Mastoid cavity obliteration in treatment of middle ear cholesteatoma

Petar Rouev

ENT Dept., Trakia Hospital Stara Zagora, Bulgaria

Abstract

Objective: The primary goal in the surgical management of chronic otitis media with cholesteatoma is the creation of a dry and safe ear. The method of choice for management of cholesteatoma is the inside out or reverse mastoidectomy. If external auditory canal reconstruction after complete cholesteatoma removal is not possible, mastoid cavity obliteration techniques are recommended to reduce the size of the open mastoid cavity. The goal of our study is to evaluate the frequency of postoperative ear secretion and hearing situation in patients with mastoid cavity obliteration in treatment of middle ear cholesteatoma.

Methods: Retrospective study of 155 patients with middle ear cholesteatoma were surgically treatment during 52 months from 01.06.2014 to 30.09.2018 in Hospital Trakia Park, Stara Zagora (Bulgaria) with canal wall reconstruction or mastoid cavity obliteration with cartilage, bone paté or bone replacement alloplastic materials.

Results: After complete cholesteatoma removal we perform ear canal reconstruction in 51.61% of cases (80; n=155), and in others 41.94% of cases (65; n=155) we perform mastoid cavity obliteration. In our patient group we perform type I tympanoplasty in 36.77% (57; n=155), type III tympanoplasty in 46.45% (72; n=155), Second-look operations in 14% (21, n = 155) and only in 5 cases we left the operating cavity open (3.23%; n=155). After mean follow-up period from 11.34 months (1÷48 months; SD 13.10 months) our frequency of postoperative ear secretion is 6.45% (10; n=155) and our cholesteatoma residual rate is 9.03% (14; n=155).

Conclusion: Mastoid cavity obliteration procedures can prevent the development of postoperative retraction pockets by isolation the tympanic cavity from the attic and mastoid. This is a safe and effective technique for rehabilitation of mastoid cavities. Hearing results of this technique is variable according to the involvement of the middle ear ossicles, but with the possibility of fitting a hearing aids or middle ear implants.

Keywords: Middle ear cholesteatoma, Mastoid cavity obliteration, Inside out mastoidectomy, Residual cholesteatoma

Introduction

The primary goal in the surgical management of chronic otitis media with cholesteatoma is the complete removal of squamous epithelium from the middle ear spaces and the creation of a dry and safe ear. Postoperatively, the ear should be easy to care and free of residual or recurrent cholesteatoma. The method of choice for the surgical management of middle ear cholesteatoma is following the matrix of cholesteatoma from anterior to posterior with partial or total removal of posterior canal wall, the so called inside out canal wall down or reverse mastoidectomy. After complete cholesteatoma removal, partial or total mastoid cavity obliteration is considered if a posterior canal wall reconstruction is not possible. In rare cases of extensive or recurrent cholesteatoma, a subtotal petrosectomy with closure of the Eustachian tube and external ear canal will be performed, completely isolating the mastoid cavity from the exterior. Hearing improvement is considered to be the secondary task of complex treatment of cholesteatoma.

The basic question when to use either closed (Canal Wall-Up, CWU) or open (Canal Wall-Down, CWD) technique existed not more. The criteria for selecting a technique for cholesteatoma surgery described from Jahnke et al. we use to influence our decision for canal wall reconstruction or mastoid cavity obliteration (Table. 1) (1), equating indications for canal wall reconstruction to indications

for close technique and equating indications for mastoid cavity obliteration to characteristics for open technique indications. A large mastoid, normal Eustachian tube function, young patients (who often require a staged procedure), and reliable aftercare are criteria for preserving or reconstructing the posterior canal wall. Recurrent cholesteatoma, a small mastoid, a prominent sinus, prolonged Eustachian tube dysfunction, and uncertain aftercare are indications for creating an open mastoid cavity with obliteration. CWD surgery with primary obliteration seems to be a safe and reliable one-staged procedure for the treatment of cholesteatoma in adults with poor mastoid pneumatization, which is associated with good clinical, functional and social long-term results (2). Before turning to partial or complete mastoid cavity obliteration, the surgeon must be certain that all cholesteatoma matrix have been removed. If there is the slightest doubt, the surgeon must create an open, small and self-cleaning cavity. Surgical measures for obtaining a small, self-cleaning cavity are lower the facial ridge to the level of the facial nerve; smooth all bony overhangs and cell septa with a diamond bur; if necessary, drill down the mastoid tip; reduce the sinus-dura angle by partial obliteration; widen the ear canal entrance by cartilage excision, additional anterior canal skin incision, and tacking the concha posteriorly (3).

