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Endoscopic Tympanoplasty: The Fringed Shield Technique

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Research Article

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Abstract

Introduction: Endoscopic tympanoplasty has become popular in the past few years. To reach anterior quadrants of the middle-ear for adequate graft setting and complete perforation closure, most surgeons detach the remaining tympanic membrane from the umbus. This maneuver may cause elevation of the anterior tympanomeatal angle and result in blunting and worse audiometric thresholds.

Objectives: Describe a tympanoplasty endoscopic technique with a modified full thickness cartilage graft that allows its positioning without the need to detach the malleus handle from the tympanic membrane.

Data Synthesis: Because endoscopic ear surgery is an one-handed procedure, the graft needs to be stiff and easy to manipulate to facilitate its positioning and complete closure of the tympanic perforation. We describe a full thickness tragal cartilage graft shaped as an oval island with a wedge to accommodate the malleus handle and with the anterior and posterior edges fringed. This design allows its positioning in an underlay technique without the need to detach the malleus handle from the tympanic membrane. Thereby, without this maneuver, it is possible to prevent blunting and, consequently, reduce the odds of hearing loss.

Conclusion: The fringed shield technique is a promising endoscopic approach with good hearing results. Although the hearing outcomes presented in this paper are not exclusive for the fringed shield technique, we would not expect different results since we have applied full thickness cartilage graft in most cases. Nevertheless, a larger series of patients submitted exclusively to the fringed shield graft would be necessary to confirm these data.

Keywords: Tympanoplasty; Endoscope; Ear Cartilage; Tympanic Membrane Perforation; Otitis Media

Introduction

The term tympanoplasty was described in 1953 by Horst Wüllstein, who reported a reconstruction technique for eardrum and ossicular chain in patients with chronic otitis media [1]. The procedure can be performed microscopically and, more recently, endoscopically. The use of the endoscope has become popular in the past few years. It provides a wide view of the surgical field, with magnification and better view of all perforation margins, high resolution, and it uses the external auditory canal as a natural surgical gateway [2]. Reduced morbidity, shorter operation time, less postoperative pain and higher cosmetic satisfaction are also benefits of endoscopic tympanoplasty [3-5].

Currently, there are several studies about tympanoplasties in the literature, which describes novel techniques, methods and varying types of grafts for tympanic

membrane reconstruction [6]. Regarding the grafts, their use depends on the preferences and experiences of the surgeons, and also on the quadrant of the tympanic membrane in which the perforation or retraction is located [7].

In 1995, Duckert et al were the first to report the cartilage shield tympanoplasty, a round full-thickness cartilage-perichondrium composite island with a wedge to accommodate the malleus handle [8]. Over the years, different types of cartilages have been used, such as tragal, conchal and costal cartilage [9]. Currently, the cartilage shield graft has been popularized by various authors Cavaliere M, et al. [10-13], mainly because of the acoustic gain obtained by the incorporation of the malleus in the graft [10,14].

Despite the generally good audiometric postoperative results, some authors claim that cartilage shield tympanoplasty can lead to reduction in hearing thresholds when the detachment of the tympanic membrane from the umbus is needed. This maneuver facilitates and allows a correctly cartilage graft positioning in patients with anterior perforation. According to them, this maneuver may cause an elevation of the tympanomeatal angle, the "blunting", that leads to worsen audiometric results [15,16]. However, the real impact of detaching and reinserting the tympanic membrane from the umbus during endoscopic ear approach has not been properly reported yet [16].

Considering these possible complications and the types of grafts that can be used, the present study describes an endoscopic tympanoplasty surgical technique using a modified cartilage perichondrium shield graft in which it is not necessary to detach the malleus handle from the tympanic membrane to reach its anterosuperior quadrant and to close its perforation. Thus, because of the graft design, it is possible to prevent the "blunting" and, consequently, worse hearing thresholds.

Review of a Particular Subject

Tympanic membrane perforation is a common condition in an otorhinolaryngology practice that usually requires surgical repair [17]. Patients complain of hearing loss and intermittent otorrhea, and this condition can lead to numerous complications such as mastoiditis or even meningitis. During tympanoplasty, the tympanic membrane is mobilized from its original position and the middle ear and ossicles are evaluated [1].

