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Reconstruction of Posterior Meatal Wall After Canal Wall Down Mastoidectomy: Cartilage versus Bone Graft

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ABSTRACT

Background: Acquired middle ear cholesteatoma remains a common problem nowadays. The mainstay of treatment is surgery. Surgeries for cholesteatoma are usually classified as canal wall down (CWD) or canal wall up (CWU) procedures. The concept of canal wall reconstruction (CWR) mastoidectomy has been shown up in an attempt to combine the advantages of both CWD and CWU techniques. In this procedure, the posterior meatal wall (PMW) is removed, providing exposure to the entire attic and middle ear, helping to ensure complete disease eradication. Hence, the recurrence rate is as low as 2% for this procedure.

Objective: This study aimed to assess the results of the reconstruction of the posterior meatal wall with bone and cartilage graft. **Patients and Methods:** This study was carried out on 24 ears of 24 patients in the Department of Otorhinolaryngology, Head and Neck Surgery, Zagazig University Hospitals during the period from September 2019 to September 2021. Twenty-four subjects were divided into two groups, group A (treated by canal wall down mastoidectomy with the reconstruction of the posterior meatal wall with cartilage from conchal cartilage), and group B (treated by canal wall down mastoidectomy with the reconstruction of the posterior meatal wall with bone from cortical bone). **Results**: There was a statistically insignificant difference between the cartilage graft group and bone graft group regarding post-operative complications. There was a decreased median of PTA-AC at post-operative cartilage graft compared to pre-operative; the difference was statistically significant with a percent of improvement of 31.36%.

Conclusions: We concluded that CWDM eradicates disease in the middle ear and epitympanum by direct visualization and prevents common complications of the traditional CWDM technique.

Keywords: CWD, CWU, CWR, Cholesteatoma, Mastoidectomy.

INTRODUCTION

Acquired middle ear cholesteatoma remains a common problem nowadays. The mainstay of treatment is surgery. Surgeries for cholesteatoma are usually classified as canal wall down (CWD) or canal wall up (CWU) procedures [1]. The canal wall-down (CWD) operation, offers a lower rate of cholesteatoma recurrence but frequently results in postoperative otorrhea, the latter is mainly due to the absence of the posterior canal wall and hence exposed mastoid bowl that quite often catches infection on its surface [2]. The canal wall-up (CWU) procedure, yields a high rate of "dry ear" but can lead to a substantially high cholesteatoma recurrence rate [3].

The posterior canal wall hinders the eradication of cholesteatoma in the middle ear, especially the anterior epitympanum, facial recess, and sinus tympani. This may explain the reported high rate of cholesteatoma recurrence in patients subjected to the closed procedure. Removal of the posterior canal wall was reported to significantly reduce the rate of postoperative cholesteatoma recurrence[4]. The concept of canal wall reconstruction (CWR) mastoidectomy has been shown up in an attempt to combine the advantages of both CWD and CWU techniques [5, 6].

In the canal wall down (CWD) mastoidectomy, the posterior meatal wall (PMW) is removed, providing exposure to the entire attic and middle ear, helping to ensure complete disease eradication. Hence, the recurrence rate is as low as 2% for this procedure [7].

CWD mastoidectomy followed by concomitant reconstruction of the PMW achieves a low recurrence rate of cholesteatoma after it besides the advantages of CWU mastoidectomy. This provides structural support, which plays an important role in the prevention of the postoperative formation of a retraction pocket and subsequent cholesteatoma development [8].

The goal of reconstruction of the posterior external auditory canal is to provide a safe, dry mastoid and restore hearing to near-normal levels. No single procedure has yet been devised that entirely accomplishes these purposes consistently [9]. Various materials have been used to fill the mastoid, including fascia, fat, muscle, cartilage, bone paste, cancellous bone strips, bioactive glass ceramics, Proplast (a combination of polytetrafluoroethylene and glassy carbon fibers) methylmethacrylate, and ionomer-based bone substitutes [10].

