Journal Pre-proof Postoperative safety and satisfaction in patients with microtia Postoperative safety and satisfaction in patients with microtia

Article *in* Journal of Oral and Maxillofacial Surgery · September 2020

DOI: 10.1016/j.joms.2020.09.004

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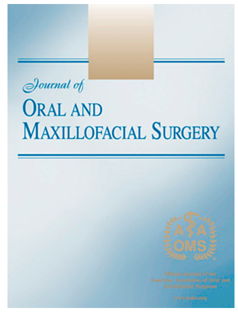

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PII: S0278-2391(20)31110-1

DOI: https://doi.org/10.1016/j.joms.2020.09.004

Reference: YJOMS 59407

To appear in: *Journal of Oral and Maxillofacial Surgery*

Received Date: 16 April 2020

Revised Date: 1 September 2020

Accepted Date: 2 September 2020

Please cite this article as: Torres Ìn, Martinez JdC, Sanabria R, González LV, Ďiaz-Báez D, Postoperative safety and satisfaction in patients with microtia, *Journal of Oral and Maxillofacial Surgery* (2020), doi: https://doi.org/10.1016/j.joms.2020.09.004.

Postoperative safety and satisfaction in patients with microtia

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Financial Disclosure Statement: I declare that this paper did not receive any financial support.

Presented at (if applicable): I declare that this paper had never been submitted or published before.

Running heading: Auricular Reconstruction in Microtia

Abstract

Purpose: The reconstructive approach for microtia should employ a surgical technique that reconstructs the atrial anatomy; therefore, multiple surgical techniques have been described, and these have undergone variations due to adaptation by different authors. This study aims to assess the postoperative safety and satisfaction of patients with microtia undergoing surgery with the ear reconstruction technique.

Methods: A retrospective cohort study was performed in patients undergoing ear reconstruction with costochondral grafts. The patients were treated in the craniomaxillofacial surgery services of hospitals in Mexico and Colombia from 2008 to 2018. All medical records from the entire study population were included, including complete photographic records and informed consents. A descriptive analysis was performed to characterize the clinical variables and complications. Bivariate analysis was performed using Fisher's exact chi-square test to explore the relationship between clinical and demographic variables with respect to complications.

Results: A total of 410 patients were followed for a period of 12 to 16 months. Only 10% of the sample presented some type of complication. A common complication was dehiscence of the atrial area (23 patients), as well as poor anatomical reproduction (7 patients) due to the collapse of the drainage tubes in the first postoperative phase. No connection was found between the presence of complications and side or type, and no congenital anomalies were found to be associated with microtia ($p>0.05$). The helix and the antihelix were the anatomical areas with greater satisfaction scores. **Conclusions:** Costochondral cartilage is the gold standard reconstruction technique; the results of this

study suggest a low complication rate and high scores of satisfaction after reconstruction. However, the technique requires constant adaptation to obtain better satisfaction results.

Introduction

Ear reconstruction is a challenging surgical technique and is described as a marriage of art and science.[1] In 1945, Peer was the first to describe the prefabrication of a fenestrated vitallium auricle mold that was filled with costochondral cartilage particles and embedded in the patient's abdominal wall and then removed. However, the results were not positive due to the marked fibrosis observed.[2] In his studies, Tanzer[3,4] described a method for the reconstruction of the microtia, employing costochondral autologous grafts that were a starting point in the evolution of this surgical technique. In 1999, Brent, who used the same principle in 1200 cases followed for 17 years, used 4 stages for ear reconstruction, giving importance to the anatomy of the future ear.[5] However, this technique has been modified by multiple authors in the search for better anatomical results.[6,7] In 1992, Nagata et al. reduced the phases of the procedure to two surgical stages and the addition of cartilaginous pieces to create a costochondral insole with greater anatomical support.[8] In 2009, Zhanng suggested that it was possible to achieve better results using the rib cartilage, taking into account the precision in size, orientation and symmetry in the front and posterior view; the duplication of more than 10 atrial anatomical points; the stable and permanent projection of the atrium; and middle thoracic deformity. It is important that the doctor, the patient, and the family are satisfied with the result. However, favorable results are subjective and depend on many external variables.[9]

