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Mastoid Obliteration Decreases the Recurrent and Residual Disease: Systematic Review and Meta-analysis

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Objective: Our study aims to evaluate the effectiveness of mastoid obliteration compared to the canal wall up (CWU) technique in cholesteatoma surgery based on the systematic review of the literature and the meta-analysis of the data.

Methods: The systematic search was performed in four major databases (MEDLINE, Web of Science, Embase, and CENTRAL) on October 14, 2021. Studies comparing the CWU technique and mastoid obliteration were included. The exclusion criteria were less than 12 months follow-up, congenital cholesteatoma, indefinite description of the surgical method, and animal studies. The protocol was registered on Prospero (registration number: CRD42021282485). The risk of bias was evaluated with the ROBINS-I tool. Residual and recurrent disease proportions as primary outcomes, quality of life, ear discharge, infection rates, hearing results, and operation time as secondary outcomes were analyzed. In the quantitative synthesis, the random effect model was used, and heterogeneity was identified.

Results: A total of 11 articles with 2077 operations' data were found eligible. All the identified studies were retrospective cohorts. The odds of pooled residual and recurrent disease proportion were significantly lower in the obliteration group compared to CWU (OR = 0.45, CI:0.28;0.80, $p = 0.014$). However, when separated, the proportion of ears with recurrent (OR = 0.41, CI:0.11;1.57, $p = 0.140$) or residual (OR = 0.59, CI:0.23, 1.50, $p = 0.207$) disease did not show a significant difference, even though the odds were quite similar. The qualitative synthesis identified no significant difference in the secondary outcomes, but obliteration elongated the operation time.

Conclusion: Mastoid obliteration significantly decreased the proportion of residual and recurrent cholesteatoma in pooled analyses compared to the CWU technique with low-quality of data.

Key Words: cholesteatoma, mastoid obliteration, meta-analysis, recurrence, residuum, systematic review.

Level of Evidence: NA

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INTRODUCTION

In cholesteatoma surgery, the two major and traditional surgical approaches which are commonly used are more or less antagonistic in their concept. The functional approach is called Canal Wall Up (CWU), which keeps the posterior wall of the outer ear canal intact during surgery.[1] By using this technique, the surgeon is allowed to create a functional middle ear in the original dimensions of the tympanic cavity at the end of the surgery, and the shape of the outer ear canal and its entrance will not be changed. However, the intact posterior wall hampers the intraoperative control of the cholesteatoma, a potential residual disease can be hidden in the mastoid cavity during follow-up, and recurrences can grow into this space again. The radical approach is called Canal Wall Down (CWD) surgery, usually ending up in an open cavity. When applying this technique, the posterior wall of the ear canal is removed during surgery, and a common cavity is created from the outer ear canal and the mastoid bowl. The advantage of the procedure is improved intraoperative control of the tympanic cavity, and the postoperative follow-up is easy in the mastoid part through the ability for direct visualization. However, there are numerous disadvantages, like the need for frequent cleaning, water avoidance, cosmetic points,

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recurrent infections, and potential difficulties in fitting hearing aids.[2–4]

Mastoid obliteration is a technique that tries to combine the advantages of these two procedures. It has been claimed that if the mastoid cavity is obliterated at the end of the surgery, the risk of developing a recurrent cholesteatoma there is reduced. Besides this, obliteration helps reconstructing the posterior wall of the ear canal in CWD surgery; hence, it has been named the canal wall reconstruction (CWR) technique.[5] However, the surgery is elongated when the mastoid cavity is obliterated, patients must be radiologically followed postoperatively, and reoperations can sometimes be challenging.[6]

The first attempts with mastoid obliteration were published in 1911.[7] Although it has become more popular in the last two decades in parallel with the introduction of the non-EPI DW-MRI technique for follow-up, there is still debate among middle ear surgeons about its usefulness.[8,9] The personal preferences are only supported by scarce scientific data: high-quality evidence is missing, and we lack mastoid obliteration trials. As far as we know, no previous research has investigated the effectiveness of mastoid obliteration comprehensively compared to the CWU approach. In this study, we aimed to summarize the knowledge from the published comparative studies to assess the effectiveness of mastoid obliteration compared to the CWU technique. We hypothesized that mastoid obliteration reduces the rate of recurrent and residual cholesteatoma compared to the CWU approach, with a similar postoperative quality of life.

METHODS

Our systematic review and meta-analysis followed Cochrane Handbook recommendations.[10] We applied the PICO framework to create the study protocol, which was registered on PROSPERO (registration number: CRD42021282485), and our investigation fully adhered to this. Prisma 2020 updated guideline for reporting systematic review was used for transparent and structured manuscript writing.[11]

Eligibility Criteria

The included studies were reported on patients of any age or sex who had tympanomastoid surgery due to cholesteatoma, and they were followed at least 12 months after the surgery, where the outcomes of mastoid obliteration in CWU tympanoplasties or CWD with the reconstruction of the posterior wall were compared with CWU without obliteration. Studies about congenital cholesteatoma were excluded. Our investigation concentrated on the effect of the mastoid obliteration directly after the CWD, CWU, or CWR technique compared to the CWU approach; therefore, these, comparable studies were included. Any kind of obliteration material was accepted, for example, autologous bone dust, any synthetic material, cartilage, muscle, muscle flap, or a combination of any of these if the surgical description was well designed and clear.