Most alloplastic implant materials, such as plastic mesh, Proplast, and porous polypropylene, have not been successful long-term due to difficulties in the face of infection [11], Although there was initial enthusiasm for Proplast, it was subsequently discovered that the material caused a lasting giant cell reaction. Antibiotics could not clear the infection when the organisms became harbored in the pores [12].

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This study aimed to assess the results of the reconstruction of the posterior meatal wall with bone and cartilage graft.

PATIENTS AND METHODS

This interventional cohort study was carried out on 24 ears of 24 patients in the Department of Otorhinolaryngology, Head and Neck Surgery, Zagazig University Hospitals during the period from September 2019 to September 2021.

Inclusion criteria: Adult patients between 18-60 years old, both sex groups, patients with acquired cholesteatoma, and all patients who suffered from chronic otitis media with acquired cholesteatoma were included in the study.

Exclusion criteria: Complicated cholesteatoma e.g. (cranial, intracranial, and extracranial complications) or extensive destruction of posterior canal wall and mastoid cortex, patients operated before previous canal wall down procedure, history of head trauma, and patients with contraindications for general anesthesia were excluded.

Study population:

Studied subjects were divided into two groups regarding age and sex: **Group A:** was treated by canal wall down mastoidectomy with reconstruction of the posterior meatal wall with cartilage from conchal cartilage, and **Group B:** was treated by canal wall down mastoidectomy with the reconstruction of the posterior meatal wall with bone from cortical bone.

Pre-operative steps:

A detailed history was taken with stress on type of ear discharge, hearing loss, tinnitus, and vertigo. Complete otorhinolaryngological examination and otoendoscopic and otomicroscopic examination of the ear were done. Pre-operative audiological assessment: Pure Tone Audiogram (PTA) also was done. Pre-operative high resolution computed tomography scanning (HRCT scan) of the temporal bone was acquired in both axial and coronal planes in all cases. Routine pre-operative laboratory investigations included complete blood count, liver function tests, kidney function tests, random blood sugar, coagulation profile, and viral markers.

Surgical technique:

All cases were operated under general anesthesia. Intraoperative parenteral antibiotic (3rd generation cephalosporin) was given to all patients. The retroauricular approach was used in all cases. The palva flap was closed with vicryl sutures. The post auricular incision was closed in two layers by interrupted sutures. The posterior canal wall skin flap was lifted down to the tympanum underneath the tympanic annulus and transected in the middle for visualization of the tympanic membrane and the retraction pocket. Exploration of middle ear content was done. Decorticalization started either at the antrum if the cholesteatoma extended beyond the antrum or at the lateral wall of the epitympanum if the cholesteatoma was confined to the epitympanum. The upper portion of the posterior external ear canal wall and the lateral wall of the epitympanum were removed including the so-called “bridge”, an anterolateral border of the aditus of the antrum. The middle ear, attic, aditus, and antrum were made disease-free.

Post-operative care:

All patients were discharged home on the operative day with oral antibiotics (ciprofloxacin in adults or amoxicillin-clavulanate) to complete 14 days course and oral analgesic. The mastoid dressing, canal pack, and wound sutures were removed after one week postoperatively. Antibiotic ear drops were instilled until follow-up after another 2 weeks (3 weeks postoperatively). The patients were instructed to keep the external auditory canal dry.

Patients follow–up:

All patients were followed up once weekly in the first month postoperatively, then once monthly for 6 months then after one year. The follow-up visit was done by: History taking for symptomatic assessment, otoendoscopic examination, high resolution computed tomography scanning (HRCT scan) of the temporal bone was acquired in both axial and coronal planes after 1 month of operation, and audiological assessment with pure tone audiogram.

Ethical consent:

Approval of the study was obtained from Zagazig University Academic and Ethical Committee. Every patient signed informed written consent for the acceptance of participation in the study. This work has been carried out following The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistic analysis

All data were collected, tabulated, and statistically analyzed using (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). Quantitative data were expressed as the mean ± SD & median (range), and qualitative data were expressed as & (percentage). A t-test was used to compare the two groups of normally distributed variables. Mann Whinney -U was used to compare the two groups of not normally distributed variables. Wilcoxon Signed Ranks Test was used to compare the two paired of not normally distributed variables. Percentage of categorical variables were compared using the Chi-square test or Fisher exact test when appropriate. P-value < 0.05 was considered significant.

