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The role of cartilage in the treatment of tympanic perforations – Type I Tympanoplasty

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THE ROLE OF CARTILAGE IN THE TREATMENT OF TYMPANIC PERFORATIONS - TYPE I TYMPANOPLASTY

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ABREVIATION LIST

AB-GAP – Air-Bone Gap
AC – Air Conduction
BC – Bone Conduction
dBs – Decibels
LTM – Limiar Tonal Médio
PTA – Pure Tone Average
VA – Via aérea
VO – Via óssea

ABSTRACT

Introduction: Temporal fascia is the most common used graft for primary type I tympanoplasty, with cartilage being reserved for revision cases or in patients whom higher risk of graft failure is anticipated such as otitis media with cholesteatoma or known auditive tube dysfunction. Cartilage is known by its higher stability and durability, but reservations about hearing outcomes have limited its widespread use. The present study aims to evaluate the anatomical and functional results of tympanoplasty, in which cartilage was used in primary tympanoplasty and compare them with the results obtained with temporal fascia graft.

Material and Methods: This was a cohort retrospective study that included 23 patients. Temporal fascia tympanoplasty was undertaken in 10 patients (group 1), whereas conchal/tragal cartilage tympanoplasty was performed in 13 patients (group 2). Both microscopic posterosuperior and transcanal approach were employed. Age, gender, perforation localization, type of graft used, pre/post operatory audiometric results, complications, and follow-up were evaluated. The main outcomes were the audiometric post-operative result and the presence of an intact tympanic membrane.

Results: Pre-operative AC PTA was 30,75 ± 11,77 dBs (group 1) and 34,71 ± 13,03 dBs (group 2). Pre-operative AB-GAP was 17,5 ± 9,26 dBs (group 1) and 17,69 ± 8,9 dBs (group 2). The post-operative AC PTA was 25 ± 11,46 dBs and 25,96 ± 11,79 dBs for fascia and cartilage group, respectively. Post-operative AB-GAP was 10,63 ± 8,67 dBs for group 1 and 11,15 ± 9,27 dBs for group 2. An AB-GAP gain after surgery of 6,88 ± 5,78 dBs and 6,54 ± 7,59 dBs was observed for fascia and cartilage group, respectively. Perforation persistence rate was 30% in group 1 (n=3) and 30,77% group 2 (n=4). Higher perforation persistence rates were observed in subtotal perforations (n= 4).

Discussion/Conclusion: No statistically significant differences were found in perforation persistence rate or audiological outcomes between groups, which is supported by similar results in literature. Cartilage is as suitable as temporal fascia regarding closure of tympanic perforations and therefore can be used in primary type I tympanoplasty without reservations concerning poorer audiological outcomes.

Keywords: *tympanic membrane perforation, simple chronic otitis media, cartilage graft, fascia graft, type I tympanoplasty*

RESUMO

Introdução: A fáscia do músculo temporal é o principal enxerto usado na timpanoplastia tipo I, sendo a cartilagem reservada para casos de revisão ou em doentes cujo alto risco de falência do enxerto possa ser antecipado, nomeadamente na presença de otite média com colesteatoma ou doentes com disfunção documentada da tuba auditiva. A cartilagem é conhecida pela sua maior estabilidade e durabilidade, mas reservas em relação aos seus resultados audiométricos têm limitado o seu uso de uma forma generalizada. O presente estudo tem como principal objetivo avaliar os resultados anatómicos e funcionais de timpanoplastias tipo I primárias em que cartilagem foi utilizada e comparar esses resultados com os obtidos quando a fáscia temporal foi o enxerto escolhido.

Material e Métodos: Foi realizado um estudo de coorte retrospetivo que incluiu 23 doentes. A timpanoplastia com recurso a fáscia temporal foi realizada em 10 doentes (grupo 1) enquanto a timpanoplastia utilizando cartilagem conchal/tragal foi realizada em 13 doentes (grupo 2). As timpanoplastias foram efetuadas utilizando a abordagem póstero-superior ou a via transcanal. Foram avaliadas variáveis como a idade, o sexo, o local da perfuração, o tipo de enxerto usado, os resultados audiométricos pré e pós-operatórios, as complicações e o seguimento. Os principais resultados foram os resultados audiológicos pós-operatórios e a presença de uma membrana timpânica íntegra.