Since its introduction in the 1950s [18], varieties of surgical techniques and graft materials have been described to repair perforations and retractions of the membrane [10]. Endoscopic ear surgeries were initially performed in the 1990s and, despite the popularity they have gained during the last years, conventional microscopic tympanoplasty remains the most common technique [4]. The possibility of elevation of the tympanomeatal flap by transcanal approach avoids unnecessary incisions and soft tissue dissections. [5] Moreover, the endoscope provides better and larger field of view, with better visualization of hidden areas in the middle ear cavity, such as the hypotympanum, the facial recess, the tympanic sinus and the anterior and posterior epitympanic spaces when compared to the microscope. Its use allows a broad visualization of the tympanic cavity and proper reconstruction of the tympanic membrane, even when the perforation is on the anterior quadrant of the membrane [19,20].

Regarding grafts used to repair membrane perforation, biological materials such as temporalis muscle fascia, perichondrium, tragal cartilage, fat, skin and veins are preferable to artificial grafts [7,21]. Its use varies depending on the preference and experience of the surgeon, but temporalis fascia and perichondrium remains the most used grafts, with a successful closure rate of 80 to 90% [22,23]. Utech was the first to introduce cartilage in middle ear surgery in 1959 Utech H, et al. [24] and Heermann introduced the cartilage palisade technique in 1962, in which cartilage strips were placed parallel to the malleus until the middle-ear cavity was covered, preserving its perichondrium on the outer surface [25].

Over the years, the design of composite cartilage–perichondrial graft has been modified into the shape of a "shield" [8] "double islands" [23] "Mercedes Benz" sign [26] "wheel" [27] "Boomerang", [28] "lamellae" [29] or "crowncork" [30] among others. This increasing interest in the use of cartilage graft with or without perichondrium to repair tympanic membrane perforations is due to its rigidity and bradytrophic metabolism that makes it particularly suitable for difficult conditions, such as adhesive otitis, subtotal perforations and reoperation [31]. Besides, this material is also known for its resistance to reabsorption, retraction and negative pressure in the middle ear, with adequate elasticity for sound transmission [32,33]. However, there are no significant differences in hearing improvement between patients submitted to tympanoplasty using fascia temporalis or cartilage graft [34,35].

Attic reconstructions, atelectasis and cases of suspected eustachian tube dysfunction requires the use of a rigid graft, such as cartilage. Tragal cartilage is an excellent graft, especially for endoscopic tympanoplasties, because it is easily accessible and its rigidity makes it easy to fashion and manipulate, reducing the learning curve in endoscopic tympanoplasty [36]. The main controversy about its use is related to its thickness, and there are few data in literature on the acoustic benefits of trimming a tragal cartilage graft

[37].

Gokgoz, et al. [37]; Atef, et al. [38] analyzed the use of full and partial thickness tragal cartilage-perichondrium grafts in two groups of patients and observed that the hearing improvement in both groups was similar. Vadiya, et al. [39] reported the same findings, except at the frequency of 4.000 Hz, in which the hearing improvement in patients who received partial thickness cartilage graft was better, but not statistically significant, than in those who the full thickness cartilage was used. The full thickness graft is easier to manipulate and to place in the right position than the partial thickness graft, since the sliced perichondrium contracts and leads the edges of the graft to curl to the same side, making it difficult to be placed in an underlay manner [6,36].

In endoscopic ear procedures, to access anterior extensions of middle-ear diseases, most surgeons detach the tympanic membrane from the umbus [16]. Although there are few data in the literature, the main complication of this maneuver may be the development of blunting, an obliteration of the tympanomeatal angle due to excess of fibrous tissue formation, without any underlying pathology, caused by an excessive release of the anterior edge of the annulus, that may lead to hearing loss [40,41]. Mullin, et al. [15] corroborated that blunting of the tympanomeatal angle decreases the sound transfer function of the tympanic membrane and middle ear, emphasizing the importance of its prevention during tympanoplasty surgeries.

One has to remember that since endoscopic ear surgery is a one-handed procedure, the graft needs to be rigid but also easy to manipulate, in order to facilitate its positioning and complete closure of the membrane perforation. As a result of this, a cartilage graft would be preferable. It is important, although, to create a design that would maintain stiffness and at the same time permit good maneuverability inside middle ear in order to diminish ossicles and membrane manipulation. Based on these data and considering the site of perforation in the membrane, 33 of our patients had a full thickness tragal cartilage and perichondrium graft with different designs.

Although hearing loss due to blunting of the tympanomeatal angle was not observed in our patients, we describe the fringed shield technique which is a modified full thickness tragal cartilage graft that does not require detachment of the malleus handle from the tympanic membrane even when the perforation site is on anterior quadrants.

