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The Role of Cartilage-perichondrium Tympanoplasty in the Treatment of Tympanic Membrane Retractions: Systematic Review of the Literature

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Abstract

Introduction Tympanic retraction is a condition characterized by the displacement of the tympanic membrane toward the structures of the middle ear. Clinically, tympanic retractions can lead to hearing loss, ear discharge and/or ear pain. In most of the cases, however, tympanic retractions are asymptomatic and are found accidentally during an ear, nose, and throat (ENT) examination. This condition has created numerous debates regarding the optimal choice of treatment, especially in the asymptomatic forms. The main controversy is regarding the relationship between retraction and the development of cholesteatoma, which would justify a surgical intervention performed for preventive purposes.

Objectives To study the effectiveness of cartilage tympanoplasty in the management of tympanic membrane retractions by analyzing the results of the studies conducted on the use of cartilage as a reconstruction material.

Data Synthesis A literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses group (PRISMA). Study selection, data extraction, and quality assessment were conducted independently by two reviewers. Our initial literature search yielded 2,258 references. Applying the PRISMA flow chart, 1,415 duplicates were excluded, and the remaining 843 abstracts were examined. Afterwards, 794 articles were excluded based on the research protocol criteria. Only 8 papers were included in the review by applying the inclusion and exclusion criteria.

Conclusions Despite the limitations of the studies taken into consideration, we can conclude that cartilage tympanoplasty may successfully rehabilitate the atelectatic ear especially in the more advanced stages of retraction, unlike the conservative strategies.

Keywords
- tympanoplasty
- otitis media
- systematic review
- cartilage
- hearing loss

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Introduction

Tympanic retraction is a condition characterized by the displacement of the tympanic membrane (TM) toward the structures of the middle ear (ME).[1] The physiological relationships between the TM and the ME are guaranteed by the presence of a pressure balance between the tympanic cavity and the external environment. However, when this balance is subverted, it can determine alteration of the physiological position of the TM, meaning its whole atelectasis, or development of retraction pocket (RP), if the TM is partially collapsed. The repeated inflammatory phenomena would also determine a greater tendency for the TM to collapse due to destruction of the collagen fibers in the lamina propria of the intermediate layer of the TM. This would consequently reduce its thickness and elasticity. According to some authors, the insertion of ventilation tubes (VTs) would also be related to a higher incidence of the development of RP.[2]

Clinically, tympanic retractions can lead to hearing loss, ear discharge and/or ear pain. In most of the cases, however, tympanic retractions are asymptomatic and are found accidentally during an ENT examination.[3] This condition has created numerous debates regarding the optimal choice of treatment, especially in the asymptomatic forms. The main controversy is regarding the relationship between retraction and development of cholesteatoma, which would justify a surgical intervention performed for preventive purposes. However, surgery is not risk-free for the patient: worsening of the transmission component, loss of sensorineural hearing, dizziness, tinnitus, facial paralysis, tympanic perforation, or iatrogenic cholesteatoma are possible complications.[4] Although there is a wide variety of treatments for the management of this condition, it is possible to say that different techniques have common goals: stabilization or improvement of tympanic retraction, stabilization or improvement of hearing, and prevention of cholesteatoma and its complications. The authors of the present systematic review decided to address the issues related to the treatment choice by analyzing the results of the studies conducted on the use of cartilage as a reconstruction material for the TM.

Review of the Literature

The present study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses group (PRISMA). In the present systematic review, we intend to review the data from the studies selected using the PRISMA 2020 Checklist (http://www.prisma-statement.org).

We conducted a systematic search on the main databases (PubMed, Medline, EMBASE, the Cochrane library, and Google Scholar) by using the keywords: *retraction pocket (*OR *Tympanic atelectasis* OR *tympanic retraction* OR *atelectatic otitis")* AND *management (*OR *treatment* OR surgery). We included all the studies regardless publication date or publication status until May 2020. We excluded all studies that were not in English.

Studies were included if they met the following criteria:

1) Type of participants: studies on patients of all ages, genders, and ethnicities with clinically diagnosed RP or atelectatic otitis in both symptomatic and asymptomatic forms.
2) Type of intervention: studies in which patients underwent cartilage tympanoplasty (CT), under any technique, with both the postaural and the transmeatal endoscopic approach.
3) Types of outcome measures and clinical assessment: monitoring of the TM (RP resolution, no progression, no effect, or even continued progression), improvement in hearing thresholds, adverse events (TM perforation, discharge, need for reintervention).
4) Types of study: randomized controlled trials (RCTs), nonrandomized controlled trials (NRCTs), cohort studies, before-and-after studies (including before-and-after comparison case studies), and case-control studies were included.

