Clinically Derived Indications for Canal Wall-Up versus Canal Wall-Down Surgery in Children with Cholesteatoma

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ABSTRACT

Background

Pediatric cholesteatoma is an aggressive middle ear disease with high recurrence, making the choice between Canal Wall-Up (CWU) and Canal Wall-Down (CWD) surgery crucial yet controversial.

Aim

To evaluate clinically derived indications guiding the selection of CWU versus CWD techniques in children with cholesteatoma.

Methodology

A retrospective observational study was conducted on 43 pediatric patients at a tertiary care center in Gujarat, India, over two years. Clinical, radiological, intraoperative, and audiological data were analyzed. Disease severity was assessed using the Mills classification, and surgical outcomes were compared.

Results

CWU was predominantly performed in patients with Mills score ≤3 (79.3%), while CWD was more common in advanced disease (≥4). Key indications for CWD included poor mastoid pneumatization (42.9%), ossicular erosion (35.7%), and canal wall erosion (21.4%). CWU showed better hearing outcomes (mean PTA 31.2 dB vs. 46.5 dB in CWD) but required more staged surgeries with higher recidivism (24.1%). CWD demonstrated lower revision rates (21.4%) with improved disease clearance.

Conclusion

Surgical choice should be individualized. CWU is suitable for limited disease with better hearing outcomes, whereas CWD is preferred for extensive disease and unfavorable anatomy.

Keywords: Cholesteatoma, Canal Wall-Up, Canal Wall-Down, Pediatric, Mastoidectomy, Hearing outcomes.

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1. Introduction

Cholesteatoma is a devastating middle ear and mastoid lesion that may cause great morbidity among the children unless it is properly addressed. Surgery is the leading mode of treatment and the basic objectives of the surgery to remove cholesteatoma, provide a dry ear and achieve or preserve serviceable hearing [1]. These goals in the pediatric population are not easier to achieve when children are compared with adults because their anatomical, physiological and behavioral mechanisms are not the same. Therefore, the ideal surgical treatment of pediatric cholesteatoma remains a controversial issue in the field of otologic surgery.

The two main surgical techniques which have been used in the past to treat cholesteatoma include canal wall-up (CWU) and canal wall-down (CWD). Both procedures have their own benefits and drawbacks, and the decision on which option to use is frequently determined by the level of disease, individual characteristics of a patient, and the preferences of a surgeon [2]. The CWU method spares the posterior canal wall thus keeping the external auditory canal anatomy normal. These supporters highlight some of the benefits, such as development of a maintenance-free ear, reduction in the amount of postoperative activity restraint, simplification of the fitting of the hearing aids, and more natural postoperative appearance [3]. The benefits apply especially to the pediatric patient, where postoperative adherence and long-term quality of life are a crucial factor.

Conversely, the CWD method entails the removal of the posterior canal wall, leaving the mastoid cavity open to provide more room in the skull, exposing the middle ear and mastoid anatomy, which is directly seen in the surgery. Advocates of this method claim that better exposure will allow a more effective extermination of the disease and thus lower the chances of residual or recurrent cholesteatoma. Also, there is a correlation between the CWD technique and reduced recidivism rates and could potentially reduce the number of surgical operations over the long run [4]. Where the cholesteatoma is extensive or has presented with complications, the benefits of better visualization and suppression of the disease can supersede the disadvantages of the mastoid cavity.

Preservation and restoration also are crucial in the determination of the outcome of surgery on pediatric cholesteatoma. Overall, CWU procedures are likely to show increased hearing outcomes than CWD procedures [5,6]. It is, however, reported in several studies that hearing results might be more severely reliant on the condition of the middle ear than the approach to surgery itself. Other considerations like the condition of middle ear mucosa, and stapes superstructure integrity have been identified to play a significant role in determining the postoperative hearing outcomes [7] in the same way. These results suggest that the existence or absence of the posterior canal wall is possibly not the only determinant of auditory performance, and intraoperative evaluation of structures of the middle ear is heavily important [8].

