



Comparison of the Hearing Results of Ossicular Chain Reconstruction Using MCBO and TiTORP in Patients with Cholesteatoma

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Received 2020 November 19; Revised 2020 December 05; Accepted 2020 December 20.

Abstract

Background: No studies have investigated the results of ossicular chain reconstruction using mastoid cortical bone ossiculoplasty (MCBO) and titanium total ossicular replacement prosthesis (TiTORP) in Austin-Kartush Group D cholesteatoma patients with severe middle ear risk index (MERI).

Objectives: The present study aimed to compare the hearing results of MCBO and TiTORP in Austin-Kartush Group D cholesteatoma patients with severe MERI who underwent ossicular chain reconstruction during primary surgery.

Methods: The hearing results of 28 adult cholesteatoma patients who underwent tympanomastoidectomy and ossicular chain reconstruction with MCBO (n=15) or TiTORP (n=13) were analyzed in the current study. The postoperative hearing was tested 12 months after the surgery. The hearing-related functional success rate was determined in accordance with the American Academy of Otolaryngology-Head and Neck Surgery Foundation criteria.

Results: When all patients were taken into account, the mean preoperative and postoperative air-bone gaps (ABG) were reported as 32.2 decibel (dB) and 17.6 dB, respectively, ($P < 0.001$). In 57.1% of the patients, the mean postoperative ABG was ≤ 20 dB. The mean preoperative and postoperative ABGs of the MCBO group were obtained at 29.9 and 16.2 dB, while these values were reported as 35.0 and 19.3 dB in the TiTORP group ($P = 0.001$ and $P < 0.001$, respectively). Hearing-related functional success rates were calculated at 60.0% and 53.8% in MCBO and TiTORP groups, respectively, without any significant difference between the groups ($P = 0.743$).

Conclusion: As evidenced by the obtained results, MCBO and TiTORP can provide similar and successful hearing results in Austin-Kartush Group D patients with cholesteatoma; nonetheless, MCBO is a more cost-effective option in this regard.

Keywords: Cholesteatoma, Hearing outcomes, Mastoid bone, Ossiculoplasty, Ossicular replacement prostheses

1. Background

Cholesteatoma is an epithelial structure with keratin inclusions filling the pneumatized cells of the temporal bone, resulting in erosion. Ossicular chain erosion is observed two times more frequently in the presence of cholesteatoma in patients with chronic suppurative otitis media (CSOM). The long process of incus was found to be the most susceptible region of the ossicular chain to erosion, followed by the stapes superstructure (1). Disease eradication is the first aim of surgical treatment, and ossicular chain reconstruction may be performed during the primary surgery or in a second-look procedure (1).

In 1972, Austin assigned ossicular chain defect to four groups: A to D (2), and Kartush modified this categorization in 1994 (3). It is now referred to as Austin-Kartush classification, in which group D ossicular chain defect suggests erosion of malleus, incus, and stapes superstructure with an intact stapes footplate. Ossicular chain reconstruction has been performed for a century, aiming to restore ossicular

integrity and hearing using various techniques and materials (4, 5).

Middle ear risk index (MERI) combines the preoperative and intraoperative risk factors for tympanoplasty prognosis into a numerical value and has been used to predict the success of tympanoplasty (6). Based on MERI score, the disease is classified as mild (1-3), moderate (4-6) and severe (7- 12) (6).

2. Objectives

To the best of our knowledge, no studies have investigated the results of ossicular chain reconstruction using mastoid cortical bone ossiculoplasty (MCBO) and titanium total ossicular replacement prosthesis (TiTORP) in Austin-Kartush Group D cholesteatoma patients with severe middle ear risk index (MERI). The present study aimed to compare the hearing results of MCBO and TiTORP in Austin-Kartush Group D cholesteatoma patients with severe MERI who underwent ossicular chain

reconstruction during primary surgery.

3. Methods

In the current study, we retrospectively analyzed 28 Austin-Kartush Group D cholesteatoma patients (3) with severe MERI (6) who underwent ossicular chain reconstruction using autogenous MCBO or TiTORP (TTP-VARIAC System Total; Kurz Medical, Dußlingen, Germany) during the primary surgical procedure for CSOM between January 2014 and December 2018. Before the surgery, appropriate medical treatment was performed to control active infection in all patients. As approved by the local ethics committee, the study was conducted in compliance with the ethical principles determined by the Helsinki Declaration (2019/E-19-062). The informed consent was obtained from all patients before the surgery. The exclusion criteria were as follows: the presence of primary acquired cholesteatoma, intraoperative complications, revision surgery, preoperative profound sensorineural hearing loss, intracranial or temporal complications of CSOM, and stapes footplate fixation. Medical history, otomicroscopic findings, High Resolution Temporal Bone Computed Tomography (HRCT) imaging, as well as pre-and postoperative audiometric results of all patients were analyzed.

