Therapeutic Mastoidectomy in the Management of Noncholesteatomatous Chronic Otitis Media: Literature Review and Cost Analysis

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Abstract

Objective. Despite evidence that therapeutic mastoidectomy does not improve outcomes in noncholesteatomatous chronic otitis media, it remains widely performed. An up-to-date systematic review is undertaken and conclusions drawn regarding the best evidence-based practice of its management.

Data Sources. PubMed, Google Scholar, Medline Embase, Cochrane, and Web of Science.

Review Method. A combination of the following words was used: chronic otitis media, chronic suppurative otitis media, COM, CSOM, mastoidectomy, tympanoplasty, atelectasis, retraction, tympanic perforation, and therapeutic.

Results. From 1742 studies, 7 were selected for full analysis with respect to the benefit of mastoidectomy in the management of active and inactive mucosal chronic otitis media. Most were retrospective studies, with 1 prospective randomized controlled trial available. Overall, there was no evidence to support routine mastoidectomy in conjunction with tympanoplasty in chronic otitis media. For ears with sclerotic mastoids, the evidence suggested that there may be some benefit as a staged procedure. Two studies were analyzed for the benefit of mastoidectomy in addition to tympanoplasty for the management of the atelectatic ear (inactive squamous chronic otitis media). The conclusion was also that mastoidectomy added no benefit.

Conclusions. Examination of the available literature supports the notion that therapeutic mastoidectomy does not lend any additional benefit to the management of noncholesteatomatous chronic otitis media. This has implications for patient care, both clinically and financially. Further research, ideally in the form of a prospective, multi-institutional, geographically wide, ethnically diverse, randomized controlled trial, is needed to further support this notion.

Keywords

mastoidectomy, chronic otitis media, tympanic perforation, atelectasis, retraction pocket, cost analysis

Introduction

Rationale

Mastoidectomy and its evolution have come to define modern otological practice. Yet despite evidence that therapeutic mastoidectomy does not improve outcomes in the management of noncholesteatomatous chronic otitis media, it remains a widely performed procedure in many centers.

The term chronic, noncholesteatomatous disease is applied here to encompass 3 types of chronic otitis media (COM) (after Browning1; see Table 1): active mucosal (chronic suppurative otitis media, CSOM), inactive mucosal (dry tympanic perforation or quiescent CSOM), and inactive squamous (tympanic retraction or atelectasis).

Active and inactive mucosal COM are considered part of a spectrum of otomastoiditis due to the anatomical connection of the middle ear cleft with the mastoid air cell system. This concept is supported by histopathological evidence that diseased mucosa, osteitis, and micro-abscess formation are commonly observed in temporal bone specimens that have been severely affected by chronic ear disease in life.2 Postoperative phenomena such as cholesterol granuloma and air cell effusions are regularly encountered as well. Radiologically, severely diseased chronic ears frequently demonstrate evidence of diffuse mastoid air cell opacification and indicators of mastoiditis even when the ear has been made dry and temporarily stable clinically.3 These factors have led many otologists to perform therapeutic mastoidectomy in addition to tympanic membrane repair in an attempt to eliminate chronic tympanomastoid infection, and failure to thoroughly address mastoid air cell disease and persistent mastoiditis has been frequently cited as

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a reason for surgical failure, both in canal wall-up and canal wall-down scenarios. Particular air cell tracts have even been identified as being most commonly associated with surgical failure.4,5

With respect to the atelectasis encountered in inactive squamous COM, the physiologic role of the mastoid air cell system in the regulation of gas pressure within the mastoid and the middle ear cleft is still poorly understood. There is still debate as to whether a healthy mucosa of the mastoid and epitympanum is vital in maintaining postoperative tympanic gas homeostasis or whether mucosal gas absorption in these areas is partially responsible for negative middle ear pressure, subsequent recurrent tympanic membrane retraction, and ultimately active squamous COM (cholesteatoma).6-9 Canal wall-up with or without posterior tympanotomy has been advocated as a means of counteracting such middle ear underventilation.10

Objective
This article serves to objectively review the literature and draw conclusions about the role of mastoidectomy in noncholesteatomatous COM and its clinical and financial implications for patient care.

