The Egyptian Journal of Otolaryngology

REVIEW ARTICLE Open Access

Recidivism of childhood cholesteatoma and surgical techniques: a meta-analysis study

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Abstract

Background: There is a debate in the literature about surgical management of childhood cholesteatoma. We aimed to conduct a meta-analysis study about the recidivism of acquired cholesteatoma in children after two primary surgical procedures, namely canal wall up (CWU) and canal wall down (CWD) mastoidectomy.

Main body of the abstract: A Medline search of English language literature on PubMed and Cochrane Collaboration from their dates of inception until August 2019 was conducted using the following search terms: "pediatric or child and Cholesteatoma Surgery". Twenty-eight full-text papers fulfilled the selection criteria and were included in this meta-analysis

This analysis showed an odd risk of 1.72 for recidivism of childhood cholesteatoma in single-stage canal wall up procedure relative to canal wall down procedures. The 95% confidence interval (CI) for the overall odds ratio was 1.27–2.34. The I^2 statistic was 37%, representing low heterogeneity. Comparing the rate of recidivism before and after the year 2000 showed that there was still increased risk of recidivism in the canal wall up versus canal wall down mastoidectomy (the odds ratio was 1.87 and 1.57 respectively).

Short conclusion: Single-stage canal wall up mastoidectomy was significantly associated with a higher risk of cholesteatoma recidivism compared to canal wall down technique in children with acquired cholesteatoma

Keywords: Cholesteatoma, Recidivism, Children, Meta-analysis, Mastoidectomy

Background

Surgical management of cholesteatoma in children carries more challenges to otologist compared to the adults. Pediatric cholesteatoma is characterized by its aggressive behavior and a higher rate of recidivism. Increased incidence of upper respiratory tract infection and special features of Eustachian tube in children make them more vulnerable to a higher incidence of ear infection; in addition, good pneumatization of mastoids in children helps for more spread of disease compared with the sclerotic mastoid bones in adults. The pediatric cholesteatoma has more proliferative activity than that of the adult and may be another cause of aggressiveness of cholesteatoma in this age group [1–3].

Early intervention of pediatric cholesteatoma is crucial to avoid hearing loss that may have a great influence on the development of language and learning performance [4].

The aforementioned features specific to childhood cholesteatoma pose a serious challenge to otologist regarding surgical treatment of cholesteatoma.

The objectives of surgery for cholesteatoma in children are complete exenteration of the disease, prevention of recidivism, and improvement of hearing. Canal wall up (CWU) and canal wall down mastoidectomy (CWD) are the primary surgical approaches to accomplish these objectives [5].

The major surgical distinction between CWU and CWD procedures is whether or not to keep the canal wall intact. CWU mastoidectomy entails the removal of all mastoid air cells while preserving the integrity of the ear canal, while lowering the bony posterior canal wall

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up to the vertical part of the facial nerve is an essential surgical step in CWD mastoidectomy [6, 7].

In the CWU procedure, preserving the normal anatomy of the ear prevents the cavity problems that associated with CWD including frequent recurrent otorrhea, avoidance of exposure to water and water sport like swimming, shallow middle ear space with possible less favorable hearing results, vertigo because of exposure of lateral semicircular canal to cold air or water, prolonged postoperative recovery, a cosmetically unpleasing meatoplasty, and fitting of hearing aids is difficult [8, 9].

However, the main argument of the CWU procedure is the inability of this surgical technique of proper and adequate exposure of critical and hidden areas of the middle ear cleft such as sinus tympani, and epitympanic recess and therefore higher incidence of recidivism [10, 11]. To overcome the higher residual rate, many ear surgeons prefer to perform CWU surgery with a planned second look [12, 13]. Some otologist reported higher recidivism with CWD technique [14, 15], yet others have stated similar recurrence rates regardless of the status of the canal wall [13, 16, 17].

On reviewing the published data in literature, no meta-analysis was carried out about recidivism of childhood cholesteatoma following the two main surgical approaches; therefore, the aim of this study was to analyze available studies in literature and to carry meta-analysis about recidivism after single-stage canal wall up (CWU) and canal wall down (CWD) surgery in children with acquired cholesteatoma.

Materials and methods

Study design

This meta-analysis was carried out in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Different phases of this study were illustrated using the PRISMA flow diagram [18]. The ethical committee in our institution approved this research.

Literature search

A Medline review of English language literature on PubMed and Cochrane Collaboration from inception date until August 2019 was performed using the following search terms: "pediatric or child and Cholesteatoma Surgery".

Subsequent to the above-mentioned search terms, abstracts and titles were obtained and checked by two authors to identify the eligible articles for further analysis.

Selection criteria

To be included in the study, patients should be under 18 years old, original studies from peer-reviewed scientific journals were published in English, undergoing surgery for acquired cholesteatoma, rate of recidivism in both canal wall up and canal wall down approaches was analyzed in the same study, one-stage mastoid surgery, and follow-up time was nearly similar between both groups in same paper.

The following researches were excluded: animal, in vitro studies, review papers, case reports, studies on congenital cholesteatoma, studies without reference to original articles (e.g., only abstracts), and publications in which canal wall up surgery was undergone in two stages. In cases of using the same data in many publications by the same authors, the recently published study was included in the meta-analysis.

Full-text articles have been evaluated to see whether or not they meet the inclusion criteria. References of each study were checked manually to add more additional eligible articles.