Resultados: O LTM pré-operatório da VA foi de 30,75 ± 11,77 dBs (grupo 1) e de 34,71 ± 13,03 dBs (grupo 2). O GAP aéreo-ósseo pré-operatório foi de 17,5 ± 9,26 dBs (grupo 1) e de 17,69 ± 8,9 dBs (grupo 2). O LTM pós-operatório da VA foi de 25 ± 11,46 e de 25,96 ± 11,79 no grupo que utilizou a fáscia e no da cartilagem, respetivamente. O GAP aéreo-ósseo pós-operatório foi de 10,63 ± 8,67 no grupo 1 e de 11,15 ± 9,27 no grupo 2. Posteriormente à cirurgia, a melhoria de GAP aéreo-ósseo foi de 6,88 ± 5,78 dBs e 6,54 ± 7,59 dBs no grupo 1 e 2, respetivamente. Observou-se uma taxa de persistência da perfuração de 30% no grupo 1 (n=3) e de 30,77% no grupo 2 (n=4). A maior taxa de persistência de perfuração ocorreu nos casos de perfuração subtotal (n= 4).

Discussão/Conclusão: Não foram encontradas diferenças estatisticamente significativas entre os grupos em relação à taxa de persistência de perfuração ou aos resultados audiológicos, o que está em concordância com outros resultados na literatura. Comparativamente à fáscia do músculo temporal, a cartilagem é igualmente adequada para o encerramento da perfuração da membrana timpânica e por isso pode ser usada nas timpanoplastias tipo I sem reservas em relação a piores resultados audiométricos.

Palavras-chave: *perfuração timpânica, otite media crónica simples, cartilagem, fáscia, timpanoplastia tipo I*

INTRODUCTION

Tympanic membrane perforation is characterized by the lack of integrity of tympanic membrane that leads to severe consequences such as conductive hearing loss and episodic otorrhea. There are several aetiologies for tympanic perforation with simple chronic otitis media being the most common. (1)

Tympanoplasty is a surgical procedure that was introduced in the 50s by Wullstein (2) and later by Zollner, (3) in order to reconstruct the tympanic membrane integrity and improve hearing status in patients with chronic otitis media.

In the search for the ideal graft, several materials have been proposed. From the most widespread, such as temporal fascia and cartilage, to the periosteum and perichondrium, in all of them advantages and disadvantages were found. (4) Classically, the temporal fascia is used for the initial treatment of tympanic perforations and the use of cartilage is reserved for more complex or recurrent perforations, due to its resistance and durability. (5–7)

Some otologic surgeons advocate that a rigid material like cartilage can disrupt the sound conductive characteristics of the tympanic membrane and lead to worse audiometric results, increasing the concerns about its use in primary otologic surgery. (8)

This study aims to evaluate the anatomical and audiometric results of patients undergoing type I tympanoplasty in which the graft used at first approach was cartilage (either conchal or tragal) and compare the results with temporal fascia grafts.

METHODS

This was a cohort retrospective study with patients submitted to tympanoplasty type I (Portmann´s classification) in Otorhinolaryngology Department of Coimbra´s University Hospitals, for 3 years and 6 moths (from 2017 to 2020).

Patients

The inclusion criteria were age between 18 and 75 years old, presence of tympanic perforation caused by simple chronic otitis media, iatrogenic or trauma, submitted to primary tympanoplasty type I by the same surgeon. The exclusion criteria were the presence of cholesteatoma, others otology diseases rather than the

abovementioned, recurrent perforation, lack of relevant clinical information for the study and less than 6 moths of follow-up.

Surgical techniques and grafts

There were 2 different approaches used for the surgical procedure: microscopic posterosuperior and transcanal approach. In the first approach the graft used was temporal fascia or conchal cartilage/ perichondrium, and in the second cartilage/ perichondrium from tragus. All grafts were put in place by an underlay technique. The same surgeon performed all the surgeries in compliance with the otologic surgery principles.

