A Retrospective Analysis and Comparison of the STAM and STAMCO Classification and EAONO/JOS Cholesteatoma Staging System in Predicting Surgical Treatment Outcomes of Middle Ear Cholesteatoma

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Objective: To evaluate and compare the STAM classification, STAMCO classification and the EAONO/JOS staging system as predictors for cholesteatoma recidivism and postoperative hearing, using a large patient cohort in our tertiary referral center.

Method: Two hundred thirty-one patients who underwent surgery for primary cholesteatoma between 2003 and December 2012 were included and retrospectively classified and staged according to the STAM classification, STAMCO classification, and EAONO/JOS staging system. Data on cholesteatoma recidivism rates and postoperative hearing were collected. The predictive value of the three instruments for recurrent and residual cholesteatoma was compared by using receiver operating characteristic curves.

Results: For predicting recurrent cholesteatoma, the STAMCO classification was significantly superior compared to the other two instruments. For predicting residual cholesteatoma, the STAMCO classification was superior to the EANO/JOS Staging system. The postoperative hearing shows a significant increase in ABG with increasing extension of cholesteatoma in the CWU group and a significant decrease in AC threshold level with increasing stage and a significant increase in AC with increasing ossicular chain status in the CWD group.

Conclusion: Based on our study, the STAMCO classification represents the best available predictor for recurrent cholesteatoma and holds most promise for predicting residual cholesteatoma. Extension of cholesteatoma seems to be linked to postoperative hearing and thus the classifications and staging systems may be able to predict postoperative hearing. More studies are needed to assess the validation of these classifications. **Key Words:** Cholesteatoma—Classification—EANO/JOS—EJS—Recurrence—Recurrent—Residual—Stage—Staging—Stam—Stamco—Surgery.

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To uniformly report the extension of cholesteatoma, to inform patients on prognosis, and to compare results of surgery, there is a great need for a cholesteatoma classification system. In 2017, the European Academy of Otology and Neurotology (EAONO) and the Japan Otological Society (JOS) published the joint consensus statements on the definitions, classification, and staging of middle ear cholesteatoma (1). In this statement, the STAM classification and a subsequent EAONO/JOS staging system (EJS) were proposed. In the STAM classification (Table 1), the middle ear and mastoid region are divided into four sites to simplify the description of the cholesteatoma extension. Merkus et al. (2) adjusted the STAM classification by further defining the anatomical borders of those sites and by including the complications caused by the cholesteatoma (C) and perioperative ossicular chain status (O), resulting in the ''STAMCO classification.'' They suggest registering the extension of the cholesteatoma in an ascending scale referring to the number of sites affected by the cholesteatoma (Table 1).

The EJS staging system (Table 2) consists of four stages, in which a higher stage refers to a more severe cholesteatoma. It aims to reflect the difficulty to achieve complete removal and the subsequent restoration of normal function (1) and could therefore be a predictor of postoperative recurrent and residual cholesteatoma. The classifications aim to facilitate an accurate comparison of outcome in cholesteatoma surgery and could also have a prognostic value for predicting recurrent and residual disease. Furthermore, these instruments may be potential predictors in postoperative hearing.

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TABLE 1. *STAM and STAMCO classification*

Letter	Explanation	Further Classified as
S	Difficult access sites	S1—difficult anterior area[a] S2—difficult posterior area[b]
T	Tympanic cavity	
A	Attic/epitympanic space	
M	Mastoid and antrum	
STAM 1 = cholesteatoma in 1 location STAM 2 = cholesteatoma in 2 locations STAM 3 = cholesteatoma in 3 locations or one of the S locations involved.		
C	Complications caused by the cholesteatoma	Cn—no complication C1—extracranial complication C2—intracranial complication
O	Ossicular status at the beginning of surgery	On—no ossicles missing or destroyed O1—one ossicle missing or destroyed O2—two ossicles missing or destroyed O3—three ossicles missing or destroyed Ox- unknown status of the ossicles

STAM classification according to the European Academy of Otology and Neurotology (EAONO) and the Japan Otological Society (JOS) and STAMCO classification according to Merkus et al.