Therefore, the purpose of this study is to describe a surgical technique used by the author, based on the different surgical methods described and developed by Brent [10], Zhang [9], and Firmin.[11] The authors of this article hypothesized that the development of an individual surgical technique, based on different methods previously described, is a safe approach for patients with microtia. Therefore, the objective of this work was to characterize the clinical and demographic complications of patients who underwent surgery between 2008 and 2018 for the treatment of ear reconstruction for microtia, as well as to evaluate the author's surgical evolution and satisfaction with the results.

Materials and Methods

To address the purpose of this study, the researchers designed and employed a retrospective cohort study. The sample population was composed of all patients who attended the Department of Craniomaxillofacial Surgery at the Orinoquia Regional Hospital (HORO), Colombia, and the Morelese Children and Adolescents' Hospital, Cuernavaca, Morelos, Mexico, between 2008 and 2018, for the evaluation and management of microtia.

To be included in the study sample, those who met the following inclusion criteria were chosen: patients with syndromic or isolated congenital microtia anomaly, patients who signed and agreed to be part of the research and were committed to rigorous postsurgical follow-up, patients with indications for the management of autologous ear costochondral reconstruction, and patients who presented fully completed medical, photographic and interview records. The following exclusion criteria were applied: patients with traumatic alterations deforming the auricle, patients with after-effects from previous reconstruction surgeries, and patients who did not accept management with costochondral grafts having the Medport option.

The study protocol met the requirements of the research ethics committees (REC) of both institutions: (HNM/DDM/DUEI/318/2019) following the guidelines of the Declaration of Helsinki. Data collection of fully completed medical records was performed and informed consent was included. Demographic variables such as age and gender were extracted, as well as clinical information organized in the following groups: isolated microtias (*Meurman 1957)*[12] **(Table 1)**; microtias associated with Treacher Collins syndrome; and nonsyndromic microtias associated with hemifacial microsomia[13.] In addition, data on postoperative complications was also collected, considering flap necrosis and dehiscence, anatomical loss, infection, bruising, frame exposure and injury of the facial nerve as potential complications. For the evaluation of satisfaction, a trained and calibrated maxillofacial surgeon carried out an evaluation by means of postoperative clinical photographs, calibrated using measurement (ICC: 0.90, CI 95%: 0.85 to 0.92) based on a questionnaire adapted for the surgeon's perception and satisfaction with the results of the reconstruction conducted [14]. The photographs corresponded to the first postoperative surgical phase. All interventions in both hospitals were performed by the same surgeon (IT). The technique used is described in detail in the following sections.

Research Variables

The presence of postoperative complications and satisfaction scores were considered to be outcome variables.

The predictive variables of complications included demographic variables such as age and gender, as well as clinical variables including isolated microtias grade, microtias associated with Treacher Collins syndrome, nonsyndromic microtias associated with hemifacial microsomia and microtia side.

The presence of postoperative complications was considered to be an independent variable of satisfaction for each anatomical point evaluated.

Pre-Surgical Preparation

The careful placement of the new auricle was important to obtain a proper esthetic result. Anatomically, the auricle is located outside the face mask, based on the temporal bone [15]. Therefore, the position of the affected auricle was planned with respect to the patient's healthy auricle in unilateral cases and, in bilateral cases, it was located with respect to the neighboring facial structures. The axial axis of the auricle should have 10 to 15 degrees of posterior inclination, as evidenced by anthropometric studies [16]. In all patients, an upper measurement defined as a line from the top of the helix to the corner of the eyebrow (hex-ce), a lower measurement from the earlobe to the base of the spinal column (lob-colm), a third measurement ensuring correct spatial location measured from the outer edge of the eye to the tragus (cant-trg), and another measurement from the outer edge to the posterior point of the helix (cant-helix post) were quantified **(Fig. 1)**. It is important to emphasize that some cases may present orbital dystopia, which would not be a reliable position of the external canthus to place the ear. In these cases, the patient wears glasses when making the marking, which shows that—through glasses—the healthy side corrects the position in the affected side, which adopts the position of the external canthus.