Patients were divided in two groups, one when were used fascia´s grafts and other where the tympanoplasties were performed with cartilage (from conchal or tragus region).

Data, variables, and measurements

The following data were collected: age, gender, aetiology, and perforation localization, type of graft, pre/post- operatory audiometric results, complications, and follow-up.

The main outcomes were the audiometric post-operative result and the presence of an intact tympanic membrane.

Hearing evaluations consisted of pure-tone air-conduction and bone-conduction tests performed before the surgery and 3 to 6 months after the surgery. The average air, bone and air/bone gap hearing thresholds at 0.5 1, 2 and 4 kHz frequencies were evaluated, according to the audiologic criteria of *Bureau Internacional d'Audiophonologie.*

The anatomical success was defined by presence of an intact tympanic membrane without any retraction or lateralization in the post-operative visits (1 week, 1/3/6 moths, 1 year, and annually after the 1st year). Reduction of air-bone gap value below 15 dB (average of the four frequencies) in the post-operative audiogram was considered as audiometric success.

Statistical analysis

All analysis will be performed using SPSS®, v27.0 (SPSS INC, IL, USA). Normality of data distribution was verified by Kolmogorov–Smirnov test. Fisher´s exact test, t-student test and two way repeated measures Anova were used, *p* values less than 0.05 were considered statistically significant.

Categorical variables will be presented as frequencies and percentages, and continuous variables as means and standard deviation or median and interquartile range.

RESULTS

In total, this study includes 23 patients, 6 male (26,1%) and 17 female (73,9%), with tympanic perforations that underwent tympanoplasty type I for the first time and fulfilled the inclusion criteria. Patients' ages at diagnosis range from 19 to 74 years old (41,2 ± 15,9). Group 1 (fascia graft) included 10 patients, 8 female and 2 male, with 35,9 ± 16,3 years. Group 2 (cartilage graft) included 13 patients, 9 female and 1 male, with 45,3 ± 14,3 years.

Among the aetiologies for perforation we found trauma (4,35%; n=1), iatrogenic (4,35%; n=1) and, most commonly, simple chronic otitis media (91,3%; n=21). In both trauma and iatrogenic perforation, it was used cartilage graft.

Of the patients, 69,6% [n=16 (group 1 n=8; group 2 n=8)] were operated on the right ear and 30,4% [n=7 (group 1 n=2; group 2 n=5)] on the left ear.

Overall follow-up was 22,61 ± 7,52 moths (24,1 ± 5,11 - group 1; 23,92 ± 7,67 - group 2).

Perforations were most frequently located in posterior quadrant (52,17%; n= 12), followed by the anterior (26,09%; n=6) and subtotal (21,74%; n=5). At group 1, 30% (n=3) of the perforations were in the anterior quadrant, 50% (n=5) in the posterior and 20% (n=2) were subtotal perforation. At group 2, 23,08% (n=3) were in the anterior quadrant, 53,85% (n=7) in the posterior quadrant and 23,08% (n=3) were subtotal, according to Table 1.

Perforation localization	Group 1	Group 2
Anterior quadrants	30% (n=3)	23,08% (n=3)
Posterior quadrants	50% (n=5)	53,85% (n=7)
Subtotal perforation	20% (n=2)	23,08% (n=3)

Table 1 - Perforation localization distribution in the two groups.

Audiometric results are show in Table 2.

The pre-operative bone conduction pure tone average (PTA) results was in group 1 13,63 ± 5,43 dBs and in group 2 17,21 ± 10,87 dBs. Pre-operative air-conduction PTA was 30,75 ± 11,77 dBs (group 1) and 34,71 ± 13,03 dBs (group 2). Pre-operative air-bone GAP was 17,5 ± 9,26 dBs (group 1) and 17,69 ± 8,9 dBs (group 2).