[a]Difficult anterior area is defined as the area anterior/antero-inferior to the malleus head, cog, tendon of the tensor tympani, cochleariform process, or virtual plane drawn through the anterior margin of the tympanic annulus.

[b]Difficult posterior area is defined as the area posterior to an imaginary line between posterior boundaries of the round and oval window, medial and caudal to the pyramidal process, and medial to the vertical portion of the facial nerve.

The primary aim of this study is to evaluate and compare the STAM classification, STAMCO classification, and EJS as predictors for recurrent and residual cholesteatoma after primary surgery for cholesteatoma in a clinical setting using data from a tertiary referral center. Secondary, we aim to evaluate the predictive value of the classifications and staging system for postoperative hearing.

METHODS

Patients

A retrospective case review was performed at the Department of Otorhinolaryngology of the Erasmus Medical Center (Rotterdam, the Netherlands). The study was conducted under the guidelines that have been approved by the Medical Ethics Committee of the Erasmus Medical Center. All patients 16 years of age and above who underwent surgery for primary cholesteatoma between January 2003 and December 2012 were included. We excluded revision cases and cases with cholesteatoma extension into the petrous part of the temporal bone, as the classification systems and staging system do not differentiate for extension in this area.

Patient demographics, type of surgery, origin of cholesteatoma, postoperative recurrent and residual cholesteatoma rates, follow-up time, and the pure-tone average of 0.5, 1, 2, and 4 kHz for the pre- and postoperative air conduction (AC) threshold levels and bone conduction (BC) threshold levels were collected from electronic patient records. For each case, the postoperative air-bone gap (ABG) and the change in AC threshold level between pre- and postoperative were calculated. For change in AC threshold level, a result above 0 refers to a gain in AC threshold level whereas a result below 0 refers to a deterioration of AC threshold level. Follow-up time was defined as the time from the primary procedure to the date of detection of residual/recurrent cholesteatoma or to last follow-up date in cases with no residual/recurrent cholesteatoma. The type of surgery was classified as either canal wall up (CWU) or canal wall down (CWD) and the origin of cholesteatoma was classified as pars flaccida, pars tensa, or both. The presence of recurrent and residual cholesteatoma was scored based on the surgical report according to the definitions of the EAONO/JOS consensus statement: recurrent cholesteatoma is defined as a reformation of a retraction pocket with accumulation of keratin and residual cholesteatoma results from incomplete removal of the cholesteatoma matrix without reformation of a retraction pocket. Therefore, a retraction without accumulation of keratin that did not need surgery was not considered as a recurrence.

Classification and Staging

All cases were independently scored by two independent investigators (H.F.E.T. and J.M.H.J.) on intraoperative findings

TABLE 2. *EAONO/JOS staging system and proportion of cases within each stage*

Stage	Description	N (%) in CWU	N (%) in CWD
Stage 1	Cholesteatoma localized in the primary site	33 (16%)	4 (4.1%)
Stage 2	Cholesteatoma involving two or more sites	161 (69.7%)	73 (75.3%)
Stage 3	Cholesteatoma with extracranial complications	33 (14.3%)	20 (20.6%)
Stage 4	Cholesteatoma with intracranial complications	0 (0%)	0 (0%)

Staging system according to the European Academy of Otology and Neurotology (EAONO) and the Japan Otological Society (JOS).
CWD indicates canal wall down; CWU, canal wall up.

according to the STAM classification, STAMCO classification and EJS. Differences were solved by discussion. The extension of cholesteatoma was based on the anatomical sites of mastoid and middle ear space as described by Merkus et al. (2). The STAM classification was classified according to the scale (STAM 1–3) by Merkus et al.