First Mosher, 1911 use posterior musculo-periosteal flap for partial mastoid cavity obliteration (4). Than Kisch, 1928 and Rambo, 1958 make total obliteration of the middle ear cleft after middle ear surgery with temporalis muscle (5). Palva, 1961 use anterior musculo-periosteal flap with tympanoplasty in combination with posterior canal wall reconstruction (6). We prefer to use cartilage and bone for mastoid obliteration. In recent days Bioactive glass S53P4 was used for frontal sinus obliteration. Sarin et al. first used Bioactive glass S53P4 for mastoid obliteration (7). We perform cavity obliteration in the first operation, but more often do it in revision surgery. If not indicated primarily, the obliteration can be performed in a second stage procedure, especially after several previous operations. Our primary goal of surgery is one-stage procedure if possible. The mastoid cavity obliteration can be partial or complete. Complete obliteration with abdominal fat and closure of the outer ear canal is rare procedure.

The indications for and extent of obliterating mastoid air cells varies considerably from surgeon to

surgeon. The decision for mastoid obliteration is influenced mainly by the school and routine, but also from the individual personality and sensitivity of the surgeon. Various materials are used, including autogenous bone and cartilage, free or vascularized soft tissue, and bioactive or biocompatible alloplastic materials. Finally, the experience of the surgeon is decisive for the result of the entire surgical procedure.

The aim of this study is to present our current concept of our Plester School for mastoid cavity obliteration procedure. Middle ear cholesteatoma surgery, based on techniques developed by Dietrich Plester and further developed by Jan Helms and Henning Hildmann, use standardized procedures called "Individualized Approach to Cholesteatoma Surgery" (8). We use this technique in routine practice over last 20 years, therefore the principles presented here are results of acquired surgical and clinical knowledge.

Methods

The here presented patient collective included 176 cholesteatoma operations (38.85%) from 453 consecutive middle ear surgery for 4 years and 4 months in Trakia Park Hospital Stara Zagora, Bulgaria from 01.06.2014 to 30.09.2018. This retrospective study describes 155 patients with congenital (4) and acquired (151) cholesteatoma of the middle ear with age distribution from 4 to 76 years (mean age 35.8 years; SD 18.0 years) and follow-up period from 1 to 48 months (mean 11.34 months; SD 13.10) and female/male distribution 67 to 88; left ear 78, right ear 77. Preoperatively, the patients were evaluated according to the Bellucci Classification (n=176): Gr. 1/9 (5%), Gr. 2/37 (21%), Gr. 3/120 (68%), Gr. 4/10 (6%). One surgeon performed 106 Primary Cholesteatoma Surgery (60.22%, n=176), 49 Revision Surgery (27.84%, n=176), previous operations in another hospital (x5/1; x4/2; x3/3; x2/6; x1/37) and 21 Second-Look Surgery (11.93%, n=176).

Mastoid cavity obliteration was performed in revision but also in primary surgery. Biological and alloplastic obliteration materials were applied. Homologous materials are no longer allowed due to medicolegal reasons. Our material collection for mastoid obliteration technique included cartilage, bone or bone replacement alloplastic materials and soft tissue flaps.