Post-operative bone conduction PTA was 14,25 ± 7,52 dBs (group 1) and 15,19 ± 10,54 dBs (group 2). Post-operative air conduction PTA was 25 ± 11,46 dBs (group 1) and 25,96 ± 11,79 dBs (group 2). Air-bone GAP after surgery was 10,63 ± 8,67 dBs (group 1) and 11,15 ± 9,27 dBs (group 2).

It was observed a similar improvement in air-bone GAP after surgery in both groups. Group 1 had a gap gain of 6,88 ± 5,78 dBs and group 2 had 6,54 ± 7,59 dBs. Comparing gap gain between the two groups, the difference was not statistic significant (p = 0.908).

	Pre-operative			**Post-operative**			
	BC	AC	AB-GAP	BC	AC	AB-GAP	AB-GAP gain
Group 1	13,63 ±5,43	30,75 ±11,77	17,5 ±9.26	14,25 ±7,52	25 ±11,46	10,63 ±8,67	6,88 ±5,78
Group 2	17,21 ±10,87	34,71 ±13,03	17,69 ±8,9	15,19 ±10,54	25,96 ±11,79	11,15 ±9,27	6,54 ±7,59

Table 2 – Pre- and post-operative audiometric results in both groups. BC: bone conduction; AC: air conduction; AB-GAP: air bone GAP.

Perforation's persistence occurred in 30,4% (n=7). It was observed a perforation persistence rate of 30% in group 1 (n=3) and 30,77% in group 2 (n=4). This difference was not considered statistically significant (p = 0.663). The subsistence of perforations occurred 3 to 11 months after the surgeries.

Analysing perforation location and perforation persistence rate, it was observed higher perforation persistence rate in subtotal perforation (n= 4), followed by posterior (n=3) and no one in anterior quadrants (Table 3). These differences were statistically significant (p=0,016) and show that subtotal perforations are more susceptible to persist, when was used cartilage or temporal fascia grafts.

When analysing AB-GAP gain in function of location perforation, it was found that there was no statistically significant difference between the different locations (p=0,313) (Table 3).

Perforation localization	AB-GAP Gain	Reperforation
Anterior quadrants	7,08 ± 5,34	n = 0
Posterior quadrants	8,13 ± 7,12	n = 3
Subtotal perforation	2,75 ± 6,87	n = 4

Table 3 – Perforation location, audiometric results, and cases of perforation persistence in all 23 patients. AB GAP: air-bone GAP

There were 3 cases of self-limited infection, requiring antibiotic therapy and without functional sequel (1 case in group 1 and 2 cases in group 2). There were no others major complications observed in the post-operative follow-up period, namely facial paresis, vertigo, and significant bleeding. All patients were discharged the day after surgery.

DISCUSSION

Previous studies aimed to compare cartilage and fascia graft in terms of anatomical and functional results, since some anatomical advantages such as its stiffness and resistance do retraction and infection, were thought to come with audiological disadvantages and impairment of hearing. (8)

As far as audiometric results are concerned, in the present study the mean pre-operative AB-GAP was 17,5 ± 9,26 dBs and 17,69 ± 8,9 dBs (group 1 and 2, respectively) and the mean AB-GAP after surgery was 10,63 ± 8,67 dBs (group 1) and 11,15 ± 9,27 dBs (group 2). It was observed an improvement in AB-GAP after surgery in both groups even though no statistically significant difference was found between the two groups.

Those outcomes are in line with the literature. (9,10) Demirpehlivan *et al* (11) conducted a study to assess the functional results with temporal fascia, perichondrium/cartilage island and palisade cartilage grafts in type I tympanoplasty, and obtained similar results. In this study, the mean pre-operative AB-GAP was 24.4 dBs and the mean post-operative AB-GAP was 13.58 dBs (p = 0.001). No statistically significant difference between the three groups for pre and post-operative AB-GAP was found.

Kim *et al* (12) compared 31 patients who underwent type I temporal fascia tympanoplasty with 83 patients who underwent perichondrium/cartilage type I tympanoplasty and similar outcomes in terms of post-operative AB-GAP were found. The fascia group had a pre-operative AB-GAP of 28.74 ± 6.92 dBs and a post-operative AB-GAP of 19.03 ± 9.23 dBs, whereas cartilage group had a pre-operative AB-GAP of 28.62 ± 10.16 dBs and a post-operative AB-GAP of 18.84 ± 12.14 dBs. Pre-operative and post-

operative AB-GAP were compared between the two groups and no significant difference was found (p = 0.384 and p = 0.938).

