its 95% confidence interval.

This article is written in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines[12].

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Results and analysis

Baseline patient characteristics and demographics

Thirteen out of 17 patients were male (76%) and four female (24%). The median age at first surgery was 13 years (minimum: nine years, maximum: 23 years). Ten patients underwent surgery on the left ear (59%) and seven on the right side (41%). Additional canaloplasty with meatoplasty was performed in 13 cases (76%). Figures 5 and 6 show the median and standard deviations of the rated postoperative outcome score of each patient for the «EAR Scale» (n=17) and the «OEC Scale» (n=12).

Interrater reliability

The interrater agreement was highest with a Krippendorff's alpha coefficient of 0.45 (95 % CI of 0.23 - 0.67) for the «EAR Scale». The Skarzynski Scale showed a coefficient of 0.42 (95 % CI of 0.22 - 0.62). The coefficient for the Sharma Scale was only slightly lower at 0.40 (95 % CI of 0.26 - 0.55) (Table 3).

Correlations

The highest intraclass correlation (ICC) was obtained with an ICC value of 0.70 (95% CI of 0.60 - 0.77) when comparing the rating scales of Sharma and Skarzynski. The « EAR Scale» was correlated with the Skarzynski scale with an ICC value of 0.65 (95% CI of 0.54 – 0.73) and with the Sharma scale with an ICC value of 0.57 (95% CI 0.45 – 0.66). The correlation between the « EAR Scale» and the VAS was practically equivalent, with an ICC value of 0.57 (95% CI of 0.45 – 0.67). The Sharma scale and the VAS were correlated with an ICC value of 0.55 (95% CI of 0.43 – 0.65), and the ICC value for the correlation between the Skarzynski scale and the VAS was 0.49 (95% CI of 0.36 – 0.60). The «OEC Scale» for the cartilage framework was poorly correlated with all other scales with an ICC value ranging from 0.05 – 0.15 (Table 4).

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We summarized the correlation of all scales evaluating postoperative photographs («EAR Scale», VAS, Sharma Scale and Skarzynski Scale, while excluding the «OEC Scale») in an "Overall Agreement". The ICC value for these four scales was 0.59 (95% CI of 0.51 - 0.66). When excluding the VAS, the ICC value even increased to 0.63 (95% CI of 0.55 - 0.71).

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Discussion

Cosmetic and functional reconstruction of CAA remains challenging. A thorough analysis of the final outcome, a retrospective review of each surgical step and a score result should help the surgical team to improve their learning curve. Close collaboration between the otologist and the ENT plastic surgeon is essential to achieve the best possible outcome for the patient. Our « EAR Scale» provides a simple, quick way of assessing postoperative results. Existing rating scales mainly rely on the presence or absence of anatomical landmarks of the ear to assess the final result. The «EAR Scale» not only takes the presence or absence of anatomical landmarks into account, but also scores them from an aesthetic point of view. It also evaluates the alignment and projection of the ears, which are important factors in the assessment of the aesthetic result that were not included in formerly published grading systems.

Statistical interpretation was limited owing to the small number of only 12 patients. In summary, all three postoperative assessment scales («EAR Scale», Skarzynski Scale und Sharma Scale) correlate well with each other, measuring approximately the same features. The strongest correlation was found between the Skarzynski and the Sharma scales, as both rate solely the anatomical landmarks without considering the alignment or projection of the ears, unlike the «EAR Scale».

The interrater reliability was measured to determine the level of consensus of various physicians. The interrater agreement was highest in the «EAR Scale» compared to the other grading systems (Krippendorff's α: 0.45 = moderate correlation). The Skarzynski Scale showed an equal interrater agreement with a Krippendorff's α of 0.42.

Unexpectedly, the «OEC Scale» correlated poorly with the «EAR Scale», the Sharma scale and the Skarzynski scale. Other factors such as wound healing, skin texture, circumscribed postoperative infections or foreign body reactions to the suture material also have an influence on the postoperative outcome. Therefore, the aesthetics of the cartilage framework alone does not allow a firm conclusion to be drawn about the postoperative aesthetic outcome. The variety

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of malformations and therefore limited standardized reconstruction technique of the cartilage framework and soft tissue may also explain the lack of correlation.

The VAS did not correlate either with the abovementioned scales. It does not seem to be a suitable tool owing to the subjectivity of rating an aesthetical outcome on a visual analogue scale.

Our pilot study involved various ENT physicians. We did not take into account the patients' own opinions or those of lay persons. However, the result should please the patients and their families, an issue that has not yet been addressed.

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Conclusion

In summary, this study has shown that the «EAR-Scale» is an easily applicable tool for rating postoperative aesthetic outcome after CAA reconstructive surgery, as it assesses more aesthetically relevant aspects than formerly published rating systems. Further research should seek to validate the scale by applying it in a larger patient and rater population. Furthermore, it would be interesting to compare the reconstructed side with the healthy side in unilateral cases. It would also be interesting to compare the correlation between physician-rated outcome and patient-rated outcome. It can also be used to evaluate results after artificial framework implantations, which has not been implemented at our center, yet.

