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EFFECTIVENESS AND SAFETY OF OTOENDOSCOPIC SURGERY USING ATTIC EXPOSITION-ANTRUM EXCLUSION VERSUS MICROSCOPIC CANAL WALL-UP TYMPANOMASTOIDECTOMY IN PATIENTS WITH ACQUIRED CHOLESTEATOMA STAGES IB AND II AFFECTING THE TYMPANIC CAVITY AND ATTIC.

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Disclosure of interest

- We confirm that neither the manuscript nor any parts of its content are currently under consideration or published in any other journal.
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Ethics

This research was approved by the Ethics Committee (2020/86).

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ABSTRACT:

The aim of this study is to test the effectiveness and safety of AE-AE surgery combining otoendoscopy and surgical microscopy in the treatment of acquired pars flaccida cholesteatoma in stages Ib and II of the Japan Otological Society classification occupying the tympanic cavity and attic. A historical cohort study on 65 patients. Of the total, 44 patients were treated by AE-AE surgery using an otoendoscope and 21 with canal wall-up tympanomastoidectomy (CWUT). Patients in whom the AE-AE technique was performed had a lower recurrence rate (9%) compared to those treated with CWUT (38%); p=0.013. In addition, the median time to recurrence was lower in the AE-AE group (4 years [P25-75= 1.25-2-75]) than in CWUT group (2 years [P25-75= 3.25-4.75]); p=0.048. Thresholds were higher in the CWUT group compared to the AE-AE group in pre-surgery (53±16 vs 44±15; p=0.039) and post-surgery (52±18 vs 42±16 dB dB; p=0.042), but not in pre-post-surgery comparisons neither in the AE-AE technique (p= 0.89) nor in the CWUT technique (p= 0.96). We concluded that AE with otoendoscopic support is an effective and safe technique for acquired cholesteatomas occupying box and attic in stages IB and II.

Keywords: Cholesteatoma, attic exposition-antrum exclusion, wall-up tympanomastoidectomy.

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INTRODUCTION

Middle ear cholesteatoma consists in the existence of epithelial tissue in the tympanic and mastoid cavity with an aggressive and destructive behavior [1]. Although the prevalence differs according to ethnic group, the annual incidence of acquired cholesteatoma is estimated between 9-12.6 cases/100,000 adults and 3-15 cases/100,000 children [2]. As an alternative, Olaizola *et al*. [3] described the on-demand technique in the treatment of cholesteatoma, the technique of attic exposition-antrum exclusion (AE-AE).

AE-AE is technically and conceptually characterized by the complete exposure of the attic by reaming the upper wall of the external auditory canal called transcanal epitympanectomy, which allows the exclusion of the antrum and mastoid by closing the additus using cartilaginous grafts.

The attic is then successfully exposed for a complete excision of the cholesteatoma and the probability of recurrence of acquired cholesteatomas that frequently affect this space is reduced. The closure of the mastoid space reduces the exposed space and favors the self-cleaning of the attic, allowing the entry of water without vertigo crisis and with low risk of infections. This technique does not interfere with the performance of ossiculoplasty.

Finally, we believe that the use of otoendoscopy in this technique reduces recurrence due to persistent cholesteatoma, mainly in sinus-tympani and mastoid antrum. The introduction of the endoscope has also been significant in ossicular reconstruction.

The objective of this study is to estimate the effectiveness and safety of AE-AE with endoscopic support when used for acquired cholesteatomas occupying the tympanic cavity and attic stages Ib and II of the Japan Otological Society classification [1] (Table 1) (Figure 1).