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics 25 (SPSS Inc., Chicago, IL) and Graphpad Prism 7.0 (GraphPad Software, La Jolla, CA). Survival curves were constructed using the Kaplan–Meier method and compared using the Log-Rank test. There was no minimum follow-up time as the Kaplan–Meier method corrects for censored data (for example patients lost to follow-up). Cox-regression analyses were used to analyze the predictive value of the STAM classification, STAMCO classification, and EJS on recurrent and residual cholesteatoma. The proportional hazards assumption was assessed with interaction of variables with time. The choice to perform a CWU or CWD procedure was made perioperatively by the surgeon based on factors such as the pneumatization and size of the mastoid, the extension of cholesteatoma, and the surgeon's preference. Therefore, analyses were stratified for the technique used (CWU or CWD) to prevent biased results. Receiver operating characteristic (ROC) curves, graphical plots illustrating diagnostic performances of tests, were constructed and used to compare the predictive value of the STAM classification, STAMCO classification, and EJS for residual and recurrent disease at a given time point in the CWU group. The area under the curves (AUCs) were compared using the method by DeLong et al. (3). For hearing results, data were not normally distributed (Shapiro–Wilk test). Therefore, the Jonckheere–Terpstra test for ordered alternatives was used to determine whether there was a statistically significant trend for change in AC threshold levels and postoperative ABG with higher levels of stage, STAM, complication status, and ossicular chain status. p values less than 0.05 were considered statistically significant.

RESULTS

Between January 2003 and December 2012, 231 ears were operated for primary cholesteatoma in the Erasmus Medical Center. A CWU procedure was performed in 134 patients (58%) and a CWD procedure in 97 patients (42%). Of the 134 CWU procedures, follow-up was done by a planned second look in 103 cases (77%), diffusion weighted MRI (DW-MRI) in 13 cases (9.7%), and otoscopy in 12 cases (9%). A planned 2nd look was usually performed 12 months after primary surgery. In the CWD group, follow-up was done by otoscopy in 95 cases (97.9%) and DW-MRI in 2 cases (2.1%). The follow-up time ranged from 0 to 180 months, with a median follow-up time of 20.7 months (IQR 11.6–63.0) in the CWU group and 76 months (IQR 30.8–124.4) in the CWD group. Two cases were lost to follow-up directly after surgery as follow-up was done in the patient's secondary hospital. The median time to recurrent or residual cholesteatoma in the CWU group was 13.5 months (IQR 10.8– 17.4) and 12.6 months (IQR 9.8–21.0) respectively, whereas the time to recurrent cholesteatoma was 33.7 and 58.0 months for the two cases in the CWD group. In the CWU group, recurrent and residual cholesteatoma was found in 43 and 35 cases respectively, whereas this was 2 cases and 0 cases respectively in the CWD group. When using Kaplan–Meier analysis (Fig. 1), the recurrent and residual cholesteatoma rates were 34.5% and 28.3% respectively for CWU procedures and 3.1% and 0% respectively for CWD procedures at 60 months of follow-up. In univariate analyses, there was no difference in the risk of recurrent and residual cholesteatoma according to sex, side of the cholesteatoma, or cholesteatoma origin (supplemental Table 1, http://links.lww.com/MAO/A918).

Cholesteatoma Classification and Staging

When using multivariate cox regression analyses including the STAM, complications caused by the cholesteatoma (C) and ossicular chain status (O) (Table 3 and supplemental Table 2, http://links.lww.com/MAO/A919), STAM 3 was associated with a significant higher