Analysing the difference between pre and post-operative AB-GAP, we obtained an average of AB-GAP gain of 6,88 ± 5,78 dBs in group 1 and 6,54 ± 7,59 dBs in group 2. Therefore, in this study the mean AB-GAP gain was similar in both groups and no statistical significative differences were found (p = 0.908), which is in conformity with other studies. Kim *et al* (12) also concluded that in terms of gain, no significant difference was found between groups (p = 0.98). In that study AB-GAP gain was found to be 9.71 ± 8.94 dBs in 9.78 ± 15.25 dBs in fascia and cartilage group, respectively.

Callioglu *et al* (13) conducted a retrospective study with 108 patients aiming to compare both anatomic and audiological results in type I tympanoplasty using temporal fascia and cartilage as grafts. AB-GAP gain was found to be and 10.8 ± 5.38 dBs in fascia group and 10.1 ± 7.0 dBs in cartilage group. Nevertheless, no statistically significant difference was seen in AB-GAP gain values (p = 0.608).

A study performed by Gerber *et al* (14) investigated functional results after primary cartilage and temporal fascia tympanoplasties. They evaluate AB-GAP gains in different frequencies (500 Hz, 1k Hz, 2k Hz and 4k Hz) in both fascia and cartilage groups and, even though an improvement in the AB-GAP at all frequencies after surgery was proved, there was no significant difference when comparing the two grafts.

A systematic review written by Mohamad *et al* (15) produced equal results, concluding that there was no statistically significant difference in hearing outcomes between cartilage and fascia temporal graft.

All abovementioned results are in concordance with our study and there are no recent studies published that endorse the superiority of fascia graft over cartilage with respect to hearing outcomes. Our study and the studies mentioned before exclude revision surgery and tympanoplasties other than type I and include patients with an overall better audiometric and eustachian tube function. This might attenuate results regarding superiority of cartilage and make it more complicated to note the differences between fascia or cartilage groups in general.

The anatomical success rate obtained with tympanoplasty type I reported in literature ranges from 75-98%. (16) In our study the overall perforation persistence rate was 30,4%, meaning tympanoplasty type I overall success rate was 69,6%. This outcome falls short when compared with literature and may be explained by the small sample size of this study, compared with the literature (which normally include more than 50 patients) and the restricted inclusion criteria.

When comparing our two groups regarding anatomical outcomes, the graft take rate was superior in fascia group (70%) when confronted with the cartilage group

(69,23%). However, this difference was not statistically significative (p = 0.663). Those results are in accordance with other studies, even if our success rates are lower. (10)

Mouna *et al* (17) studied 46 patients who underwent type I tympanoplasty with temporal fascia and cartilage graft. In follow-up period, 4,3% of the patients undergoing cartilage tympanoplasty had incidence of persistent perforation against 8,7% of the fascia group, which was found to be statistically non-significant (p > 0.05). Moreover, a systematic review conducted by Lyons *et al* (18) evaluated the effectiveness of type I tympanoplasty with cartilage-perichondrium graft and compared it to type I temporal fascia tympanoplasty in patients with subtotal membrane perforation and chronic otitis media and provide similar outcomes.

Despite all studies favoured cartilage-perichondrium grafting for tympanic membrane closure, the results were not statistically significative. Kazikdas *et al* (19) compared fascia temporal type I tympanoplasty with palisade cartilage technique in 51 patients with subtotal perforations and found no differences between the groups regarding graft take rate (p = 0.059).

Nevertheless, contradictory results are found in literature. In a retrospective study conducted by Onal *et al* (20) the incidence of graft success was 92,3% in the cartilage group, whereas fascia group success rate was 65,9%. This difference between groups was statistically significant (p = 0.005). Yang *et al* (21) conducted a systematic review and a meta-analyses accessing 915 patients and also reported that differences in graft integration rate between cartilage group and fascia were statistically significant, with higher rates for cartilage group (*odds ratio* = 3.11, p = 0,43).