Data extraction

All full texts were reviewed and analyzed by two authors independently to obtain the following data: author(s), year of publication, number of patients, demographic features of patients, number of ear surgeries, duration of follow-up for both approaches, and finally recidivism rates (including recurrent and residual cholesteatoma) for each technique.

Study quality assessment

The quality of included studies was checked using the Newcastle-Ottawa quality assessment Scale (NOS). The NOS has nine "stars," and the quality of the studies are graded into high (score > 6stars), moderate (4–6 stars), and low (≤ 3 stars). The score of all studies was more than 6 stars and considered as good-quality studies.

Statistical analysis

All of the previously mentioned data were fed to Review Manager 5.3 (RevMan) program (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration 2014). The odds ratios and weight of each study were calculated with 95% confidence intervals (CI) using the Mantel-Haenszel method of meta-analysis. A forest plot was created showing the individual odds ratios and weights in addition to the pooled risk. The I^2 was calculated to determine the degree of heterogeneity which was classified into low (I^2 < 0–50%), moderate (I^2 between 50–75%), or high (I^2 > 75%).

We finally compare the recidivism of cholesteatoma in children before and after the year 2000 to determine any change in the rate of recidivism due to new innovation in imaging and surgical tools.

Results

Characteristics of the studies

A flow diagram was created to show the search process, the initial detection, reasons for exclusion, and the final choice of the studies (Fig. 1).

After running the search terms "pediatric or child and Cholesteatoma Surgery", 2069 abstracts were obtained, and 255 abstracts were duplicated and excluded.

After the initial analysis of the abstracts, 1733 abstracts were excluded including 147 abstracts about congenital cholesteatoma; therefore, we reviewed 81 full-text articles to check for fulfilling the selection criteria.

Out of 81 full-text studies, 53 papers were excluded because of the following: insufficient data (n = 9), no distinguish between operative results in children versus adults (n = 1), using either CWU or CWD as only standard procedure (n = 23), no comparison between recidivism in CWU versus CWD procedure (n = 4), surgical outcome of congenital and acquired cholesteatoma was pooled together (n = 6) and older publication by same authors (n = 10). Only 28 studies fulfilled the selection criteria and were included in the meta-analysis.

The 28 studies included 3298 patients (3411 affected ears). On analyzing the previous 28 studies, 348 ears were excluded because they did not fulfill the inclusion criteria and had a congenital cholesteatoma, revision cases, or underwent surgical procedures other than CWU or CWD mastoidectomy; therefore, this study was carried out on 3063 ears with pediatric-acquired cholesteatoma. Canal wall up mastoidectomy was performed in 1905 ears, while 1158 ears underwent a canal wall down procedure.