Cartilage (large plates or palisades) is taking from cavum or cymba conchae or from tragus. Bone dust

s. Bone Paté can be collected in a special glass vessel (Collector) connected to the suction apparatus during drilling (9), or it may be harvested with a Jansen Raspatorium. We use this material to obliterate the deepest areas located above and behind the lateral semicircular canal and after that we covered it with cartilage plates with overlapping perichondrium or connective tissue. When it is not possible to deliver Bone Paté, we use Bioactive or biocompatible alloplastic materials, for example Bioactive glass S53P4 (silicon dioxide, SiO_2 53%; disodium oxide, Na_2O 23%; calcium oxide, CaO 20% and phosphate pentoxide, P_2O_5 4%/) (10, 11). These materials even more categorically must be covered with connective tissue flaps, perichondrium or cartilage to keep in place and to induce new bone formation. Some authors suggest fibrin glue, platelet rich plasma or similar materials to cover the obliterated area (12, 13).

Soft tissue flaps as material for mastoid obliteration included Palva muscle-periosteal posterior flap or inferior musculo-fascial pedicle flap. For example M. Tos associated mastoid obliteration with Palva flap and there modifications (14). Paparella et al. also described inferior musculo-fascial pedicle from behind the ear as more commonly employed method of mastoid obliteration (15).

The personal experience of the surgeon influences the techniques that are preferred in any given case of cholesteatoma. Our treatment concepts define clearly surgical principles in our operative protocol and individual surgical steps:

1. Periauricular local anesthesia with Lidocain + Adrenalin, 1:100,000 before surgery.
2. Retroauricular approach allows extensive exposure of the mastoid according to the extent of the disease and of the end of operation allows better view in anterior tympanomeatal angle area. Only for smaller cholesteatoma not extending into the mastoid is the endaural or endomeatal approach preferable. When performing retroauricular incision of posterior canal skin the lateral canal skin must be preserved.
3. Carefully preparation and removal of the meatal skin flap and re-implant it at the end of the operation as a free graft. This allows more space for drilling and prevents damage of the skin flap by the drilling. Additionally it improves the overview and saves time.
4. Enlargement of external auditory canal with posterior bone drilling with bone collection.

This is extremely important in cases of narrow ear canals. At this point of surgery we perform additional elevation of anterior canal skin and the remnants of anterior-superior part of tympanic membrane to allow a reconstruction with a cartilage in one plane at the end of the operation.

5. Following the matrix of cholesteatoma including complete cholesteatoma removal from anterior to posterior with preservation of malleus handle and m. tensor tympani tendon if it is possible. The drill should not touch the epithelium and should avoid spreading cholesteatoma particles. The bone has to be drilled down to the facial nerve, leaving it covered by thin layer of bone. Identify the position of the facial nerve at an early stage in the operation. Perineural vascular plexus is indirect landmark for the position of the facial nerve. Critical areas are S1 and S2 from STAM System (16) – inspection with 30° otoendoscope. If the epithelium extends medially to the labyrinth, the treatment might require the destruction of the labyrinth.
6. Concha cartilage preparation with sufficient excision and ear canal enlargement with additional meatoplasty through outer meatal skin incision at about 12 and 6 o'clock. The flap is pulled backwards by subcutaneous sutures of the end of operation.
7. Tympanoplasty in combination with posterior canal wall reconstruction with cartilage in cases with normal mastoid pneumatization. Partial or total defects of the posterior wall can be reconstructed, especially in cases that the cholesteatoma is small. Epitympanic space also should be reconstructed by cartilage. Cartilages must fit exactly one another.
8. Tympanoplasty in combination with mastoid cavity obliteration with bone and cartilage in poor mastoid pneumatization or if posterior canal wall reconstruction is not possible. Mastoid cavity obliteration cut be done after certain removal of all epithelium from the mastoid. Fill the cavity adequately and the Bone Paté or nonbiological granules must be fully covered with cartilage or connective tissue.
9. Reimplantation of the removed meatal skin flap or split-thickness skin grafts from the postauricular region as a free graft and package closely the external ear canal with antibiotic filled Gelfoam after covered with silicone foil

or cigarettes paper.

