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Review

Mastoid obliteration and reconstruction techniques: A review of the literature

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A B S T R A C T

Objective: To review the published literature related to the different obliteration and reconstruction techniques in the management of the canal wall down mastoidectomy.
Methods: A PubMed (Medline) and LILACS databases as well as crossed references search was performed with the following Mesh terms: "cholesteatoma", "cholesteatoma-middle ear", "otitis media", "otitis media, suppurative", "mastoiditis", "mastoidectomy", "canal wall down mastoidectomy", "radical mastoidectomy", "mastoid obliteration" and crossed references. Inclusion criteria were adult patients subject to mastoid cavity obliteration and posterior canal wall reconstruction. The technique and materials used, anatomic and functional results, complications, recurrence rates, and changes in quality of life, were analyzed. A total of 94 articles were screened, 38 were included for full-text detailed review.
Results: Twenty-one articles fulfilled the inclusion criteria. Techniques and materials used for canal wall reconstruction, tympanoplasty, and ossiculoplasty were varied and included autologous, biosynthetic, or both. Auditory results were reported in 16 studies and were inconsistent. Three studies reported improvement in the quality of life using the GBI scale. Follow-up time ranged from 1 to 83 months. Eleven articles used imaging studies to evaluate postoperative disease recurrence. The highest recurrence rate reported for cholesteatoma after obliteration was 19%. The most frequently reported complications were retraction pockets and transient otorrhea.
Conclusion: Plenty of techniques combining grafts and other materials have been used to overcome mastoidectomy cavity problems. So far, it is still not possible to standardize an ideal procedure. The available level of evidence for this topic is low and limited.

Contents

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1. Introduction

Chronic otitis media with cholesteatoma (COMC) is characterized by the presence of epithelial tissue, which can expand and erode adjacent structures and cause hearing loss, vestibular dysfunction, facial paralysis, and intracranial complications, among others.

Otologic surgery is the treatment of choice to create a dry, safe cavity without recurrence (Hamed et al., 2016). Additionally, this procedure aims to preserve or restore the anatomy and functionality of the ear to the extent permitted by the cholesteatoma (Schwager and Zirkler, 2014) (Walker et al., 2014) (Gantz et al., 2005). The surgical management of COMC can be classified into two main techniques: Canal wall down mastoidectomy (CWDM) and canal wall up mastoidectomy (CWUM), each one having advantages and disadvantages (Schwager and Zirkler, 2014) (Suzuki et al., 2014) (Sorour et al., 2018). In CWUM, the posterior wall of the external auditory canal (EAC) is preserved; this avoids the need for mastoidectomy cavity cleaning and also does not require water restriction since the tympanic membrane is kept intact. However, due to the limited exposure of the attic and other hidden spaces in the middle ear, this technique has a high risk of recurrence (40–60% in children and 30% in adults). In CWDM, the posterior wall of the EAC and the ossicular chain is removed and the Eustachian Tube is obliterated to completely isolate the middle ear. CWDM has a low recurrence of cholesteatoma (2%–17%) (Gantz et al., 2005) (Sorour et al., 2018); however, the accumulation of epithelial debris in the cavity requires frequent in-office cleaning and water restriction to prevent complications. Even with adequate care, 10%–60% of CWDM patients present chronic otorrhea, and may also manifest vertigo or dizziness with exposure to extreme temperatures. The episodes of chronic otorrhea, hearing loss, difficulty in fitting hearing aids, the costs of follow-up consultations, and the need for medications have an impact on the patients' quality of life (Mokbel and Khafagy, 2012).

Different techniques attempt to combine the adequate exposure and low recurrence afforded by a CWDM with the preservation or reconstruction of the posterior wall of the EAC, and the restoration of the middle ear hearing mechanisms (with tympanoplasty and ossiculoplasty) offered by a CWUM with or without mastoid cavity obliteration. These techniques primary objectives are the eradication of the disease and prevention of its recurrence. Hearing gain is considered a secondary goal. Also, by restoring the anatomy of the EAC, the adaptation of hearing aids can be facilitated. Different modifications to the technique have been made; however, there is no Gold Standard technique so far.