Pre-and postoperative pure-tone and speech audiometry were performed, and postoperative test was carried out 12 months after the surgery. Air conduction (AC) thresholds were measured at 250, 500, 1000, 2000, 4000, and 6000 hertz (Hz), and bone conduction (BC) thresholds were obtained at 500, 1000, 2000, and 4000 Hz. The pure-tone averages (PTAs) were determined based on the thresholds values at 500, 1000, 2000 and 3000 Hz, and the air-bone gap (ABG) PTA values were calculated. An AC 40 Clinical Audiometer (AC 40; Interacuostic, Middelfart, Denmark) was used for audiometric tests.

All surgical procedures were performed under general anesthesia using an operation microscope

(Möller-Wedel Optical; Hamburg, Germany). A retroauricular approach was preferred, and all surgical procedures were supervised by experienced senior otologic surgeons. Temporalis fascia and tragal cartilage were prepared for grafting purposes. Anthrotomy and cortical mastoidectomy were completed, tympanomeatal flap was elevated, and the middle ear was exposed. The extent of the cholesteatoma matrix, the status of middle ear mucosa, as well as ossicular chain integrity and movement were noted. Canal wall up (CWU) or canal wall down (CWD) procedures were employed depending on the localization and extent of the cholesteatoma.

Ossiculoplasty was performed after the removal of cholesteatoma matrix. A 5x10 mm-piece of cortical bone was removed from the posterior border of the mastoidectomy cavity and drilled to give it a pyramidal shape. This fashioned cortical bone was used as MCBO, its apex was placed on the mobile stapes footplate, and a piece of tragal cartilage was placed over the base of the pyramidal bone which is in contact with the temporalis muscle fascia (Figure 1A). In case of ossicular chain reconstruction with TiTORP, the tragal cartilage graft was fixed on the prosthesis; thereafter, the height of the prosthesis was adjusted and placed over the stapes footplate (Figure 1B). The temporalis fascia graft was placed with an underlay technique over MCBO and TiTORP, both stabilized by a piece of tragal cartilage.

The otoscopic and microscopic examinations were performed in 1, 3, 6, and 12 postoperative months. To determine the long-term effect of surgery on hearing, it was preferred to make a comparison between preoperative and 12-month postoperative hearing results. The patients who missed the follow-up or had ear drum re-perforation were excluded. The 12th month functional hearing results of MCBO and TiTORP groups were compared in accordance with the criteria described by the American Academy of Otolaryngology-Head and Neck Surgery Foundation, where hearing-related functional success rate was defined as ≤ 20 dB PTA ABG (7).



Figure 1. A mastoid cortical bone ossiculoplasty (MCBO) B-Titanium total ossicular replacement prosthesis (TiTORP)

3.1. Statistical analysis

All the statistical analyses were performed in SPSS software (version 21, SPSS Inc., Chicago, IL, USA). The data distribution was tested with Shapiro-Wilk test. Categorical variables were expressed as number and percentage, whereas continuous variables were defined as mean and standard deviation. Categorical variables were evaluated with Chi-square test. Differences between two independent groups were analyzed with unpaired t-test or Mann-Whitney U-test. A p-value less than 0.05 was considered statistically significant.

4. Results

A total of 28 patients, including 15 (53.7%) males

and 13 (46.3%) females, within the age range of 18-58 years (44.21±10.57) who met the inclusion criteria were enrolled in the present study. There were assigned to two groups of MCBO (n=15) and TiTORP (n=13). In the MCBO group, 12 (80%) and 3 (20%) patients had CWU and CWD mastoidectomy, while these values were reported as 9 (69.2%) and 4 (30.8%) in the TiTORP group, respectively. MCBO and TiTORP groups were similar in terms of demographic data and the preferred surgical techniques (Table 1).