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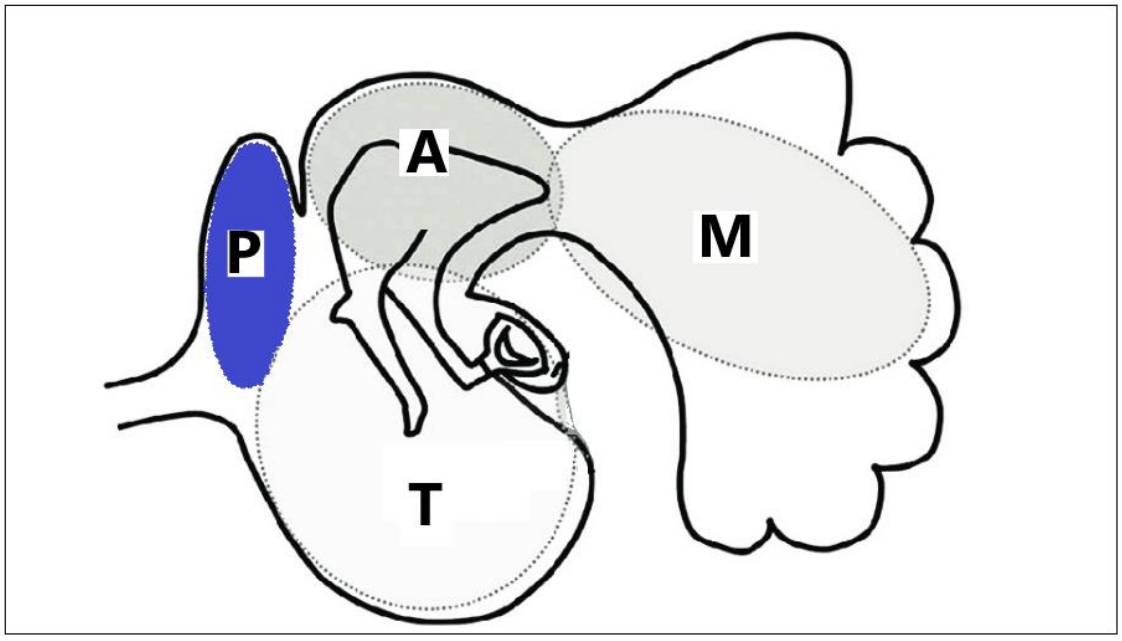
Table 1. Japan Otological Society classification Stages of cholesteatoma. (Adapted from Tetsuya Tono et al. [1] 2017).

Stage
I: Cholesteatoma localized in the attic.
Ia: A retraction pocket with epithelial self-cleaning function.
Ib: A retraction pocket with persistent accumulation of keratin-debris.
II: Cholesteatoma involving two or more sites.
III: cholesteatoma with intratemporal complications and/or pathologic complications.
IV : Cholesteatoma with intracranial complications

Figure 1. Schematic drawing of divisions of the tympanomastoid space. The tympanomastoid space is divided into four sections: the protympanum (P), the tympanic cavity (T), the attic (A) and the mastoid (M) in order to represent the extent of cholesteatoma. (Adapted from Tetsuya Tono et al. [1] 2017).



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MATERIALS AND METHODS

Design and patients

Using a historical cohort design, 65 patients undergoing first surgery between 2001 and 2019 with the diagnosis of acquired attic and case cholesteatoma, stage Ib and II were included [1].

This research was approved by the Ethics Committee (2020/86). All patients were operated by a) AE-AE technique with the use of otoendoscopes or b) canal wall-up tympanomastoidectomy technique. The stage was established from the operative findings recorded in the clinical history, reviewing the extent described in the surgical protocol and confirming the histopathological diagnosis of pathological anatomy.

All patients underwent preoperative computed axial tomography and underwent surgery with intraoperative facial nerve monitoring according to protocol [4].

Audiometry was performed before surgery and between 3 and 6 months post-surgery, measuring the hearing levels of the bone and airways in the 500, 1000 and 2000 Hz frequencies (pure tone average: PTA) to assess hearing levels and hearing gain [5]. We also determined the difference between airway and bone conduction gap (ABG) pre- and post-surgery and determined if it was less than 20 dB, which we will use as a criterion of good post-surgical hearing outcome.

