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Hearing results after type III tympanoplasty: incus transposition versus PORP. A systematic review

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ABSTRACT

Objective: The objective of this study is to compare hearing improvements in the air-bone gap (ABG) after type III tympanoplasties, comparing between incus transposition (IT) and partial ossicular replacement prosthesis (PORP).

Materials and methods: Publications in English were searched in PUBMED database and were systematically reviewed. A total of 14 articles were included, obtaining 1055 patients, 614 for the IT group and 441 for the PORP group. Preoperative ABG, postoperative ABG, dB gain and ABG closure rate were compared.

Results: IT group: preoperative ABG of 31.74 dB (SD 10.51); postoperative ABG of 18.97 dB (SD 10.6); dB gain of 12.76 dB (SD 14.97); and ABG closure rate of 64.48%. PORP group: preoperative ABG of 28.02 dB (SD 10.47); postoperative ABG of 16.27 dB (SD 10.45); dB gain of 11.75 (SD 15.02); and ABG closure rate of 71.32%. No significant statistical difference was found in dB mean gain between groups ($p > .05$), although a difference was found in the ABG closure rate between groups favouring PORP series ($p < .05$).

Conclusion: An improvement in hearing results was observed within both groups after type III tympanoplasty. There is no difference in decibels gained between both ossiculoplasty materials, but a better closure rate (%) was observed in the PORP group.

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Type III tympanoplasty; incus; PORP; ossiculoplasty; ossicular chain

Introduction

The rehabilitation of conductive hearing loss is one of the major challenges for otologic surgeons. Since the 1950s when the surgery of ossicular reconstruction was introduced, it has made more sense to address the hearing problem. The success of the ossicular reconstruction mainly depends on the characteristics of the material used for the prosthesis; the ideal prosthesis should be biocompatible, stable, easy to fit, and capable of optimal sound transmission. Although a variety of materials have been used for reconstruction of the ossicular chain, such as autograft, gold prosthesis, ceramic prosthesis, hydroxyapatite, and polyethylene, none of them has proved to have overwhelming superiority over the others [1].

A defect of the long process of the incus is one of the most frequent causes of ossicular discontinuity. There are several aetiological factors for incudostapedial joint discontinuity, including chronic middle ear disease with or without cholesteatoma, adhesive otitis media, retraction pockets, tympanosclerosis, and temporal bone trauma. Separation of the incudostapedial joint may lead to conductive hearing loss. Various techniques have been described with which to reconstruct incudostapedial joint continuity, including transposition of a biological autograft or homograft, and use of

partial ossicular replacement prostheses (PORP) and bone cements [2].

Also a recent meta-analysis showed that titanium prostheses did not show any significant superiority to the non-titanium prostheses in terms of effectiveness and stability, despite the opposite results reported by many investigators [1].

As commented previously, the most frequently seen ossicular problem is a defective or missing incus with an intact and mobile stapes and the malleus handle (60% of all ossicular defects). In cases with intact stapes but defective incus and/or malleus, type II and III tympanoplasties were the choice of ossiculoplasty according to the Wullstein classification in 1956 [3].

The aim of the present study is to assess the existing evidence in favor of or against IT type III tympanoplasty in comparison with PORP type III tympanoplasty, with regard to postoperative hearing results.

Materials and methods

An extensive search of the literature was performed in PUBMED database up to December 2016. Having as primary objective studies with hearing results within the first year post-operative, that had undergone type III

tympanoplasties with an intact stapes, using either IT or PORP for ossicular reconstruction.

Using this framework, 3 reviewers were retrieving studies that were critically appraised. Language restrictions were applied and only articles written in English were included. Fourteen studies continued to meet the defined criteria, and were further analyzed (Tables 1 and 2). During the search, the keywords selected for the study were “tympanoplasty”, “type III tympanoplasty”, “PORP”, “partial ossicular replacement prostheses”, “incus tympanoplasty”, “incus transposition”, and “ossicular reconstruction” were utilized. Keywords were either combined to each of the other keywords individually or in groups. Also references of the retrieved articles were searched.