First Surgical Phase

Costochondral Graft, Ear Template and Skin Insertion

All patients received a dose of preoperative prophylactic antibiotics, namely, a single dose of cephalothin 100 mg/kg. A single preoperative dose of clindamycin 40 mg/kg was used for patients allergic to penicillin.

The costochondral cartilage template should be a few millimeters smaller in all dimensions than the previously established dimensions so that, when inserted into the skin pocket, it can be free of tension in all areas of skin coverage [17].

It was suggested to take the graft from the fifth to the ninth rib on the same side of the microtia [18], while other authors suggest taking it from the contralateral side, advantageously adapting the anatomical curve of the costal remnant, as well as trying to preserve most of the anterior and posterior perichondrium, which mainly takes the subperichondrial plane to reduce the risk of pleural tears [19]. In this study, all grafts correspond to the ipsilateral side of the defect, including the sixth, seventh and eighth ribs **(Fig. 2a).**

To create the cartilaginous template, the following five different parts were isolated: 1) base, 2) antihelix, 3) helix, 4) tragus and antitragus, and 5) projection piece, which will be placed in the second surgical sequence to reconstruct the posterior wall. The initial carving of the antihelix and the upper and lower edges was performed [10], and these structures were added as a cartilaginous complex that was attached to the base. The cartilage of the eighth rib was used to reconstruct the helix and the crus helicis; each cartilaginous structure was carefully carved and attached to the base by means of 4.0 nylon sutures **(Fig. 2b)**.

Once the cartilaginous template was completed, the transfixion incision technique[7] was performed to obtain the adhesion of the remaining part to the posterior auricular skin and to recreate the auricular lobe. By creating a 2-mm-thick skin pocket that would respect the dimensions of the previously established measurements, the upper part of the skin area was completely lifted to cover the entire template **(Fig. 2c)**.

Negative suction drainages

Two small polyethylene drainage tubes with multiple perforations were used once the skin covering the template was closed. Then, these were inserted near the shell ear and scaphoid fossa. Two 20-mL syringes were connected to each drainage tube to provide negative pressure and verification of the proper air seal of the skin pocket **(Fig. 3)**. Drainage tubes were monitored every 30 minutes during the first 2 hours to verify drainage and avoid hematomas[20]. Postoperative recommendations were standardized to include head position during sleep to avoid pressure on the reconstructed auricle and removal of drainage tubes on the fourth day after surgery. Patients were kept under inpatient observation for 24–48 hours with intravenous administration of cefazolin 50 mg/kg/day every 8 hours and oral administration of dicloxacillin 250 mg every 8 hours on an outpatient basis. Analgesic therapy was managed using non-steroidal anti-inflammatory drugs.

Second surgical phase

Recreation of the posterior auricular sulcus

The starting point for the reconstruction of the retroauricular sulcus occurred three to five months after the first stage. The extra costochondral cartilage for the projection of the cartilaginous template is not relevant for the second-stage surgery. The fundamental technique for reconstructing the atriocephalic retroauricular sulcus was based on making a cutaneous incision a few millimeters from the outer edge of the costochondral template; with careful dissection, most of the posterior surface of the graft base and the ear was separated from the skull, leaving a nutritional bed of connective tissue (Fig. 4a). The base portion of the template was covered with a skin graft taken from the inguinal region that was sutured to the posterior portion of the cartilage.