Discussion

Surgical Technique

The patient is laid on supine position and there is no need for trichotomy. A three-chip high-definition camera (Astus medical, São Paulo, Brazil) is placed in front of the surgeon and the surgical instruments are the same as in surgeries performed with a microscope. It is used a Storz® rigid endoscope with 3-mm diameter and 14-cm long, at 0º angulation (Karl Storz GmbH & Co. KG -Tuttlingen, Germany).

The procedure is performed under general anesthesia, preferably total intravenous anesthesia. Local anesthetic (2% lidocaine with adrenaline) is injected retroauricular in a three-way maneuver and on the concha and tragus after skin disinfection (Figure 1).

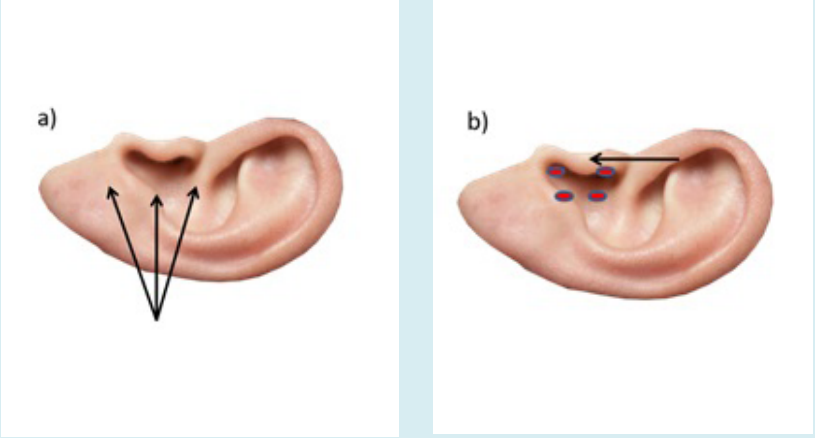

Figure 1: Local retroauricular anesthesia in a three-way maneuver (a); and in concha and tragus (b).

Refreshing the edges of the perforation margins is carried out and adrenaline soaked on cotton balls is placed in the ear canal lateral to the tympanic membrane. Posterior ear canal incision can be performed with a sharp instrument or ball tip electrocautery. The horizontal incision is approximately 1,5cm lateral to the membrane and the vertical incision is done at 6 and 12 o´clock. Subsequently, a tympanomeatal flap is elevated and the mobility of the ossicular chain is tested.

Video 1:
https://medwinpublishers.com/articlevideos/ooajarticle.php

A full thickness cartilage graft is collected from tragus and perichondrium is removed from both sides. The average thickness of the graft is around 1mm and it is shaped as an oval island with a wedge to accommodate the malleus handle. Anterior and posterior edges of the graft are then fringed to facilitate its positioning in an underlay technique without the need to detach the malleus handle from the tympanic membrane (Figure 2). The graft is slid in between the malleus handle and incus and positioned on the perforation site. Tragal perichondrium is applied to reinforce the reconstruction where needed. Afterwards, the tympanomeatal flap is repositioned and an absorbable packing (Gelfoam®) is placed inside the external auditory canal.

Figure 2: Fringed shield graft design.

Endoscopic Ear Surgery Experience and Results

A retrospective study was conducted from the analysis of medical records of patients submitted to endoscopic tympanoplasty in a Brazilian tertiary hospital from June 2017 to October 2020 by the same surgeon. All patients diagnosed with chronic otitis media and tympanic membrane perforation, without evidence of mastoid involvement on tomographic study, were included. Medical records with incomplete data and patients who were lost through follow-up were excluded.

Statistical analyses were performed using SPSS version 20.0 software. Data were presented in tables and graphics with the absolute frequencies and their respective percentages, as well as the descriptive measures for the quantitative data. These quantitative variables were tested for normality using the Kolmogorov-Smirnov test. As they had a normal distribution, parametric tests were used. A pre and postoperative comparison of the audiometric parameters was made through paired sample T test. In all tests, the level of significance adopted was 5%.

We analyzed patients´ age, gender, graft shape used in the tympanoplasty, the need to detach the malleus handle from the tympanic membrane during the procedure and postoperative complications. The pre and postoperative tone audiograms were analyzed in individual frequencies from 250 Hz and 8000 Hz, as well as the mean air-bone gap and speech recognition threshold (SRT) improvement. The project was submitted and approved by the local Research Ethics Committee, under the protocol number 36476920.6.0000.5125.