Based on the results of conducted analyses, preoperative and postoperative mean ABG were reported as 32.28±6.59 decibel (dB) and 17.64±5.59 dB, respectively (P<0.001). The postoperative mean ABG was < 20 dB in 16 patients (57.1%). Pre- and

Table 1. Comparison of MCBO and TiTORP groups

		MCBO (n=15)	TiTORP (n=13)	P
Gender	Female	8 (53.3%)	5 (38.5%)	0.431
	Male	7 (46.7%)	8 (61.5%)	
Age (years)		41.3±10.1 (range: 20-55)	47.5±10.5 (range: 18-58)	0.068
Surgery Type	CWU	12 (%80.0)	9 (%69.2)	0.670
	CWD	3 (%20.0)	4 (%30.8)	

MCBO: Mastoid cortical bone ossiculaplasty

TiTORP: Titanium total ossicular chain reconstruction prosthesis

n: Number of ears

CWU: Canal Wall Up

CWD: Canal Wall Down

Table 2. Comparison of audiometric findings of the groups (pure tone average, dB)

	MCBO (n=15)	TiTORP (n=13)	P value
Preoperative ABG	29.93±5.90	35.00±6.49	0.040
Postoperative ABG	16.20±4.78	19.30±6.18	0.151
ABG difference (Hearing gain)	13.73±4.58	15.69±2.52	0.183

All values are mean ± standard deviation.

Bold value signifies a p level < 0.05

dB: Decibel

n: Number of ears

MCBO: Mastoid cortical bone ossiculaplasty

TiTORP: titanium total ossicular chain reconstruction prosthesis

ABG: Air Bone Gap

postoperative mean ABG values were obtained at 29.93±5.90 and 16.20±4.78 dB in the MCBO group, and 35.0±6.49 and 19.30±6.18 in the TiTORP group (Table 1). A significant improvement was observed in hearing results in both groups (P=0.001 and P<0.001, respectively). It is worth noting that preoperative mean ABG was higher in the TiTORP group (P=0.040); nonetheless, mean postoperative ABG and

hearing gains were similar in the two groups (P=0.151;P=0.183) (Table 2).

The analysis for functional success revealed postoperative ≤20 dB mean postoperative ABG in 9 (60.0%) patients in the MCBO group, and in 7 (53.8%) patients in the TiTORP group, without any significant difference between the two groups (P=0.743; Table 3).

Table 3. Comparison of functional success between the groups

	MCB (n=15)	TiTORP (n=13)	P value
Postoperative ABG (≤20 PTA dB)	9/15 (60.0%)	7/13 (53.8%)	0.743
Postoperative ABG (>21 PTA dB)	6/15 (40.0%)	6/13 (46.2%)	

Bold value signifies a p level < 0.05

PTA: Pure Tone Average

dB: Decibel

n: Number of ears

ABG: Air Bone Gap

MCBO: Mastoid cortical bone ossiculaplasty

TiTORP: Titanium total ossicular chain reconstruction prosthesis

5. Discussion

As evidenced by the results of the present study, when performed during the primary surgery, ossicular chain reconstruction using MCBO and TiTORP was successful after one year in terms of postoperative hearing gain in Austin-Kartush Group D cholesteatoma patients with severe MERI. To date, a number of alloplastic materials have been used for ossicular chain reconstruction including plastipore, teflon, ceramic, glass ionomer (bone cement), hydroxyapatite, and titanium (8). Various autogenous materials, including bone and cartilage, have also been utilized (9).

It is not always possible to use autologous ossicles for hearing reconstruction in patients with cholesteatoma. Ossicular remnants seeming undamaged by cholesteatoma may harbor microscopic infiltration with squamous epithelium, and they should not be used in ossicular chain reconstruction. In addition, the use of osteitic ossicles may increase the risk of postoperative failure (10, 11). On the other hand, some authors suggested that the ossicles do not harbor epithelial inclusions in cases of partial or non-encapsulated cholesteatoma, regardless of their macroscopic appearance. Therefore, they can be safely used for reconstruction following a cleaning procedure by drilling, stripping, or autoclaving (12). Almost none of our cases had any residual ossicles, malleus residues were present in three patients; however, they were not used for ossicular chain reconstruction.