Methods
For this review, PRISMA guidelines were followed.

Eligibility Criteria
For studies concerned with mastoidectomy in active and inactive mucosal COM, a literature review of the past 20 years (1996 to present) was undertaken. Exclusion criteria included studies published prior to 1996, case reports, non-English-language studies, and studies on mastoidectomy for cholesteatoma. Studies that did not directly compare management of noncholesteatomatous COM with and without mastoidectomy were also excluded. Of the studies yielded, particular attention was paid to the quality of the study, concentrating on those with sufficient numbers and a long enough follow-up period. All studies with a mean follow-up period of less than 12 months and/or a total of fewer than 50 patients or ears were therefore eliminated to maintain scientific integrity. For studies concerned with mastoidectomy in inactive squamous COM, since these were much less in quantity, the review was extended to the past 25 years (1991 to present) instead, but eligibility criteria remained the same.

Information Sources
PubMed, Google Scholar, Medline Embase, Cochrane, and Web of Science were used for the literature search.

Search
This was undertaken independently by 2 authors (A.T. and J.C.P.). A combination of the following terms was used for each search: chronic otitis media, chronic suppurative otitis media, COM, CSOM, mastoidectomy, tympanoplasty, atelectasis, retraction pocket, tympanic membrane perforation, and therapeutic.

Data Collection Process
Studies were independently selected by each author based on inclusion and exclusion criteria. They were then analyzed and data extracted independently and inserted onto a predetermined proforma of data items. A consensus was then reached. It was decided that when there was a conflict, a study would be rejected according to majority vote. Strict adherence to the inclusion and exclusion criteria prevented major conflicts about which studies were eventually included in the review.

Data Items
Data items included author, year published, population size, type of study performed, pathology studied, interventions used, graft types, outcome measures, statistical results, and author conclusions.

Synthesis of Results
The data items used formed the basis of Table 2 and Table 3, with Table 2 representing a summary of studies concerned with mastoidectomy in active and inactive mucosal

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Table 1. Clinicopathological Classification of Chronic Otitis Media (COM).4

<table>
<thead>
<tr>
<th>COM Classification</th>
<th>Synonyms</th>
<th>Otoscopic Findings</th>
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<tbody>
<tr>
<td>Inactive mucosal</td>
<td>Perforation</td>
<td>Permanent perforation of pars tensa, inactive middle ear mucosa</td>
</tr>
<tr>
<td>Active mucosal</td>
<td>Chronic suppurative otitis media</td>
<td>Permanent perforation of pars tensa, inflamed middle ear mucosa, mucus discharge</td>
</tr>
<tr>
<td>Inactive squamous</td>
<td>Retraction</td>
<td>Retracted pars tensa/flaccid usually at posterosuperior segment, with potential of becoming active with retained debris</td>
</tr>
<tr>
<td>Active squamous</td>
<td>Cholesteatoma</td>
<td>Retraction of pars tensa/flaccida, retained squamous epithelium, debris and pus</td>
</tr>
<tr>
<td>Healed</td>
<td>Healed perforation/tymanosclerosis</td>
<td>Thinning and/or local or generalized opacification of the pars tensa without perforation or retraction</td>
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</table>