Studies with the following features were excluded:

1) Type of participants: patients with cholesteatoma and/or chronic otitis media with tympanic perforation.
2) Type of intervention: patients who underwent other types of intervention than the ones listed in the inclusion criteria.
3) Types of study: case reports.

Two reviewers extracted data. Any differences in opinion regarding the data were resolved by discussion until a consensus was reached. Then, we combined the results of the studies, integrated, and analyzed the data by organizing the characteristics of the study and the results for each result variable.

We selected studies based on the inclusion/exclusion criteria by reviewing the title and abstract of each study after removing duplicate articles from the primary search. We confirmed the remaining studies and validated them by applying the inclusion and exclusion criteria.

Our initial literature search yielded 2,258 references. Applying the PRISMA 2020 flow diagram, 1,415 duplicates were excluded, and the remaining 843 abstracts were examined. Afterwards, 794 articles were excluded based on the criteria of the research protocol. Two authors independently read the remaining 49 papers in detail. Discussion was then held before making a final decision regarding inclusion or exclusion from the present study. Only eight papers were included in the review by applying the inclusion and exclusion criteria.[5–12] In most of the cases, the exclusion from the review was due to the types of study design (case reports), to the initial clinical condition of the treated cases (cholesteatoma, chronic otitis media with perforation), to the use of surgical techniques other than CT and/or the lack of relevant clinical data.

Three of the eight studies were randomized controlled studies, three were prospective, and two were retrospective cohort studies (►**Table 1**).

Table 1 Selected studies

Author	Study title	Year	Study design	Cases (*n* of ears)	Intervention (*n*)
Barbara[5]	Lateral Attic Reconstruction Technique: Preventive Surgery for Epitympanic Retraction Pockets	2008	Randomized controlled trial	25 (25)	Wait and see/ placebo (10) CT (15)
Elsheikh et al.[6]	Cartilage Tympanoplasty for Management of Tympanic Membrane Atelectasis: Is Ventilatory Tube Necessary?	2006	Randomized controlled trial	46 (46)	CT (23) CT + VT (23)
Si et al.[7]	Cartilage Tympanoplasty Combined with Eustachian Tube Balloon Dilatation in the Treatment of Adhesive Otitis Media	2018	Randomized controlled trial	120 (120)	Medical therapy (30) CT (30) CT + ETBD (30) ETBD (30)
Kalra et al.[8]	Treatment of Tympanic Membrane Retraction Pockets by Excision and Cartilage Tympanoplasty: A Prospective Study	2018	Prospective study	20 (20)	RP excision + CT (20)
Parab et al.[9]	Endoscopic Management of Tympanic Membrane Retraction Pockets: A Two Handed Technique with Endoscope Holder	2019	Prospective study	41 (41)	Endoscopic CT (41)
Spielmann et al.[10]	Surgical management of retraction pockets of the pars tensa with cartilage and perichondrial grafts	2006	Prospective study	51 (51)	CT (47) "Mercedes-Benz" CT (4)
Page et al.[11]	Cartilage tympanoplasty: postoperative functional results	2008	Retrospective study	230 (230)	CT (230)
Ozbek et al.[12]	Long-term anatomic and functional results of cartilage tympanoplasty in atelectatic ears	2009	Retrospective study	54 (56)	"Palisade" CT (56)

Abbreviations: CT, cartilage tympanoplasty; RP, retraction pocket; VT, ventilation tube; ETBD, eustachian tube baloon dilatation.

Barbara[5] conducted a prospective RCT with sequential randomization of 30 patients in 2 groups: 15 patients were randomized in the active treatment arm and underwent lateral attic reconstruction surgery with cartilage-perichondrium graft; the other 15 patients did not undergo any intervention (control group). The follow-up period was of up to 12 months.

Elsheikh et al.[6] conducted a prospective RCT in a tertiary referral center, with randomization of 46 patients in 2 groups: 23 underwent reconstruction of the atelectatic tympanic membrane using the cartilage-perichondrium graft performed with concomitant VT insertion; the other 23 patients underwent the same reconstruction only with cartilage-perichondrium grafting. The follow-up period was of up to 40 months.

Si et al.[7] conducted a prospective RCT with sequential randomization of 120 patients in 4 groups: 30 patients underwent an eustachian tube baloon dilatation (ETBD), 30 patients underwent a CT combined with ETBD, 30 patients underwent a CT, 30 patients underwent medical therapy (nasal steroids + Valsalva maneuver). The follow-up period was of up to 24 months..