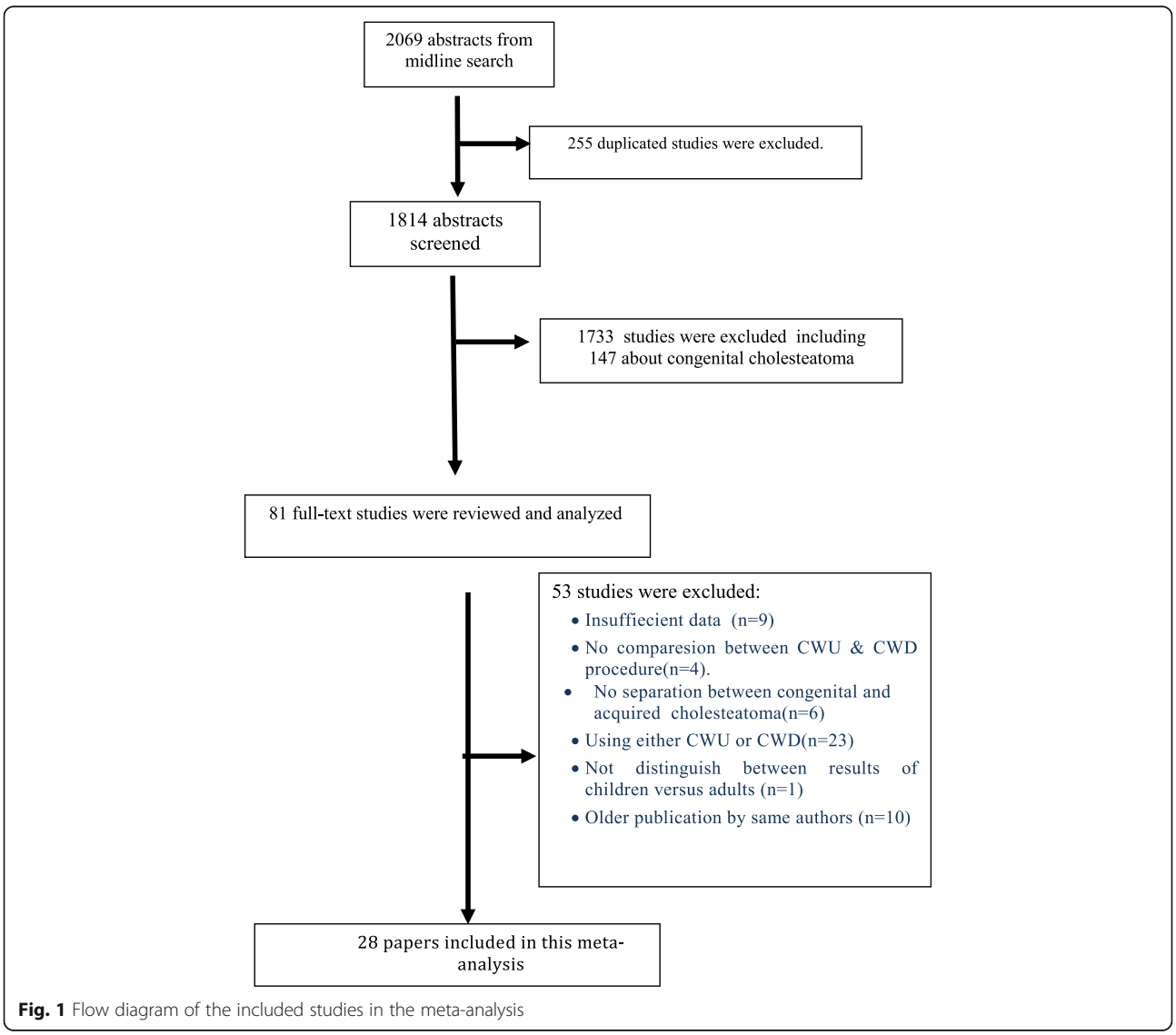

Fig. 1 Flow diagram of the included studies in the meta-analysis

Difference between included studies

The studies varied widely in many aspects especially the demographic features of patients and mean duration of follow-up. Follow-up times among studies demonstrated significant variation, though, within each study, it was consistent. The follow-up periods ranged in from 1 to 10 years (Table 1).

The patient's number was variable from one study to another ranging from 18 to 493 patients. The mean age of patients varied from 8 to 13 years. These studies were conducted on 2061 (62.5%) male and 1237 (37.5%) female patients.

The rate of recidivism (recurrent and residual cholesteatoma) was highly variable from one study to another. Recidivism of cholesteatoma ranged from 5.26 to 80% in canal wall up approach while it ranged from 0 to 48% in canal wall down approach (Table 2).

The overall recidivism was 526/1905 (27.61%) for CWU mastoidectomy, while it was 202/1158 (17.44%) for CWD mastoidectomy (Table 2).

Meta-analysis

For each study, the odds ratio (OR) and the 95% confidence interval were demonstrated in Figs. 2 and 3. Based on the number of patients included in each study, the pooled odds ratio (OR) was weighted. The individual odds ratios varied from 0.53 to 9.33 and were weighted according to the number of patients included in this analysis to yield an odds ratio of 1.73 for recidivism of childhood cholesteatoma in canal wall up procedure relative to canal wall down procedures. The 95% confidence interval (CI) for the overall odds ratio was 1.27–2.34. The I^2 statistic was 37%, representing low heterogeneity (Fig. 3).

There was no bias of publication as shown in the funnel plot (Fig. 4).

Comparing the results before and after the year 2000 showed that the aggregate odds ratio was 1.87 and 1.57 respectively for recidivism of cholesteatoma in canal wall up versus canal wall down mastoidectomy (Figs. 5 and 6).

Discussion

Surgical treatment of cholesteatoma is still a controversial issue, especially in the pediatric age group. The main surgical techniques commonly used for management of cholesteatoma are canal wall up (CWU) and canal wall down (CWD) mastoidectomy. Removal of the posterior and superior wall of the ear canal represents the major surgical difference between the previous approaches.

Many surgeons prefer canal wall up mastoidectomy, others favor performing canal wall down mastoidectomy, yet some authors advocated that the choice of surgical procedure should be tailored individually, considering many factors: the site and spread of the cholesteatoma, status of Eustachian tube function, the mastoid size and pneumatization, anatomical factor like low-lying dura of middle fossa and anterior position of sigmoid sinus, erosion of external auditory canal, presence of lateral canal fistula, ossicular involvement, and presence of complications [41, 42]. Patients with extensive cholesteatoma, Eustachian tube dysfunction, and contracted mastoids are candidates for canal wall down mastoidectomy [15].

Preoperative indications of CWD procedure include operating on an only hearing ear, poor anesthetic risk, or difficult follow-up [7].

Recidivism is one of the most crucial parameters that should be considered when comparing the outcomes of surgical approaches for the management of cholesteatoma.

Many ear surgeons believed that cholesteatoma recurrence is more common in CWD procedure than CWU procedure [13, 15, 26, 34].

On the other hand, other studies demonstrated that recidivism of cholesteatoma is more in CWU mastoidectomy than CWD mastoidectomy [7, 19–25, 28, 29].

In this meta-analysis, we investigated the percentage of recidivism (recurrent and/or residual cholesteatoma) in two main surgical approaches (CWU and CWD mastoidectomy) for treatment of the acquired type of childhood cholesteatoma.

Data from literature included in our meta-analysis study showed a variable range of recidivism of cholesteatoma for canal wall up and canal wall down groups. For canal wall up, the lowest recorded recurrence rate was 5.26% and the highest was 80% with a mean of 27.61% while for canal wall down the lowest recurrence rate was 0% and the highest was 48% with a mean of 17.44%.

This study showed a significant aggregate odds ratio of 1.73 for recidivism which means that children who underwent the canal wall up approach are 1.73 times to have residual and/or recurrent cholesteatoma compared to children who received the canal wall down approach.

We compared the result of canal wall mastoidectomy versus canal wall down mastoidectomy before and after the year of 2000 to show if the advances of imaging or surgical technology have effects on the recidivism rate. The meta-analysis showed that the risk of recidivism was still higher in canal wall up than canal wall down mastoidectomy before and after the year 2000 (the aggregate odds ratio was 1.87 before year 2000 versus 1.57 after the year 2000).