When necessary, patients underwent an ossiculoplasty in the same surgical act of cholesteatoma exeresis, using pinna or tragus cartilage over the stapes in partial recurrences or total titanium prosthesis. Treatment of the tympanic membrane was performed with temporalis muscle fascia or tragus perichondrium.

Exclusion criteria were the absence of cholesteatoma during surgery, that the cholesteatoma was not acquired from pars flaccida, that it was not a cholesteatoma stage other than Ib or II, that it was not a first intervention on the pathological ear and that a surgical technique other than AE-AE with the use of otoendoscopes or canal wall-up tympanomastoidectomies was used.

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Age, sex, ear operated, and time of recurrence, if any, were also recorded in the clinical history.

Surgical Procedure

The phases of the surgical techniques are presented below, which follow the steps previously described [6,7,8], adding the use of 14 mm long and 2.7 mm diameter otoendocope with angulations of 0º and 30º.

Incision and surgical approach

Surgery is performed under general anesthesia, infiltration of the external auditory canal and retroauricular planes with local anesthetic and vasoconstrictor. The posterior and superior tympanomeatal flap is performed and the approach is retroauricular to access the external auditory canal (EAC) and tympanic membrane.

Aticotomy

Under microscopic control the superior wall of the EAC is reamed, exposing the entire tegmen tympani. Once the attic is completely exposed (fig. 2), the cholesteatoma is removed. If it invades the medial region of the attic, it would be necessary to remove the incus and the head of the malleus. At this point we implemented the use of otoendoscopes of 0º and 30º degrees to check the sinus tympani and excise the cholesteatoma if present in this space, checking that there was no disease in the antrum and mastoid. **Figure 2.** Potsurgical image of AE-AE without osiculoplasty. The yellow star: Atticotomy. Blue circle: Head of the malleus. Blue arrow: Handle of the malleus. Green arrow: Incus. Red arrow: Antro exclusion with cartilage. Blue square: tympanic membrane.

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Tympanoplasty

This technique allows the tympano-ossicular reconstruction according to the needs. At this time we perform it with otoendoscopy, which allows us to ensure the correct contact in the reconstruction.

Closure of the additus

Once the cholesteatoma has been removed, we proceed to the closure of the additus and therefore to the antroexclusion using several pieces of cartilage. Here again the use of endoscopes allows for perfect antroexclusion.

Meatoplasty

To favor the marsupialization of the attic and self-cleaning we perform an upper meatoplasty by incision at 12 o'clock in the upper wall of the EAC and removal of cartilaginous tissues. We place tamponade with edge gauze soaked in cream with antibiotics and corticosteroids and remove it in 10 days.

Statistical analysis

Categorical variables are expressed as frequencies and percentages. Quantitative variables are expressed as means and standard deviations. The proportions between surgical groups for sex, affected ear, stage of cholesteatoma, facial nerve dehiscence, reconstruction, recurrence and GAP were compared with the chi-square test or Fisher's exact test, as appropriated. Comparison between surgical groups for age, time to

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recurrence and audiometry was carried out with the Mann-Whitney test. The pre/post-surgery period within each surgical group was carried out with the Friedman or Wilkoxon tests, as appropriated. All p-values below 0.05 were considered statistically significant. Statistical analysis was performed with SPSS (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY).

RESULTS

Sixty-five patients were included in the analysis, divided into 2 groups according to whether the surgical technique was AE-AE with endoscopes or canal wall-up tympanomastoidectomy. The distribution and demographic variables are shown in Table 2. No differences were observed between the 2 groups regarding age, sex or affected ear.

In patients in whom AE-AE technique was performed, a lower recurrence rate was observed (9%) compared to those treated with CWUT (38%); p=0.013, in addition, the median time to recurrence was lower in the AE-AE group (4 years [P25-75= 1.25-2-75]) than in CWUT (2 years [P25-75= 3.25-4.75]); p=0.048. (Figure 3 and Table 2).

