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# Challenges and outcomes of cholesteatoma management in children with Down syndrome☆

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ABSTRACT

*Introduction:* The high incidence of chronic otitis media with effusion and Eustachian tube dysfunction in children with Down syndrome (DS) may predispose them to cholesteatoma formation. Establishing the diagnosis, choosing the appropriate operative intervention, and post-operative care can be challenging.
*Objective:* To describe management strategies for cholesteatoma diagnosis, surgical treatment, and post-operative management in children with Down syndrome.
*Methods:* Retrospective case series of 14 patients (17 total ears) with Down syndrome diagnosed with cholesteatoma over a 9-year period.
*Results:* A total of 14 patients with cholesteatoma (3 with bilateral disease) were analyzed. Thirteen ears (76.5%) had ≥2 tympanostomy tubes insertions prior to cholesteatoma diagnosis, and otorrhea and hearing loss were the most common presenting symptoms. Common pre-operative CT scan findings included mastoid sclerosis and ossicular erosion. The average age at first surgery was 9.8 years, and the average follow-up was 4.3 years. For acquired cholesteatoma, most ears were managed with canal wall up (CWU) approaches, but ultimately 6/15 (40.0%) required canal wall down (CWD) approaches. Postoperatively, 3 (20.0%) ears developed new tympanic membrane retraction pockets, but no recurrent cholesteatoma. Four (26.7%) ears developed recurrent disease, and 3 (20.0%) had residual disease at secondary procedures. Ossiculoplasty was performed in 4 ears. Twelve (70.6%) ears were rehabilitated with hearing aids or FM systems.
*Conclusions:* The diagnosis of cholesteatoma in Down syndrome was associated with otorrhea, hearing loss, and CT scan findings of ossicular erosion and mastoid sclerosis. Most cases were managed with CWU surgical approaches. Hearing aid use was common post-operatively.

## 1. Introduction

The prevalence of chronic otitis media with effusion (COME) in children with down syndrome (DS) has been reported to be 93% by age 1 and 68% by age 5 [1,2]. Eustachian tube (ET) dysfunction, impairing the ability of the middle ear to clear fluid and equalize middle ear pressure, is thought to be more severe and prolonged in children with DS. This is likely due to multiple factors including craniofacial abnormalities, reduced density of ET cartilage predisposing to collapse, and generalized hypotonia affecting palatal muscles that open the ET [2,3]. ET dysfunction predisposes DS children to fluctuating and persistent conductive hearing loss due to middle ear effusion. It is estimated that chronic otitis media with effusion (COME) with conductive loss occurs in 80% of children with DS [4]. Placement of tympanostomy tubes (TT), is standard treatment for COME and has been demonstrated to improve hearing levels in 93% of children with DS by one year after TT placement [5]. Given the propensity and persistence of COME in DS, some affected children will require repeated TT insertions. DS children requiring 3 or more sets of TT are reported to have increased rates of chronic perforation, retraction pockets, atelectasis, and cholesteatoma [4].

Although the exact incidence of cholesteatoma in children with DS is unknown, it has been suggested that acquired cholesteatoma may occur more commonly and may be more extensive at time of diagnosis than in children without multiple risk factors for ET dysfunction [6,7]. Ear examinations in those with DS can be more challenging for clinicians due to narrow external auditory canals and poor patient cooperation, potentially delaying diagnosis. Surgery to excise

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cholesteatomas may also be difficult due to narrow ear canals and poorly developed, sclerotic mastoid anatomy. The goal of this retrospective review is to analyze our experience with cholesteatoma management in children with DS seen at a tertiary care children's hospital over the last decade. The analysis will focus on diagnostic challenges and findings, surgical challenges and outcomes, recurrence rates, post-operative hearing outcomes, and complications associated with the cholesteatoma or surgical interventions.