The higher rate of recidivism dictates second-look surgery after canal wall up mastoidectomy. Second-look surgery is not without its drawbacks, including the financial burden of the second surgery on patient and

Table 1 Description of studies included in the meta-analysis

Time	Author	Year	Location	Total patients	Affected ears	Patient demographics			No. of excluded ears*
						Male	Female	Mean age (years)	
	Brown [16]	**1982**	Canada	98	98	60	38	9	-
Before 2000	**Charachon and Gratacap** [19]	**1985**	France	141	141	85	56	9.5	-
	Lau and Tos [13]	**1987**	Denmark	120	122	82	38	8.8	26 no mastoidectomy
	Edelstein et al. [15]	**1988**	USA	125	127	80	45	9.65	22 CC
	Marco-Algarra et al. [20]	**1991**	Spain	52	55	25	27	9.8	-
	Cruz et al. [21]	**1990**	Brazil	101	101	60	41	10.7	
	Schmid et al. [22]	**1991**	Switzerland	55	57	32	23	8	2 CC
	Crellin et al. [23]	**1991**	UK	67	67	38	29	11	2
	Mills and Padgham [24]	**1991**	UK	54	57	30	24	10	27 other procedures
	Rigner et al. [25]	**1991**	Sweden	19	19	9	10	9	-
	Stern and Fazekas–May [26]	**1992**	USA	53	54	30	23	12	
	Vartiainen and Nuutinen [27]	**1993**	Finland	50	54	36	14	10	10 no mastoidectomy
	Parisier et al. [28]	**1996**	USA	209	216	136	73	8.6	51 no mastoidectomy
	Stangerup et al. [29]	**1998**	Denmark	114	114	69	45	9	49 no mastoidectomy
	Dodson et al. [7]	**1998**	USA	66	73	34	32	10	15 no mastoidectomy
	Silvola and Palva [30]	**1999**	Finland	84	84	55	29	9.7	17 no mastoidectomy
During and after 2000	**Darrouzet et al.** [31]	**2000**	France	199	215	105	94	9.6	4 revision
	Ueda et al. [32]	**2001**	Japan	56	58	30	26	11	6 CC
	Gocmen et al [33]	**2003**	Turkey	114	114	71	43	13	
	Ahn et al. [34]	**2003**	South Korea	118	121	90	28	10	
	Schraff and Strasnick [8]	**2006**	USA	262	278	170	92	9	
	Shirazi et al. [5]	**2006**	USA	106	106	68	38	10	20 CC
	Yung et al. [35]	**2007**	UK	50	52	29	21	10.5	11 no mastoidectomy
	Drahy et al. [36]	**2012**	France	21	22	14	7	9.7	
	McRackan et al. [37]	**2011**	USA	493	517	304	189	9.78	57 no mastoidectomy
	Osborn et al. [38]	**2012**	Canada	420	435	289	131	10.8	26 revision
	Vincenti et al. [39]	**2014**	Italy	18	18	11	7	10.7	-
	Sergi et al. [40]	**2014**	Italy	33	36	19	14	10	3 lost follow up

USA United States of America, *UK* United Kingdom, *CC* congenital cholesteatoma
*These ears did not fulfill inclusion criteria of our study

Table 2 Recidivism after canal wall up and canal wall down approaches

Time	Author	Mean follow-up	CWU Recidivism (%)	CWD Recidivism (%)	Total recidivism rate (%) CWU and CWD
	Brown [16]	10	22/62 (35.48%)	12/36 (33.33%)	34/98 (34.69%)
Before 2000	**Charachon and Gratacap** [19]	> 3 years	45/99 (45.45%)	7/42 (8.95%)	59/136 (43.38%)
	Lau and Tos [13]	9.5	9/51 (18%)	10/45 (22.22%)	19/96 (19.79%)
	Edelstein D. et al. [15]	3.9 years	3/39 (7.69%)	9/66 (13.36%)	12/105 (11.42%)
	Marco-Algarra et al. [18]	7.1	15/40 (37.50%)	2/15 (13.33%)	17/55 (30.91%)
	Cruz et al. [21]	> 2 years	12/26 (46.15%)	10/75 (13.33%)	22/101 (21.78%)
	Schmid et al. [22]	7 years	6/16 (37.50%)	6/39 (15.38%)	12/55 (21.81%)
	Crellin et al. [23]	> 18 months	4/5 (80%)	18/60 (30%)	22/65 (33.84%)
	Mills and Padgham [24]	50 months	1/3 (33.33%)	3/27 (11.11%)	4/30 (13.33%)
	Rigner et al. [25]	5 years	6/10(60%)	1/9(11.11%)	7/19(63.84)
	Stern and Fazekas–May [26]	29 months	10/29 (34.48%)	12/25 (48%)	22/54 (40.74%)
	Vartiainen and Nuutinen [27]	7.1 years	2/9 (22.22%)	6/35 (17.14%)	8/44 (18.18%)
	Parisier et al. [28]	7.2 years	11/62 (17.74%)	11/103 (10.68%)	22/165 (13.33%)
	Stangerup et al. [29]	5.8 years	17/44 (38.64%)	4/21 (19.04%)	21/65 (32.30%)
	Dodson et al. [7]	37.7 months	17/41 (41.46%)	2/17 (11.76%)	19/58 (32.75%)
	Silvola and Palva [30]	4.8 years	4/17 (23.53%)	16/50 (32%)	20/67 (29.85%)
During and after 2000	**Darrouzet et al.** [31]	70 months	56/190 (29.47%)	9/21 (42.86%)	65/211 (30.80%)
	Ueda et al. [32]	> 1 years	14/32 (43.75%)	3/20 (15%)	17/52 (32.69%)
	Gocmen et al. [33]	3.7 years	9/35 (25.71%)	12/79 (15.19%)	21/114 (18.42%)
	Ahn et al. [34]	5 years	2/19 (10.53%)	17/102 (16.67%)	19/121 (15.70%)
	Schraff and Strasnick [8]	2.6 years	38/221 (17.19%)	7/57 (12.28%)	45/278 (16.18%)
	Shirazi et al [5]	6 years	2/38 (5.26%)	2/48 (4.17%)	4/86 (4.65%)
	Yung et al. [35]	5 years	2/6 (33.33%)	4/35 (11.43%)	6/41 (14.63%)
	Drahy et al. [36]	74 months	4/18 (22.22)	0/4 (0%)	4/22(18.18%)
	McRackan et al. [37]	36.5 months	101/409 (24.69%)	9/51 (17.65%)	110/460 (23.91%)
	Osborn et al. [38]	at least 1 year	106/352 (30.11%)	8/57 (14.04%)	114/409 (27.87%)
	Vincenti et al. [39]	8	4/12 (33.33%)	0/6 (0%)	4/18 (22.22%)
	Sergi et al. [40]	38 months	4/20 (20%)	2/13 (15.38%)	6/33 (18.18%)
	Total		**526/1905 (27.61%)**	**202/1158 (17.44%)**	**728/3063 (23.77%)**