Figure 3. Comparison of recurrence rates according to type of surgery.

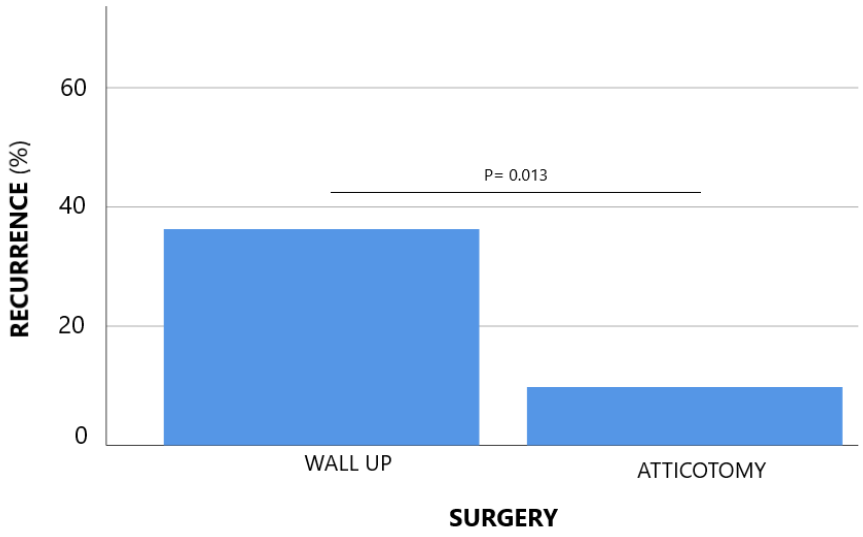

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Table 2. Baseline clinical characteristics.

	TYPE OF SURGERY		
	WALL-UP n= 21	ATTICOTOMY n= 44	**p-value**
Age (years)	48±20	43±16	0.23
Sex (male)	17(81)	27(61)	0.11
Affected Ear (right) − n(%)	10(47.6)	25(56.8)	0.49
Surgery Time (min)	-	146±30.7	
Healing time (days)	-	59±36.7	
Stage of cholesteatoma − n (%)			0.18
A1b	5(24)	18(41)	
2	16(76)	26(59)	
Reconstruction − n(%)			0.36
No	3(14.3)	10(22.7)	
Stapes stabilizing cartilage graft	11(52.4)	26(59.1)	
Total Protesis	7(33.3)	8(18.2)	
Facial nerve dehiscence − n(%)	3(15.8)	8(15.9)	0.99
Recurrence − n(%)	8(38.1)	4 (9.1)	0.013
Time to recurrence* (years)	2 (1.25-2.75)	4(3.25-4.75)	0.048

*Expressed as Median (P_{25}-P_{75})

The most frequent reconstruction technique for the chain was cartilage over stapes, both in the AE-AE group (59.1%) and in the CWUT group (52.4%). No differences were observed in the neurophysiological dehiscence of the facial tympanic portion.

Thresholds were higher in the CWUT group compared to the AE-AE group in pre-surgery (53±16 dB vs 44±15 dB; p=0.039) as well as post-surgery (52±18 dB vs 42±16 dB; p= 0.042), but not in pre-post-surgery comparisons either within the AE-AE technique (p= 0.89) or within the CWUT technique (p= 0.96) (Table 3).

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Table 3. Audiological results comparing for types of surgery and reconstruction.