RESULTS

Table 1 showed that there was no statistically significant difference between both groups regarding the demographic data.

Table (1): Demographic data of the studied patients

Variables	Reconstruction of posterior meatal wall				t-test	P-value
	Cartilage graft group N=12		Bone graft group N=12			
Age per years						
• Mean ± SD	34.92±11.8		36.42±12.4		0.302	0.765
• Range	21-57		21-55			
Sex	**N**	**%**	**N**	**%**	χ^2 0	1
• Females	5	41.7%	5	41.7%		
• Males	7	58.3%	7	58.3%		

SD: standard deviation, χ^2 Chi-square test t= t test of sig p>0.05 non-significant

Table 2 showed that the difference was statistically non-significant between both groups regarding the duration of symptoms.

Table (2): Duration of symptoms of the studied patients

	Reconstruction of posterior meatal wall		u-test	P-value
	Cartilage graft group N=12	Bone graft group N=12		
Duration of symptoms /years				
• Mean ± SD	7 ±3.04	5.92±2.71	0.871	0.384
• Median	7.5	6.5		
• Range	(2-11)	(1-9)		

SD: standard deviation, U= Mann-Whitney test of sig p>0.05 non-significant

Table 3 showed that there was a statistically insignificant difference between the cartilage graft group and the bone graft group regarding the pathology site. Most of the patients (50%) in the cartilage graft group had posterosuperior pathology and 25% had attic pathology while in the bone graft group 41.7% of patients had posterosuperior pathology and 41.7% had attic pathology.

Table (3): Pathology site of the studied patients

			Reconstruction of posterior meatal wall		P-value
			Cartilage graft group N=12	Bone graft group N=12	
Pathology site	**Attic**	n	3	5	0.5
		%	25.0%	41.7%	
	Aural polyp	n	2	1	0.99
		%	16.7%	8.3%	
	Mesotympanic	n	1	1	1
		%	8.3%	8.3%	
	Posterosuperior	n	6	5	0.99
		%	50.0%	41.7%	

F=Fisher Exact test p>0.05 non-significant

Table 4 showed that the difference was statistically non-significant between both groups regarding pre-operative and post-operative PTA-AC and ABG.

Table (4): Pre-operative and post-operative PTA-AC, and ABG of the studied patients

	Reconstruction of posterior meatal wall		u-test	P-value
	Cartilage graft group N=12	Bone graft group N=12		
Pre-operative PTA-AC				
Mean ± SD	54.75±17.46	47.83±20.35	1.011	0.312
Median (range)	53(27-83)	49(20-75)		
Post-operative PTA-AC				
Mean ± SD	37.58±17.77	28.75±12.14	1.185	0.236
Median (range)	33(15-76)	29(12-48)		
Pre-operative ABG				
Mean ± SD	41.83±10.91	33.5±12.75	1.622	0.105
Median (range)	42(25-58)	34(15-55)		
Post-operative ABG				
Mean ± SD	24.83±9.63	16.33±9.19	1.823	0.068
Median (range)	22.5(15-49)	18(4-32)		

PTA-AC: Pure-tone averages- air conduction, ABG: Air bone gaps, U= Mann-Whitney, a test of sig, p>0.05 non-significant.

Table 5 shows that there was a statistically insignificant difference between the cartilage graft group and the bone graft group regarding post-operative complications.