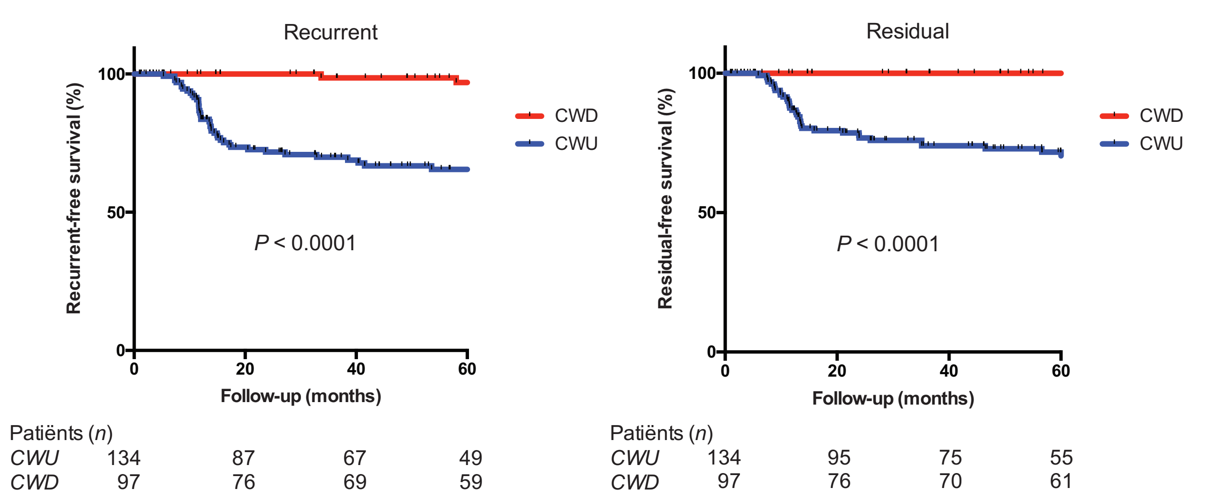

FIG. 1. Recurrent- and residual-free survival curves for patients who underwent either CWU or CWD. (*A*) Recurrent cholesteatoma and (B) residual cholesteatoma. Survival curves were compared using Log Rank (Mantel-Cox) test. CWD indicates canal wall down; CWU, canal wall up.

TABLE 3. *Multivariate cox regression analyses on the risk of recurrent and residual cholesteatoma after CWU tympanoplasty according to STAM and STAMCO classification*

	Recurrent Cholesteatoma		Residual Cholesteatoma	
	HR (95% CI)	*p* Value	HR (95% CI)	*p* Value
STAM				
1	Reference		Reference	
2	2.427 (0.642–9.175)	0.191	1.372 (0.386–4.875)	0.625
3	3.889 (1.148–13.177)	0.029	2.042 (0.665–6.271)	0.212
Complications caused by cholesteatoma				
0	Reference		Reference	
1	0.462 (0.110–1.947)	0.293	0.559 (0.131–2.387)	0.432
2	No cases		No cases	
Ossicular chain status				
0	Reference		Reference	
1	1.917 (0.708–5.188)	0.200	1.245 (0.427–3.632)	0.688
2	2.702 (0.927–7.878)	0.069	3.410 (1.169–9.948)	0.025
3	8.068 (2.056–31.662)	0.003	1.664 (0.308–8.994)	0.554

CI indicates confidence interval; CWU, canal wall up; HR, hazard ratio.

risk of recurrent cholesteatoma compared to STAM 1 in the CWU group (HR 3.705, 95% CI 1.090–12.590; $p = 0.036$). When focusing on ossicular chain status as part of the STAMCO classification, a significant higher risk of recurrent cholesteatoma was found when O 3 was compared to O 0 in the CWU group (HR 9.304, 95% CI 2.123–40.782; $p = 0.003$). For residual cholesteatoma, a higher risk was found when O 2 was compared to O 0 in the CWU group (HR 4.3168, 95% CI 1.368–12.699; $p = 0.012$). Complications caused by the cholesteatoma as parts of the STAMCO classification were not associated with recurrent or residual cholesteatoma.

The number of cases per EJS stage is shown in Table 2. There was a significant higher risk of recurrent cholesteatoma when stage 2 was compared to stage 1 in the CWU group (Table 4). There was no association between EJS and residual cholesteatoma.

There were no analyses performed in the CWD group due to low recurrent cholesteatoma rates and no residual cholesteatoma.