The primary outcome was recidivism, including the proportion of recurrent and residual disease; the secondary outcomes were quality of life, hearing results, infection rates, operation time, and the rate of discharge of the ear. Interpretation of the primary outcomes was based on the European Academy of Otology and Neurotology/Japanese Otological Society (EAONO/JOS) Joint Consensus Statements.[12]

The accepted study designs were comparative studies such as experimental studies with or without randomization or observational studies with the control group of interest. Case reports, animal studies, review of literature, meta-analysis, and guidelines were excluded.

Systematic Search

Our systematic search was conducted on four databases (MEDLINE, Web of Science, Embase, and Cochrane) on October 14, 2021. The following search key was used without any filters or restrictions:

(cholesteatoma OR cholesteatomas OR mastoidectomy OR "canal wall up" OR CWU OR CWUM OR "intact canal wall" OR ICW OR ICWM) AND (obliteration OR "canal wall reconstruction" OR CWR OR BOT OR "bone pâté" OR autologous OR synthetic OR cartilage OR bioglass OR "osteoplastic flap" OR muscle OR silicon OR hydroxyapatite OR fascia).

The reference lists of the identified studies were reviewed for additional eligible articles.

Selection Process

Two independent review authors (Kata Illés and Fanni Adél Meznerics) performed the selection after the duplicates were removed. Management programs (EndNote X9, Clarivate Analytics, Philadelphia, PA, USA) were used for selection. The disagreements after the title and abstract selection were resolved by a third reviewer. The full-text selection was performed by two independent reviewers (Kata Illés and Fanni Adél Meznerics) without any disagreement. Inter-rater reliability with Cohen's kappa calculation was measured after the title and abstract selection and after the full-text selection.

Data Extraction

Two independent review authors (Kata Illés and Fanni Adél Meznerics) completed the data extraction using a predefined Excel (Microsoft Corporation, Redmond, Washington, United States) datasheet. The following data were extracted from each eligible article: the first author, year of publication, country of origin, study design, basic demographic characteristic (female percentage, age, number of patients), follow-up period, bivariate data of the residual, and recurrent disease. If it was possible, the data of the secondary outcomes (quality of life, hearing results, complication rates, and rate of discharge of the ear) were also collected. The disagreement on the data extraction was resolved by discussion among the authors.

The follow-up assessment of the patient was different in each study, although the regular patient visit and otomicroscopic evaluation were documented in all articles. Four studies applied magnetic resonance imaging (MRI) examination at one year to identify potential recidivism. One study from 2001 used computer tomography (CT) examination at 12 and 18 months for all patients of obliterated group and second-stage surgery for individuals who underwent CWU approach to verify the results. The rest of three articles was written in 1984, 1988, and 1997; hence, the new imaging techniques were not available. Recidivism was evaluated in those studies by regular patient visits and otomicroscopic examination and second option was at that time the two-staged surgery strategy which was applied by one study.[13]

Only single (primary or revision) surgical data were extracted from the articles; one ear's operation was counted once in each analysis. A patient could appear twice in the analysis only if it was a bilateral operation.

Study Risk of Bias Assessment

According to the actual Cochrane recommendation for non-randomized studies of intervention, we applied the ROBINS-I tool to assess the risk of bias, which was evaluated by two independent review authors (Kata Illés and Fanni Adél Meznerics), and the disagreement was solved by discussion.[10,14]

Publication Bias Test

Publication bias was visualized with contour enhanced funnel plots; however, it was not statistically tested for (due to the $K < 10$ studies involved) as per the recommendations of Harrer et al.[15]

Certainty Assessment and Level of Evidence

The level of evidence was judged according to the Center for Evidence-Based Medicine (OCEBM) Levels of Evidence table, 2011.[16]

Subgroup Analyses

Two subgroup analyses were carried out with data based on clinical aspects. The first one was derived from the studies which used bone or bone replacement material for obliteration; the other group was based on surgical techniques. The reason for the latter subgroup analysis was based on our hypothesis that the most determinant and clearly stated surgical approach is the CWU, and comparing it with the same but combined technique with obliteration in our theory would yield the most reliable comparison.

Synthesis Methods

The odds ratio with 95% CI was used for the effect measure; the total number of patients in each group and those with the event of interest were extracted from each study to calculate the odds ratio.