In a prospective study of Jain *et al,* (22) that analysed 70 patients with dry subtotal perforations, significant differences were obtained regarding graft take rate between temporal fascia group and cartilage group. Temporal fascia group had 82,9% graft take rate whilst cartilage fascia group had 97,1% (p < 0,05).

A systematic review undertaken by Lacovou *et al* (4) including 1,286 patients aimed to compare hearing results and anatomical outcomes in patients undergoing type I tympanoplasty, using temporal fascia or cartilage as grafts, demonstrated a mean graft integration rate of 92,4% in the cartilage group and 84,3% in the fascia group. In this respect, perforation persistence rates were 7,6 and 15,5%, respectively. This difference proved to be statistically significant (p < 0.05), with cartilage having superior outcomes.

Considering the site of perforation, 52,17% were in the posterior quadrant, followed by the anterior with 26,09%; and 21,74% were subtotal perforations. We compared the graft success rate with the perforation's location and found that subtotal perforations are associated with more persistent perforation cases than the other locations, and this difference was statistically significant (p = 0,016). Sharma *et al* (23)

studied 53 patients with tympanic perforation persistence and concluded that the rate of persistent perforation was increased in large and subtotal perforation compared to medium and small size perforation. Also, the rate of perforation persistence was higher in the repair of anterior perforation when compared to posterior and central perforation. The association between perforation's site and graft take rate was found to be statistically significant (p = 0.0002). Reduced vascularity and a more difficult exposure of the anterior tympanic membrane during the procedure may explain these results. (24)

Salvador *et al* (25) studied prognostic factors in paediatric tympanoplasty and demonstrated that although the impact of location on surgical outcome was not confirmed on multivariate analyse, subtotal perforations had the worse success rate (53.3%, $p = 0.045$).

Even so, some studies fail to find a correlation between site and graft success. (26,27) Tan *et al* (24) carried out a meta-analysis that indicated that perforations greater than 50% had a lower success rate, while the location of the perforation had no significant effect on success rate.

Despite the influence of the graft material and perforation location in perforation persistence rates other variables have been proposed as to influencing the rate of graft take such as age, gender, smoking habits, size of perforation and surgeon expertise. (28,29) In a study conducted by Emir *et al* (29) they concluded that male gender had higher rates of morphologic success ($p = 0.031$). Moreover, the same study suggests senior surgeons have better graft take rates ($p = 0.007$) when compared with residents. Once our study is mainly made in women, which can justified the higher perforation persistence rate in our study when compared with the literature in addition with a small sample size and restricted inclusion criteria. However, consensus regarding this matter is yet to be achieved since contradictory results can be found in literature. (5,13,17)

Analyses were also made regarding AB-GAP gain in function of location perforation and was found that there was no statistically significant difference between the different locations ($p = 0,313$). Kaya *et al* (30) evaluated both short and long terms results of tympanoplasty using both temporal fascia and butterfly cartilage graft and concluded that AB-GAP improvement did not differed significantly between anterior, posterior and central perforations ($p = 0.365$). Karela *et al* (31) found that site and size of perforation didn't correlate to hearing improvement as well.

In spite of that, Dawood (32) carried out a study to evaluate factors that may influence hearing improvement after temporal fascia tympanoplasty and found that posterior central perforations had better post-operative hearing gain than anterior central perforations ($p = 0.04$).

Despite limitations of our cohort study in terms of a small sample size of patients, our results are in line with studies published previously and therefore aims to propel the widespread use of cartilage in primary tympanoplasties and not only in revision or more difficult cases as there is no evidence of worse hearing outcomes or lower graft rake rates when this graft is selected. Furthermore, we believe that studies regarding correlation between the perforation site with perforation persistence rate are of most importance and are lacking in literature and may provide explanation to which factor is more relevant to type I tympanoplasty success: perforation site or graft material, and further studies should be carried out in order to clarify this issue.

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