Comparison Between STAM Classification, STAMCO Classification, and STAM Stage for Predicting Recurrent and Residual Cholesteatoma

The predictive values of the STAM classification, STAMCO classification, and EJS for recurrent and residual cholesteatoma were compared by using receiver operating characteristic curves (Fig. 2). The EJS did not significantly predict either recurrent or residual disease (AUC 0.60; 95% CI 0.50–0.68 and AUC 0.59; 95% CI 0.49–0.60 respectively). The STAM classification resulted in an AUC of 0.67 and 0.61 for predicting recurrent and residual cholesteatoma, respectively. The STAMCO classification resulted in the highest area under the curve for predicting both recurrent and residual cholesteatoma (AUC 0.73; 95% CI 0.64–0.82 and AUC 0.69; 95% CI 0.59–0.80, respectively), and was accompanied by a sensitivity and specificity of 78% and 56% for recurrent and 69% and 57% for residual cholesteatoma, respectively. The AUC of the STAMCO classification for predicting recurrent cholesteatoma was significantly higher compared to both the STAM classification and the EJS ($p = 0.003$ and $p = 0.03$ respectively). For predicting residual cholesteatoma, the STAMCO classification was superior to EJS for predicting residual cholesteatoma ($p = 0.02$) and a trend was observed when compared with STAM classification ($p = 0.1$).

Hearing Results

Postoperative audiometry was available in 125 cases in the CWU group (93.3%) and in 90 cases in the CWD

TABLE 4. *Univariate cox regression analyses on the risk of recurrent and residual cholesteatoma after CWU tympanoplasty according to the STAM staging system*

	Recurrent Cholesteatoma		Residual Cholesteatoma	
	HR (95% CI)	*p* Value	HR (95% CI)	*p* Value
Stage				
1	Reference		Reference	
2	5.274 (1.625–17.113)	0.006	2.452 (0.858–7.011)	0.094
3	2.666 (0.537–13.238)	0.231	2.598 (0.649–10.404)	0.177
4	No cases	No cases	No cases	No cases

CI indicates confidence interval; HR, hazard ratio.