Kalra et a.l[8] conducted a prospective nonrandomized trial on 20 patients at a tertiary care center. Retraction pockets were treated by excision and CT. The follow-up period was of up to 3 months.

Parab et al.[9] conducted a prospective nonrandomized trial. The study included 41 ears operated with the 2-handed endoscopic CT technique performed with endoscope holders. The follow-up period was of up to 53 months.

Spielmann et al.[10] conducted a prospective nonrandomized trial. This study presents the results of 51 RPs involving the posterior half of the tympanic membrane treated with classic cartilage-perichondrium grafts (47 patients) or with "Mercedes-benz" shaped graft (4 patients). The follow-up period was of up to 12 months.

Page et al.[11] conducted a retrospective trial showing the clinical outcome of 230 CTs based on postoperative auditory performance levels. The follow-up period was of up to 12 months.

Ozbek et al.[12] conducted a retrospective trial showing long-term anatomic and audiologic results in patients undergoing CT using the "palisade" technique with or without mastoidectomy for the treatment of TM atelectasis. The follow-up period was of up to 68 months.

Seven of the selected papers reported data about clinical assessment in terms of TM healing rate, RP recurrence, progression, or stabilization (►**Table 2**). The mean TM healing rate in the sole CT groups[5–10,12] was 93.28%.

Barbara et al.[5] reported, 1 year postoperatively, a 100% (15/15) RP resolution rate in the CT group. The control arm showed disease progression in 33.3% (3/10) of the cases, with the development of bone erosion (2) and cholesteatoma (1). Elsheikh et al.[6] reported, 1 year postoperatively, a 100% (23/23) RP resolution rate both in the CT and in the CT + VT

Table 2 Clinical tympanic membrane assessment

Author	Study group	TM healing rate (*n*)	RP recurrence (*n*)	RP stabilization (*n*)	RP progression (*n*)
Barbara[5]	Wait and see	NA	NA	70% (7)	30% (3)
	CT	100% (15)	0% (0)	0% (0)	0% (0)
Elsheikh et al.[6]	CT	100% (23)	0% (0)	0% (0)	0% (0)
	CT + VT	100% (23)	0% (0)	0% (0)	0% (0)
Si et al.[7]	Steroids+ Valsalva maneuver	NA	NA	93.34% (28)	6.67% (2)
	CT	90% (27)	6.67% (2)	0% (0)	0% (0)
	CT + ETBD	93.34% (28)	0% (0)	0% (0)	0% (0)
	ETBD	NA	NA	100% (30)	0% (0)
*Kalra et al.[8]	RP excision + CT	90% (18)	30% (6)	0% (0)	0% (0)
Parab et al.[9]	Endoscopic CT	100% (41)	0% (0)	0% (0)	0% (0)
**Spielmann et al.[10]	CT	82% (51)	17.02% (8)	0% (0)	0% (0)
	"Mercedes-Benz" CT		0% (0)	0% (0)	0% (0)
Ozbek et al.[12]	"Palisade" CT	91% (51)	25% (14)	0% (0)	0% (0)

Abbreviations: CT, cartilage tympanoplasty; NA; not available; n, number of cases; RP, retraction pocket; TM, tympanic membrane; VT, ventilation tube; ETBD, eustachian tube baloon dilatation.
12 months postoperative results, *3 months postoperative results, ** healing rate not available for each group..

insertion (23/23) groups. Si et al.[7] proved that, 1 year postoperatively, the morphology of the TM improved with a 90% (27/30) RP resolution rate in the CT group and with a 93.33% (28/30) RP resolution rate in the ETBD + CT group, although RP reoccurred in 2 cases of the CT group. In 6.67% (2/30) of the cases in the medical therapy group presented disease progression with the development of cholesteatoma, 93.33% (28/30) and 100% (30/30) of the cases in the medical therapy group and in the ETBD group respectively, RP remained unchanged. Kalra et al.[8] reported, 3 months postoperatively, a 90% (18/20) graft take up with an RP recurrence of 30% (6/18). Parab et al.[9] reported a 100% (41/41) success rate 1 year postoperatively. No recurrence of RP was detected. Spielmann et al.[10] achieved an overall healing rate of 82% (42/51) 1 year postoperatively. Retraction pocket recurrence occurred in 16% (8/51) of the cases; 100% (8/8) of these occurred in the CT group. Ozbek et al.[12] reported a 91% (51/56) TM healing rate with a 27.45% (14/51) RP recurrence rate.