Over the past years, there has been an increase in surgical methods which have resulted in the emergence of hybrid methods and reconstructive methods which are meant to have the merits of both CWU and CWD procedures. These methods are aimed at offering enhanced intraoperative exposure of CWD techniques while maintaining the postoperative anatomical and functional advantages CWU technique [9]. These include canal walls

reconstruction and alternate methods of mastoidectomy which aim at minimizing disease recurrence without altering the natural ear canal structure. As more methods of these approaches have become available and access to medical care has improved, the use of a standard form of CWD approach has become rarer [10].

In children, the number of surgical methods that should be chosen is especially complicated. Also, when it comes to long-term care of the mastoid cavity, such as regular cleaning and check-ups that could potentially be needed after a CWD procedure, the tolerance of the pediatric patients is also lower. On this basis, CWU method has often been prescribed in the treatment of pediatric cholesteatoma. However, there are some clinical circumstances that might indicate the application of a CWD approach despite the age of the patients. The degree of the disease, anatomy and the chances of subsequent adherence to therapy, are some of the factors that can play a role in making a surgical decision.

Although there is a debate on the issue, there is comparatively minimal literature on the clinical conditions that may favor the use of a CWD approach in children with cholesteatoma. Knowledge of these signs is critical in maximising the outcome of surgery and reducing the recurrence of diseases and morbidity after surgery. Thus, it can be concluded that the assessment of large clinical series and evaluation of the experience of surgery can be used to gain an insight into this decision-making process to choose the most appropriate surgical technique.

In this regard the current study evaluates the experience of surgery and clinical outcomes of a large group of pediatric cases of cholesteatoma to ascertain the clinically figured out indicators of conducting canal wall-down surgery in children. Reviewing the characteristics of the diseases, findings that observed during surgery, and postoperative results, the research will help to understand under which conditions the CWD method can be beneficial compared to the CWU technique in the pediatric population.

2. "Methodology

2.1 Study Design

This study was conducted as a retrospective observational study to evaluate clinically derived indications for Canal Wall-Up (CWU) versus Canal Wall-Down (CWD) mastoidectomy in pediatric patients diagnosed with cholesteatoma. The study involved reviewing previously recorded clinical and surgical data to analyze the extent of disease, surgical decision-making, and hearing outcomes associated with the two surgical techniques.

2.2 Study Area

The study was carried out in the Department of ENT, Tertiary care center, Gujarat, India.

2.3 Study Duration

The study was conducted over a period of two year.

2.4 Sample Size

The study included a total of 43 pediatric patients diagnosed with cholesteatoma who underwent surgical treatment during the study period. The sample size was determined based on the number of eligible cases treated in the department during the study duration and meeting the predefined inclusion criteria.

2.5 Study Population

The study population consisted of children diagnosed with middle ear cholesteatoma who underwent surgical management using either Canal Wall-Up mastoidectomy or Canal Wall-Down mastoidectomy. These patients were treated in the ENT department of the study institution and had complete clinical, operative, and audiological records available for analysis.

2.6 Data Collection

Data were collected through a retrospective review of hospital records and operative reports. A structured database was created to document relevant patient information including demographic details such as age and sex, clinical presentation, otoscopic findings, radiological findings, intraoperative observations, type of surgical procedure performed, and reasons for choosing either CWU or CWD technique. The extent of cholesteatoma was graded using the Mills Classification System, which evaluates the disease based on stage of involvement, ossicular erosion, and associated complications. Audiological evaluation was performed using pure tone audiometry by averaging air-conduction thresholds at 500 Hz, 1 kHz, 2 kHz, and 4 kHz according to the guidelines of the American Academy of Otolaryngology–Head and Neck Surgery.

2.7 Inclusion Criteria

Patients were included in the study if they met the following criteria:

- Children aged ≤18 years
- Diagnosed with middle ear cholesteatoma
- Underwent Canal Wall-Up or Canal Wall-Down mastoidectomy
- Complete clinical, operative, and audiological records available
- Surgery performed within the study duration at the study institution

2.8 Exclusion Criteria

Patients were excluded if they met any of the following conditions:

- Age greater than 18 years
- Patients with incomplete medical or surgical records
- Patients who underwent revision surgery performed elsewhere

2.9 Study Procedure

This retrospective record-based study utilized anonymized patient data from hospital records. As no direct patient interaction or intervention was involved, formal ethical approval was not obtained. Relevant clinical, surgical, and audiological information was extracted and entered into a structured database. The extent of the disease was classified according to the Mills classification system. Operative reports were carefully analyzed to determine the indications for selecting either the CWU or CWD surgical technique. Particular attention was given to factors such as disease extent, ossicular involvement, and presence of complications. Preoperative and postoperative hearing thresholds were evaluated using pure tone audiometry to assess surgical outcomes.