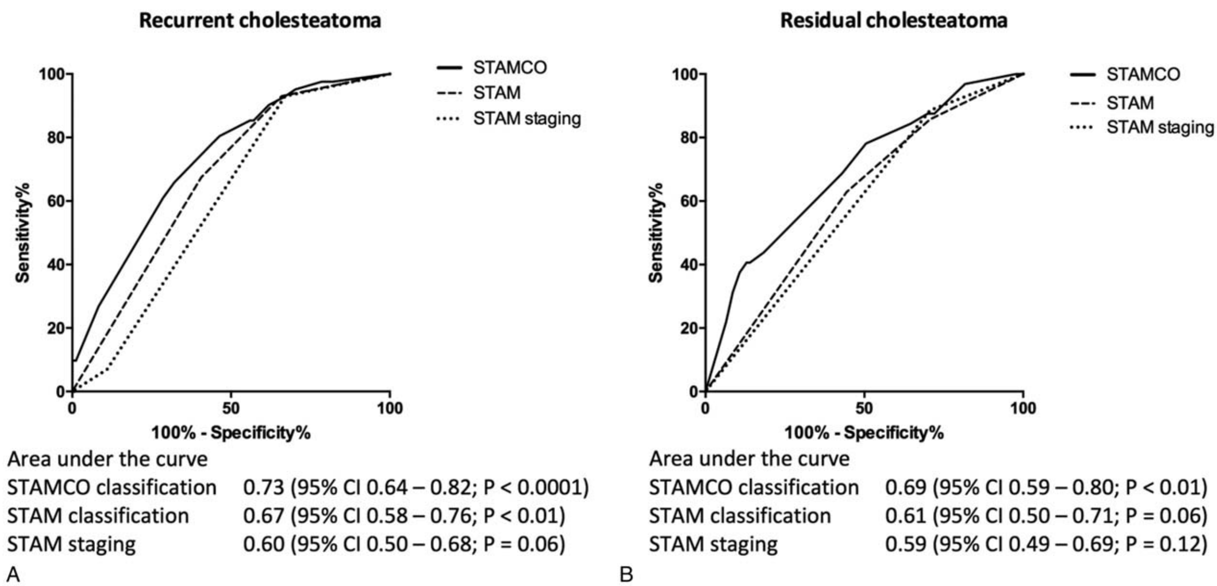

FIG. 2. Receiver operating characteristic curves of the STAMCO, STAM, and STAM staging for predicting recurrent (*A*) or residual (*B*) cholesteatoma. Only patients in the CWU group were included. AUC indicates area under the curve; CI, confidence interval.

group (92.8%). The median time from surgery to audiometry was 9.0 weeks (IQR 6.0) in the CWU group and 11.0 weeks (IQR 8.3) in the CWD group. The median change in AC and median postoperative ABG for the different surgical techniques are shown in Table 5. In the CWU group, there was a significant larger postoperative ABG with increasing stage ($p = 0.030$), increasing STAM ($p = 0.032$), increasing complication status ($p = 0.036$), and increasing ossicular chain status ($p = 0.000$)). For the change in AC threshold level, the effect was not significant. In the CWD group, with increasing stage a significant lower gain in AC threshold level was seen with even deterioration in AC threshold level in stage 3 ($p = 0.038$). In the CWD group, an increasing ossicular chain status was associated with a gain in AC threshold level ($p = 0.043$). Effects for other factors and for the postoperative ABG were not significant in this group.

DISCUSSION

In this study, we evaluate for the first time the STAM classification, STAMCO classification, and EAONO/JOS staging system in their predictive value for postoperative recurrent and residual cholesteatoma and hearing, using a historical cohort in a tertiary referral center setting.

Cholesteatoma recurrent and residual disease rates were 34.5% and 28.3% respectively in CWU tympanoplasty, and 3.1% and 0% respectively in CWD tympanoplasty; these rates are in line with the literature (4). It is challenging to compare the different surgical techniques, as cholesteatoma characteristics are not uniformly presented. A classification system would offer uniform reporting on cholesteatoma characteristics and comparison of surgical outcomes, besides open up opportunities for better patient counselling. Previously, several attempts to classify cholesteatoma have been made (5), focusing for example on extension of disease (6–8), presumed etiology and pathophysiology (9), origin and location of disease (10), direction of extension (11,12), and radiological findings (13). More recently, Linder et al. (14) proposed a classification system based on extension of cholesteatoma, postoperative ossicular chain status, complications and degree of pneumatization and ventilation. However, until now none of these classification systems has been widely adopted.

The STAM classification is based on the extension of cholesteatoma in four different areas. This classification was elaborated to STAMCO by adding the complications caused by the cholesteatoma (C) and the ossicular chain status (O). We show that extension of cholesteatoma and the ossicular chain status as addressed in the STAM and STAMCO classification are predictive factors for recurrent cholesteatoma, with a gradually increasing risk with a higher score on the separate parameters. Cholesteatoma-associated complications (C) were not predictive for postoperative recurrent or residual cholesteatoma. It was against our expectations that the STAM classification was not associated with residual cholesteatoma, as we hypothesized that surgeons might be more likely to leave residual cholesteatoma behind in the difficult access sites (S1 and S2) during surgery. A potential explanation could be that a cholesteatoma with extension in the difficult access sites triggers the surgeons to be even more vigilant and to pursue complete removal of the disease. It may on the other hand also be the result of a lack of power in our study. The fact that three ossicles missing or destroyed (O 3) was not associated with a higher risk for residual cholesteatoma, in contrast to an O

TABLE 5. *Hearing results after CWU and CWD tympanoplasty according to STAM and STAMCO classification and EJS staging system*