No patients with intact stapes were excluded. No difference between canal wall up, canal wall down or absence of mastoidectomy added to the tympanoplasty was made. No difference between transcanal or post-auricular approach was made. The idea is to obtain global information in hearing results regarding IT and PORP ossiculoplasty regardless the type of surgical technique utilized. No ossiculoplasty difference was made in relation to prostheses material.

Table 1. Incus transposition articles review.

IT Group	N	ABG preop	ABG postop	ABG gain	ABG closure rate <20 dB (%)
Alaani A. et al. [10]	–	–	–	–	–
Baker A. et al. [11]	–	–	–	–	–
Celenk F. et al. [2]	49.0	37.5	21.6	15.9	63.2
Emir H. et al. [3]	136.0	33.2	20.4	12.8	58.1
Felek S. et al. [12]	149.0	33.4	15.5	17.9	78.5
Galy-Bernadoy C. et al. [13]	11.0	25.6	13.3	12.3	45.5
Mardassi A. et al. [14]	–	–	–	–	–
Maulemans J. et al. [15]	–	–	–	–	–
Naragund A. et al. [16]	12.0	43.3	24.5	18.8	58.3
Neudert M. et al. [17]	27.0	26.4	19.1	7.3	81.5
O'Reilly R. et al. [4]	137.0	26.8	18.6	8.2	66.4
Quérat C. et al. [18]	–	–	–	–	–
Somers T. et al. [19]	14.0	22.8	15.3	7.5	71.4
Yazici H. et al. [20]	79.0	33.6	22.6	11.0	43.0
Total	614				

ABG: Air bone gap; IT: Incus Transposition; Postop: Postoperative; Preop: preoperative.

Table 2. PORP articles review.

PORP Group	N	ABG preop	ABG postop	ABG gain	ABG closure rate <20 dB (%)
Alaani A. et al. [10]	65.0	26.3	10.6	15.6	84.6
Baker A. et al. [11]	56.0	28.2	16.5	11.7	79.5
Celenk F. et al. [2]	–	–	–	–	–
Emir H. et al. [3]	32.0	31.7	17.6	14.1	56.3
Felek S. et al. [12]	47.0	35.7	19.3	16.4	55.3
Galy-Bernadoy C. et al. [13]	34.0	28.5	18.7	9.8	76.5
Mardassi A. et al. [14]	37.0	27.2	15.1	12.2	78.4
Maulemans J. et al. [15]	89.0	26.2	15.6	10.6	73.0
Naragund A. et al. [16]	5.0	42.0	25.0	17.0	40.0
Neudert M. et al. [17]	38.0	24.9	16.7	8.2	68.4
O'Reilly R. et al. [4]	–	–	–	–	–
Quérat C. et al. [18]	38.0	24.1	19.8	4.3	60.5
Somers T. et al. [19]	–	–	–	–	–
Yazici H. et al. [20]	–	–	–	–	–
Total	441				

ABG: Air bone gap; PORP: partial ossicular replacement prostheses; Postop: Postoperative; Preop: preoperative.

Tables with analytic data were made using for each group 4 variables; preoperative air-bone gap (ABG), postoperative ABG, decibel (dB) gain, and ABG closure rate (%), considering as a closed air-bone gap a result of a postoperative ABG lesser than 20 dB.

Statistical tables and analysis of data was carried out using Google Sheets with Google Statistics add-on software. Statistical significance was accepted to a maximum p value at the level of .05. For calculating statistical differences for quantitative continuous variables, a t -student test was performed comparing the two groups, and for qualitative comparison between closure rates, a chi-squared test was performed.

Results

Among the 14 analyzed studies, a total of 1055 patients were gathered, nine studies had the needed information in relation to IT type III tympanoplasties, counting a total of 614 patients with hearing results between 3 and 12 months postoperative time. Ten studies had the needed information regarding PORP type III tympanoplasties, counting a total of 441 patients with hearing results between 3 and 12 months postoperative time. Among these studies, five studies had direct data comparing hearing results between IT and PORP type III tympanoplasties.