The purpose of this study is to review the published literature related to the different obliteration and reconstruction techniques for the management of CWDM; including modifications in surgical techniques, functional outcomes of the procedure, complications, recurrence, and impact on the quality of life.

2. Material and methods

We searched PubMed (Medline) and LILACS databases as well as crossed references. Using the following terms: "Cholesteatoma"[Mesh] "Cholesteatoma, Middle Ear"[Mesh] "Otitis Media"[Mesh] "Otitis Media, Suppurative"[Mesh] "Mastoiditis"[Mesh] "Mastoidectomy"[Mesh] "canal wall down mastoidectomy" [All Fields] "radical mastoidectomy" [All Fields] "mastoid obliteration"[All Fields].

2.1. Inclusion criteria

Inclusion criteria for citations were patients older than 18 years, with COMC diagnosis, subject to mastoid cavity obliteration, and EAC wall reconstruction (done simultaneously during CWDM or on a second surgery). Citations were required to specify the technique and materials used and also report one or more of the following outcomes: auditory results, complications, recurrence rate and impact in the quality of life. All study types were included.

A total of 95 citations have been identified through database searching (84 from MEDLINE, 11 from LILACS), and three additional records through crossed references. After the removal of duplicates, a total of 94 records had been screened. Initially, the abstracts and titles of the 94 papers were screened independently by two of the authors (L.M and M.D), who subsequently met and discussed the points they disagreed on within the articles that were eligible. A total of 38 articles were included for a full-text detailed review and analysis, 17 articles were excluded for different reasons (detailed in Fig. 1); the final number of papers included for the literature review was 21.

3. Results

Throughout time, multiple modifications in the surgical technique of obliteration and reconstruction for the management of CWDM have been made. Soft tissue reconstruction was described by Smith et al., in 1986 (Yung and Smith, 2007). This technique was associated with fewer postoperative complications. However, its main disadvantage was the difficulty in reconstructing the middle ear due to the absence of support structures (Lee et al., 2017) (Takahashi, 1991). Mokbel KM et al. modified this technique with a partial thickness skin graft to coat the newly reconstructed canal (Mokbel and Khafagy, 2012). Deveza et al. proposed the use of titanium prostheses to reconstruct the EAC. Subsequently, Bernardeschi D et al. published a paper on this titanium prosthesis and reported that its predetermined size limited reconstruction due to the difficulty of adaptating it to the different mastoid cavity sizes and because of the variation in the height of the canal wall (Deveze et al., 2010) (Bernardeschi et al., 2014). Walker PC et al. proposed partial obliteration of the attic (Walker et al., 2014). Trinidade A et al. used a middle temporal artery periosteal flap to reconstruct the canal wall (Bernardeschi et al., 2014). Geerse S et al. reported their results with a vascularized graft and hydroxyapatite (HA) with bone paté to obliterate the cavity with good results: 93% of patients with dry ear and 98% without recurrence (Geerse et al., 2017). Kim J-S et al. reported the use of a modified Palva graft to cover the attic space and aditus ad antrum, to reinforce the posterior wall of the EAC (Kim et al., 2019). Dornhoffer et al. studied the impact of mastoid obliteration on the patients' quality of life using the Glasgow Benefit Inventory (GBI). Most subjects reported an improvement in the quality of life and control of otorrhea after this procedure (Dornhoffer et al., 2008).

The most controversial aspect of mastoid obliteration is the risk of a 'silent' cholesteatoma recurrence within the obliterated cavity. After CWDM reconstruction, a recurrence of 0–16.7% has been reported (Gopalakrishnan et al., 2001). Currently, there are imaging techniques, such as diffusion-weighted magnetic resonance imaging (DWI-MRI), that facilitate the detection of cholesteatoma in obliterated or reconstructed cavities (Leatherman and Dornhoffer, 2004) (Kurien et al., 2013) (Uluyol et al., 2018).