Table 2. Summary of Studies Comparing the Success Rate of Tympanoplasty\(^a\) with and without Concurrent Cortical Mastoidectomy in Active Mucosal (CSOM) and Inactive Mucosal (Dry Perforation) Chronic Otitis Media.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>n</th>
<th>Follow-up, mo</th>
<th>Study Type</th>
<th>Pathology by Group</th>
<th>Intervention (n)</th>
<th>Outcome Measure</th>
<th>Results</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albu et al(^1)</td>
<td>2012</td>
<td>282</td>
<td>12</td>
<td>Single blinded RCT</td>
<td>A, B: CSOM</td>
<td>A: TWOM</td>
<td>Graft—Success rates:</td>
<td>No difference</td>
<td>A: TWOM (76%)</td>
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<td></td>
<td></td>
<td></td>
<td>without</td>
<td>B: TWM</td>
<td>A: TM perforation(^3)+</td>
<td></td>
<td>B: TM perforation + TWM (82.8%)</td>
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<td></td>
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<td></td>
<td></td>
<td>cholesteatoma</td>
<td>Graft type:</td>
<td>B: TM perforation + TWM (82.8%)</td>
<td></td>
<td>Graft closure (both groups) good ((P &lt; .0001))</td>
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<td></td>
<td>temporalis fascia</td>
<td>ABG</td>
<td>ABG closure—difference between groups not significant ((P &gt; .05)):</td>
<td></td>
<td>A: CSOM + TWOM (90.5%)</td>
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<td>B: CSOM + TWM (85.7%)</td>
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<td>ABG closure—difference between groups not significant ((P &gt; .05))</td>
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<td>Subsequent procedures more likely in the TWOM group (14.1% vs 6.1%; (P &lt; .05))</td>
</tr>
<tr>
<td>McGrew et al(^2)</td>
<td>2010</td>
<td>92</td>
<td>&gt;12</td>
<td>Retrospective review</td>
<td>A, B: CSOM</td>
<td>A: TWOM</td>
<td>Graft—success rates:</td>
<td>No difference</td>
<td>A: TWOM (90.6%)</td>
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<td></td>
<td></td>
<td>without</td>
<td>B: TWM</td>
<td>A: TM perforation + TWM (90.6%)</td>
<td></td>
<td>B: TM perforation + TWM (91.6%)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>cholesteatoma</td>
<td>Graft type: not stated</td>
<td>Graft closure—difference overall between groups not significant ((P &gt; .05)):</td>
<td></td>
<td>Cortical mastoidectomy reduces need for subsequent procedure</td>
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\(^a\) TM = temporal bone; TWOM = Tympanomeatal window graft; TWM = Tympanomeatal wall graft.

(continued)
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
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<th>Study Type</th>
<th>Pathology by Group</th>
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<th>Outcome Measure</th>
<th>Results</th>
<th>Conclusion</th>
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<tbody>
<tr>
<td>Mishiro et al</td>
<td>2009</td>
<td>213</td>
<td>60</td>
<td>Retrospective review</td>
<td>A: CSOM without cholesteatoma</td>
<td>A, B: TWOM (179)</td>
<td>Graft success</td>
<td>No difference between groups not significant ($P = .913$) and overall success rate was 95.8%</td>
<td>No difference</td>
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<tr>
<td>Mishiro et al</td>
<td>2001</td>
<td>251</td>
<td>Mean, 31.7</td>
<td>Retrospective review</td>
<td>A: CSOM without cholesteatoma</td>
<td>A1: TWOM (14)</td>
<td>Graft success</td>
<td>No difference among groups not significant ($P = .441$):</td>
<td></td>
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<tr>
<td>Balyan et al</td>
<td>1997</td>
<td>323</td>
<td>Mean, 34</td>
<td>Retrospective review</td>
<td>A, B: CSOM without cholesteatoma</td>
<td>A1: TWOM (14)</td>
<td>Graft success</td>
<td>No difference among groups not significant ($P = .056$)</td>
<td>No difference</td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
<td>n</td>
<td>mo</td>
<td>Study Type</td>
<td>Pathology by Group</td>
<td>Intervention (n)</td>
<td>Outcome Measure</td>
<td>Results</td>
<td>Conclusion</td>
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<tr>
<td>Krishnan et al²</td>
<td>2002</td>
<td>123</td>
<td>24</td>
<td>Case-control study</td>
<td>A: Dry TM perforation</td>
<td>A1: TWOM (36)</td>
<td>Graft success</td>
<td>ABG closure—difference among groups not significant (P &gt; .05)</td>
<td>No difference</td>
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<td>B: Quiescent CSOM without cholesteatoma</td>
<td>A2: TWM (40)</td>
<td>(intact, mobile)</td>
<td>Graft—Success: A1: TM perforation + TWOM (55%)</td>
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<td>B1: TWOM (8)</td>
<td>Mean</td>
<td>A2: TM perforation + TWM (80%)</td>
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<td></td>
<td>B2: TWM (36)</td>
<td>postoperative ABG</td>
<td>B1: CSOM + TWOM (50%)</td>
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<td>B2: CSOM + TWM (89%)</td>
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</table>