In the mastoid portion, subcutaneous dissection was performed later until a retroauricular pocket was created to perform the remodeling and the primary closure of the retroauricular mastoid portion (Fig. 4b). As a space and shape maintainer, the atriocephalic angle was made of a silicone molder, which was individually used for each patient (Fig. 4c).

Statistical Analysis

All patient data included in the study was recorded in a database and analyzed using IBM-SPSS-V23 (IBM SPSS Statistics) A descriptive analysis was performed using frequencies to assess the main clinical characteristics of the subjects (type of syndrome, location and type of microtia, and type of complication). In the same way, the χ2 statistics and Fisher's exact test were performed to compare the distribution of the presence and absence of complications in relation to the clinical characteristics and the year of surgery grouped by tertiles. The relative risk (RR) was used to assess the magnitude of the risk of complications.

The distribution of satisfaction scores for each of the anatomical points was evaluated by using the Shapiro-Wilk test; consequently, the analysis was performed using nonparametric statistics, the interpretation of median and interquartile range (IQR) and the comparison according to the presence of complications using the Mann-Whitney U test. All tests were performed at a significance level of 5% ($p < 0.05$).

Results

A total of 410 patients underwent surgery for auricular reconstruction with costochondral grafts, 325 (79.3%) in Colombia and 85 (20.7%) in Mexico. The average age of patients was 10 ± 4 years, the ages ranged from 7 to 20 years; 315 (76.8%) male subjects and 95 (22.9%) female subjects had surgery. There were 375 unilateral microtias: 212 (51.7%) on the right side, 163 (39.8%) on the left side, and 35 (8.5%) bilateral. Of the total number of microtias managed, 358 (87.3%) were diagnosed as not related to craniofacial syndromes, and 52 (12.7%) were related to craniofacial syndromes. Additionally, 248 (60.5%) were classified as type II microtias, and 10% of cases reported postoperative complications in the first surgical phase (Table 2). The average time from presurgical preparation to the end of the second phase was 5 ± 1 months.

A total of 5.60% of the patients presented with dehiscence in the area of the tragus and helix. All patients who presented with dehiscence started with congestion and bruising around the flap area, necrosis and finally cartilage exposure. A total of 52.17% of these patients required a temporoparietal fascia flap in a second surgical phase as a rescue measure for the exposed costochondral graft. The loss of total auricular anatomy occurred in the postoperative period in 3.4% of the patients due to malfunctioning of the drainages that maintain negative pressure, within the first 72 hours in the family care stage; 1.0% of the patients presented with scar adhesion in the second phase during the healing period after the auricular elevation. No patients presented infection of the donor surgical area in the chest, thoracic deformity, facial nerve damage or pleural perforation. A total of 96.6% of complications were observed in the first surgical phase.

When evaluating the distribution of complications with respect to the presence of syndromes, only 9.76% of complications were observed in this type of patient. The highest percentage of complications (51.2%) was reported in microtias on the right side. In relation to the types of microtia, the presence of complications behaved similarly with 21 (21.2%) and 20 (48.8%). No statistically significant differences were observed between the presence of complications and the clinical variables evaluated in the bivariate analysis ($p > 0.05$) (Table 2).

The average number of surgeries during the 11 years evaluated was 37 ± 10 per year; 142 surgeries were performed from 2006 to 2010; 138 interventions were performed from 2011 to 2015, and 130 auricular reconstructions were performed from 2016 to 2018. When the complications reported in the different years of treated groups were evaluated, a trend towards fewer events was observed (Fig. 5).

Photographic clinical records were used for the satisfaction survey two weeks postsurgery. In patients without complications, statistically higher satisfaction scores were observed compared to complicated subjects at all upper anatomical points ($p < 0.05$) (Table 3). The upper part generally showed satisfactory results for an IQR median of 4 (4–4). In the lower segment, acceptable to satisfactory results had an IQR median of 4 (3–5). In the overall evaluation of the result of the auricular reconstruction, the outcome of the procedures in the study period was satisfactory with an IQR median of 4 (4–4). The anatomical points evaluated are shown in Fig. 6.