2.10 Statistical Analysis

The collected data were entered into statistical software for analysis. Continuous variables such as age and hearing thresholds were expressed as mean and standard deviation, while categorical variables such as gender, disease stage, and type of surgery were presented as frequency and percentage. Comparative analysis between CWU and CWD groups was performed using appropriate statistical tests including the independent t-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. Preoperative and postoperative hearing thresholds were compared using paired statistical tests where appropriate. A p-value less than 0.05 was considered statistically significant."

3. "Result

Table 1 presents the stratification of Canal Wall-Up (CWU) and Canal Wall-Down (CWD) procedures according to the Mills S score among 43 patients. It was observed that the majority of patients with a Mills score ≤3 underwent CWU surgery (23 out of 29), while a smaller proportion required CWD (6 out of 29). In contrast, among patients with a Mills score ≥4, a higher number underwent CWD (8 out of 14) compared to CWU (6 out of 14), indicating a tendency for more extensive disease to be managed with CWD procedures. The diagnostic performance of a Mills S score ≥4 in predicting the need for CWD showed a sensitivity of 57.1% and specificity of 79.3%, suggesting moderate ability to correctly identify patients requiring CWD and good accuracy in ruling out those who do not. The positive predictive value was 57.1%, indicating that just over half of patients with a score ≥4 actually required CWD, while the negative predictive value was relatively high at 79.3%, reflecting that patient with a score ≤3 was more likely to be appropriately managed with CWU procedures. Overall, the Mills S score demonstrates moderate predictive utility, with better performance in excluding the need for CWD than confirming it.

Table 1. Stratification of CWU and CWD Procedures with Diagnostic Performance of Mills Stage (n = 43)

S Score	CWU (No.)	CWD (No.)	Total
≤3	23	6	29
≥4	6	8	14
Total	**29**	**14**	**43**

Diagnostic Performance of Mills S Score ≥4 in Predicting CWD	
Parameter	**% (No./Total)**
Sensitivity	57.1 (8/14)
Specificity	79.3 (23/29)
Positive Predictive Value	57.1 (8/14)
Negative Predictive Value	79.3 (23/29)

Table 2 shows the various factors contributing to the decision to perform a Canal Wall-Down (CWD) procedure. The most common indication was poor mastoid pneumatization or low tegmen, observed in 6 patients (42.9%). This was followed by extensive disease with ossicular erosion in 5 cases (35.7%) and posterior canal wall erosion in 3 cases (21.4%). Other contributing factors included the desire to avoid further surgery, Eustachian tube dysfunction, and aggressive disease, each reported in 2 cases (14.3%). Less frequent reasons were poor patient follow-up, complications of cholesteatoma, and undocumented reasons, each noted in 1 case (7.1%). Overall, anatomical limitations and extensive disease were the predominant factors influencing the choice of the CWD surgical technique.

Table 2. Factors Contributing to the Decision to Perform a Canal Wall-Down (CWD) Procedure

Factor Contributing to CWD	No.	%
Poor mastoid pneumatization / low tegmen	6	42.90%
Extensive disease with ossicular erosion	5	35.70%
Posterior canal wall erosion	3	21.40%
Desire to avoid further surgery	2	14.30%
Eustachian tube dysfunction	2	14.30%
Aggressive disease	2	14.30%
Poor follow-up	1	7.10%
Complication of cholesteatoma	1	7.10%
No reason documented	1	7.10%

Table 3 presents the pattern of revision surgery among patients undergoing Canal Wall-Down (CWD) and Canal Wall-Up (CWU) procedures (n = 43). In the CWD group, out of 14 total cases, revision surgery was required in 3 patients (21.40%), with equal distribution of causes including recurrent cholesteatoma (1 case), cholesteatoma pearl (1 case), and cavity granulation or debris (1 case). In contrast, the CWU group (n = 29) followed a staged surgical approach, where 12 patients (41.4%) underwent second-look surgery. Among these, recidivism was detected in 7 cases, accounting for 24.1% of the total CWU cases and 58.3% of second-look surgeries, while 5 patients showed no evidence of cholesteatoma. Additionally, 3 patients (10.3% of total; 25% of second-look cases) required third-look surgeries. Overall, the findings indicate a higher need for planned staged procedures and greater detection of residual or recurrent disease in the CWU group compared to the relatively lower but notable revision rate in the CWD group.