In Table 1 we report author, year of publication, country, and the time surgical reconstruction was performed. The article's

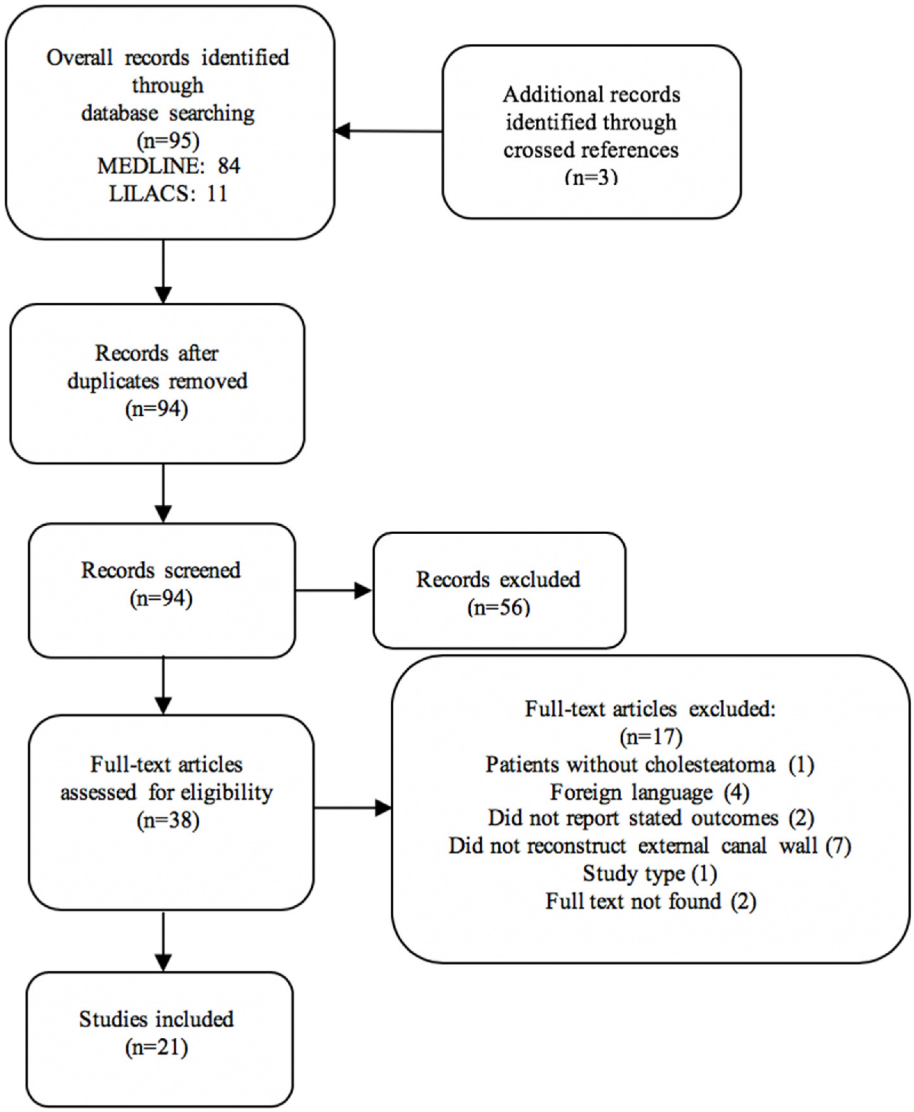

Fig. 1. Flow chart of article selection.
95 record were identified through database screening, 3 additional records were identified through crossed references. A total of 21 articles were included.

publication year ranged from 1990 to 2019. The number of patients included in each study was variable, ranging from 11 to 273 patients. Regarding the time the reconstruction was performed, we divided the articles into two groups (1. done simultaneously, i.e., reconstruction was performed during the CWDM procedure. 2. During a second surgery, i.e., reconstruction was done on a previously operated CWDM patient) (Walker et al., 2014). Reconstruction was performed simultaneously in ten of the studies and during a subsequent surgery in two of the studies. In six of the studies, both groups were mixed, and in two the obliteration was performed simultaneously however, tympanoplasty and ossiculoplasty were deferred to a second surgery.

In Table 2 we present the surgical techniques and materials for obliteration and reconstruction. In two of the studies, a partial cavity obliteration (atticotomy) was performed, without obliteration of the rest of the cavity, creating a microcavity rather than a new EAC. In three of the studies, the material used for the obliteration was biosynthetic (most frequently HA granules); in ten of the studies, autologous materials were used; the rest of the studies used a combination of both autologous and biosynthetic materials.