CWU canal wall up, *CWD* canal wall down

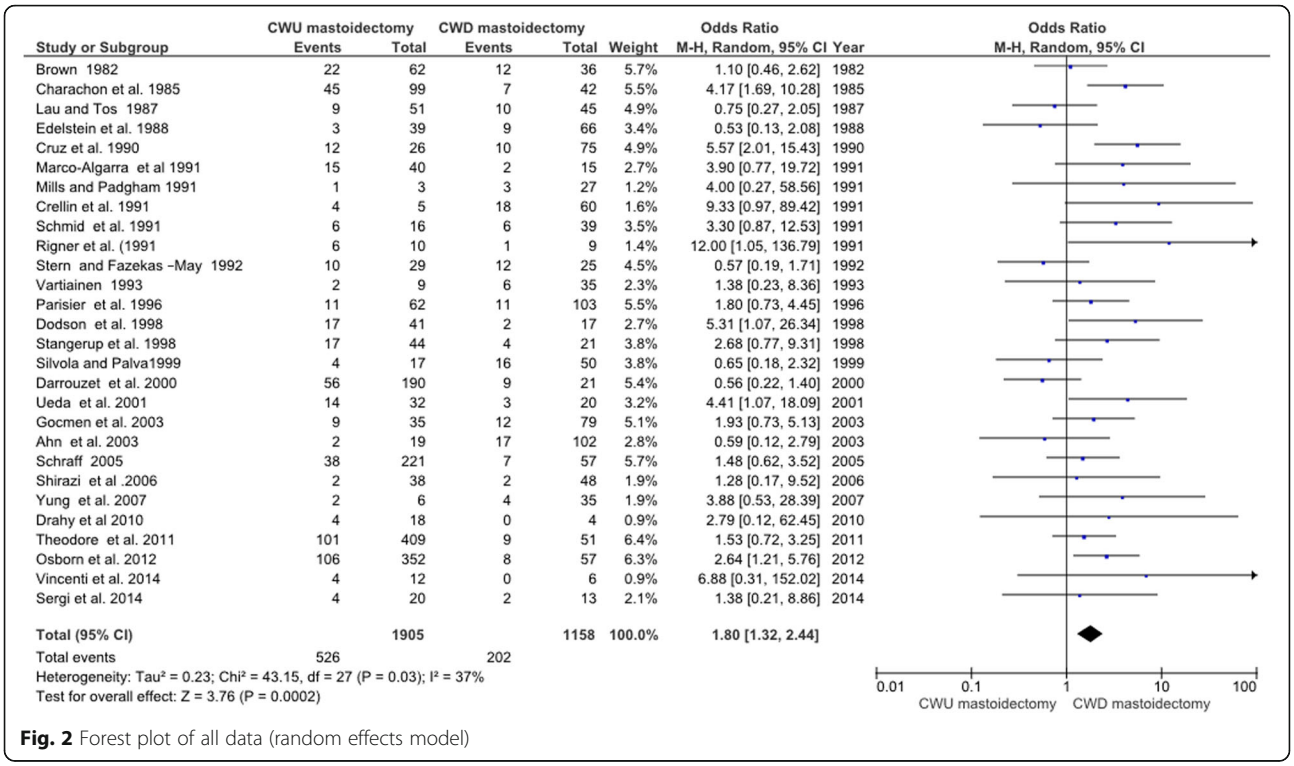

Fig. 2 Forest plot of all data (random effects model)