		CWU					CWD				
		N	AC Change (Median, iqr)	*p* Value	ABG Postop (Median, iqr)	*p* Value	N	AC Change (Median, iqr)	*p* Value	ABG Postop (Median, iqr)	P-value
STAM	1	N = 31	2.50 (10.00)	0.105	16.25 (20.00)	**0.032**	N = 4	10.63 (25.63)	0.951	18.13 (31.88)	0.606
	2	N = 33	1.25 (14.38)		15.00 (12.50)		N = 23	0.00 (18.75)		26.25 (21.25)	
	3	N = 61	0.00 (20.00)		20.00 (18.13)		N = 63	0.00 (13.75)		23.75 (15.00)	
Complications caused by cholesteatoma	0	N = 114	2.50 (15.31)	0.357	17.50 (15.31)	**0.036**	N = 73	1.25 (16.88)	0.094	23.75 (16.88)	0.745
	1	N = 11	0.00 (16.25)		25.00 (16.25)		N = 17	−3.75 (8.75)		23.75 (23.75)	
	2			No cases					No cases		
Ossicular chain status	0	N = 35	−1.25 (13.75)	0.440	12.50 (21.25)	**0.000**	N = 12	−10.00 (37.81)	0.043	21.88 (24.38)	0.398
	1	N = 61	2.50 (16.25)		16.25 (13.13)		N = 36	0.00 (13.75)		24.38 (14.69)	
	2	N = 25	2.50 (12.50)		23.75 (15.00)		N = 25	2.50 (15.63)		23.75 (21.25)	
	3	N = 3	3.75 (NA)		20.00 (NA)		N = 15	1.25 (8.75)		26.25 (10.00)	
Stage	1	30	2.50 (10.63)	0.202	16.25 (20.00)	**0.030**	4	10.63 (25.63)	0.038	18.13 (31.88)	0.605
	2	84	1.25 (17.50)		17.50 (15.94)		69	1.25 (16.25)		23.75 (16.88)	
	3	11	0.00 (16.25)		25.00 (16.25)		17	−3.75 (8.75)		23.75 (23.75)	
	4			No cases					No cases		

Bold data indicates statistically significant ($P < 0.05$).
ABG postop indicates postoperative air-bone gap; AC change, change in air conduction between pre- and postoperative; CWD, canal wall down; CWU, canal wall up; iqr, interquartile range.

2 status, might be due to a lack of power as well, since there were only 19 patients in this group. Another explanation could be that, in cases where there are three ossicles destroyed, the surgeon removes all remnants of the chain and therewith creates a better visualization of the middle ear sites. In the other cases (O 1 and O 2), the surgeon is likely to carefully remove the cholesteatoma from the remaining ossicles, with the risk of leaving residual cholesteatoma behind.

Besides the STAM and STAMCO classification, the EJS and the association with postsurgical outcome was investigated. Cholesteatoma stage 2 (cholesteatoma involving two or more sites) was associated with an increased risk for recurrent cholesteatoma compared to stage 1 (cholesteatoma localized in the primary site). Cholesteatoma stage 3 (cholesteatoma with extracranial complications) was however not associated with a higher risk for recurrent cholesteatoma, which could be explained by the absence of a correlation of extracranial complications with recurrent cholesteatoma. In all analyses, the cholesteatoma stage was not associated with residual cholesteatoma. The prognostic value of the EJS for predicting residual or recurrent cholesteatoma was recently studied by James et al. (15). In their study, the rate of recurrent cholesteatoma was significantly lower for stage 1 compared to stage 4 (intracranial complications), with no significant difference in recurrent cholesteatoma with other stages. The rate of residual cholesteatoma was significantly different between all stages, except between stages 2 and 3. They state that dividing stage 2 into subgroups may lead to a more even distribution of cases and thereby a more reliable staging system, with which we agree. The EJS simplifies the cholesteatoma extension by staging them as stage 1 or 2. By doing this, information on the extension of cholesteatoma is lost as there is no differentiation possible between 2 and 3 or more affected subsites.