Raw data from the selected studies were pooled using a random effect model with the Mantel–Haenszel method and the Hartung-Knapp adjustment.[17–20] Subgroup comparisons were carried out following the description in Harrer et al.[15] To estimate τ^2, we used the Paule-Mandel method and the Q profile method for calculating the confidence interval of τ^2.[15,21] Statistical heterogeneity across trials was assessed by means of the Cochrane Q test and the I^2 values.[22] I^2 statistic of 25%, 50%, and 75% was identified as low, moderate, and high estimates, respectively. Outlier and influence analyses were carried out following the recommendations of Harrer et al. and Viechtbauer and Cheung.[15,23]

Forest plots were used to summarize the results graphically.[24,25] Where applicable, we reported the prediction intervals (i.e., the expected range of effects of future studies) of results following the recommendations of IntHout et al.[25]

All analyses were carried out using the R 4.1.3[26,27] using the packages "meta"[28] and "dmetar."[29]

RESULTS

Search and Selection

The result of the systematic search was 2756 articles after the duplicates were removed. The selection process is listed in the PRISMA-Flowchart 2020 (see Fig. 1). Cohen's kappa of the title and abstract selection was 0.91, and after the full-text selection, it was 1. No additional studies were found eligible during the reference

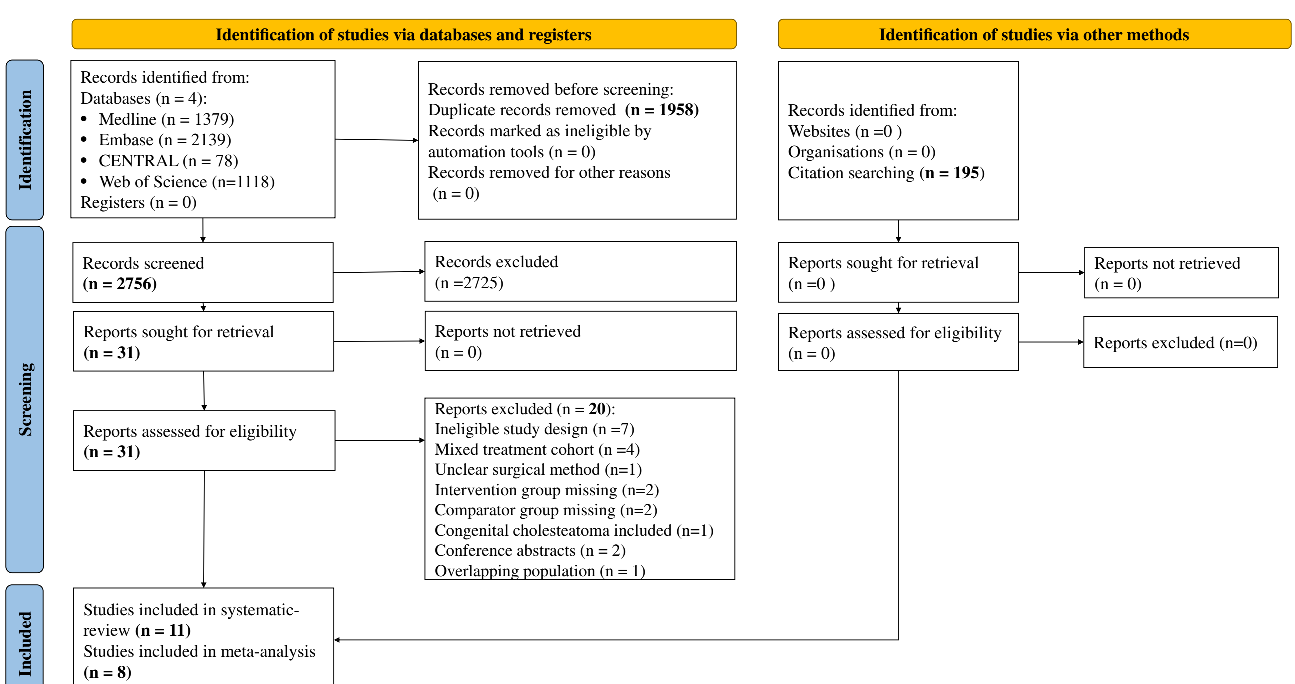

Fig. 1. Prisma flow diagram of the screening and selection process [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

checking process. We included eight studies in the quantitative analysis[13,30–36] and six studies in the quantitative analysis.[30,32,34,35,37,38]

Basic Characteristics of Included Studies

The baseline characteristics of the involved studies are shown in Table I. All the included studies were retrospective cohort studies. Ten of the eleven studies were from Europe, and one study was from the USA. The age distribution among the patients was wide; five studies included their analysis of children's data and six of them used only the adult population. The follow-up period of the included studies was 12–144 months. The number of surgeries were counted, and all surgeries were counted once. Nine original studies stated or suggested including only primary operations, whereas two studies also included patients who have had prior operations.

The separation of the recurrency and residuum was based on clinical reports in every study. The residual cholesteatoma is a result of incomplete removal, usually presenting as an epithelial pearl independent of the tympanic membrane, whereas the recurrency is the reformation of retraction pocket in the tympanic membrane.[12]

Quantitative Analysis

Disease Recidivisms. In the first forest plot, seven articles with 1847 operations' data were assessed, and the result is shown in Fig. 2.[13,30–35] The targets of the measurement were the residual and recurrent disease proportions which were reported together in two articles[31,35] and separately in five articles.[13,30,32–34] According to the analysis in the first forest plot, mastoid obliteration can significantly reduce the proportion of recurrent and residual cholesteatoma (OR $= 0.45$, CI:0.26;0.8, $p = 0.014$). The between-study heterogeneity was moderate ($I^2 = 67\%$, $p < 0.01$).