Five of the selected papers reported data about the mean air-bone gap (ABG) improvement (►**Table 3**).

The mean hearing threshold improvement in the sole CT groups[6–8,11,12] was of 11.3 dB.

In the study conducted by Barbara,[5] all patients had normal hearing at the beginning and at the end of the study after 12 months. Elsheikh et al.[6] reported a mean ABG improvement of 11.81 dB and of 12.4 dB in the CT and CT + VT groups, respectively. Si et al.[7] reported a mean ABG

Table 3 Hearing threshold assessment

Author	Study group	Preoperative mean ABG (dB)	Postoperative mean ABG (dB)	Mean ABG improvement (dB)
Elsheikh et al.[6]	CT	22.71	10.9	11.81
	CT + VT	24.6	12.2	12.4
Si et al.[7]	Steroids+ Valsalva maneuver	32.68	34.5	1.82
	CT	33.19	18.87	14.32
	CT + ETBD	35.59	17.63	17.96
	ETBD	31.67	29.89	1.78
Parab et al.[9]	Endoscopic CT	24.53	14.13	10.4
Page et al.[11]	CT	23.04	14.37	8.67
Ozbek et al.[12]	"Palisade" CT	28.4	16.9	11.5

Abbreviations: ABG, air-bone gap; CT, cartilage tympanoplasty; n, number of cases; VT, ventilation tube.
12 months postoperative results.

Table 4 Adverse events

Author	Study group	Discharge (*n*)	Perforation (*n*)	Other (*n*)	Revision surgery (*n*)
Barbara[5]	CT	6.67% (1)	0% (0)	0% (0)	33.34% (5)
Elsheikh et al.[6]	CT	8.69% (2)	0% (0)	4.35% (1)	13.04% (3)
	CT + VT	4.35% (1)	0% (0)	4.35% (1)	8.69% (2)
Si et al.[7]	CT	10% (3)	0% (0)	0% (0)	3.34% (1)
	CT+ ETBD	10% (3)	3.34% (1)	0% (0)	3.34% (1)
*Kalra et al.[8]	RP excision + CT	15% (3)	10% (2)	0% (0)	0% (0)
Spielmann et al.[10]	CT	14.89% (7)	0% (0)	0% (0)	0% (0)
	"Mercedes-Benz" CT	50% (2)	25% (1)	0% (0)	25% (1)
Ozbek et al.[12]	"Palisade" CT	0% (0)	8.93% (5)	0% (0)	8.93% (5)

Abbreviations: CT, cartilage tympanoplasty; n, number of cases; RP, retraction pocket; VT, ventilation tube.
12 months postoperative results, *three months postoperative results.

improvement of 14.32 dB in the CT group, of 17,96 dB in the CT + ETBD group, and of 1,78 dB in the ETBD group. Worsening of conductive hearing loss was detected in the steroids + Valsalva group with a mean ABG increase of 1.83 dB. Parab et al.[9] reported a mean ABG improvement of 10.4 dB. Page et al.[11] reported a mean ABG improvement of 8,67 dB. Ozbek et al.[12] reported a mean ABG improvement of 11.5dB.

Six of the selected papers reported data about adverse events in the 1st year postoperatively (►**Table 4**).

The mean postoperative adverse events rate in the sole CT groups[5–8,10,12] was 13.87%.

Barbara[5] reported 1 case of a postoperative infection at day 15 in the CT group. Five patients, in whom a postoperative high-resolution computed tomography scan was performed, hypodense material was shown to occupy the epitympanic space and prompted the authors to perform a revision procedure, but no evidence of pathologic tissue was found. Elsheikh et al.[6] reported a conductive hearing loss recurrence in three CT group patients and in two CT + VT group patients. In the CT group, two patients developed ear discharge and one patient developed fibrous bands ensheathing the malleus and the incus, hindering the ossicular chain mobility: In both cases, a revision surgery was performed with secondary intubation of the TM and debriding of fibrous bands, respectively. On exploration of the first patient in the CT + VT group, the malleus was medially rotated, and required removal of 1 mm of the manubrium at the umbo. The second patient underwent a tube exchange due to a VT obstruction. Si et al.[7] reported three cases of ear swelling accompanied by discharge both in the CT and in the CT + ETBD groups. One patient in each group needed to undergo ear drainage. In addition, one patient in the ETBD + CT group had a small TM perforation. Kalra et al.[8] reported three cases of ear discharge and two cases TM perforation. Spielmann et al.[10] reported nine cases of aural discharge: seven in the CT group and two in the "palisade" CT group, respectively. In addition, one patient in the "palisade" CT group had a TM perforation requiring a surgical revision. Ozbek et al.[12] reported five cases of TM perforation and revision surgery was performed on all five ears.