Among 35 patients who underwent endoscopic tympanoplasty surgeries, 15 were females (42.9%) and 20 were males (57.1%), with a mean age of 37.8 years (± 16,8), ranging from 6 to 73 years. Regarding the type of graft used, cartilage and perichondrium were used in 32 patients (91.4%). In 2 patients (5.7%) a temporalis fascia graft was used, and another patient (2.9%) received a temporalis fascia associated with cartilage and perichondrium graft. All patients had complete closure of perforation in 6 months follow up.

Before fringed shield technique, in 7 patients (20%) we had to completely detach the tympanic membrane from the malleus handle to allow correct positioning of the full thickness tragal cartilage graft. This maneuver had to be done very carefully since the tympanic membrane connective layer is rigidly connected to the malleus periosteum. Considering that the inner ear acts as a lever, any force exerted on the apical portion of the malleus increases its effects on incus, stapes, and inner ear, the "lever's resistance arm", escalating the risk of a possible sensorineural hearing loss. [42] We did not detect blunting or hearing loss in these patients.

Statistical analysis of the pre and postoperative data described in Table 1 revealed that preoperative hearing thresholds were worse than postoperative values, with significant difference in low and medium frequencies. These data were corroborated by Gokgoz, et al. [37], who observed significant reduction in postoperative air-bone gap and improvement in postoperative pure tone audiometry values between 500 Hz and 4.000 Hz in 55 patients submitted to endoscopic tympanoplasty.

Audiometric frequencies	N	Preoperative	Postoperative mean values (±SD)	CI 95%	p value
		mean values (±SD)			
250	35	41,8 (±16,2)	24,2 (±12,1)	13,0 ; 22,2	<0,001
500 a	35	38,0 (±15,7)	23,1 (±11,1)	10,5 ; 19,2	<0,001
500 b	35	14,3 (±10,7)	12,7 (±9,1)	-1,8 ; 4,9	0,348
1000 a	35	34,7 (±15,9)	21,4 (±10,0)	9,3 ; 17,3	<0,001
1000 b	35	12,9 (±10,3)	11,0 (±9,2)	-0,75 ; 4,5	0,156
2000 a	35	35,7 (±18,9)	21,3 (±16,4)	10,5 ; 18,3	<0,001
2000 b	35	16,6 (±15,7)	13,9 (±15,3)	-0,8 ; 6,2	0,126
3000 a	35	39,4 (±19,6)	27,7 (±18,6)	7,7 ; 15,7	<0,001
3000 b	34	17,6 (±15,6)	16,8 (±15,6)	-2,4 ; 4,1	0,585
4000 a	34	42,8 (±21,5)	36,0 (±22,0)	2,4 ; 11,1	0,004
4000 b	34	20,9 (±18,7)	19,4 (±17,8)	-2,9 ; 5,8	0,496
6000	33	44,2 (±24,8)	40,9 (±22,8)	-1,7 ; 8,3	0,185
8000	32	37,3 (±20,0)	36,7 (±18,2)	-4,5 ; 5,8	0,806

SD - standard deviation; a - air conduction; b - bone conduction.

Table 1: Comparison of pre and postoperative hearing thresholds classified per frequencies.

Pre and postoperative mean air-bone gap (ABG) (500 Hz – 4000 Hz) and speech recognition threshold (SRT) are represented in figures 3 and 4, with a 95% confidence interval. The widest mean air-bone gap was 28.1 (± 8.1) dB in the preoperative period and 16.7 (± 9.3) dB after the procedure ($p < 0.001$). Similarly, the mean SRT ranged from 35.8 (± 13.5) dB in the preoperative period to 24.4 (± 11.2) dB ($p < 0.001$) after surgery (Figures 3 & 4).

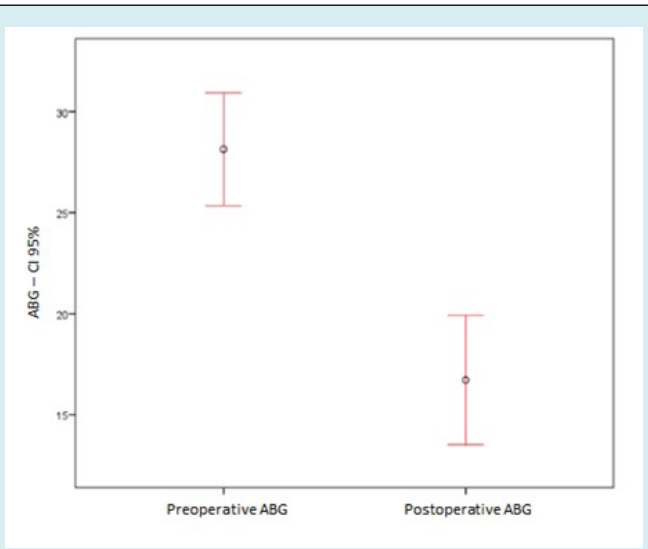

Figure 3: Comparison of the pre and postoperative ABG results. ABG: air-bone gap; CI: confidence interval.