The recurrent and residual cholesteatoma rate is not only affected by extension of cholesteatoma and surgical technique but also by many other factors, e.g., relative lack of experience of the surgeon (16), cholesteatoma in children (age < 15 yr) (17), and the statistical method of analysis used (18). In 2000, Stangerup et al. (18) illustrated the impact on recurrence cholesteatoma rate (recurrent and residual cholesteatoma together) after applying different calculation methods to the same database and concluded that the rate of recurrence cholesteatoma in a group of 33 patients varied from 30 to 67% depending on the statistical method used. It was suggested to use the incidence at risk method, actuarial survival analysis, or the Kaplan–Meier survival analysis in studies involving censored data, as survival analyses account for patients who are lost to follow-up. As reviewed by Mor et al. (19), there is no uniformity in the literature of the statistical method used when reporting on the surgical outcome of cholesteatoma. In their review of 43 articles, data was reported as Kaplan–Meier analysis in only 12%. This may implicate an underestimating in cholesteatoma recurrent and residual rates in the remaining studies. Because of differences in follow-up length (0–180 mo), we reported the recurrent and residual cholesteatoma rates using Kaplan–Meier survival analysis, and we urge to make this statistical method common practice to gain more uniformity in reported cholesteatoma outcome.

The EJS and classifications systems were created based on consensus among otologists and their predictive value for postoperative recurrent and residual cholesteatoma was not analyzed before. The area under the curve is a measure of the diagnostic performance of a test, in which a higher value indicates a better performance. An area under the curve of 1 represents a perfect test, whereas an area under the curve of 0.5 represents a test with an accuracy as high as pure chance. Based on the present study, the STAMCO classification resulted in the highest area under the curve of 0.73 and 0.69 as a predictor for recurrent and residual cholesteatoma, respectively, compared to STAM and EJS. However, it can be disputed whether the diagnostic performance of this test is at this point sufficient for use in clinical practice. We do believe that this is the first step towards development of a compatible tool to predict disease outcome in cholesteatoma surgery. Further research could focus on the optimal combination of factors and weight per factor included in the STAMCO. Furthermore, there may be several other prognostic factors that were not included in the present study such as age of the patient, experience of the surgeon, and revision surgery. It could be hypothesized that the part of the STAMCO classification focusing on complicated cases (C) does not contribute to the performance of the STAMCO classification as a predictor for cholesteatoma recurrence and could therefore be removed. However, important secondary outcome measures like dry ears, waterproofing, and quality of life are not included in this study and may be predicted by the classification system as well. Further research should be performed to identify the predictive value of the STAMCO classification on these parameters.

As a secondary outcome, postoperative hearing results were analyzed. The hearing results presented in this study show a significantly higher postoperative ABG with increasing extension of cholesteatoma (stage, STAM, complication status, and ossicular chain status) in the CWU group. Besides, with increasing stage there was lower gain or even a deterioration in AC threshold levels in the CWD group and a significant gain in AC threshold levels with increasing ossicular chain status in this group. Thus, overall the extension of cholesteatoma seems to be linked to postoperative hearing and thus the classifications and staging systems may be able to predict postoperative hearing. However, in future research several potential bias factors should be evaluated, such as the type of ossicular chain reconstruction, ossicular chain status after cholesteatoma removal, number and surgical technique of revision cases, intersurgeon variability, time factors and patient-specific factors as age, sex, and comorbidity.

The generalizability of our findings for secondary referral centers needs to be addressed in further studies, since the selection in our tertiary center potentially resulted in relatively extended cholesteatoma. Considering the retrospective design of this study, prospective studies are needed to limit other potential biases and confounders. These studies should also focus on the value of the separate parameters included in the classifications.

CONCLUSION

Based on our study, the STAMCO classification represents the best available predictor for recurrent cholesteatoma and holds most promise for predicting residual cholesteatoma. The extension of cholesteatoma seems to be linked to postoperative hearing and thus the classifications and staging systems may be able to predict postoperative hearing. More studies are needed to assess the validation of these classifications.

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