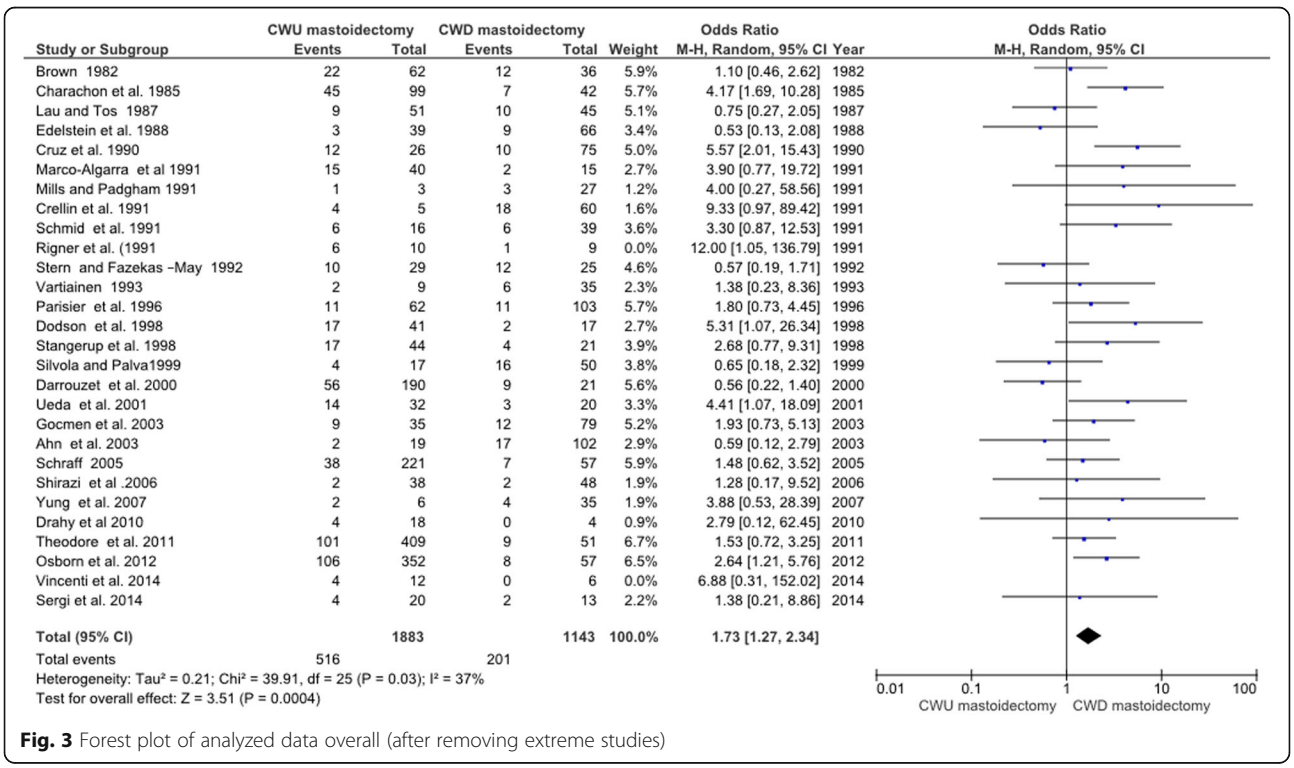

Fig. 3 Forest plot of analyzed data overall (after removing extreme studies)

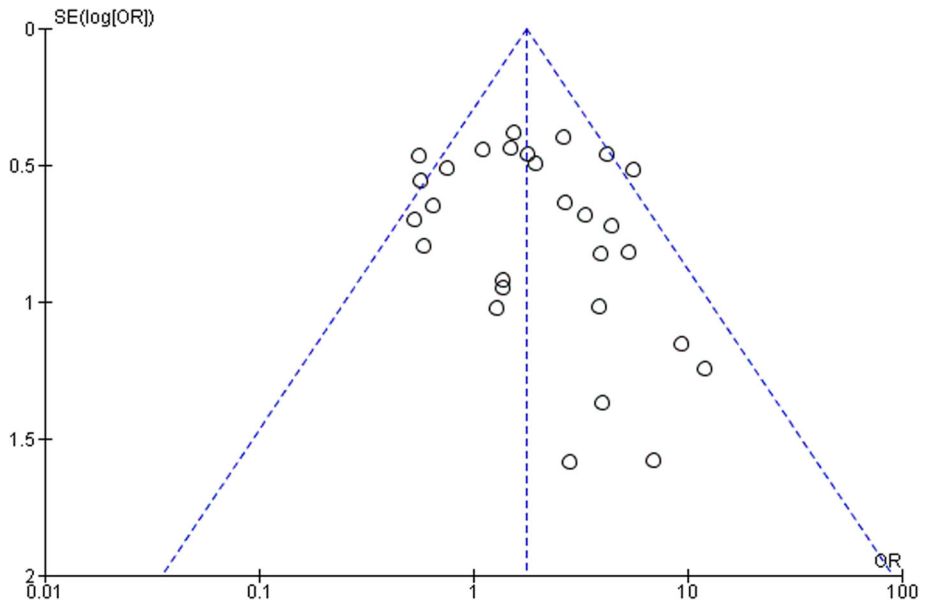

Fig. 4 Funnel plot for publication bias

institution, risk of anesthesia, and challenges related to altered anatomical landmarks due to previous surgery [43].