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Ethics

The authors assert that all procedures contributing to this work comply with the ethical standards of the Swiss ethics committee (Project ID 2021-01815).) and with the Helsinki Declaration of 1975, as revised in 2008.

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Conflicts of interest

The authors declare that they have no potential conflict of interest or financial disclosure related to this submission. This material has never been published and is not currently under evaluation in any other publication.

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Tables and Charts

TABLE I

«EAR Scale»

«EAR Scale»: Weighted grading system for aesthetic outcome after microtia reconstruction	
Helix	
- not present	0 point
- present with incomplete rim	3 points
- present with complete rim	4 points
Lobulus	
- not present	0 point
- rudimentary present	1 point
- present, but poorly positioned and/or disproportioned	2 points
- correctly positioned and well-formed	3 points
Anthelix	
- not present	0 point
- rudimentary present	1 point
- superior and inferior crus visible	2 points
Tragus	
- not present	0 point
- present	1 point
Cavum conchae and/or external meatus	
- not present	0 point
- visible/identifiable	1 point
Symmetrical alignment of ears	
- no/not assessable	0 point
- yes	1 point
Symmetrical auricular projection (ear-to-head angle)	
- no/not assessable	0 point
- yes	1 point
Total (maximum) score	13 points

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Evaluation of microtia treatment results according to 13-point and 4-grade «EAR Scale».		
Grade	Total score	Outcome
1	13 points	Perfect reconstruction
2	10-12	Good reconstruction
3	5-9	Average reconstruction
4	0-4	Poor reconstruction

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TABLE II

«OEC Scale»

«OEC Scale»: Weighted grading system for cartilage framework in microtia reconstruction	
Helix	
- not present	0 point
- present with incomplete rim	3 points
- present with complete rim	4 points
Lobulus	
- not present	0 point
- rudimentary present	1 point
- partially formed, clearly distinguishable	2 points
- fully formed	3 points
Anthelix	
- not present	0 point
- rudimentary present	1 point
- superior and inferior crus present	2 points
Tragus	
- not present	0 point
- present	1 point
Cavum conchae	
- not present	0 point
- well distinguishable	1 point
Total (maximum) score	11

Evaluation of cartilage framework according to 22-point and 4-grade «OEC Scale»		
Grade	Total score	Outcome
1	20-22 points	Perfect reconstruction
2	13-19	Good reconstruction
3	5-12	Average reconstruction
4	0-5	Poor reconstruction

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TABLE III

Interrater agreement

Interrater Agreement	Krippendorff's Alpha (95% CI)
EAR Scale	0.45 (0.23-0.67)
OEC Scale	0.34 (0.15-0.53)
VAS	0.38 (0.24-0.53)
Sharma et al.	0.40 (0.26-0.55)
Skarzynski et al.	0.42 (0.22-0.62)

Abbreviations: confidence interval (CI), outer ear cartilage (OEC), visual analogue scale (VAS)

TABLE IV

Intraclass correlation (ICC) with 95% CI

ICC Consistency of Agreement	EAR Scale	OEC Scale	VAS	Sharma et al.	Skarzinsky et al.
EAR Scale	1	0.10 (-0.09-0.29)	0.57 (0.45-0.67)	0.57 (0.45-0.66)	0.65 (0.54-0.73)
OEC Scale		1	0.15 (-0.04-0.33)	0.22 (0.04-0.39)	0.05 (-0.14-0.23)
VAS			1	0.55 (0.43-0.65)	0.49 (0.36-0.60)
Sharma et al.				1	0.70 (0.60-0.77)
Skarzynski et al.					1

Abbreviations: confidence interval (CI), intraclass correlation (ICC), visual analogue scale (VAS) , outer ear cartilage (OEC)

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Legend Tables and Charts

TABLE I: «EAR Scale»

TABLE II: «OEC Scale»

TABLE III: Interrater agreement

TABLE IV: Intraclass correlation (ICC) with 95% CI

Legend Figures

FIGURE I: reconstructed ear

FIGURE II: cartilage framework

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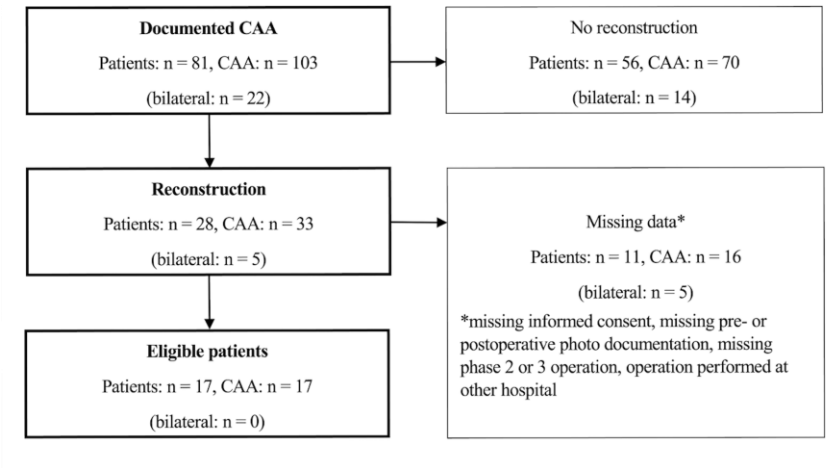