Table 3. Revision Surgery in CWD and CWU Groups (n = 43)

CWD Group			
Category	**No.**	**%**	
Total CWD cases	14	—	
Revision required	3	21.40%	
Reasons for Revision:			
Reason	**No.**		
Recurrent cholesteatoma	1		
Cholesteatoma pearl	1		
Cavity granulation/debris	1		
CWU Group			
Stage	**No.**	**% Total**	**% Stage**
First-look surgeries	29	—	—
Second-look surgeries	12	41.4% (12/29)	—
Recidivism detected	7	24.1% (7/29)	58.3% (7/12)
No cholesteatoma	5	—	—
Third-look surgeries	3	10.3% (3/29)	25% (3/12)

Table 4 presents the hearing outcomes following Canal Wall-Up (CWU) and Canal Wall-Down (CWD) procedures. Patients who underwent the CWU procedure showed better hearing outcomes, with a mean pure tone average (PTA) of 31.2 dB and 52.8% achieving PTA <30 dB, compared to the CWD group, which had a higher mean PTA of 46.5 dB and only 21.4% achieving PTA <30 dB. Among cases with intact stapes, the CWU procedure demonstrated superior results with a mean PTA of 26.4 dB and 66.7% having PTA <30 dB, whereas the CWD group showed a mean PTA of 41.3 dB with 25% achieving PTA <30 dB. In patients without stapes, CWU still produced relatively better outcomes (mean PTA 37.1 dB; 38.9% <30 dB) compared to CWD (mean PTA 48.2 dB; 14.3% <30 dB), indicating overall improved postoperative hearing with the CWU technique, particularly when the stapes is preserved.

Table 4. Hearing Results of Canal Wall-Up (CWU) and Canal Wall-Down (CWD) Procedures

Procedure Type	Mean PTA (dB)	% with PTA <30 dB

CWU	31.2	52.8
CWD	46.5	21.4
CWU with intact stapes	26.4	66.7
CWU without stapes	37.1	38.9
CWD with intact stapes	41.3	25
CWD without stapes	48.2	14.3

4. Discussion

The current paper has included the clinical derived measures of conducting Canal Wall-Up (CWU) surgery as opposed to Canal Wall-Down (CWD) surgery of children with cholesteatoma and has shown that most patients with lower scores on the Mills scale (3 and below) were treated using the CWU technique, with a smaller fraction of patients having more complex disease undergoing CWD. This result agrees with other studies that have indicated a tendency towards CWU methods in children with cholesteatoma because of the benefits of maintaining the posterior canal wall and not having to manage the mastoid cavity over the long term. Indeed, Dodson et al., (1998) [1] have studied that the benefits of intact canal wall mastoidectomy indicated that it could be successfully implemented in a significant percentage of pediatric cases and did not provoke serious postoperative cavity problems. Equally, Darrouzet et al., (2000) [11] found comparable results with a preference to closed technique in children where CWU surgery was practical in the majority of instances and that it had positive functional outcomes. Our findings that most children with lower disease scores received CWU surgery are thus in line with such previous findings."

The prognosis of the staging system, however, in predicting the method of surgery seems to be low. In our experiment, an S score of 4 and above was relatively insensitive (42.9) but more specific (77.8) in predicting the existence of a need CWD surgery. These results imply that despite the fact that disease staging gives valuable information on the extent of a disease, it cannot be the only conclusive factor when determining the approach to surgery. This finding concurs with the findings by Saleh and Mills, (1999) [12] who proposed the classification system but stressed the fact that surgical decision-making needs to be based on intraoperative observations and anatomy besides staging. It is also observed by other authors that the extent of diseases does not always have reliable prognostic values in predicting the optimal surgery technique and that the anatomical variables, including mastoid pneumatization, position of the tegmen, and status of ossicles, status of middle ear mucosa are usually significant in decision-making (Bhatia et al., 1995) [8].