Discussion

This study described the evolution of the surgical technique used by the author, based on the different surgical methods described above. The authors considered whether the development of an individual surgical technique based on different methods described was safe and effective for the surgical management of patients with microtia. This work focused on characterizing the clinical and demographic complications of the patients. The auricular reconstruction technique with costochondral cartilage for the management of microtia suggests successful results based on the low frequency of complications observed in this study, observing the tendency to present fewer complications over time, suggesting that the surgeon was becoming more familiar with the method used. This was obtained from different surgical techniques to personalize it and create its learning curve in such a way that all the phases of the procedure are of vital importance. Nevertheless, the first surgical phase was decisive in the final result of the reconstruction, because it is the stage where the anatomical and structural details of the integration of the costochondral insole and the cutaneous tissue are formed[11]; only 10% of the reported complications occurred in the recreation phase of the atrial cephalic sulcus. The second surgical phase is important and crucial, since it poses an increased risk of fibrosis and atrial contraction; therefore, the use of silicone shapers is necessary to improve the proper projection of the reconstructed atrium and prevent adhesion to the mastoid region.[20]

The result of the operation tended to improve with the clinician's learning curve. However, the evolution and modifications of the technical surgical aspects initially proposed by Brent[5] can be adapted to obtain individualized results.[21] It is possible that numerous anatomical points over time are not favorable. Carving the costochondral cartilage without the addition of the antihelix may not provide great anatomical improvement. Furthermore, management and location of the atrial lobe from the start appears to be essential for favorable cosmetic results. The surgical evolution of the procedure showed a constant and progressive variation of his technique. Fundamental points such as the correct construction of the insole are the basis of an adequate anatomical reproduction, as well as the addition of the cartilage matrix in some areas of the insole to highlight anatomy.[7,8] The learning curve of each surgeon is based on its repetition and progressive improvement, as well as a decrease in complications in the final years of the study due to the author's confidence and familiarity with the technique practiced. In this study, the chronological periods for every 4 years were evaluated. Shorter analysis periods could be established for each year to see if there was variability due to different factors that can be evaluated, such as each time the surgeries were performed and whether their frequency could influence the technique to achieve better final results.

This study established the relationship between microtia with craniofacial anomalies and craniofacial syndromic entities, reporting 11.7% of microtias related to hemifacial microsomia (HFM) and 1% related to the Treacher Collins syndromic entity. It is very important to consider the relationship of microtia intimately with hemifacial microsomia, because 40% of patients with isolated microtia have been described to have inadvertent skeletal and soft tissue findings consistent with hemifacial microsomia.[22] An analysis of the associated deformities in patients with microtia has been reported, considering this clinical entity as a microform of hemifacial microsomia due to (1) the similar asymmetric nature of the defects, (2) the incidence and pattern of paresis of cranial nerve VII, (3) the correlation of the degree of cranial nerve VII weakness with the degree of atrial deformity and not with the severity of mandibular hypoplasia, (4) the preponderance of the right side, (5) the incidence of the lip and associated cleft palate, (6) the male predilection and (7) the equivocal mode of inheritance. These clinical observations confirm the opinion that the microtia and hemifacial microsomia have the same etiopathogenesis that is not shared by mandibulofacial dysostosis.[23]