## 2. Methods

This study was approved by the Institutional Review Board at Ann & Robert H. Lurie Children's Hospital of Chicago (IRB# 2017-730). This is a retrospective case series of children age 1–18 years, treated for cholesteatoma between January 1, 2008–May 31, 2017. An electronic medical record search of patients with the *Internal Classification of Disease, Ninth or Tenth Revision, Clinical Modification* (ICD9/10-CM) diagnosis codes 758.0/Q90.9 for Down syndrome and cholesteatoma 385.32, 385.30/H71.90–93, H71.00, H71.23 was completed through Bio Integration Suite and Clarity Databases. A total of 23 patients met the search criteria. Seven patients were excluded because they did not have confirmed diagnosis of cholesteatoma, and two were lost to follow-up prior to undergoing surgical management. A total of 14 patients were identified with cholesteatoma involving the middle ear and/or mastoid who were surgically managed at our hospital. Three patients had bilateral disease.

The electronic medical records were reviewed, and data recorded including gender, age at first diagnosis/surgery, affected side, presenting signs and symptoms, and prior history of and number of tympanostomy tube (TT) placements. Computed tomography (CT) findings were evaluated including overall mastoid pneumatization, extent of opacification, scutal erosion, ossicular erosion, facial nerve exposure, and tegmen erosion.

The type of surgical procedure (canal wall up or canal wall down mastoidectomy, endoscopic transcanal), and the intraoperative findings including cholesteatoma location, involvement of the ossicular chain, facial nerve, and/or tegmen were noted. Surgical complications (i.e., cerebral spinal fluid leak) were noted. Surgical outcomes including presence of new retraction pockets, persistent otorrhea, recurrent disease, and/or residual disease were recorded. Recurrence, defined as a new retraction pocket cholesteatoma, or residual disease, defined as cholesteatoma detected in the middle ear/mastoid at the same site as previous surgery, was noted in those having secondary procedures. The total number of surgeries needed to treat disease, including eventual need for a canal wall down (CWD) procedure, was recorded.

Post-operative pure tone averages (PTA) were recorded when available. Sound field (SF) or auditory brainstem response (ABR) testing results were noted. The incidence of auditory amplification postoperatively was noted.

### 2.1. Statistics

Demographic and clinical characteristics were reported as frequencies and percentages for categorical variables. Continuous variables are presented as means ± standard deviations. Significance was determined at $p < 0.05$. All statistical analyses were performed using Stata 14.1 (Statacorp, College Station, TX).

## 3. Results

### 3.1. Patient characteristics

Fourteen DS patients (17 ears) with cholesteatoma were analyzed. One patient had bilateral congenital cholesteatomas, and the remaining 15 were acquired. Characteristics of cholesteatoma patients are shown on Table 1. The average age at initial cholesteatoma surgery was 9.8 ± 4.3 years. Most patients (n = 13, 76.5%) had a history of ≥2 sets of TTs prior to the diagnosis of their cholesteatoma, and 8 (47.1%) had ≥3 sets placed (Table 1).

**Table 1**
Characteristics features of Down syndrome patients diagnosed with cholesteatoma.

| Characteristic Features | n (%) |
|---|---|
| *Gender* | |
| Male | 11 (78.6) |
| Female | 2 (21.4) |
| *Ear Affected* | |
| Right | 7 (41.2) |
| Left | 10 (58.8) |
| *Presenting Symptoms* | |
| Otorrhea | 10 (58.8) |
| Hearing Loss | 7 (41.2) |
| Facial Nerve Paresis | 1 (5.9) |
| *Number of Prior TT Insertions* | |
| ≥3 TTs placed | 8 (47.1) |
| ≥2 TTs placed | 13 (76.5) |

TT, tympanostomy tube.

### 3.2. Diagnosis

The diagnosis of cholesteatoma was made on office-based otoscopic examination in 10 (58.8%) ears. The remaining 7 cholesteatomas (41.2%) were diagnosed in the operating room, either during a scheduled TT placement or during otoscopic exam in the operating room (done due to poor tolerance for exam in the clinical setting). The common presenting symptoms of otorrhea and hearing loss are outlined on Table 1. One patient presented with unilateral facial paresis, and a dehiscent facial nerve was noted at surgery. Preoperative CT reports were available in 15 (88.2%) cases. Poor mastoid pneumatization, complete opacification of the mastoid, and ossicular erosion were the most common findings seen on CT scanning (Table 2, Fig. 1).