Regarding posterior canal wall (PCW) reconstruction, in six of the studies, it was reconstructed with soft tissues, the most reported being temporal muscle fascia. Only two authors (Roux A et al. and Gantz et al.) removed the PCW in a block and preserved it to reposition it afterward. Only one of the authors (Mokbel KM et al.) used a skin graft to coat the reconstructed canal. In regard to tympanoplasty, most of the authors used fascia, and for ossiculoplasty, autologous graft or a partial or total ossicular replacement prosthesis were used.

In Table 3 we report surgical outcomes: Auditory results and quality of life. Auditory results were reported in sixteen of the studies as an air-bone gap (ABG), air conduction (AC), bone conduction (BC), or a combination of these. Presurgical hearing tests were reported in only ten studies, out of which, six studies reported only ABG, two reported AC and BC and, two reported BC and ABG. The postoperative hearing was reported in 15 studies: Hartwein J et al. reported ABG less than 30 dB in 70% and 10% with normal hearing. Leatherman BD et al. report ABG of 27.6 ± 12.8 dB, Takahashi H et al. reported ABG less than 15 dB in 41.7% and less than 20 dB in 61.7%, Mokbel et al. report ABG 25 ± 11.6 dB, Lee HJ et al.

Table 1
Author, year published, country and the time surgical reconstruction was performed in the included studies.

AUTHOR	COUNTRY	N (PATIENTS)	SURGICAL TIME OF RECONSTRUCTION
Hartwein and Hörmann, 1990	Germany	25	Simultaneous or second surgery
D'Arc et al., 2004	France	67	Simultaneous or second surgery
Leatherman and Dornhoffer, 2004	USA	13	Simultaneous or second surgery
Gantz et al., 2005	USA	127	Simultaneous obliteration and ossiculoplasty at 6 months
Ucar, 2006	Turkey	24	Simultaneous
Takahashi et al., 2007	Japan	96 (98 ears)	Simultaneous
Dornhoffer et al., 2008	USA	23	n.a
Mokbel and Khafagy, 2012	Egypt	100	Simultaneous
Kurien et al., 2013	Canada	58	Simultaneous or second surgery
Bernardeschi et al., 2014	France	57 (59 ears)	Simultaneous
Roux et al., 2015	France	35 (36 ears)	Simultaneous obliteration and ossiculoplasty at 1 year
Walker et al., 2014	USA	273	Simultaneous
Yamamoto et al., 2014	Japan	118	Simultaneous
Suzuki et al., 2014	Japan	69	Simultaneous
Blanco et al., 2014)	Colombia	45	Simultaneous
Trinidade et al., 2015	England	172	Simultaneous
Lee et al., 2017	Korea	36	Simultaneous or second surgery
Geerse et al., 2017	Netherlands	121	Second surgery
Uluyol et al., 2018	Turkey	11	Second surgery
El-Sayed Abd Elbary et al., 2018	Egypt	20	Simultaneous
Kim et al., 2019	Korea	31	Simultaneous or second surgery

n.a.: not available; CT: computed tomography; MRI: magnetic resonance imaging.
Simultaneous: during CWDM. Second surgery: done on a previously operated CWDM.

Table 2
Surgical technique and material used for obliteration and reconstruction.