Complications in this study occurred in 10% of the participants, of which the majority occurred in the first surgical phase. This study can be compared with that of Yao-Yao, 2019 [24], who compared the range of complications with 2 surgical techniques in a group of patients operated for 10 years. They reported 16% of complications, and the Nagata technique was the riskiest. The indispensable criteria for the success of the procedure are as follows: precision in size, orientation and symmetry in the front and rear views; accurate duplication of more than 10 atrial anatomical points; stable and permanent projection of the atrium; median chest deformity; and satisfaction with the results among at least two of the parties involved (surgeon, patient, and family). Although one of the limitations of the present study was the impossibility of evaluating the perceived satisfaction as results derived from the satisfaction of patients and relatives, this study showed a positive evaluation by an external expert doctor regarding the results of the proposed reconstruction technique to treat microtia. Another study with a long history was reported by Osorno 2007,[25] with 20 years of experience of microtia cases using the Mourman class II and III classification. Other acquired alterations of the shell ear required total or subtotal reconstruction. In that study, the complication rate was 7.53%, and the most common in his experience was scarring hypertrophy with the Brent technique.[1]

Techniques using autologous grafts are still considered the gold standard in ear reconstruction, although one of the disadvantages of the technique is related to low thoracic development that makes obtaining a large amount of costochondral cartilage difficult in pediatric patients below the established age.[1] For this reason, at an early age, other techniques such as reconstruction with allopathic atrial implants are alternatives that should be considered.

Conclusion

In this retrospective cohort study, we observed a progressively satisfactory evolution of the cosmetic results experienced among patients. Adhering to techniques that improve anatomical results is something that different authors have already experienced and are currently continuing to perfect. The solid surgical foundation of the reconstructive craniofacial surgeon plays a decisive role in the successful management of this type of surgical challenge. Costochondral cartilage is the gold standard reconstruction technique since it has a low complication rate and, although the anatomical principles for producing it are currently established, the technique requires constant adaptation to obtain better satisfaction results. In future studies, it is advisable to make annual reports where you can obtain a more concrete idea of the evolution of the surgical technique, in addition to long-term postsurgical monitoring, to evaluate possible modifications and behavior of the grafts in adulthood.

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Table 1. Mourman's Classification

Grade	Features
Grade I	Malformed auricles, with smaller size than a normal outer ear, showing. however, most of the characteristic features of the auricle normal pinna but lacking an ear canal.
Grade II	The rudimentary auricle in most was very characteristic, consisting of a low, oblong elevation, hook-formed at the cranial end corresponding to the helix. There was a complete atresia of the canal
Grade III	The auricle was more defective still, showing only a part, often a malformed lobule, while the rest of the pinna was totally absent.

Table 2. Complications in patients operated with constochondral grafts for microtia reconstruction according to clinical characteristics.

		No complications		Complications				P value
		n=369	%	n=41	%	RRc	IC 95%	
Sex								
	Female	85	23,04%	10	24,39%		1	0.845
	Male	284	76,96%	31	75,61%	0.93	(0,47-1.83)	
Age								
	7 - 10 years	247	66,90%	30	73,17%		1	0.418
	11-20 years	122	33,10%	11	26,83%	0.76	(0.39-1.47)	
Congenital microtias								
	No Syndrome	321	86,99%	37	90,24%		1	0.401
	HM IA	28	7,59%	3	7,32%	0.93	(0.30-2.86)	
	HM II	17	4,61%	0	0,00%	0.27	(0.02 -4.31)	
	Syndrome.	3	0,81%	1	2,44%	2.41	(0.43-13.5)	
Microtia side								
	Bilateral	31	8,40%	4	9,76%		1	0.957
	Right	191	51,76%	21	51,22%	0.86	(0.31-2.37)	
	Left	147	39,84%	16	39,02%	0.85	(0.30-2.41)	
Microtia grade								
	II	141	38,21%	21	51,22%		1	0.106
	III	228	61,79%	20	48,78%	0.62	(0.34-1.11)	

Performed by chi^2 and Fisher's exact test.

Table 3. Comparison of satisfaction scores according to the presence or absence of complication.