### 3.3. Surgical intervention

Of the 15 cases of acquired cholesteatoma (Table 3), 11 (73.3%) had a CWU procedure, 2 (13.3%) were managed via a transcanal endoscopic approach (disease was not extending beyond the antrum), and 2 (13.3%) had a primary CWD procedure. One CWD tympanomastoidectomy, in the patient presenting with facial paresis, included facial nerve decompression, and the other was a radical tympanomastoidectomy with ear canal closure and obliteration due to extensive cholesteatoma with tegmen erosion (a cerebrospinal fluid leak occurred on cholesteatoma resection). Neither of these children developed a recurrence. All 15 (100.0%) acquired cholesteatomas involved the mesotympanum, 10 (66.7%) the epitympanum, and 8 (53.3%) extended into the antrum. Thirteen (86.7%) ears had associated ossicular erosion. The incidence of post-operative otorrhea and retraction pocket formation

**Table 2**
Pre-operative computed tomography (CT) scans findings for 15 of the Down syndrome patients diagnosed with cholesteatoma.

| CT findings | n (%) |
|---|---|
| *Mastoid Sclerosis* | 6 (40.0) |
| *Opacification* | |
| Diffuse | 9 (60.0) |
| Focal | 6 (40.0) |
| *Erosion* | |
| Scutum | 5 (33.3) |
| Ossicular | 9 (60.0) |
| Facial Nerve Dehiscence | 3 (20.0) |
| Tegmen | 2 (13.3) |

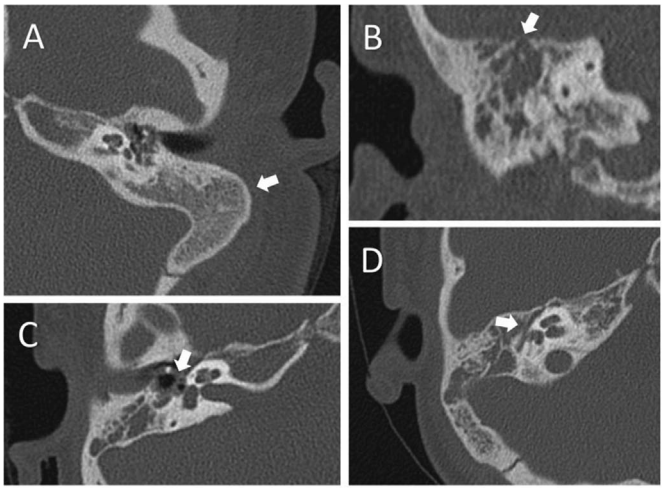


**Fig. 1.** Representative Computed Tomography (CT) findings associated with cholesteatoma in Down syndrome patients. Extensive mastoid sclerosis (A). Possible tegmen erosion (B). Erosion of the incus long process and stapes (C). Possible erosion of the horizontal facial canal (D).

are shown on Table 3. Patients were followed for an average of 4.3 ± 3.1 years (range, 0.41–10.2 years).

The congenital cholesteatomas occurred in a child without a significant history of ETD. These were diagnosed in the youngest child analyzed, who had the first surgery at 1.4 years of age (second at 3.7 years). One was confined to the mesotympanum and managed with a tympanoplasty. The other extended from the middle ear to the antrum and was managed with a CWU tympanomastoidectomy. Despite transient post-operative otorrhea, this child had no recurrence, and did not require secondary procedures.

### 3.4. Post-operative course

Of the 13 CWU/transcanal endoscopic cases done for acquired cholesteatomas, 6 (46.2%) underwent a planned second look procedure within 4–9 months (average 5.8 months) of their initial procedure. At that time, 3 (50.0%) ears had residual cholesteatoma, and 1 (16.7%) had recurrent cholesteatoma. One of the 2 patients (ear 3L, Table 4) managed endoscopically developed persistent otorrhea postoperatively but had no residual or recurrent cholesteatoma at second look. Two (13.3%) additional ears developed recurrent disease and required secondary surgeries between 2 and 4 years (average 3.0 years) after their initial surgery. Ossiculoplasty was undertaken during 4 (66.7%) of the second look procedures. One ear (ear 12) had a second look procedure with TORP placement. This child developed recurrent disease 1.5 years later and required removal of the TORP and CWD procedure (ear 12, Table 4). Four (26.6%) ears were converted to CWD given the extent of disease at their secondary surgery. All told, 6 (40.0%) ears ultimately underwent a CWD procedure.