FIGURE III: Flow chart of study enrolment: patients with congenital aural atresia (CAA) treated by auricular reconstruction surgery between 01/01/2001 and 31/12/2020 at the Clinic for ear, nose, throat and facial surgery of the Cantonal Hospital of Lucerne.

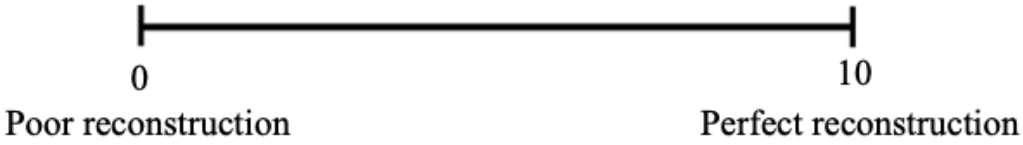

FIGURE IV: «VAS Scale»: Visual Analogue Scale

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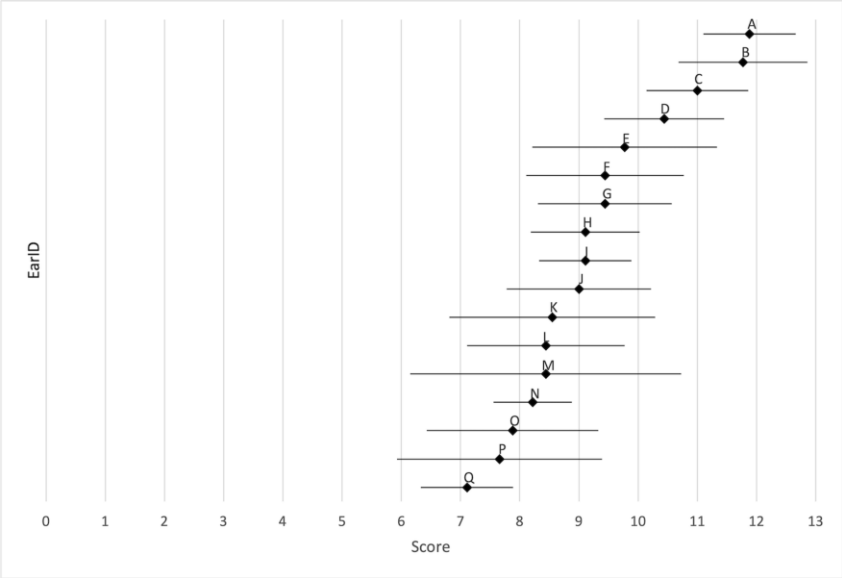

FIGURE V: «EAR Scale»: Mean (♦) and standard deviation (—) of postoperative outcome (n=17)

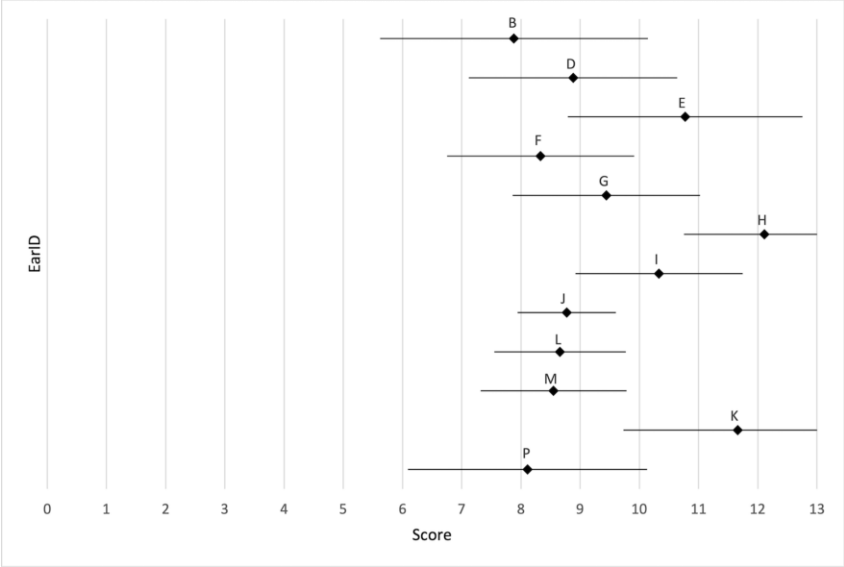

FIGURE VI: «OEC Scale»: Mean (♦) and standard deviation (—) of intraoperative cartilage framework (n=12)

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