	No complications		complications		Valor p
	Median	IQR	Mediana	IQR	
Upper	4	(4-4)	3	(3-3)	0,007
Helix	5	(4-5)	4	(3-4)	0,009
Scapha	4	(3-4)	3	(2-3)	0,042
Antihelix	4	(4-5)	3	(3-4)	0,025
Triangular_fossa	4	(3-4)	3	(2-3)	0,007
Concha	4	(3-4)	3	(2-3)	0,024
Incisura	3	(3-4)	2	(2-3)	0,023
Tragus	3	(3-4)	2	(2-3)	0,045
Antitragus	4	(3-4)	3	(2-3)	0,036
Lobe	4	(3-5)	3	(2-4)	0,094

Performed using U mann-whitney

Figure Legends

Figure 1a. Line from the top of the Helix to the tail of the eyebrow (hex-ce) (A), an inferior measurement from the earlobe to the base of the column (lob-colm) (B), **Figure 1b.** A third measurement that ensures the correctly measured spatial location made from the outer edge of the eye to the tragus (cant-trg), and another measurement of the outer edge to the posterior point of the helix (cant-helix post).

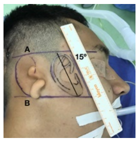
Figure 2a. Grafts corresponded with the ipsilateral side of the defect including the 6th, 7th and 8th rib **Figure 2b.** Including the 6th, 7th, and 8th ribs. 1) base, 2) antihelix, 3). helix, 4). tragus and 5). antitragus, **Figure 2c.**The projection piece for placing in the second stage of the surgical sequence, the cutaneous pocket that respects the dimensions of the previously established measurements, the upper part of the cutaneous area was elevated to cover the entire template.

Figure 3. Placement of the drains for negative pressure, hermetic closure of the tissues allows adequate adhesion of the tissue to the auricle-costochondral detail.

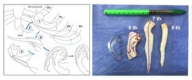
Figure 4a. Exposure of most of the posterior surface of the graft base, the ear was separated from the skull, leaving a nutritious bed of connective tissue. **Figure 4b.** The base portion of the template was covered with a skin graft taken from the inguinal region which was sutured to the posterior portion of the cartilage. Retroauricular pocket for remodeling and primary closure of the mastoid retroauricular portion. **Figure 4c.** As a space and shape maintainer, the atriocephalic angle was made of a silicone shaper, which was individually used for each patient.

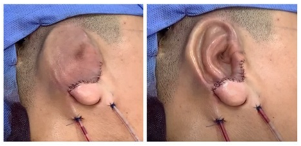
Figure 5. Distribution of complications by tertiles of year of surgical intervention.

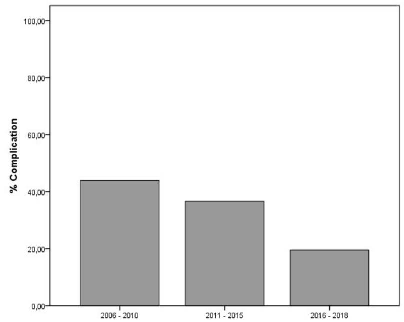
Figure 6. Satisfaction score for the different anatomical points evaluated. 5) Very dissatisfied, 4) Dissatisfied, 3) Acceptable, 2) Satisfied 1) Very satisfied.


A
15°
B

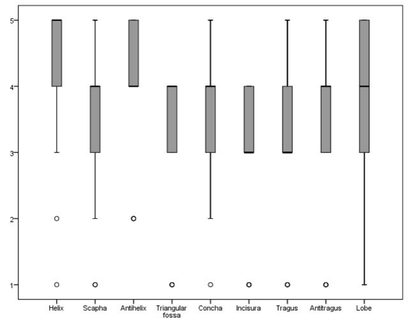

Cant-Helix Post
Cant-Trag







100,00
80,00
60,00
40,00
20,00
0,00
% Complication
2006 - 2010
2011 - 2015
2016 - 2018


5
4
3
2
1
Helix
Scapha
Antihelix
Triangular fossa
Concha
Incisura
Tragus
Antitragus
Lobe