Post-operative hearing levels were acquired in 15 of the affected ears. One patient, with an intact ossicular chain, had normal hearing levels, and the remainder had losses in the mild to moderate range (data not shown). Eight (47.1%) ears were successfully fitted with a hearing aid, 3 (17.6%) ears were rehabilitated with a FM system, and 1 (5.8%) had bone-anchored hearing aid (BAHA) placement.

**Table 4**
Findings associated with second-look or secondary procedures performed in 7 patients (8 ears) with acquired cholesteatomas. Patient 12 had 4 additional procedures. Years after 1st surgery done as a planned second look are shown in bold.

| Ear | Years after 1st surgery | Approach | Cholesteatoma Location | OCR | Residual Disease | Recurrent Disease |
|---|---|---|---|---|---|---|
| 3L | **0.4** | TC Endo | – | PORP | - | - |
| 4 | 2.8 | CWD | MT, MS | - | - | + |
| 8 | **0.5** | CWD | granulation | - | - | - |
| 9R | **0.5** | CWU | Stapes | TORP | + | - |
| 9L | **0.3** | CWU | FR, HT | TORP | - | + |
| 10 | **0.8** | CWU | RW | – | + | - |
| 12a | **0.4** | CWU | Stapes | TORP | + | - |
| 12b | 0.9 | CWU | Stapes | TORP[a] | - | - |
| 12c | 2.0 | CWU | ET, MS | - | - | + |
| 12d | 4.0 | CWD | MT, MS | - | - | + |
| 13 | 3.3 | CWD | MT, MS | - | - | + |

TC, transcanal; endo, endoscopic approach used; OCR, ossicular chain reconstruction; CWD, canal wall down; CWU, canal wall up; MT, mesotympanum; MS, mastoid; FR, facial recess; HT, hypotympanum; RW, round window niche; ET, epitympanum; PORP, partial ossicular reconstruction prosthesis; TORP, total ossicular reconstruction prosthesis.

[a] The TORP was replaced at this procedure given a fractured foot plate. It was removed at the next procedure when the canal wall was taken down.

## 4. Discussion

The management of chronic otitis media with effusion (COME),

**Table 3**
A summary of findings, age at surgery, and follow-up found in 13 patients (15 ears) with Down syndrome diagnosed with acquired cholesteatomas.

| Ear | Age (years) | Approach | Location | Erosion | Total Surgeries | Persistent Otorrhea Post-op | New Retraction Post-op | Follow-up (years) |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.3 | CWD[a] | MT | M, I, S, FN | 1 | – | – | 2.8 |
| 2 | 10.8 | CWU | MT | | 1 | – | – | 2.3 |
| 3R | 9.4 | TC endo | MT | | 2 | – | – | 1.5 |
| 3L | 9.1 | TC endo | MT, ET, AN | M, I | 1 | + | + | 1.8 |
| 4 | 7.2 | CWU | MT, ET, AN | M, I, S | 2 | – | + | 8.5 |
| 5 | 8.7 | CWU | MT, ET, AN | M, I | 1 | – | – | 6.8 |
| 6 | 14.0 | CWD[b] | MT, ET, AN | M, I, S, Teg | 1 | – | – | 0.9 |
| 7 | 14.4 | CWU | MT | I, S | 1 | – | – | 0.6 |
| 8 | 13.6 | CWU | MT | I | 2 | – | – | 4.1 |
| 9R | 12.9 | CWU | MT, ET | M, I, FN | 2 | – | + | 3.1 |
| 9L | 12.3 | CWU | MT, ET, AN | M, I, S | 2 | – | – | 2.8 |
| 10 | 11.0 | CWU | MT, ET, AN | M, I | 2 | – | – | 4.3 |
| 11 | 7.9 | CWU | MT, ET, AN, MS | M, I | 1 | – | – | 0.4 |
| 12 | 18.4 | CWU | MT, ET | M, I | 5 | – | – | 5.3 |
| 13 | 6.5 | CWU | MS, ET, AN | M, I, S, Teg | 2 | – | – | 10.2 |

R, right; L, left; CWD, canal wall down; CWU, canal wall up; TC, transcanal; endo, endoscopic approach; MT, mesotympanum; ET, epitympanum; AN, antrum; MS, mastoid; M, malleus; I, incus; S, stapes; Teg, tegmen; FN, facial nerve.