Different surgical techniques have been performed to overcome the disadvantages of CWU (high recidivism rates) and CWD (cavity problems) mastoidectomy including reconstruction of canal using cartilage and cortical bone [4] and using endoscopes for superior exposure of hidden spots in middle ear especially sinus tympani which represents most common site of recidivism during cholesteatoma surgery [44].

This meta-analysis showed that CWU mastoidectomy is a risk factor for recidivism; however, other researchers stated that there are other risk factors for recurrence of cholesteatoma rather than the surgical technique. The

Study or Subgroup	CWU mastoidectomy Events	Total	CWD mastoidectomy Events	Total	Weight	Odds Ratio M-H, Random, 95% CI	Year
Brown 1982	22	62	12	36	9.5%	1.10 [0.46, 2.62]	1982
Charachon et al. 1985	45	99	7	42	9.2%	4.17 [1.69, 10.28]	1985
Lau and Tos 1987	9	51	10	45	8.5%	0.75 [0.27, 2.05]	1987
Edelstein et al. 1988	3	39	9	66	6.3%	0.53 [0.13, 2.08]	1988
Cruz et al. 1990	12	26	10	75	8.4%	5.57 [2.01, 15.43]	1990
Marco-Algarra et al 1991	15	40	2	15	5.2%	3.90 [0.77, 19.72]	1991
Mills and Padgham 1991	1	3	3	27	2.5%	4.00 [0.27, 58.56]	1991
Crellin et al. 1991	4	5	18	60	3.2%	9.33 [0.97, 89.42]	1991
Schmid et al. 1991	6	16	6	39	6.5%	3.30 [0.87, 12.53]	1991
Rigner et al. (1991	6	10	1	9	0.0%	12.00 [1.05, 136.79]	1991
Stern and Fazekas -May 1992	10	29	12	25	7.9%	0.57 [0.19, 1.71]	1992
Vartiainen 1993	2	9	6	35	4.5%	1.38 [0.23, 8.36]	1993
Parisier et al. 1996	11	62	11	103	9.2%	1.80 [0.73, 4.45]	1996
Dodson et al. 1998	17	41	2	17	5.3%	5.31 [1.07, 26.34]	1998
Stangerup et al. 1998	17	44	4	21	7.0%	2.68 [0.77, 9.31]	1998
Silvola and Palva1999	4	17	16	50	6.9%	0.65 [0.18, 2.32]	1999
Darrouzet et al. 2000	56	190	9	21	0.0%	0.56 [0.22, 1.40]	2000
Ueda et al. 2001	14	32	3	20	0.0%	4.41 [1.07, 18.09]	2001
Gocmen et al. 2003	9	35	12	79	0.0%	1.93 [0.73, 5.13]	2003
Ahn et al. 2003	2	19	17	102	0.0%	0.59 [0.12, 2.79]	2003
Schraff 2005	38	221	7	57	0.0%	1.48 [0.62, 3.52]	2005
Shirazi et al .2006	2	38	2	48	0.0%	1.28 [0.17, 9.52]	2006
Yung et al. 2007	2	6	4	35	0.0%	3.88 [0.53, 28.39]	2007
Drahy et al 2010	4	18	0	4	0.0%	2.79 [0.12, 62.45]	2010
Theodore et al. 2011	101	409	9	51	0.0%	1.53 [0.72, 3.25]	2011
Osborn et al. 2012	106	352	8	57	0.0%	2.64 [1.21, 5.76]	2012
Vincenti et al. 2014	4	12	0	6	0.0%	6.88 [0.31, 152.02]	2014
Sergi et al. 2014	4	20	2	13	0.0%	1.38 [0.21, 8.86]	2014
Total (95% CI)		**543**		**656**	**100.0%**	**1.87 [1.18, 2.97]**	
Total events	178		128				

Heterogeneity: Tau² = 0.39; Chi² = 28.22, df = 14 (P = 0.01); I² = 50%
Test for overall effect: Z = 2.66 (P = 0.008)