Abbreviations: ABG, air-bone gap; CSOM, chronic suppurative otitis media; RCT, randomized controlled trial; TM, tympanic membrane; TWM, tympanoplasty with mastoidectomy; TWOM, tympanoplasty without mastoidectomy.

*The term tympanoplasty is used to also include myringoplasty (syn. type I tympanoplasty).
COM and Table 3 representing a summary of those concerned with mastoidectomy in inactive squamous COM.

**Ethical Approval**

This study was given full approval by the local Institutional Review Board Committee of the University of Arkansas for Medical Sciences hospital.

**Results**

**Study Selection**

Search criteria returned a total of 1742 studies, which were reduced to 602 after removal of duplicates. These were screened and a further 576 were excluded, resulting in 26 studies for full review. Of these, a total of 9 were chosen for this systematic review, 7 relating to mastoidectomy in active and inactive COM and 2 relating to inactive squamous COM (Figure 1).

**Mastoidectomy in active and inactive mucosal COM.** A total of 7 papers were deemed suitable for analysis at consensus (Table 2). There was 1 single-blinded randomized controlled trial of 282 ears with noncholesteatomatous CSOM, with a follow-up period of 12 months. Five studies were retrospective reviews. Toros et al reviewed their series of 92 ears with CSOM without cholesteatoma that were followed up for at least 12 months. McGrew et al reviewed 428 patients with dry perforations only and who had follow-up an average of 32 months. The remaining 3 retrospective reviews dealt with a combination of both CSOM without cholesteatoma and dry perforations. Mishiro et al reviewed 213 ears with a follow-up of 60 months. This represented a follow-up of their original study of 251 ears at a mean of 31.7 months, with 38 ears having been lost to follow-up. Their 2009 review included a logistical regression analysis of the role of middle ear factors on success rates. Balyan et al reviewed 323 ears with follow-up of a mean of 34 months. Finally, in the case-control study by Krishnan et al, the authors divided 2 groups of ears (one with dry perforations and one with quiescent CSOM without cholesteatoma) into those who would undergo tympanoplasty with mastoidectomy and those who would undergo tympanoplasty alone. A total of 123 ears were treated and followed up for 24 months. In all 7 studies, graft success and mean postoperative air-bone gap (ABG) were used as outcome measures. McGrew et al also used the need for a subsequent procedure as an outcome measure. In all but 1 study (McGrew et al), no difference was seen in outcomes between ears treated with an additional therapeutic mastoidectomy and those who underwent tympanoplasty alone.

**Mastoidectomy in inactive squamous COM.** A total of 2 studies were deemed suitable for analysis at consensus (Table 3). Both were retrospective reviews. Ozbek et al reviewed 56 ears with dry retraction pockets with follow-up of an average of 44.5 months. Their outcome measures were graft success and mean postoperative ABG. They found no difference between mastoidectomy and nonmastoidectomy groups. In contrast, Avraham et al reviewed 111 ears, with those undergoing tympanoplasty only having follow-up of an average of 52.8 months and those undergoing an additional mastoidectomy having follow-up of an average of 54 months. Their outcome measure was the state of atelectasis postoperatively. Their conclusion was that the addition of mastoidectomy was related to a worse postoperative outcome.