[a] Patient underwent a CWD approach with facial nerve decompression given presentation with cholesteatoma and facial nerve paresis.

[b] Patient underwent a CWD with closure of the ear canal and repair of tegmen erosion (cerebrospinal fluid leak encountered on elevation of the cholesteatoma off the dehiscent tegmen).

Eustachian tube dysfunction (ETD), and hearing impairment in children with Down syndrome can be challenging. Often these patients require multiple tympanostomy tube (TT) placements with a resultant higher complication rate, including cholesteatoma formation [4]. Although there has been no study assessing the true incidence of cholesteatoma in DS patients, Lino et al. found that 4/56 ears (7.1%) of patients with DS developed cholesteatoma during follow-up [8]. In another series, 6/102 patients (5.8%) developed cholesteatoma during follow-up, and all of these patients had undergone ≥3 TT placements [4]. Given the concern for cholesteatoma formation in children with DS, our study was undertaken to analyze specific diagnostic, surgical, and post-operative challenges in caring for children with DS seen at a tertiary care center.

### 4.1. Diagnostic challenges

The diagnosis of cholesteatoma in DS patients can be delayed due to narrow external auditory canals and behavioral problems hindering adequate exam in the clinic [6,7]. The majority of our patients presented with otorrhea (n = 10, 58.8%), and when otorrhea was persistent this raised concern for underlying cholesteatoma. In others (n = 7, 41.2%), cholesteatoma was diagnosed during routine placement of TT or scheduled ear exam under anesthesia, as thorough examination in the clinic was difficult. By comparison, in a series of non-syndromic children with cholesteatoma, 70% presented with hearing loss and 83.3% with otorrhea [9]. Our lower percentages demonstrate the challenge of cholesteatoma diagnosis in patients with DS. A high index of suspicion and close long-term follow up are a necessity in managing these patients. If not able to examine the child well in the clinical setting, intermittent examinations of high-risk children, i.e. those with deep retraction pockets, in the operating room setting may be appropriate.

Pre-operative CT scan findings can assist in the diagnosis and surgical planning in cholesteatoma patients. In a series of 30 children with cholesteatoma, preoperative CT scans showed ossicular erosion in 20 (66.7%) patients, poor mastoid pneumatization in 4 (13.3%), and tegmen erosion in 2 (6.7%) [10]. Another series reported mastoid hypoplasia in 65% of ears in children with DS [11]. In our group of DS patients, poor mastoid pneumatization (n = 6/15, 40.0%) was commonly noted. Tegmen erosion occurred in 2/15 (13.3%), and there was a similar rate of ossicular erosion (n = 9/15, 60.0%) on CT scans (a higher rate of ossicular erosion noted intraoperatively). There were no cases of semicircular canal dehiscence or intracranial complications noted on CT scans in our series. Temporal bone studies have shown a high prevalence of facial nerve dehiscence in DS patients (at-least one of our cases had FN dehiscence) [10,11]. We found that an overall awareness of these anatomic issues was valuable for preoperative planning and discussion with the family of possible surgical strategies/outcomes.

### 4.2. Surgical challenges

By the time of diagnosis in patients with DS, erosive disease involving the middle ear and mastoid may have developed. In our series, extensive disease was present in many cases. Nine patients (52.9%) had cholesteatoma extending from the middle ear into the mastoid, and 15 patients (88.2%) had ossicular erosion. Similarly, a series by Nash et al. noted disease extension at least into the mastoid antrum and ossicular erosion in all children with DS analyzed [6]. In their study of children with DS, Bacciu et al. noted mastoid extension of the cholesteatoma at least to the antrum in 8/11 (72.7%) ears, and ossicular erosion in 10/11 (90.9%) [7].