Table (5): Post-operative complications of the studied patients

Complications			Reconstruction of posterior meatal wall		P-value
			Cartilage graft group N=12	Bone graft group N=12	
Complication	yes	n	3	3	1
		%	25.0%	25.0%	
	no	n	9	9	
		%	75.0%	75.0%	
Myringitis	yes	n	1	1	1
		%	8.3%	8.3%	
Recurrent cholesteatoma	yes	n	1	0	0.99
		%	8.3%	0.0	
Residual perforation of the tympanic membrane	yes	n	1	0	0.99
		%	8.3%	0.0	
Stenosis of EAC	yes	n	0	1	0.99
		%	0.0	8.3%	
Vertigo	yes	n	0	1	0.99
		%	0.0	8.3%	

EAC: External auditory canal, F=Fisher Exact test, p>0.05 non-significant

Table 6 showed that there was a decreased median of PTA-AC at post-operative cartilage graft compared to pre-operative; the difference was statistically significant p<0.05 with a percent of improvement of 31.36%. Moreover, decrease median of ABG in post-operative cartilage grafts compared to pre-operative; the difference was statistically significant p<0.05 with a percent of improvement reaching 40.64%. Also, **Table 6** showed that there was a decreased median of PTA-AC at post-operative bone graft compared to pre-operative; the difference was statistically significant p<0.05 with a percent of improvement of 39.89%. Moreover, decrease median of ABG in post-operative bone grafts compared to pre-operative; the difference was statistically significant p<0.05 with a percent of improvement reaching 51.25%.

Table (6): Reconstruction of the posterior meatal wall via cartilage graft group and bone graft group

	Reconstruction of the posterior meatal wall via cartilage graft group		**W**	**P-value**	**% of improvement**
	Pre N=12	**Post N=12**			
PTA-AC Mean ± SD Median (range)	54.75±17.46 53(27-83)	37.58±17.77 33(15-76)	2.98	0.003 (S)	31.36%
ABG Mean ± SD Median (range)	41.83±10.91 42(25-58)	24.83±9.63 22.5(15-49)	3.06	0.002 (S)	40.64%
	Reconstruction of posterior meatal wall via bone graft		**W**	**P-value**	**% of improvement**
	pre N=12	**post N=12**			
PTA-AC Mean ± SD Median (range)	47.83±20.35 49(20-75)	28.75±12.14 29(12-48)	3.06	0.002(s)	39.89%
ABG Mean ± SD Median (range)	33.5±12.75 34(15-55)	16.33±9.19 18(4-32)	3.06	0.002(s)	51.25%

PTA-AC: Pure-tone averages- air conduction, ABG: Air bone gaps, SD: standard deviation, W= Wilcoxon Signed Ranks, Test of sig (s) $p<0.05$ significant

DISCUSSION

Acquired middle ear cholesteatoma remains a common pathology. The main treatment is surgery. Surgeries for cholesteatoma are usually classified as open or closed procedures. The open procedure, also known as canal wall-down (CWD) operation, offers a lower rate of cholesteatoma recurrence but frequently results in postoperative otorrhea, the latter is mainly due to the absence of the posterior canal wall and hence exposed mastoid bowl that quite often catches infection on its surface. The closed procedure, also called the wall-up (CWU) procedure, yields high rate of "dry ear" but can lead to substantially high cholesteatoma recurrence rate [13].

The main aim of cholesteatoma surgery as given by **Parisier**[14] is the elimination of irreversible disease to make the ear safe and dry, and restoration of serviceable unaided hearing. However, the primary goal is to maintain a normal anatomical appearance of the ear and to minimize the need for long-term care of the operated ear or the concern of getting water into the ear.

The surgery for cholesteatoma removal is of two types: Canal wall up or canal wall down type. Canal wall up technique gives better functional and anatomical results with no cavity problems as stated by **Hough** [15], but the incidence of residual and recurrent disease happens to be high which is unacceptable both to the public and the treating surgeon [16].

Canal wall down helps in wide exposure and complete eradication of disease but is associated with poor anatomical and functional results. Moreover, the problem of the cavity remains. **Smyth** [17] reported that between these extremes are those, who provide better access for the removal of cholesteatoma, temporarily remove the canal wall but later replace or reconstruct it, or having removed it used bone or soft tissue to reduce the size of mastoidectomy cavity. **Grote and Van Bitterswijk**[18] stated that this compromise has evolved to provide the best aspects of both techniques.