Separate Analyses of Recurrent and Residual Disease Proportions. The residual disease prevalence was separately reported in six studies,[13,30,32–34,36] five of them have appeared in the previous analysis (recidivism) and one article reported data only about the residual disease,[36] whereas the recurrent disease proportion was reported in the same five studies.[13,30,32–34] Analyses of these outcomes are shown in Figures 3 and 4.

The result of the pooled analyses of recurrent disease proportion alone showed reduction in odds ratio compared to CWU, although it was not statistically significant (OR $= 0.41$ CI:0.11;1.57, $p = 0.140$) as can be seen in Figure 3. Heterogeneity among the studies was moderate ($I^2 = 59\%$, $p = 0.04$).

We found no clear statistical evidence that mastoid obliteration would reduce the proportion of ears with residual disease. The p-value of the overall OR indicated that the outcome is not significant due to the wide confidence interval, which can be seen in Figure 4. Heterogeneity among the studies was moderate ($I^2 = 56\%$, $p = 0.05$).

Subgroup Analysis on Obliteration Material. A subgroup analysis was conducted among studies, where bone or bone replacement material was used for mastoid obliteration. There were four articles eligible to do this calculation; results are given in Figure 5.[31,33–35] The outcome of the measurement was the proportion of ears residual and recurrent disease. The OR of the bone or bone replacement material subgroup was 0.43 (CI:0.15; 1.30) with high between-study heterogeneity ($I^2 = 75\%$, $p < 0.01$). The pooled OR of studies that used muscle or muscle and bone for obliteration was 0.46 (CI: 0.10; 2.13) with moderate heterogeneity ($I^2 = 52\%$, $p = 0.13$).

Subgroup Analysis of Technique. Studies that compared CWU without obliteration to CWU with obliteration were analyzed as a subgroup. Only three articles eligible for inclusion were found.[31,32,34] The outcome of the measurement was also the residual and recurrent proportion. The OR of this subgroup was 0.48 with wide CI (0.05; 4.38) and high heterogeneity ($I^2 = 83\%$, $p < 0.01$). The other four studies compared CWU without obliteration to CWD or CWR with obliteration; the OR among this group was 0.41 with narrow CI (0.20; 0.81) and low heterogeneity ($I^2 = 3\%$, $p = 0.38$). There was no significant intergroup difference ($X^2 = 0.08$, df $= 1$ $p = 0.77$) according to data in Figure 6.

Risk of Bias Assessment. The results of the risk of bias assessment are presented in Figure S1. According to the Cochrane recommendation, we used the ROBINS-I tool to assess the risk of bias.

For the outcomes included in the meta-analyses, the ROB assessment was 61.5% at high and 38.5% at medium level, see it more detailed in Figure S1A. The ROB evaluation for the qualitative syntheses was 8% at high and 91% at medium risk level, see it more detailed in Figure S1B.

Funnel plots were completed as a publication bias test, which did not assume serious publication bias, as can be seen from Figures S2–S4.

OCEBM 2011 Level of Evidence. The level of evidence assessment according the OCEBM is not applicable for systematic review and meta-analyses from retrospective observational studies; therefore, we cannot classify our work.

Qualitative Analysis. The secondary outcomes such as hearing results, infection rates, discharge of the ear, operating time, and quality of life were included in this part of our study. All these outcomes could not fulfill the requirements of the mathematical synthesis, so we provide qualitative analysis.

The hearing outcomes were mentioned in five articles. Different audiometric measurements were used in the studies. Three of them reported no significant differences in hearing results among the groups, and two studies reported that the CWU group without obliteration had better hearing postoperatively.[32,35,37] However, that difference was clinically irrelevant or disappeared over time.[34,38] None of these studies reported hearing gain over 10 dB in AC.

None of the included studies found differences in infection rates or ear discharge rates.[30,34,35,38] However, several confounding factors were present in those studies. Minor complications rarely occurred, so mathematical comparison could not be performed.[34,35] No major complications were reported.

TABLE I.
Basic Characteristics of Included Studies.