10. Periosteal, subcutaneous and skin sutures retroauricular. The periosteal suture should prevent stenosis of the external auditory canal, and the subcutaneous suture – the outstanding of the auricle.
11. Compressive dressing for 2 days incl. controlled bone-conductive audiogram on first postoperative day.
12. Tamponed external auditory canal for 21 days incl. Ciprofloxacin 2 x 750 mg. for 5 or 2 x 500 mg. for 10 days p.o. Alternative in children: amoxicillin and clavulanate potassium.
13. Postoperative control: regular examination and audiogram on 1, 3, 6 month postop., and then every year or MRI especially Diffusion-Weighted Imaging with Turbo-Spin Echo 2–3 years after surgery in instable ears or 5 years in stable ears has been found to be of high sensitivity and specificity in diagnosing residual or recurrent cholesteatoma (17, 18, 19).
14. Second-look surgery 12 (in children) or 18 month (in adults) after surgery when intraoperatively indicated.

Results

According to STAM System (16) our patients divided to the following localizations: T/80; A/99; M/67; S1/27; S2/38 with extra- and intra-cranial complications: dehiscence of the canal of the facial nerve in 31 cases; lateral semicircular canal fistulas type I in 13 cases; defect of the tegmen with exposed dura (21 cases) or of the sinus sigmoideus (5 cases) that does not require repair and are not coded as intracranial complications; defect of the tegmen with otoliquorrhoe and repair (2 cases) or sinus thrombosis (1 case) are coded as intracranial complications. The staging according to same system are: I/71 (45,81%); II/41 (26,45%); III/40 (25,81%); IV/3 (1.94%).

According to Austin-Kartush classification (20) we found: Malleus handle is present in 62.58% of cases (97; n=155); Incus is preserve in only 1.94% of cases (3; n=155); Stapes superstructures is present in 56.13% of cases (87; n=155); Stapes footplate is present in 43.87% of cases (68; n=155), that corresponding to different groups: 0/3 (1.94%), A/67 (43.23%), B/27 (17.42%), C/17 (10.97%), D/37 (23.87%), F/4 (2.58%).

In our patient group we did type I tympanoplasty in 36.77% (57; n=155) and type III tympanoplasty in

46.45% (72; n=155). Canal reconstruction we did in 51.61% of cases (80; n=155), mastoid cavity obliteration – in 41.94% of cases (65; n=155). From this 65 cases of mastoid cavity obliteration we have 1/3 obliteration, on the level of facial nerve, in 20 cases (30.77%), 2/3 obliteration – in 23 cases (35.38%) and 3/3 full obliteration – in 22 cases (33.85%). In our cases we used cartilage (Fig. 1), Bone Paté (Fig. 2) and Bioactive glass S53P4 (Fig. 3). The distribution of this we show on Table 2.

In 56 from 155 operation we have intraoperative indication for second-look surgery (36.13%). For study period we make only 21 second-look operations (14%, n = 155). In 9 from this 21 second-look operation (42.86%) we found residual cholesteatoma in the following localizations: T/1, S2/1, A/3, S1/4. In 3 from this 9 residual cases we indicated a “new second-look” tympanomastoidectomy (14.29%, n=21) 18 months following the first second-look operation. Another 6 small residual pearl cholesteatoma were complete removal. Also residual rate in our study group is 9.03% (14; n=155). Only in 5 cases (3.23%, n=155) of the end of operation we establish residual cholesteatoma and leave the cavity open. Three from these 5 cases are revision surgery – we leave residual cholesteatoma near uncovered facial nerve in S1/S2 region.

Preoperative and postoperative ABG in our patients is 35,51 (SD 15,76) and 32,90 (SD 19,06), respectively, that it is significant improvement ($p=0.03662$). Additionally to our 72 stapes columella tympanoplasty in 11 second-look cases (57.14%, n=21) we perform 10 TORP (length 3.0÷4.75 mm; mean 3.68; SD 0.57) and 1 PORP (length 2.5 mm) tympanoplasty. Preoperative and postoperative ABG in this TORP/PORP group is 45,00 (SD 12,25) and 17,73 (SD 5,64), respectively, that it is significant improvement ($p=0.02213$). Against the background of this hearing improvement, we only have complications in 17 cases (10,97%; n=155), which we show on Table 3. Our frequency of postoperative ear secretion including infection and granulation is 6.45% (10; n=155).