**Discussion**

**Comparison with Other Studies**

Of the studies examining the role of mastoidectomy in active and inactive COM, the prospective randomized controlled trial by Albu et al in 2012 was the most statistically robust. In this, they compared type 1 tympanoplasty (myringoplasty) with temporalis fascia graft alone with tympanoplasty and canal wall-up (cortical) mastoidectomy in 282 cases. Both treatment arms were equally stratified according to the Middle Ear Risk Index (MERI) and were equally matched for perforation size and location, preoperative hearing, age, and sex. Cases were followed up for 12 months, at the end of which no statistically significant difference was found from the addition of mastoidectomy to the tympanic membrane repair. Nor was there any statistical difference in postoperative hearing improvement.

In 2002, Krishnan et al carried out a case-control study in which cases of dry tympanic perforation (controls) were compared with cases of CSOM (cases). Both groups underwent temporalis fascia repair of the tympanic membrane with or without additional mastoidectomy and were followed up for 24 months. In their study, they found a direct correlation between middle ear mucosal disease and the concurrent presence of mastoid antral disease. They concluded that in the presence of healthy mucosa, mastoidectomy added no additional benefit to surgical outcome, but in the presence of unhealthy middle ear mucosa, opening of the mastoid antrum and air cells could be deemed good practice. However, they were not able to statistically analyze their results due to the small numbers in some of the treatment groups.

Of the retrospective studies, that by McGrew et al was the largest with a cohort of 428 cases. In this study, they compared the role of additional mastoidectomy in simple tympanic membrane perforation repair (no otorrhea). Cartilage tympanoplasty was used in 55 (12.9%) of their patients and temporalis fascia in the rest. Cases were followed up for an average of 32 months. No statistical difference was found between the groups with respect to graft healing or hearing outcomes, as with all other studies. However, theirs was the only study to suggest that long-term clinical outcomes were worse in the tympanoplasty-only group, with 2 developing atelectasis and 4 developing cholesteatoma. Subsequent tube placement was necessary in 10 of the tympanoplasty-only group compared with 5 in the mastoidectomy group, but this result did not reach statistical significance. Of note, of the cases requiring subsequent
procedures, only 3 underwent cartilage tympanoplasty, reinforcing the concept of the superiority of cartilage as the graft of choice in tympanoplasty.20

The longest follow-up was afforded by Mishiro et al14 in 2009 and represented a 60-month data of their cohort that they first reported in 2001.15 In the original cohort, 251 cases with both dry perforations and CSOM were retrospectively reviewed after a mean follow-up period of 31.7 months following perforation repair with or without mastoidectomy. In both analyses, they found no statistical difference in either graft or audiological outcome. In the 60-month data, multivariate analysis was used to examine any prognostic factors and to determine whether mastoidectomy was useful in tympanoplasty for perforated COM. They concluded that a normal ossicular chain was the only factor shown to have a significantly favorable influence on long-term hearing outcomes after tympanoplasty for perforated COM; there were no significant predictors of long-term successful graft outcomes after tympanoplasty for perforated COM; mastoidectomy was not a significant predictor and could be avoided even for infected ears.14

One study not included in Table 2 but worthy of mention is the prospective case series by Rhul and Pensak21 in 1999. In this study, they selected 135 patients who had all undergone at least 1 attempt at tympanoplasty alone in the past for active mucosal COM. All patients underwent tympanoplasty and mastoidectomy using a variety of materials for the repair depending on availability (areolar tissue, fascia, cartilage, pericranium) and were followed up at 18 months. The success rate was 90.4%. They concluded that for patients with noncholesteatomatous COM who have failed prior tympanoplastic reconstruction, an aerating mastoidectomy may be indicated and may improve the success rate of the surgery.21

Finally, with respect to inactive squamous COM, Ozbek et al18 conducted a relatively small retrospective study of 56 cases undergoing a cartilage palisade technique to prevent recurrent tympanic membrane retractions. After a mean follow-up period of 44.5 months, closure of the tympanic membrane was achieved in 91% of ears. Otomicroscopic evaluation revealed 9 (16%) mild and 5 (8%) moderate retractions, none of which they felt necessitated tube placement. Air-bone gap closure was found to be less than 20 dB in 71% of cases. They concluded that mastoidectomy made no difference to their outcomes. Similarly, Avraham et al19 reviewed 111 atelectatic ears in which tympanoplasty was performed with mastoidectomy in 84 cases and without mastoidectomy in 27 cases. They found a statistically significant difference between the 2 operation groups with respect to presence of postoperative atelectasis, with normal aeration or at least improvement more likely in the tympanoplasty-only group (P = .0048).