First author, year of publication	Study design	Country	Sex (female% of total)	Patient's age at the time of the operation (years)	Total number of operated ears/patients	Type of surgery	Intervention	Obliteration material	Follow-up range (months)	Outcome: Meta-analysis part	Outcome: Review part
Toom, 2021	Retrospective cohort study	Netherlands	31.2%	>18	290	33.8% primary 66.2% revision	Canal wall up with mastoid obliteration	Autologous bone pate and bioactive glass	Interquartile range 16–51 Five years follow-up	Recurrent disease Residual disease	Hearing outcome Operation time Infection rate
Møller, 2019	Retrospective cohort study	Denmark	NR	Median: 33	777	All primary	Canal wall up with mastoid obliteration	Hydroxyapatite granule	Five years follow-up	Recurrent and residual disease	-
Rayneau, 2019	Retrospective, controlled	France	50%	Rage: 24–63	165	All primary	Canal wall reconstruction with mastoid obliteration	MBCP and fibrin glue	18–67	Recurrent disease Residual disease	-
Wilkie, 2019	Retrospective cohort study	UK	40%	26–82	104	All primary	Canal wall down with mastoid obliteration	Autologous bone pate	12–52	Recurrent and residual disease	Hearing outcome Ear discharge
Yung, 2001	Retrospective, controlled	UK	NR	Median: 35 Range: 5–89	72	Presumably all primary	Canal wall down with mastoid obliteration	NR	12–144	Residual disease	-
Nyrop, 1997	Retrospective, controlled	Denmark	NR	Median: 28 Range: 4–77	60	Presumably all primary	Canal wall up with mastoid obliteration	Autologous bone pate and pedicle muscle	12–94	Recurrent disease Residual disease	Hearing outcome
Smyth, 1988	Retrospective, controlled	Ireland	NR	21% of the control group and 35% of the intervention group were ≤16yrs	200	Presumably all primary	Canal wall reconstruction with mastoid obliteration	Palva flap	108–120	Recurrent disease Residual disease	-
Cody, 1984	Retrospective, controlled	USA	NR	NR	251	Presumably all primary	Canal wall down with mastoid obliteration	Pedicle muscle flap	48–72	Recurrent disease Residual disease	-
Lailach, 2015	Retrospective cohort study	Germany	NR	SD mean: 56.1 ± 14.4 Range: 9.6–82.7	58	62% Primary 38% revision	Canal wall down with mastoid obliteration	Autologous bone pate and sliced concha cartilage plates	12.8–160.5	-	Quality of life (CES questionnaire)
Quaranta, 2014	Retrospective cohort study	Italy	52%	Intervention group SD mean: 48.5 ± 17.2 Control group SD mean: 48.9 ± 14.8	100	All primary	Canal wall down with mastoid obliteration	Autologous bone pate, blood, and fibrin glue	24-NR	-	Quality of life (COMOT-15 questionnaire) Hearing outcome
Toner, 1990[a]	Retrospective, controlled	Ireland	NR	Same as Smyth, 1988	200	Presumably all primary	Canal wall reconstruction with mastoid obliteration	Palva flap	96–144	-	Hearing outcome Cavity status

In these studies, were children included: Møller, 2019, Nyrop, 1997, Yung, 2001, Smyth, 1988 (Toner, 1990).
CES = chronic ear survey; COMOT-15 = chronic otitis media outcome test 15; MBCP = biphasic calcium phosphate; NR = not reported or not reported for the target population; SD mean = standardized mean.
[a]Same population with Smyth study but the reported outcome different.

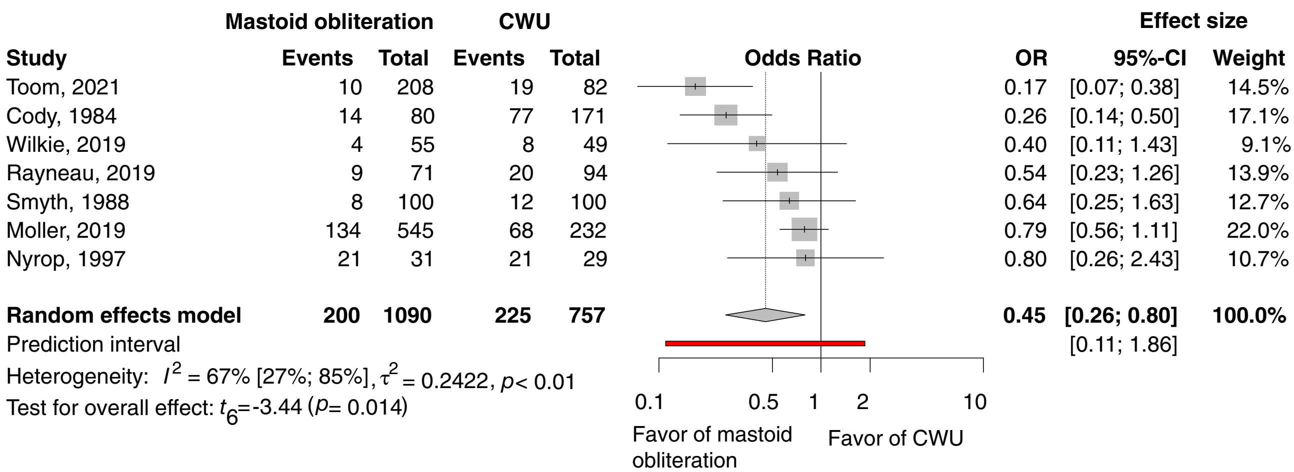

Fig. 2. Forest plot depiction representing the pooled odds ratio of recurrent and residual disease between treatment groups [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