The mean postoperative ABG values of patients with erosion of stapes superstructure and stotal ossicular replacement prosthesis (TORP) ossicular chain reconstruction were investigated in different studies, yielding varying results as 30.2 dB (13) and 12.8 dB (14). In Austin-Kartush Group D patients, Dornhoffer and Gardner (15) reported this value as 16.3 dB and Stankovic (16) calculated it at 16.6 dB. A meta-analysis investigated the effect of ossicular chain damage on hearing after chronic otitis media and cholesteatoma surgery. The results of the mentioned study indicated that the presence of malleus destruction was an important determinant of postoperative hearing, rather than the presence of stapes superstructure, independent of Austin-Kartush criteria (17). In line with other reports in the literature, the mean postoperative ABG was obtained at 17.6 dB in the present study.

Yu et al. (10) assessed the long-term hearing results of ossicular chain reconstruction using autogenous MCBO and reported that the mean preoperative ABG was increased from 31.6 to 20.3 dB postoperatively, with a significant improvement in hearing. The authors claimed that mastoid bone cortex was one of the most suitable materials for ossiculoplasty (10). A significant hearing improvement was also observed in our series with MCBO.

Titanium prostheses are lightweight materials which can be easily shaped and are capable of good sound conduction (18). The first results of titanium prostheses were published in 1999 (19). Gelfand and Chang (20) reported the preoperative mean ABG, postoperative mean ABG, and the ABG difference as 35.4 dB, 23.2 dB, and 12.3 dB in cases with TiTORP ossiculoplasty, respectively. Ho et al. (18) reported those values as 42.8 dB, 21.5 dB, and 21.3 dB, respectively. We found preoperative and postoperative ABG as 35.0 and 19.3 dB, and the difference between pre- and postoperative ABG as 15.9 dB. The results of the current study pointed to a significant improvement in hearing using TiTORP.

Felek et al. (21) classified their patients based on MERI scores and compared the results among the prognostic categories. They reported that hearing gain decreased as the risk group got higher and stated that MERI can be of great help to surgeons in the analysis of different surgical options, patient selection, and prediction of ossiculoplasty success. O' Reilly et al. (22) claimed that there was no correlation between middle ear risk groups and postoperative mean ABG. Demir et al. (8) reported significant ABG improvement in mild and moderate risk groups; however, the ABG change was insignificant in the severe risk group. All patients included in our study had severe MERI scores, and a significant improvement was detected in mean postoperative ABG, compared to mean preoperative ABG (Table 2).

The success rate (≤ 20 dB PTA ABG) was reported as 40% one year after the surgery in a study on patients without a stapes superstructure and a mobile footplate after TiTORP reconstruction (23). This rate was reported as 44% (24) and 45% (18) by other authors. Malhotra et al. (25) used an umbrella-shaped autologous total ossicular replacement prosthesis made up of mastoid cortical bone and conchal cartilage. They reported functional hearing success rate as 82.5%. Functional hearing success scores were obtained at 60.0% and 53.8% in MCBO and TiTORP groups, without any significant difference between the groups. Nevertheless, further studies with larger sample size are needed to support the findings of the current study.

6. Conclusion

The results of the present study pointed out that hearing gain can be successfully achieved using autogenous MCBO and TiTORP in Austin-Kartush Group D cholesteatoma patients with severe MERI. Autogenous MCBO, which can be easily constructed with some experience, can be used safely and successfully when TiTORP is not available or may be preferred due to its cost-effectiveness. The findings of the present study should be supported by further studies with larger sample size.

Footnotes

Authors' Contribution: Study concept and design: Mehmet Fatih Karakus, Kursat Murat Ozcan, Mustafa Colak, Suleyman Emre Karakurt and Ali Riza Yagmur; Analysis and interpretation of data: Mehmet Fatih Karakus, Suleyman Emre Karakurt, Mustafa Colak, Fakhri Cihat Eravci; Ali Riza Yagmur, Mehmet Ali Cetin; Drafting of the manuscript: Mehmet Fatih Karakus; Critical revision of the manuscript for important intellectual content: Haci Huseyin Dere, Kursat Murat Ozcan; Mehmet Ali Cetin and Fakhri Cihat Eravci; Statistical analysis: Suleyman Emre Karakurt and Fakhri Cihat Eravci.

Conflict of Interests: The authors declare that they have no conflict of interest regarding the publication of the current study.

Ethical Approval: Ethics committee approval was received from the Ethics Committee of Ministry of Health, Ankara City Hospital (Number: E-19-062, October 03, 2019).

Funding/Support: The authors declared that the current research project received no financial support or grant from any organization.

Informed consent: Informed consent was obtained from all participants.

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