The primary goal of cholesteatoma surgery centers on the creation of a safe, dry ear free of disease. Prior analyses of cholesteatoma management strategies in children with DS have advocated for early/primary aggressive surgical intervention, including CWD tympanomastoidectomy [7,12]. Two of our patients required primary CWD tympanomastoidectomy due to the facial dehiscence and extent of the disease as described in Table 3. Four additional ears with acquired cholesteatoma had CWD surgery at their secondary procedures (total of 6 or 40.0% with CWD overall). Based on our series, the surgery can be tailored to the needs of the particular patient, although eventual conversion to CWD should be considered, and discussed with families, based on extent of recurrent/residual disease.

Fifteen (88.2%) ears were managed initially with a CWU procedure (including the 2 endoscopic transcanal cases). Prior studies recommended reserving CWU procedures for cholesteatomas isolated to the epitympanum (if regular follow-up was possible) or using a canal wall reconstruction approach [6,7]. Based on our analysis, primary CWU tympanomastoidectomy was utilized in those patients with disease limited to the meso- or epitympanum, and sometimes in those with extension into the mastoid antrum. This procedure can be successful in DS patients, as long as consistent long-term follow-up arranged and intent for a second-look procedure is emphasized. CWU approaches avoid the disadvantages of cleaning a mastoid cavity in sometimes uncooperative children, and they allow better ease of hearing aid fitting.

### 4.3. Postoperative challenges

Postoperative concerns included management of residual or recurrent disease and hearing outcomes. Residual rates in general pediatric patients range from 7 to 54%, and recurrence rates from 3 to 40% [9,13,14]. A study assessing risk factors for recurrence of cholesteatoma in children, noted that age < 8 years, presence of Eustachian tube dysfunction, and extensive cholesteatoma based on size and ossicular erosion were variables associated with an increased rate of recurrence [15]. In our series of DS patients, residual cholesteatoma was noted in 3/15 (20.0%)ears, and recurrence in 5/15 (33.3%) ears (2 recurrences occurred in the same patient-ear 12c and 12 d, Table 4). These data appeared to be within the range of those reported for a general pediatric population of patients, although our numbers are small. All cases with recurrent disease in our series had extension of cholesteatoma into the mastoid antrum and erosion of all 3 ossicles at the initial surgery. The 3 patients with residual disease had planned second-look procedures; there was a small amount of cholesteatoma capsule intentionally left in the region of the stapes. Overall, consistent, regular follow-up with office-based otomicroscopy should be performed to help detect recurrent disease in these patients, and planned second look procedures if index of suspicion is high for residual/recurrent disease.

Restoration of hearing is generally considered a secondary goal of cholesteatoma management. There are several studies assessing hearing outcomes in children with cholesteatoma [16,17]. Serviceable hearing thresholds and air-bone gaps, both on short and long-term follow-up, were noted. The middle ear status, ossicular chain status, and approach (CWD vs CWU) were factors shown to effect hearing outcomes [16,17]. Hearing thresholds were not significantly improved regardless of ossicular reconstruction [6,7]. Behavioral and side specific audiometric data were not reliably acquired in our patients, often due to poor cooperation with testing. Most patients utilized auditory amplification post-operatively, including hearing aids or FM systems. Thoughtful discussion with families about potential hearing outcomes, and potential need for amplification, prior to surgical intervention would be recommended based on our analysis.

Overall this series highlights some of the challenges of managing cholesteatoma in children with DS. Otorrhea was the most common presenting symptoms, and CT scans were helpful in establishing the diagnosis of cholesteatoma. CWU approaches were generally utilized as initial treatment of cholesteatoma in our patients, but the need to convert children with extensive disease to CWD at secondary procedures must be considered. Close follow up for assessment of hearing and to check for recurrent/residual disease were essential. Despite these

suggestions, the conclusions of our study were limited due to the retrospective nature, and the relatively small patient population with no control group of non-syndromic pediatric patients.

## 5. Conclusions

Managing cholesteatoma in children with DS may pose a number of challenges. Otorrhea and hearing loss were common presenting complaints. CT scanning was a useful adjunct to diagnosis, and often demonstrated sclerotic mastoids and ossicular erosion. CWU approaches were generally successful for cholesteatoma resection in the majority of the cases, but the threshold should be low to convert to CWD if extensive disease or recurrence encountered. Ongoing hearing loss was not uncommon, necessitating hearing aids in many patients.

## Disclosures

None.

## Conflicts of interest

None.

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