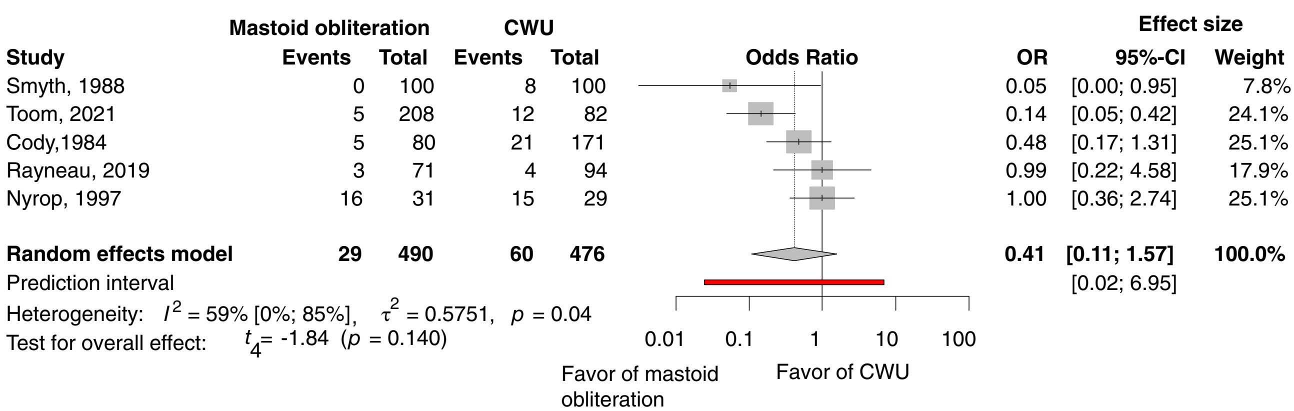

Fig. 3. Forest plot depiction representing the pooled odds ratio of recurrent disease between treatment groups [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

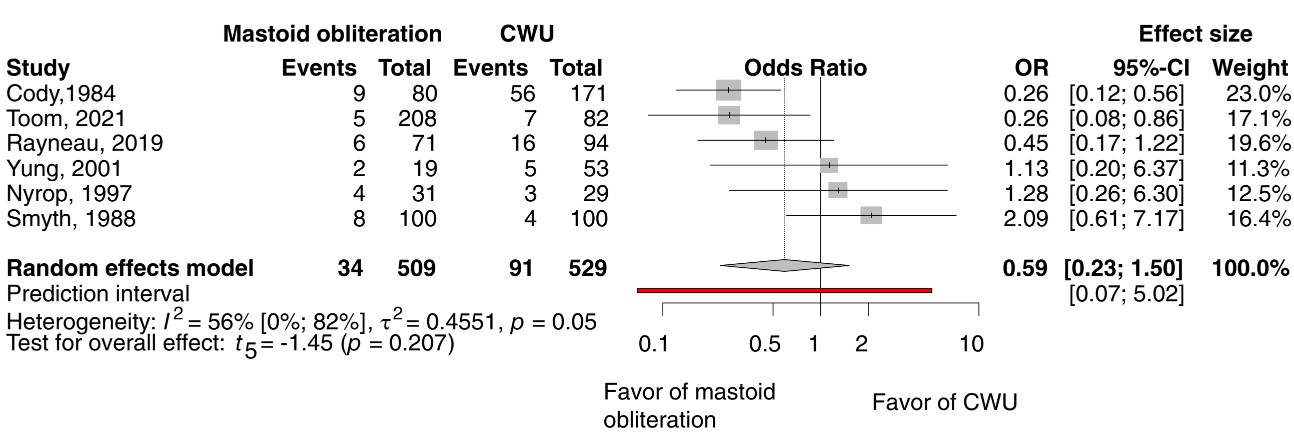

Fig. 4. Forest plot depiction representing the pooled odds ratio of residual disease between treatment groups [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

The operation time was reported in one article.[39] That study reported a significant difference in favor of the CWU technique, showing clearly that mastoid obliteration elongates the operation time.

The quality of life as an outcome could be found in two articles.[37,40] One of them compared the CWU without mastoid obliteration to the CWD with mastoid obliteration.[40] The other one compared three different surgical