AUTHOR	OBLITERATION MATERIAL	POSTERIOR WALL OF EAC	TYMPANOPLASTY/ OSSICULOPLASTY
HARTWEIN J	HA granules + cartilage (tragus) chips, covered by cartilage.	Cartilage (concha)	n.a./PORP or TORP
BAGOT D'ARC M	HA granules and calcium triphosphate (MBCP™) + fibrin (Tissucol), covered by fascia.	Soft canal wall reconstruction	Fascia/autologous graft or prosthesis (HA)
LEATHERMAN BD	Cartilage (concha) + demineralized bone matrix (Osteotech, Inc). Covered by perichondrium and Palva flap.	Soft canal wall reconstruction	Cartilage/PORP or TORP
GANTZ BJ	Cortical mastoid chips and bone pate	In block removal and afterward replacement of posterior wall EAC	Fascia/PORP or TORP
CEVAT UCAR	Osteoperiosteal graft from mastoid cortical bone	Cortical bone fragment covered by osteoplastic graft	n.a.
TAKAHASHI	Bone pate ± ceramic HA chips (Apaceram®)	Soft canal wall reconstruction	Fascia/n.a.
DORNHOFFER JL	Morselized cartilage (concha)	n.a.	Cartilage/PORP or TORP
MOKBEL KM	Bone chips and bone pate, covered by pediculated periosteal graft	Soft canal wall reconstruction covered by partial thickness skin graft	Fascia/n.a.
KURIEN G	Cortical chips	Bone pate covered by fascia	n.a.
BERNARDESCHI D	HA granules and calcium triphosphate (TricOs), covered by cartilage (tragus or concha) and fascia.	Cartilage	Fascia and cartilage/ PORP or TORP
ROUX A	Morselized cartilage, calcium phosphate (MBCP™), covered by fibrin and musculo-periosteal graft	In block removal and afterward replacement of posterior wall of EAC, covered by cartilage (tragus) and fascia	n.a./PORP or TORP
WALKER PC	Partial obliteration (attic) with cortical bone (mastoid tip)	Mastoid tip	Cartilage/PORP or TORP
YAMAMOTO Y	Bone cortical and bone pate	Bone pate covered by fascia	Fascia/autologous graft
SUZUKI H	Bone pate covered by fascia	Soft canal wall reconstruction	n.a.
BLANCO P	Powdered bone, cartilage, muscle, and/or temporal fascia.	Powdered bone	Cartilage/autologous tissue or prosthesis
TRINIDADE A	Periosteal graft + morselized cartilage or HA or fiberglass crystals, covered by vascularized graft	Cartilage	Cartilage/PORP or TORP
LEE HJ	Musclo-periosteal graft	Cartilage (tragus and concha)	n.a./PORP or TORP
GEERSE S	HA granules and bone pate covered by vascularized graft	Cartilage (tragus or concha)	n.a.
ULUYOL S	Temporalis muscle graft	Cartilage (concha)	
EL-SAYED ABD ELBARY	Mucoperiosteal graft	Titanium mesh (Titanium Micromesh, JEIL), covered by platelet rich plasma mixed with bone pate and fascia	Fascia/n.a.
KIM J-S	Partial obliteration (attic, aditus ad antrum). Covered by Palva flap and perichondrium	Soft canal wall reconstruction	n.a./TORP or PORP

n.a.: not available; EAC: external auditory canal; HA: hydroxyapatite; TORP: total ossicular reconstruction prosthesis; PORP: partial ossicular reconstruction prosthesis.

reported ABG: 21.3 ± 11.5 dB, El-Sayed Abd Elbary et al. report ABG: 29.6 ± 6.1 dB. Seven studies reported hearing gain; Bagot d'Arc M et al.: 15.6 dB, Gantz et al.: 6 dB, Bernardeschi D et al.: 9 dB ± 2.3, Walker et al.: 4 dB, Suzuky et al.: 15 dB in 48%, Kim J-S et al.: 11.16 ± 16.71. Trinidade A et al. had hearing preservation in 51.4%, gain >10 dB in 35.8%, and loss in 12.8%. Dornhoffer JL et al. reported hearing improvement in 83%, 8.6% without change and, 8.6% worsened. Only three authors (Dornhoffer JL et al. Kurien G et al. and, Uluyol S et al.) reported on patients' quality of life. All used the GBI scale, describing improvement in 83%, no change in 4%, worsening in 13%, and a total improvement of 22 and 33 points respectively.

In Table 4 we present follow-up time, postoperative imaging studies, rate of residual cholesteatoma or recurrence, and

Table 3
Surgical outcomes; audition and quality of life.