The posterior canal wall hinders the eradication of cholesteatoma in the middle ear, especially the anterior epitympanum and posterior tympanum areas, including facial recess and sinus tympani. This explains the high rate of cholesteatoma recurrence in patients subjected to the closed procedure. Removal of the posterior canal wall significantly reduces the rate of postoperative cholesteatoma recurrence. The concept of canal wall reconstruction (CWR) mastoidectomy has been created in an attempt to combine the advantages of both CWD and CWU techniques. The CWR mastoidectomy is a single-stage technique for cholesteatoma removal and canal wall reconstruction and has been used by some authors in most patients with acquired cholesteatoma, including children. Herein we present our experiences in employing this technique. One stage of reconstruction of PCW was cholesteatoma surgery helps with inadequate exposure and wide eradication of the disease with better hearing results. Moreover, there is faster healing with no cavity problems and therefore lower morbidity as stated by **Sayeed** [16].

Several materials have been utilized for PCW reconstruction. These materials could be organic or inorganic like autograft cartilage, bone pate by **Hosoi *et***

al. [19], autologous mastoid bone by **Marquet *et al.*** [20], proplast by **Johns** [21], hydroxyapatite cement by **Wiet *et al.*** [22], ionomer cement by **Geyer *et al.*** [23], titanium mesh by **Zini *et al.*** [24] and conchal cartilage perichondrial graft by **Sayeed** [16], but the research for the suitable reconstruction material is still on. Cartilage and bone grafts are two commonly used procedures.

This study aimed to assess the results of the reconstruction of the posterior meatal wall with bone and cartilage graft.

In the current study, we found that the duration of symptoms of reconstruction of the posterior meatal wall of the cartilage graft group was 7 ±3.04 years and ranged from (2-11) and the mean duration of symptoms of reconstruction of the posterior meatal wall of the bone graft group was 5.92±2.71 years and ranged from (1-9), the difference was statistically non-significant.

These findings coincided with **Jamwal *et al.*** [25], who found that most of the patients (71.8%) in their study had the duration of symptoms for a period of >5years. The duration of symptoms in the study of **Glasscock *et al.*** [26] was also more than 5 years in about 70 percent of their patients. **Manekar** [27] reported similar findings in 69% of his patients.

Our study shows a statistically insignificant difference exists between the cartilage graft group and the bone graft group regarding pathology site p>0.05. Posterosuperior pathology was seen in 50 % of cartilage graft patients and 41.7% of bone graft patients while 25% of cartilage graft patients and 41.7% of bone graft patients had attic pathology. The aural polyp was seen in 16.7% of cartilage graft patients and 8.3% of bone graft patients and mesotympanic pathology was seen in 8.3% of both cartilage and bone graft patients.

This agreed with **Jamwal *et al.*** [25] who revealed that posterosuperior pathology was seen in 43.75% of patients while 31.25% had attic pathology. The aural polyp was seen in 15.62% and mesotympanic pathology was seen in 9.38%. In a study by **Sayed** [16], 41.9% had posterosuperior pathology, 29% had Attic pathology, 19.3% had an aural polyp in EAC, 19.3% had mesotympanic pathology, 6.45% had meatomastoid fistula and the similar percentage was found in patients with postaural abscess.

The most common symptom was otorrhea seen in all (100%) cartilage and bone graft patients while CHL was in 9(75%) cartilage graft patients and 7(58.3%) bone graft patients. Tinnitus and vertigo were present in 3 (25%) cartilage graft patients and 3 (25%), 1(8.3%) bone graft patients respectively.

Similarly, **Jamwal *et al.*** [25] showed that the most common symptom was ear discharge seen in all (100%) patients while hearing impairment was in 78.12% of patients. Tinnitus and vertigo were present in 21(6%) and 11(3.13%) cartilage graft patients respectively. Also, **Glasscock *et al.*** [26] and **Manekar** [27] reported that the most common presenting symptom was ear discharge. It was found to be present in 100 percent of the cases and most of the times discharge was mucopurulent in type.

Six of 24 patients, 3 for each cartilage and bone posterior meatal wall graft had post-operative complications of the studied patients, 1(8.3%) has myringitis in both cartilage and bone graft groups, 1(8.3%) had recurrent cholesteatoma in cartilage graft group, 1(8.3%) had a residual perforation of the tympanic membrane in cartilage graft group. While in bone graft group 1 (8.3%) had Stenosis of EAC and vertigo.