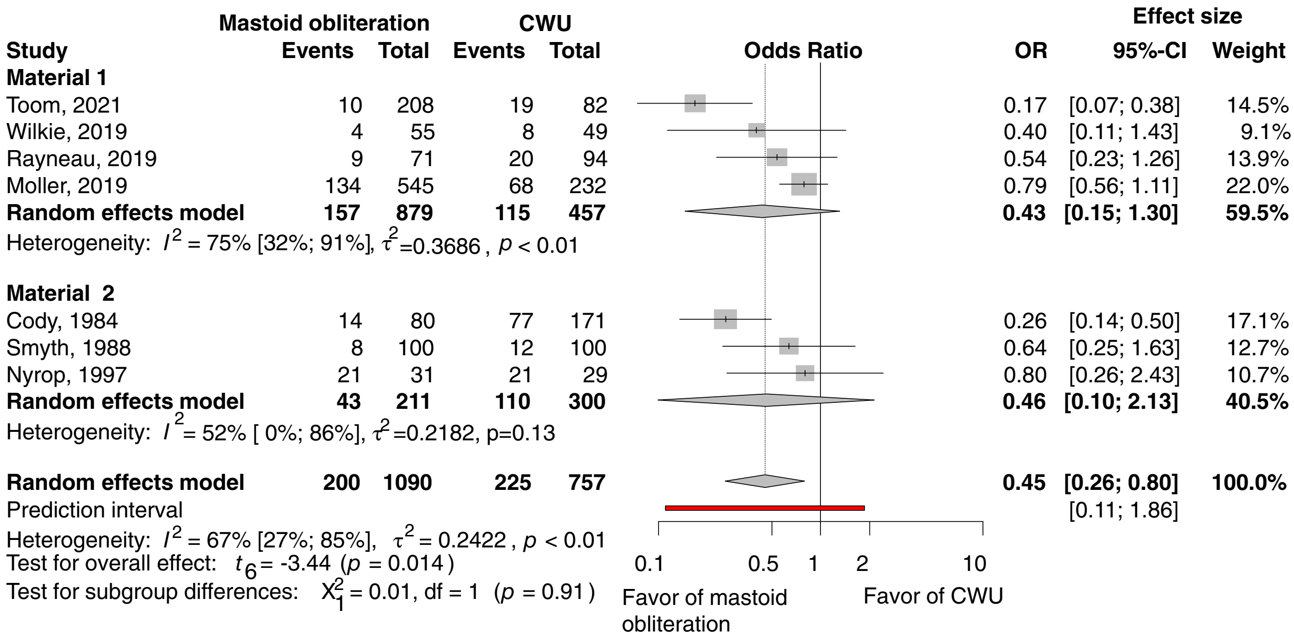

Fig. 5. Forest plot for subgroup analyses on the material used for obliteration. Material 1: bone or bone replacement material; Material 2: exclusively muscle or muscle with bone [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

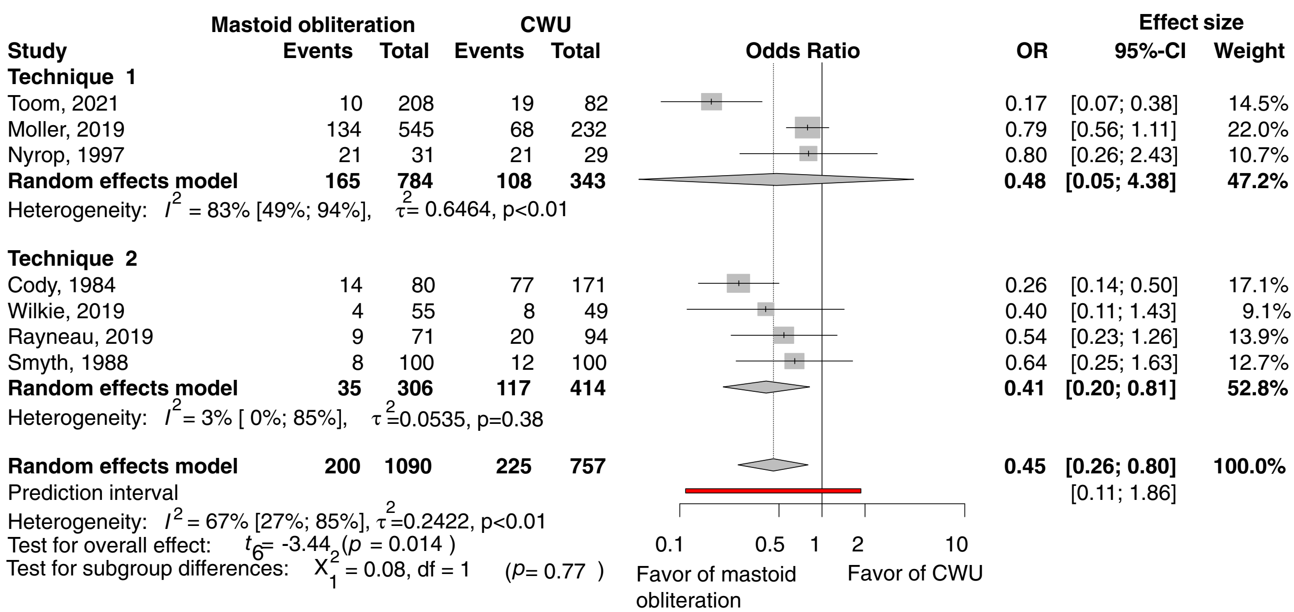

Fig. 6. Forest plot for subgroup analyses on surgical technique. Technique 1: Canal wall up (CWU) + obliteration; Technique 2: Canal wall down (CWD) + obliteration or Canal wall reconstruction (CWR) + obliteration [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

techniques, and two of them were in our target of interest: CWU without mastoid obliteration and CWU with obliteration.[37] These studies used different questionnaires and methods, but the result was similar. They found that the most important factor which determines quality of life was hearing loss, and the two groups were associated with similarly good results.

DISCUSSION

After processing the literature suitable for the meta-analysis, we found that mastoid obliteration significantly reduces the risk of developing recurrent or residual cholesteatoma compared with the CWU technique, when calculated in an integrated manner. In contrast to this, when separately calculated, neither the recurrent nor the residual disease proportions showed significant difference; however, the odds were quite similar. Although distinguishing recurrent from residual cholesteatoma could be important due to their different pathomechanisms, it is irrelevant from the patients' perspectives. Besides this, separation was not available in all the included studies.