	AUDITION (DB)		QUALITY OF LIFE
	Preop	Postop	
HARTWEIN J	n.a.	80% gain, 10% no change,10% loss 70% ABG <30. 15%: normal audition	n.a.
BAGOT D'ARC M	Average ABG: 43	Average gain: 15. 43%: ABG <20	n.a.
LEATHERMAN BD	ABG: 47 ± 14	ABG: 27 ± 12	n.a.
GANTZ BJ	ABG: 0–10: 15%, 11–20: 13%, 21–30: 24%, >30: 49%	ABG: Average gain: 6 0–10: 15%, 11–20: 35%, 21–30: 25% > 30: 25%	n.a.
CEVAT UCAR	n.a.	n.a.	n.a.
TAKAHASHI H	n.a.	61%: ABG <20, 41%: ABG <15	n.a.
DORNHOFFER JL	n.a.	83% improvement, 8.6% no change and 8.6% worsening	GBI: 83% improvement 4% no change and13% worsening
MOKBEL KM	ABG: 46 ± 12	ABG: 25 ± 11	n.a.
KURIEN G	n.a.	n.a.	GBI: improvement +22 points
BERNARDESCHI D	BC: 29 ± 3, AC: 57 ± 3	BC: 25 ± 1, AC: 46 ± 1Average gain 9 ± 2	n.a.
ROUX A	BC: 21 ± 16, AC: 54 ± 17	BC: 23 ± 16, AC: 50 ± 16	n.a.
WALKER PC	ABG: 27 ± 12	ABG: 23± 11. AC gain: 4	n.a.
YAMAMOTO Y	n.a.	n.a.	n.a.
SUZUKI H	n.a.	ABG: <20: 73.9%, <15: 52.2% Gain: >15 in 34.8%	n.a.
BLANCO P	n.a.	100% preservation	n.a.
TRINIDADE A	n.a.	Preservation: 51.4%. Gain >10: 35%. Worsening: 12%. ABG <20: 48%	n.a.
LEE HJ	AC: 60 ± 23 ABG: 34 ± 16	AC: 49 ± 17 ABG: 21 ± 11	n.a.
GEERSE S	n.a.	n.a.	n.a.
ULUYOL S	n.a.	n.a.	GBI: improvement +33.93
EL-SAYED ABD	ABG: 28 ± 6	ABG: 29 ± 6 dB	n.a.
KIM J-S	AC: 58 ± 22, ABG: 28 ± 12	AC: 47± 24, ABG:19 ± 10 Average gain: 11 ± 16.	n.a.

n.a.: not available; ABG: air bone gap; BC: bone conduction; AC: air conduction; GBI Glassgow Benefit Inventory.

complications. Follow-up time was specified in most studies; the minimum follow-up time was one month while the maximum was 83 months. Eleven articles specified imaging study for post-operative control; CT scan was used by eight authors and MRI by three, of whom only one specified using DWI-MRI (Blanco P et al.). In some of the studies, the authors used the terms residual cholesteatoma and recurrence as synonyms. Three of the studies reported a 0% recurrence, with a variable follow-up time. The highest recurrence rate was reported by Bagot d'Arc et al. with recurrence in 13 of 67 patients (19%). The most frequent complications were retraction pockets, transient otorrhea, and obliteration material reabsorption. The most severe complications were

Table 4
Follow up time, postoperative imaging study and recurrence/residual cholesteatoma and complications.

AUTHOR	FOLLOW UP/POSTOPERATIVE IMAGING STUDY	RESIDUAL CHOLESTEATOMA/ RECURRENCE	COMPLICATIONS
HARTWEIN J	6–18 months/n.a.	n.a.	Conversion to CWDM
BAGOT D'ARC M	average 46 months (1–158 months)/CT	19%	Transitory otorrhea, middle ear granuloma, retraction pocket, EAC stenosis, granules extrusion, filling resorption
LEATHERMAN BD	6–20 months/n.a.	n.a.	Transitory otorrhea, granulation tissue
GANTZ BJ	12 months/n.a.	1.5%	Partial EAC reabsorption, prosthesis extrusion, retraction pocket, wound infection
CEVAT UCAR	24 months/CT	0%	Perichondritis
TAKAHASHI H	1–6.8 years/n.a.	n.a.	Otorrhea, obliteration material exposure, retraction pocket
DORNHOFFER JL	36 months/n.a.	n.a.	n.a
MOKBEL KM	12–72 months/n.a.	0%	Granulation tissue
KURIEN G	n.a/n.a.	6.8%	Tympanic perforation
BERNARDESCHI D	12 months/CT	n.a.	Transient otorrhea, granules extrusion, reintervention, tympanic perforation, sensorineural hearing loss
ROUX A	24 months/n.a.	6%/3%	Transient otorrhea, granules exposure, wound infection
WALKER PC	Average 4 years/MRI	n.a.	Conversion to CWDM, prosthesis extrusion, retraction pocket, EAC bone exposure, wound infection, cerebrospinal fluid fistula, facial paralysis
YAMAMOTO Y	83 months/CT	7%/0%	Bone pate exposure
SUZUKI H	27 months/CT	9.6%/1.4%	n.a
BLANCO P	12 months/MRI-DWI	6.6%	Tympanic perforation, otorrhea, EAC stenosis, EAC granuloma
TRINIDADE A	Average 3 years/CT	3.5%	Reintervention
LEE HJ	n.a./n.a.	n.a.	Tinnitus, prosthesis extrusion
GEERSE S	3–5 years/MRI	2%/n.a.	EAC graft necrosis, reintervention, tympanic perforation
ULUYOL S	n.a./n.a.	n.a.	n.a
EL-SAYED AE	12–36 months/CT	0%	Non reported
KIM J-S	12 months/CT	n.a.	Retraction pocket