	TYPE OF SURGERY		p-value
	WALL-UP n= 21	ATTICOTOMY n= 44	
Audiometry (Db)			
Globally			
Presurgery	53±16	44±15	0.039
Postsurgery	52±18	42±16	0.042
p-value	0.96	0.89	
Comparing the type of reconstruction			
- No			
Presurgery	50±20	37±24	0.28
Postsurgery	48±19	39±18	0.50
p-value	0.52	0.47	
- Stapes stabilizing cartilage graft			
Presurgery	54±16	45±13	0.09
Postsurgery	50±20	41±14	0.20
p-value	0.66	0.67	
- Total Protesis			
Presurgery	45±10	47±10	0.69
Postsurgery	57±13	46±18	0.35
p-value	0.22	0.41	
GAP (-20 Db) – n(%)			
Globally	19(43.2)	11(52.4)	0.49
Comparing the type of reconstruction			
- No	7(70)	3(100)	0.33
- Stapes stabilizing cartilage graft	11(42.3)	6(54.5)	
- Total Protesis	1(12.5)	2(28.6)	
p-value	0.049	0.11	

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Finally, no differences in GAP were found overall between both groups (p=0.49) or when comparing the hearing levels of partial reconstruction with cartilage over stapes (Table 3).

The continuity of the ossicular chain was restored in 85.7% of the canal wall-up tympanomastoidectomies and in 77.3% of the AE-AE. The most frequently used ossiculoplasty in both groups was the use of cartilage over the stapes suprastructure, being less frequent the reconstruction with total titanium prosthesis (Table 3).

DISCUSSION

The main objective of surgical treatment of cholesteatoma is its removal with the minimum rate of recurrence, for which canal wall-up and canal wall-down techniques have classically been performed depending on multiple factors. For cholesteatomas of the box and attic, stages Ib and II, we have used the AE-AE techniques performed in the 80's [3,6,7,8], in which the demolition of the upper wall of the EAC allowed an optimal access to the eptympanum. By adding the use of otoendoscopes of 0 and 30º we have managed to improve the control of spaces such as the sinus tympani, frequent place of cholesteatoma recurrence, as well as the supratubaric fossa.

In the present study we have evidenced a lower recurrence rate in acquired cholesteatomas of the box and attic in stages Ib and II when using the AE-AE technique combined with the use of otoendoscopy, as opposed to the canal wall-up technique. When we contrast our results with other authors, we see that the canal wall-up techniques have a recurrence rate between 17 and 61% [9], but it is difficult to verify homogeneity in the populations. The recurrence rate of AE-AE in some series ranges from 4.2% [10], 4.8% [8] to 8.7% [7].

We believe that several factors influence the decrease in the recurrence rate in AE-AE. First, an important number of recurrences appear in superior tympanic retractions; having the attic externalized towards the EAC eliminates this possibility and having the antrum excluded prevents the emigration of epithelium from the attic towards the mastoid. On the other hand, in AE-AE the ligamentous diaphragm is removed and with it the possibility of epitympanic ventilatory dysfunction.

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The fact that the antrum is excluded could suggest that we lose control over a possible mastoid recurrence, but this situation did not occur, since all recurrences were located in the posterior part of the mesotympanum/sinus tympani, manifesting as persistent otorrhea, and were all resolved by excision with otoendoscopy, without performing mastoidectomy. In contrast to other authors[8] we monitor patients in our department through regular consultations and examination with otoendoscopes and microscopy and we only use diffusion sequence MRI in case of suspected recurrence or complication, since diffusion sequence MRI has a high reliability for the detection of cholesteatomas, especially when they are larger than 2 mm [11].

In this study there are differences in the time of recurrence, being 4 years in patients operated by AE-AE with the use of otoendoscopy and 2 years in the group operated by canal wall-up thymanomastoidectomy. We believe that this difference is due to the fact that the use of otoendoscopes with angled lenses allows the revision and cleaning of difficult access locations such as the supratubaric fossa and sinus tympani, decreasing the probability of residual cholesteatoma.