Incus transposition group: A total of 614 patients were analyzed. A mean preoperative ABG of 31.74 dB with a standard deviation (SD) of 10.51 dB was obtained. A mean postoperative ABG of 18.97 dB with a SD of 10.6 dB was obtained. A mean dB gain of 12.76 dB with a SD of 14.97 dB was obtained. An ABG closure rate of 64.48% was obtained (Table 3).

PORP group: A total of 441 patients were analyzed. A mean preoperative ABG of 28.02 dB with a standard deviation (SD) of 10.47 dB was obtained. A mean postoperative ABG of 16.27 dB with a SD of 10.45 dB was obtained. A mean dB gain of 11.75 dB with a SD of 15.02 dB was obtained. An ABG closure rate of 71.32% was obtained (Table 4).

Statistical analysis: An intragroup comparison between preoperative ABG and postoperative ABG was made obtaining a statistical significant difference on each group separately ($p < .05$) in favor of the postoperative ABG. The ABG gain between groups was compared, a nonstatistical significant difference ($p > .05$) was obtained. The closure rate between groups also was compared obtaining a statistical significant difference ($p < .05$) in favor for the PORP group.

Discussion

Reconstruction of the ossicular chain, successful physiological and functional results with long-term stability are still a challenge even for experienced otologists.

The aim of ossicular chain reconstruction is to restore the middle ear conduction mechanism, but if cochlear function is poor particularly with regard to word discrimination

Table 3. Incus transposition results.

IT	N	Ponderation	Mean ABG preop	SD	Mean ABG postop	SD	Mean ABG gain	SD	ABG closure rate <20 dB (%)
Celenk F.	49	0.08	37.48	8.20	21.56	7.30	15.92	10.98	63.2
Emir H.	136	0.22	33.18	11.94	20.42	14.54	12.76	18.81	58.1
Felek S.	149	0.24	33.4	8.10	15.5	8.00	17.9	11.38	78.5
Galy-Bernadov C.	11	0.02	25.56	10.34	13.31	9.03	12.25	13.73	45.45
Naragund A.	12	0.02	43.3	8.34	24.5	9.50	18.8	12.64	58.33
Neudert M.	27	0.04	26.4	1.70	19.1	1.50	7.3	2.27	81.48
O' Reilly R.	137	0.22	26.81	11.90	18.61	11.05	8.2	16.24	66.4
Somers T.	14	0.02	22.8	27.50	15.3	16.7	7.5	32.17	71.4
Yazici H.	79	0.13	33.6	11.99	22.6	12.4	11	17.24	43
Total	614	1.00	31.74	10.51	18.97	10.60	12.76	14.97	64.48

ABG: Air bone gap; IT: Incus Transposition; Postop: Postoperative; Preop: preoperative.

Table 4. PORP results.

PORP	N	Ponderation	Mean ABG preop	SD	Mean ABG postop	SD	Mean ABG gain	SD	ABG closure rate <20 dB (%)
Alaani A.	65	0.15	26.27	12.29	10.63	9.7	15.64	15.66	84.6
Baker A.	56	0.13	28.2	11.70	16.5	9	11.7	14.76	79.5
Emir H.	32	0.07	31.69	9.57	17.59	11.66	14.1	15.08	56.3
Felek S.	47	0.11	35.7	8.10	19.3	19	16.4	20.65	55.3
Galy-Bernadov C.	34	0.08	28.47	11.96	18.67	11.64	9.8	16.69	76.47
Mardassi A.	37	0.08	27.2	13.23	15.05	9.61	12.15	16.35	78.38
Maulemans J.	89	0.20	26.19	11.53	15.58	9.8	10.61	15.13	73.03
Naragund A.	5	0.01	42	5.70	25	6.12	17	8.36	40
Neudert M.	38	0.09	24.9	2.07	16.67	1.49	8.23	2.55	68.42
Quérat C.	38	0.09	24.1	11.70	19.8	13.1	4.3	17.56	60.52
Total	441	1.00	28.02	10.47	16.27	10.45	11.75	15.02	71.32

ABG: Air bone gap; Postop: Postoperative; PORP: partial ossicular replacement prostheses; Preop: preoperative.

or in an only hearing ear a hearing aid can be another option instead of performing ossicular chain reconstruction.