**Synopsis of Key Findings**

A review of the current literature thus suggests that with respect to active and inactive COM, therapeutic mastoidectomy is most likely only useful in selected complicated
cases, while most cases seem to respond to closure of the middle ear space via tympanoplasty in combination with culture-directed systemic and/or topical antibiotics. Mastoidectomy may be useful in cases of refractory infection with evidence of antimicrobial resistance, past surgical failures with radiological evidence of extensive mastoid disease, or cases involving an infectious complication. There is as yet still insufficient evidence, however, to make a strong recommendation for mastoidectomy in any of these situations. The findings of this review are in keeping with those found in a similar review performed by Eliades and Limb in 2013.

With respect to inactive squamous COM, while the creation of a volumetric pressure buffer seems a sound theory in concept, evidence supporting therapeutic mastoidectomy in this instance is also lacking. This lack of evidence may be in part due to an inherently flawed theory regarding the volumetric buffer effect.

Limitations of This Study
The impetus of this article was our own belief that therapeutic mastoidectomy is not beneficial in the management of the noncholesteatomatous ear. This can be seen as a bias. However, we feel that this belief is founded in the long experience of the senior author (J.L.D.) and the evidence that is currently available.

Only the English literature was analyzed, but necessarily so, given that none of the reviewers are fluent in other languages. Therefore, relevant non-English articles may have been omitted and likewise with respect to excluding studies prior to 1996 (1991 in the case of inactive squamous COM).

Clinical Applicability of This Study
The cost of a potentially unnecessary mastoidectomy can be viewed from both a clinical and financial standpoint. Clinically, while mastoidectomy is relatively safe in the hands of an experienced otologist, it still carries inherent risks, such as facial nerve palsy, worsened hearing, vertigo, and tinnitus, and at higher rates than with tympanoplasty alone. Conversely, the financial cost must also be considered. The senior author (J.L.D.) does not routinely perform therapeutic mastoidectomy for the chronic noncholesteatomatous ear. In 2015, 153 cartilage tympanoplasties without mastoidectomy were performed on such ears. If it is presumed that the average cortical mastoidectomy takes approximately 15 to 30 minutes to perform, then at a current local 1-day surgery operating room cost of $486.38 for every extra 15 minutes past the first 30 minutes of operating, having routinely performed mastoidectomies for these cases would have cost an additional $74,416.14 to $148,832.28 of operating room time at our institution in 2015 alone. This cost represents a sizable additional financial burden on the health care system and still has not yet taken into account the further additional costs of anesthesia, supplies, medications, devices, or implants.

Conclusion
The current literature supports an evidence-based practice of not routinely performing therapeutic mastoidectomy in the chronic noncholesteatomatous ear but instead considering it only in cases where prior tympanoplasty has failed, antimicrobial resistance has been found, middle ear environment
is found to be particularly unsuitable, or in the case of patients with sclerotic mastoids. Even then, tympanoplasty alone may still suffice. Such practice will lead to reduced cost to the patient both clinically and financially. Further research, ideally in the form of a prospective, multi-institutional, geographically wide, ethnically diverse, randomized controlled trial, is needed to further support this notion.

**Author Contributions**

Aaron Trinidad, substantial contributions to the conception and design of the work, acquisition/analysis/interpretation of data for the work, drafting the work and revising it critically for important intellectual content, final approval of the version to be published;

Joshua C. Page, substantial contributions to the conception and design of the work, acquisition/analysis/interpretation of data for the work, drafting the work and revising it critically for important intellectual content, final approval of the version to be published;

John L. Dornhoffer, substantial contributions to the conception and design of the work, acquisition/analysis/interpretation of data for the work, drafting the work and revising it critically for important intellectual content, final approval of the version to be published;

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**References**