This came in agreement with **Wei** [2] who found that a 16% recurrence rate in their series is an acceptable long-term outcome. **Kalcioglu *et al.*** [10] found that only one of their patients had residual or recurrent cholesteatoma postoperatively. The patient with residual cholesteatoma underwent revision surgery and was treated without complication. Mastoid cavity obliteration can hide problems during follow-up, especially regarding residual cholesteatoma, as the materials used for obliteration might act as a barrier to visualizing the residual cholesteatoma. Some reports have suggested that diffusion-weighted MRI helps to diagnose and identify postoperative residual or recurrent disease during follow-up [28].

Our study showed that there was a decreased median of PTA-AC at post-operative cartilage graft compared to pre-operative; the difference was statistically significant p<0.05 with a percent of improvement of 31.36%. Moreover, the decreased median of ABG in post-operative cartilage graft compared to pre-operative; the difference was statistically significant p<0.05 with a percent of improvement of 40.64%.

This came in agreement with **Jamwal *et al.*** [25] who demonstrated that postoperatively 72.72% had an air-bone gap of <20dB. While **Shewel and Abougabal** [1] revealed that 33 ± 5.6 dB postoperatively. The preoperative PTA-ABG was 30 ± 5.4 dB while it was 21 ± 6.4 dB postoperatively, and this change was statistically significant (P < 0.0001). **Kim *et al.*** [29] found that the average air-bone gap values were 26.7±10.9 dB HL before the operation and 20.8±10.8 dB HL after the operation (P=0.001). Postoperative hearing outcomes improved significantly after the operation.

Autologous cartilage has some advantages, such as ready availability in the surgery field, ease of shaping, and no extra cost [30]. Cartilage is resistant to negative middle ear pressure, increases stability, and minimizes postoperative adhesions [31]. It has a low metabolic rate and receives nutrients by diffusion [30, 31]. The perichondrium has an important role in the nourishment and viability of cartilage; therefore, it is recommended that at least one side of the perichondrium be left intact, for long-term viability [30].

The ideal procedure for MR should be simple, easy, and quick to do with fast learning curves and unique results. The new cavity should heal quickly and

promote the complete epithelial lining of the mastoid cavity, leading to a safe, dry, and self-cleaning ear. There should be minimal complications. The created cavity should be easy to inspect for the detection of recurrent disease. Unfortunately, such a perfect solution is yet to show up [7, 32]. The chosen surgical procedure should be tailored to the patient's condition, size of the mastoid cavity, and surgeon's experience [7, 30].

In our study, we present a simple, safe, easy, and effective technique for the reconstruction of the mastoid cavity after CWD mastoidectomy. We used autologous tissues: cartilage and cortical bone pate. The current study reported a high efficacy rate with few reported complications.

These results are compatible with other works [7, 30, 32]. Another important point to be mentioned (as regards the use of self-materials) is that it does not react, thus (in case of recurrence) no hazards of hidden disease [33].

The proposed technique is readily available, less costly, and economic. This point has the utmost importance in developing countries with limited health budgets. However, the evident limitation of MR techniques is the requirement for the surgeon to ensure complete removal of the cholesteatoma matrix from the entire mastoid cavity [33].

The greatest advantage of the cartilage technique is its technical simplicity and quickness to do, heal quickly and promote complete epithelialization of the mastoid cavity lining, leading to a dry, self-cleaning ear than bone graft. In this procedure first, the mastoid cavity is obliterated with cartilage and is shaped more smoothly than bone graft with less time of operation [7].

CONCLUSION

Our results suggest that CWDM eradicates disease in the middle ear and epitympanum by direct visualization and prevents common complications of the traditional CWDM technique. The cartilage graft technique is better than the bone graft technique in its technical simplicity and quick to do, heal quickly, and promotes complete epithelialization of the mastoid cavity lining, leading to a dry, self-cleaning ear.

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