In the current series, the most common conditions which affected the decision to proceed with the CWD surgery were poor mastoid pneumatization or low tegmen, widespread disease with ossicular erosion, and erosion of the posterior canal wall. The determinants are similar to those reported in pediatric cholesterol. According to Edelstein et al., (1988) [7], large cholesteatoma with ossicular erosion may require a more radical procedure, which is necessary in removing the disease completely. Similarly, Schraff & Strasnickx (2006) [6] have determined that a large area of the epitympanic or mastoid area often prompts surgeons to choose the CWD technique in order to gain sufficient visualization and disease clearance. These findings hence prove the idea that anatomical constraints and disease severity are the most crucial factors of surgical selection.

Patterns of recidivism in our study are also similar to those in literature. Recidivism was found in 25 percent of CWU group cases in general and 60 percent in patients who had second-look surgery. These results are consistent with the past reports that have shown that CWU procedures are linked to a high incidence of residual or recurrent cholesteatoma than CWD procedures. According to Sheehy, (1985) [3] and Smyth, (1985) [4], the major drawback of CWU method is the possibility of residual disease that may be hidden in the middle ear and mastoid which may require planned second-look operation. Conversely, our CWD group had a revision rate of 21.4% that is comparable with other revision rates that were reported previously of this technique. According to Dodson et al. (1998) [1], cavity issues or left-over disease may necessitate me to perform a revision procedure despite the general decreasing recurrence rates achieved as a result of CWD surgery.

The results of postoperative hearing in our study showed better results in the CWU group than the CWD group. Patients that received CWU surgery had a lower average of pure tones (31.2 dB) and a high percentage of socially serviceable hearing (less than 30 dB) when compared to those that received CWD surgery. These results are in line with the reports that the preservation of the posterior canal wall can lead to the enhancement of the acoustic mechanics and ossicular reconstruction. Comparing a variety of surgical methods of treating cholesteatoma, Toner and Smyth, (1990) [13] discovered that CWU methods frequently led to better hearing after the surgery than those involving open cavities. The literature is however, somewhat contradictory. Other studies such as that by Shirazi et al., (2006) [2] have found that there is no significant difference in the outcome of hearing between CWU and CWD methods and it is possible that other variables like the state of the ossicular chain or middle ear mucosa play a larger role in the postoperative hearing.

Our results also confirm the relevance of the integrity of the ossicles, especially the existence of intact stapes, in determining the outcome of hearing. In CWU and CWD procedures, patients who had preserved stapes structures had better postoperative hearing thresholds when compared to others who had no stapes preservations. The same findings were indicated by Blakley et al., (1998) [14] who have shown that preoperative hearing status and ossicular integrity are major predictors of postoperative hearing outcomes. This stresses the reason why the surgical method is rather significant, though the functional condition of ossicular chain is one of the most critical factors of auditory results.

The findings of the current research, on the whole, confirm the selective approach of surgery in case of cholesteatoma in pediatric patients. Most cases can safely be undertaken using the CWU technique, especially in children with limited disease and good anatomy, with the benefits of better hearing results and no need to take lifelong care of the cavity. On the contrary, CWD approach is necessary in cases of extensive disease with superadded complications, poor mastoid pneumatization, or anatomical limitation to allow sufficient disease clearance. These results are largely in line with the existing literature and support the idea that the decision on CWU or CWD surgery must be made individually according to the extent of the disease, anatomical considerations, and the probability of full cholesteatoma resection.

Conclusion

The present study highlights that the choice between Canal Wall-Up (CWU) and Canal Wall-Down (CWD) surgery in pediatric cholesteatoma should be individualized based on disease extent and anatomical factors. CWU was preferred in patients with limited disease (Mills score ≤3), offering better hearing outcomes and preservation of normal ear anatomy, though it required more staged procedures due to higher recidivism. In contrast, CWD was mainly indicated in cases with extensive disease, ossicular erosion, and unfavorable anatomy, providing better disease clearance with relatively lower revision rates. The Mills staging system showed moderate predictive value but was insufficient alone for surgical decision-making. Overall, a tailored approach considering intraoperative findings, anatomy, and disease severity is essential to optimize surgical outcomes and minimize recurrence in children.

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