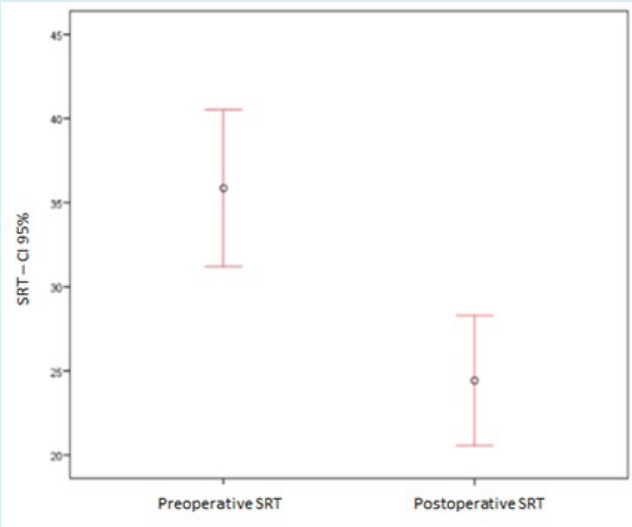

Figure 4: Comparison of the pre and postoperative SRT results. SRT: speech recognition threshold; CI: confidence interval.

Significant hearing improvements were observed in pure tone audiometric air conduction thresholds from 250 to 4000 Hz. Although there was a significant increase at 4000 Hz thresholds, its improvement was minor when compared to other frequencies. Previous papers reported that there is no significant difference in terms of hearing outcomes at 4000 Hz when the graft used is fascia or cartilage or when the cartilage graft is trimmed or not [34-38]. However, similar to

our results, other authors observed a smaller gain at 4 kHz with full thickness cartilage graft [16,39].

The highest preoperative air-bone gap was 40 dB, except in one patient who had a 55 dB air-bone gap, with a mean of 28.1 (± 8.1) dB. In the postoperative analysis, the highest air-bone gap was 35 dB, and the mean was 16.7 (± 9.3) dB. According to many authors, a successful outcome is considered when the postoperative air-bone gap is less than 20 dB [16]. In our study, 68.6% (24) patients had an air-bone gap less than or equal to 20 dB.

Endoscopic ear surgery has gained popularity in the past few years due to its wide view, magnification and high resolution of the surgical field, reduced patient morbidity, shorter operation time and less postoperative pain [2-5]. Despite some disadvantages, such as one handed surgery, more and more surgeons are using the endoscope to perform timpanoplasties [16,37]. The choice and design of the graft in these procedures has to keep the same goals of the surgery: be less invasive and create less morbidity. By using the fringed shield technique, we no longer have to detach the malleus handle from the tympanic membrane in order to achieve complete closure of anterior quadrants perforations. Although we did not have any complications regarding blunting or sensorineural hearing loss in our first surgeries when detaching the malleus from the membrane, it is important to keep in mind that these complications exist, and it is always better to avoid them.

Final Comments

The fringed shield is an endoscopic tympanoplasty technique that uses a modified full thickness tragal cartilage graft. In this technique, the graft is positioned underlay and it is not necessary to detach the malleus handle from the tympanic membrane to reach its anterior quadrants to close the perforation. By avoiding this maneuver, the risk of blunting or sensorineural hearing loss because of ossicles manipulation is diminished. Although our hearing outcomes are not exclusive for the fringed shield technique, we would not expect different results since we have applied full thickness cartilage graft to most cases. Nevertheless, a larger series of patients submitted exclusively to the fringed shield graft would be necessary to confirm these data [40].

Declarations

- **Funding**

No funding was received to assist with the preparation of this manuscript.

- **Conflicts of interest/Competing Interests**

The authors have no conflicts of interest to declare that are relevant to the content of this article.

- **Ethics Approval**

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the local Bioethics Committee under the protocol number 36476920.6.0000.5125.

- **Availability of Data and Material**

All data is available for appraisal.

- **Code Availability**

Not applicable

- **Authors' Contributions**

Rossi-Monteiro, EM: selected patients, conceived and outlined the study, coordinated and supervised data collection, analyzed and interpreted the data, drafted, edited and critically reviewed the manuscript for important intellectual content.

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