Here, we would like to emphasize, that these results are based on a minimum follow-up of one year with a heterogenous way of disease control. Surveillance would be optimal above this time limit, calculating a survival analysis similar to tumors, because recurrency is related to length of observation time.[41,42] Besides this, recurrent diseases can be easily detected by otomicroscopy, but correct residual disease control in the mastoid bowl requires obvious second-stage surgery or imaging techniques. The latter means non-EPI DWI MRI, which has its sensitivity limits regarding to the size of the cholesteatoma and was not available in the era of many of the processed studies.[43] Moreover, patient selection for a certain type of surgery was not homogenized in these studies. It was stated in one study and suggested in two others that selection for obliteration instead of CWU was based on the extension and severity of the cholesteatoma: obliteration was chosen in more extended cases.[31,33,34]

We did not find enough raw data in the analyzed studies to create a comparison on a higher statistical level regarding the location of residual and recurrent disease, particularly in the mastoid bowl. Only two of the studies made a comparison based on the location between the outcomes of the obliteration group and the CWU group.[33,34] One study showed benefit regarding the mastoid cavity, whereas the other showed better results in the tympanic cavity. In the latter study, CWD with CWR and obliteration was compared to CWU. The authors hypothesized that a better visualization of the tympanic cavity after the CWD procedure can be the explanation for better outcomes in the tympanic cavity.

The heterogeneity among the available articles was considered moderate. The differences may come from the diverse surgical approaches, reconstruction techniques, various materials used for obliteration, different follow-up periods, or the age gap between the included patients. Although we tried to make the groups more compact and homogenized by creating subgroups, the heterogeneity paradoxically increased even more, probably because of the low number of studies included and their retrospective nature (see Fig. 5 and 6).

We could not perform an analysis regarding the age of the patients. Although cholesteatoma in children is considered more dangerous and unstable, we could not statistically determine whether age affects the outcomes in mastoid obliteration.[44–46] According to one article, only children benefited from the obliteration after CWU,[31] but in contrast to this, other articles reported that it is advantageous for adults as well.[34] These findings warrant the need for additional studies to understand more about age groups separately.

Most cholesteatoma recurrences are detected within the first few years after surgery, and traditionally the accepted minimum follow-up in middle ear surgery is one year.[31,47] We were able only to select studies with a minimum follow-up of 12 months, but each study has a mean or median follow-up of at least 30 months. The differences between the follow-up periods might cause divergence in the results, but because of the previously mentioned reason and the fact that the subgroups had approximately similar follow-up times without significant deviation from the main outcome's OR, we concluded that it is a limitation, but the analyses should be performed.

It was recognized that muscle as a material for obliteration shrinks and atrophies over the years, which might affect the outcomes.[6,48,49] A histopathological study also proved that bone dust remains in the mastoid cavity without a change in size, unlike muscle.[50] For this reason, we decided to do a subgroup analysis on studies that used autologous bone dust or bone replacement material. We included bone replacement materials such as hydroxyapatite granulate or bioglass because these materials behave consistently like bone paté.[51]

The result of this analysis did not assume differences in material, but we cannot make further conclusions without randomized controlled trials and a larger sample size.

The clearest comparison regarding the effect of mastoid obliteration is to compare CWU alone with CWU with obliteration. We were able to do a subgroup analysis according to this, but we could include only three articles. The heterogeneity was high for the previously mentioned reasons. The subgroup analyses did not estimate any intergroup difference; however, the small sample size and the quality of the studies necessitate re-evaluating this question with more and higher quality data.

The length of the operation could depend on many factors. In cases of mastoid obliteration, it indeed takes extra time to completely remove all the air cells in the mastoid cavity, to collect bone dust in the bony obliteration technique, and to reconstruct the posterior wall in cases of CWD. The only study that compared the length of the surgery proved that obliteration significantly elongates the operation.[34] Although it is impossible to estimate the general extent of the elongation based only on one article, we think that the correlation must be true.

Strengths and Limitation

Regarding the strengths of our analysis, the previously reported PROSPERO protocol and the Cochrane recommendation were followed, and rigorous methodology was used. A total of 2077 operations' data were assessed from 11 articles, and the first comprehensive analysis of this topic was created. Subgroup analysis was performed on clinically relevant data.

The main limitation of our study is that we could include only retrospective observational studies with several confounding factors and a serious risk of bias. Therefore, our results are only assumptions; causation between the surgical techniques could be verified by prospective trials. Furthermore, there are no clear indications for each technique.

Besides this, from the statistical point of view, the odds ratio is not suitable for time-varying variables such as the hazard ratio (HR), which we were not able to calculate without the appropriate data in five out of seven articles. Also, some of the analyzed studies reported or suggested that the obliteration groups had more patients with extensive disease than the CWU group.

Implications for Practice and Research

We suggest for further studies reporting the data in a more uniform manner, making survival analyses, and calculating HR or using Cox regression models to control for the increased risk of recurrence over time. The follow-up period should be at least 12 months or more, and the surgical comparison should be the CWU to CWU with obliteration. Also reporting the observations gathered during reoperations in obliterated mastoid cavities would be a way forward.

CONCLUSION

According to our results, the obliteration of the mastoid cavity could be an effective surgical option without severe complications and deterioration of quality of life. However, we cannot make recommendations due to the low quality of data. This article addresses the need for randomized controlled trials which are so far lacking in the scientific literature.

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