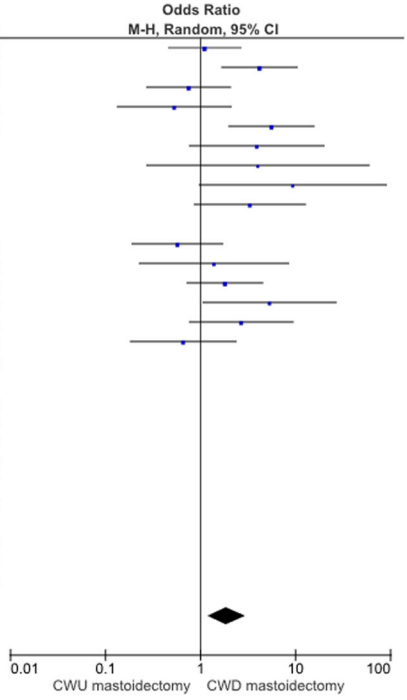

Fig. 5 Forest plot of analyzed data before the year 2000

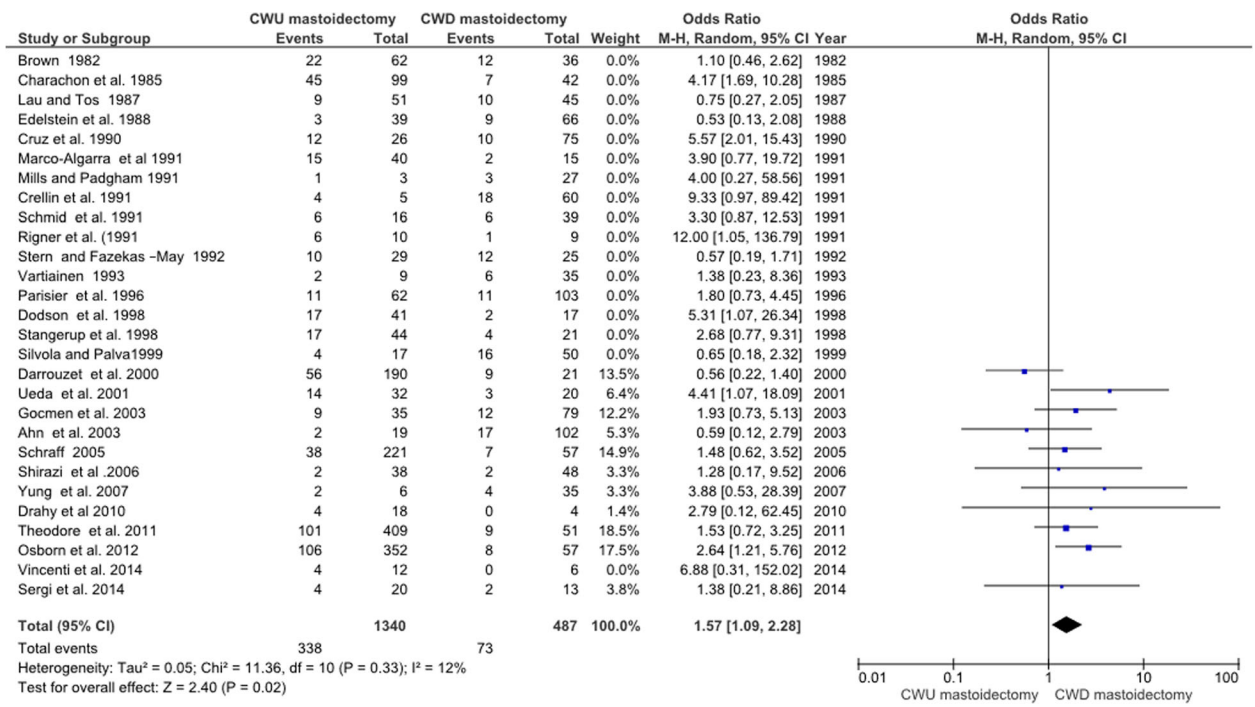

Fig. 6 Forest plot of analyzed data during and after the year 2000

ossicular erosion was reported to be linked with cholesteatoma recidivism [45].

Involvement of the facial recess or the sinus tympani by cholesteatoma was considered one of the most common causes of failure of the CWU approach [46].

Roger et al. found that extension of cholesteatoma to posterior mesotympanum, interruption of the ossicular chain after cholesteatoma excision, surgeon experience, and incomplete excision of cholesteatoma are associated with recidivism of cholesteatoma [17].

The value of this analysis lies in the data consistency. It is clear from forest plot that recidivism was lower in canal wall down mastoidectomy in 22 out of the 28 studies while only 6 studies favor the canal wall up approach due to lower recidivism compared to canal wall up technique.

One of the critiques in this review was the variability of postoperative follow-up time from one study to another. Many studies reported that longer postoperative follow-up was associated with higher rates of recidivism [13, 47, 48]. However, the postoperative follow-up was the same within each study which is essential to compare the rate of the recidivism between the two surgical approaches.

Another point of criticism is the detection method of the recidivism in the postoperative follow-up. Many authors detected recurrent disease by otomicroscopy; however, the majority does not determine the exact methods of detection of recurrence. Others detected recurrence during second-stage surgery especially in canal wall up mastoidectomy which commonly revised months to years after primary surgery. Therefore, it is essential to standardize our method of detection of recurrent disease. The diffuse-weighted MRI may be used in postoperative follow-up for detection recurrent and residual disease, reducing the rate of second-look surgery. A recent meta-analysis study showed that diffusion-weighted MRI is highly sensitive and specific for detection of recidivism after cholesteatoma surgery as MRI can detect cholesteatoma as small as 3 mm [49, 50].

Despite enormous studies on cholesteatoma, we faced many difficulties during the analysis of data including reporting of recidivism rate as recurrent and residual rates are often used interchangeably. Another major problem related to inconsistencies among reports regarding the staging of cholesteatoma and variation in the description of surgical techniques and their surgical modifications, which can impede the comparison of the outcomes.

Conclusion

This meta-analysis showed that canal wall up mastoidectomy had a higher risk of recidivism compared to canal down technique in children with acquired cholesteatoma

Abbreviations

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; COM: Chronic otitis media; CWU: Canal wall up; CWD: Canal wall down

Acknowledgements
Not applicable

Authors' contributions
All authors have read and approved the manuscript. YS: contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data; drafted the work, revised it, approved the submitted version, and agreed to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. ST: contributions to the conception, substantively revised it, and approved the submitted version, and agreed to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. AA: the acquisition, analysis, and interpretation of data; drafted the work, revised it, and approved the submitted version and agreed to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. NS: analysis, interpretation of data; revised it and approved the submitted version and agreed to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

Funding
None

Availability of data and materials
All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate
The ethical committee of Faculty of Medicine, Alexandria University, Egypt, approved this work (ethical number 00007555). Consent to participate is not applicable.

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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Received: 12 March 2020 Accepted: 29 September 2020
Published online: 14 October 2020

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