According to the Wullstein classification, there are five types of tympanoplasties, and in the cases with intact and mobile stapes with other ossicular defects, type II or III tympanoplasty is the choice for reconstruction. With an intact mobile stapes, there are two primary methods available to reconstruct the ossicular defect: either by columella effect to tympanic membrane or graft; or by a malleus stapes assembly between the stapes capitulum and Malleus. Type III tympanoplasties are performed in cases that had extensive incus defects with normal stapes, by interpositioning a prosthesis between the malleus handle/tympanic membrane and stapes head [3].

Otologic surgeons have used a variety of materials for reconstruction of the ossicular chain; autograft, homograft, or allograft materials [4–7]. There are both advantages and disadvantages of all these materials. Although autograft prostheses have a very low extrusion rate, no risk of transmitting disease, low cost, biocompatibility and no necessity for reconstitution, they also have disadvantages such as displacement, complete absorption (particularly with cartilage), small remnant size, and the possibility of harboring microscopic disease as well as residual cholesteatoma [4,6,7]. Homograft prostheses are derived from human donor tissue, they are ready to use and easy to reshape but they need to be stored in special conditions for reconstruction [8]. Allograft prostheses are readily available, presculpted and made of synthetic materials designed to be biocompatible but they are generally less cost-effective, not well-tolerated and had a significant extrusion rate [9]. Ossicular necrosis, extrusion, displacement, and unsatisfactory hearing results can be seen with every kind of reconstruction material. Although

autograft materials are still among the most commonly used materials, biocompatible synthetic materials are used with good success at many institutions.

According to Zhang et al. in their meta-analysis in 2011, titanium prostheses did not show any significant superiority to the non-titanium prostheses in terms of effectiveness and stability, despite the opposite results reported by many investigators [1].

Regardless of the overwhelming quantity for ossicular reconstruction materials and options surgeons have, nowadays for surgical tendencies, literature and surgical experiences, the most commonly utilized ossiculoplasty materials in type III tympanoplasties are the incus sculpted autograft transposition or the titanium PORP allograft. Literature results are very erratic (Table 1) depending on the surgeon, institutions, and surgical techniques performed, that is the reason why this revision was decided to be made, to try to have homogeneous results with the larger number of intervened ears possible.

Probably, the reproducibility of the PORP results is better than the incus transposition for the different surgical sculpting incus techniques that have been described.

In this review, it was found that there is no real difference on hearing results regarding which graft is utilized for type III tympanoplasty in matter for gaining decibels after surgery, although apparently the chances of closing the air-bone gap to less than 20 decibels are better with the PORPs.

Both IT and PORP ossiculoplasties have advantages and disadvantages. Normally for the IT, they do not need many resources as it can be harvested in the vast majority of the patients with results comparable to PORPs that usually are expensive, in exchange for more surgical reproducibility, less surgical time, and better stability at the stapes head. Besides

of it all, the hearing results within the first year point out that there is no difference for gaining decibels between the two ossiculoplasty materials.

One of the major disadvantages of this study is that no difference between canal wall up, canal wall down or absence of mastoidectomy were made, no complete data available was found. The idea was to manage an overall performance between the two types of ossiculoplasty techniques.

Conclusion

Ossiculoplasty is still a challenging problem for otologic surgeons. Although many prostheses have been used to bridge the gap between the stapes capitulum and tympanic membrane for the treatment of conductive hearing loss, autologous incus has achieved comparable successful hearing results with allograft prostheses.


The results of the review evidenced that is better to perform a type III tympanoplasty independently if IT technique or PORP than not performing it regarding hearing results. Postoperative hearing results were considerably better after surgery than before.

The quantity of decibels gained after surgery were comparable between IT and PORP not having a real difference between them. Although a better chance to close the air-bone gap to less than 20 decibels is better achieved with PORP than with a incus sculpted transposition technique.

Disclosure statement

The authors certify that they have no affiliations or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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