Discussion

Tympanic retraction is a condition frequently faced by the otolaryngologist, arising numerous doubts about which is the most correct therapeutic approach to be performed. These doubts arise from the fact that the progression of the RP or its evolution with cholesteatoma and/or bone erosion development cannot be predicted. In fact, RP can remain asymptomatic for a long time, causing hearing loss only in the advanced stages of the disease.[6] The uncertainty about the clinical evolution of a silent RP often tends to make the specialist tend to apply conservative strategies and, consequently, to apply more demolitive surgical strategies where an effective evolution of the pathology has been detected.[13] Since there is no univocal consensus among the specialists regarding indications, timing, and type of treatment to be performed, the literature appears to be rich in clinical studies performed on this class of patients, and especially on the use of cartilage-perichondrium as a material for reconstruction of the atelectatic TM.

As demonstrated by the high healing rate between 82 and 100% and the low recurrence rate between 0 and 30% among the cases presented by the studies taken into consideration,[5–10,12] it is possible to affirm that cartilage-perichondrium graft is an effective material for the reconstruction of the TM in patients with atelectatic ear. The rigid quality of the cartilage-perichondrium graft seems to resist resorption and retraction, even in a condition of negative middle ear pressure. Barbara[5] proved that preventive surgery performed with cartilage-perichondrium graft is an appropriate and safe option also to avoid the progression of the disease; in fact, even if in a minimal percentage of cases (33.3%), a progression trend with the "wait and see" protocol was demonstrated. Kalra et al.[8] demonstrated with a 90% of graft take-up that RP can also be well managed by excision and cartilage-perichondrium tympanoplasty. Given the good results in line with the other considered studies, Parab et al.[9] demonstrated that good outcomes can also be achieved performing the "noninvasive" two-handed endoscopic CT technique. Spielmann et al.[10] support the view that CT is the treatment of choice for limited RP and suggest that

large pockets may be successfully treated with a "Mercedes-Benz" shaped graft; however, more experience will be required to confirm this finding. Ozbek et al,[12] stating that CT effectively strengthen the tympanic membrane but do not remedy the cause of retraction, pointed out that retraction and perforation may still occur in other regions of the TM left unsupported by cartilage. To prevent these postoperative retractions, they recommended to support the entire TM performing a "palisade" CT. Some authors have proposed the use of cartilage-perichondrium graft with concomitant placement of a VT to improve the middle ear ventilation.[14] In the study by Elsheikh et al.,[6] the morphological and functional improvement in both the CT and CT + VT groups suggests that primary insertion of a ventilation tube into the cartilage-perichondrium graft does not change the results. According to the literature, a better ET function is the premise of successful surgical treatment. Some authors have demonstrated good results of ETBD in the treatment of ET disfunction-related diseases.[15] Si et al.[7] attempted to determine whether the sole cartilage-perichondrium tympanoplasty or the sole application of ETBD is effective and whether the combination of these two techniques could provide more benefits for the recovery of TM retraction. As pointed out in the results, ETBD alone could not solve the problem. Conversely, the morphology of the TM was improved and the middle ear pneumatization was restored in > 90% of the patients in the CT group, resulting in postoperative ABG reduction. This demonstrates that CT plays a key role in the treatment of RP in patients affected by Eustachian tube disfunction. However, the combination of ETBD and CT could be used as an appropriate surgical technique with a low incidence of complications by helping softening possible changes in the atmospheric pressure across the rebuilt TM.

In all the studies reporting data regarding the hearing threshold,[6,7,9,11,12] the results seem satisfactory, and cartilage-perichondrium reinforcement seems to provide the TM with greater strength in the setting of negative middle ear pressure, increasing the closure rate without affecting audiometric results.

Final Comments

The authors of the present systematic review found some limitations in the analysis of the current literature. The studies included in the present review showed wide heterogeneity regarding the type of study design, the number of cases treated, the preoperative clinical conditions and, above all, regarding the use of a reproducible retraction staging system, which makes it difficult to objectively interpret both the starting degree of retraction and the results achieved with the surgical techniques applied. Despite the limitations of the present review, CT may successfully rehabilitate the atelectatic ear, especially in the more advanced stages of retraction, unlike conservative strategies such as medication, ETBD, and VT insertion, which remain uncertain if performed alone. Anyway, better studies are much needed to ascertain the optimal management of TM retractions.

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