In the group of patients treated with AE-AE with otoendoscopes, the most frequent treatment of the chain was partial reconstruction with cartilage on the stapes superstructure. We preferred autologous material to other types of materials, as we believe, in line with other authors, that it does not provide functional benefits [12], and allows us to reinforce the tympanic membrane, achieving acceptable functional results with post-surgical thresholds of 41 dB and a residual ABG of less than 20 dB, data consistent with the resulting bibliography [12]. In 18.2% of the patients we performed a total reconstruction with titanium prosthesis, obtaining thresholds of 46 dB and a residual ABG of less than 20 dB in 28.6%. We found no statistically significant differences between partial reconstruction with cartilage over stapes and total reconstruction with titanium prosthesis when studying ABG, which is consistent with the literature [13].

CONCLUSIONS

AE-AE utilizing the otoendoscope is a technique that significantly reduces the rate of cholesteatoma recurrence and its time of appearance with good auditive results. It

allows an excellent quality of life, a normalization of bathing and a reduction of surgical revisions when we use it in attic acquired cholesteatomas.

REFERENCES

1. Tono, T. *et al.* Staging and classification criteria for middle ear cholesteatoma proposed by the Japan Otological Society. *Auris Nasu. Larynx* ***2017***, 44, 135–140.

2. Kuo C-L, Shiao A-S, Yung M, Sakagami M, Sudhoff H, Wang C-H, et al. Updates and knowledge gaps in cho- lesteatoma research. BioMed Res Int **2015**, 1-17, http://dx.doi.org/10.1155/2015/854024.

3. Olaizola, F. Tympanoplasty: a 5-year review of results using the a la demanda (AAD) technique - PubMed. *Am J Otol.* Available at: https://pubmed.ncbi.nlm.nih.gov/3177617/.

4. Arias-Marzán, F. *et al.* Facial canal dehiscence in patients with cholesteatoma: concordance between intraoperative inspection, computed tomography and neurophysiological findings. *Eur. Arch. Otorhinolaryngol* **2019**, 276, 1915–1920.

5. Debonis, DA; Donohue, C. *Survery of Audiology : Fundamentals for Audiologist and Health Professionals.* (Allyn & Bacon, 2007).

6. R A Ramírez Camacho. [Cholesteatoma: controversies between the functional and healing purpose of its surgical treatment] - PubMed. *An Otorrinolaringol Ibero Am* **1985**, 12, 559–67.

7. Villarejo, P. Lóp., BaÑOs, E. C. & Ramos, J. The antrum exclusion technique in cholesteatoma surgery. *J Laryngol Otol* **1992**, 106, 120–123.

8. Manrique, R., Sanhueza, I. & Manrique, M. [Attic exposure-antrum exclusion as an on demand surgical technique for cholesteatoma]. *Acta Otorrinolaringol Esp* **2013**, 64, 22–30.

9. Kerckhoffs, K. G. P. *et al.* The disease recurrence rate after the canal wall up or canal wall down technique in adults. *Laryngoscope* **2016**, 126, 980–987.

10. Vaamonde Lago, P., Frade González, C., Castro Vilas, C., Lechuga García, R. & Labella Caballero, T. [Results of tympanoplasty with antrum exclusion in the treatment of middle ear cholesteatoma]. *Acta Otorrinolaringol Esp* **2001**, 52, 9–13 (2001).

11. Migirov, L., Wolf, M., Greenberg, G. & Eyal, A. Non-EPI DW MRI in planning the surgical approach to primary and recurrent cholesteatoma. *Otol Neurotol* **2014,** 35, 121–

 doi:10.20944/preprints202207.0235.v1

125.

12. Quérat, C., Martin, C., Prades, J. M. & Richard, C. Canal wall up tympanoplasty for cholesteatoma with intact stapes. Comparison of hearing results between cartilage and PORP on stapes and impact of malleus removal and total reinforcement of the tympanic membrane by cartilage. *Eur. Ann. Otorhinolaryngol. Head Neck Dis* **2014**, 131, 211–216.

13. Lailach, S. *et al.* Hearing outcome after sequential cholesteatoma surgery. *Eur. Arch. Otorhinolaryngol* **2016**, 273, 2035–2046.