n.a.: not available; CT: computed tomography; MRI: magnetic resonance imaging; DWI: diffusion weighted imaging.

cerebrospinal fluid fistula, facial paralysis, and reintervention.

4. Discussion

We included a total of 21 articles and detected methodological flaws in most of them, e.g., lack of clarity regarding terminological exactitude, surgical technique, materials used for the obliteration and reconstruction and, reported outcomes.

The terms CWDM obliteration and reconstruction are frequently used interchangeably. The latter includes the reconstruction of the PWC; thus, when the use of these concepts is ambiguous, article selection bias may occur. Another frequently used imprecise term, is soft canal wall reconstruction, which is usually performed with temporal muscle fascia and is considered a modification of the reconstruction technique, so it should be included in the topic review.

The materials used vary widely for each technique. The most common autologous materials used for obliteration and reconstruction were cartilage grafts, mastoid bone cortical, and bone paté. The most used biosynthetic material was HA. Since similar results were reported when surgery was performed simultaneously or in a second procedure, a clear recommendation cannot be made, regarding the ideal moment for obliteration and reconstruction. However, when surgery was performed during a second procedure, it was possible to identify residual cholesteatomas that could have remained unnoticed even with imaging studies. Regarding audiological results, in most studies, data was incomplete and ambiguous; only in 10 out of 21 articles, the preoperative hearing was reported. Also, most of the authors report the closure of the postoperative ABG without mentioning the BC, which makes it difficult to assess the real auditory improvement. The follow-up time and imaging methods used for postoperative control vary in each study; therefore, the recurrence was also complicated to assess. It is currently acknowledged that imaging studies, specifically MRI-DWI, are essential for monitoring and non-recurrence control in these patients. Only 11 of the 21 articles mentioned the use of imaging studies for post-obliteration follow-up, three of the authors used MRI and only one MRI-DWI.

There is a limited number of publications that mention the impact on the quality of life. Only three articles were included in this review however, all concluded that obliteration and reconstruction procedures resulted in an improvement in the quality of life of the patients.

5. Conclusion

According to our review, although plenty of techniques combining grafts and other materials have been used to overcome mastoidectomy cavity problems, so far it is still not possible to standardize an ideal procedure, recommended materials (autologous or synthetic), or the ideal timing for surgery (simultaneous or during revision surgery). Most of the analyzed studies suggest advantages when performing mastoid obliteration or reconstruction. Concluding it is a safe technique for restoring the functional anatomy of the ear while eliminating most of the CWDM issues.

Reports vary widely in terms of surgical technique, results, hearing outcomes, follow-up time and, rate of complications, and recurrence. The level of evidence available for this topic is limited, and most of the studies lack a sound methodological base. Most of the publications consisting of case reports or retrospective studies, there are very few clinical reports. Therefore, we are not able to carry out a systematic revision.

This fact highlights the need for additional research, precisely addressing these methodological voids. For identifying the ideal technique, it is fundamental to design randomized and controlled clinical trials comparing the outcomes of the different mastoid obliteration and reconstruction techniques.

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Conflicts of interest

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