Discussions

A closed technique requires that the posterior wall of the ear canal is preserved or reconstructed, and an aerated antrum is present behind the canal wall (8). This ensures that the middle ear cavity has an approximately normal depth and pneumatization. All other middle ear conditions are considered to be

open techniques with or without obliteration. The pathophysiological idea of mastoid cavity obliteration in cholesteatoma cases is a surgical reduction of mucosal surface for gas exchange resulting to surgical adaptation of the middle ear pressure balance to the limited outer gas supply due to prolonged ET dysfunction, thus lowering the recurrence rate and improving long-term surgical outcome (21).

The cholesteatoma has to be completely exposed during the surgical procedure. Only 4% from residual cholesteatoma is in mastoid area (22). Critical areas for complete cholesteatoma removal are anterior epitympanum (S1) and sinus tympani posterior (S2). Inspection with 30° otoendoscope is useful. According to M. Tarabichi, 1997 in all cholesteatoma cases intraoperative, the mastoid cavity must be inspected endoscopically (23). In most cases residual cholesteatoma are in S2 area, that's why we use an otoendoscope to identifying it in facial recesses. Recurrent cholesteatoma refers to a retraction pocket and must be differentiated from residual cholesteatoma. The causes, prevention and treatment are different. Recurrent cholesteatoma was detected in 5% (24). The mastoid cavity obliteration is designed to prevent development of postoperative retraction pockets by obliterating the mastoid cavity and isolating the tympanum from the mastoid. Extended cholesteatoma in combination with extended mastoid pneumatization is another important point of interest. In this challenging cases canal wall down obliteration technique is operative method of choice, using Bioactive glass S53P4, which we cover with Bone Paté. The Bone Paté in over 75% of patients will lead to osteoneogenesis, achieving in 2–3 months (25).

Twelve months for postoperative follow-up is the minimum period to estimate the otorrhea and hearing outcomes (26). We follow-up our patients from 1 to 48 months (mean 11.34 months; SD 13.10 months). Tympanic membrane shrinking with retraction pocket is a sign for long term follow up. For hearing reconstruction, PORP and TORP are used in a primary or staged setting. We have better results in the cases of two stage operation with TORP and PORP insertion on second-look operation. For prevention of TORP luxation we increase the measured length with 0.25 mm.

Patients with cholesteatoma was predisposed to facial nerve dysfunction (FND). Tympanic segment of facial nerve is frequently involved. We found

that if the stapes superstructure was absent, there was a greater potential for FND. Hence, otologic surgeons should carefully dissect neighboring structures of the facial canal during mastoidectomy, particularly if there is preoperative CT Scan evidence of damage to the stapedia superstructure. Another important point for postoperative hearing status is unsecure stapes footplate (27). For example fractures of the stapes footplate or in cases in which the footplate is partially or fully absent or stapes luxation during surgery.

In 67 cases (43.23%, n=155) we found mastoid involvement of cholesteatoma, that define microscopic surgery. Endoscopic ear surgery can be performed in the remainder of cases. Modern surgical approaches include open and closed cavities performed with or without obliteration techniques, and these approaches can be accomplished using a microscope, endoscope, or a combination of both (28).

Conclusions

The mastoid cavity and epitympanic obliteration procedure prevent development of postoperative retraction pockets and isolating the tympanum from the attic and mastoid and in this way is a safe and effective technique for the rehabilitation of CWD mastoidectomies. It is very well tolerated from the patients and recommend not only for revision surgery, but also for initial surgical management. In cases with mastoid cavity obliteration open or closed technique should not be opposed anymore, and to be complementary each other. We call this an adapted technique for cholesteatoma surgery. Hearing results of this technique is variable according to the involvement of the ossicles of the middle ear, but with the possibility of fitting a hearing aids or middle ear implants.

Compliance with ethical standards

Disclosure of potential conflicts of Interest: The author have no conflict of interest to declare. Financial Disclosure: The author declared that this study has received no financial support. Informed Content: This articles does not contain patient data. Part of this study is presented at 90. Jahresversammlung der Deutschen Gesellschaft für HNO-Heilkunde, Kopf- und Hals-Chirurgie, Berlin, 2019 (Vortrag auf Einladung Nr. 350: Mehrstufige Behandlung des Mittelohr-Cholesteatoms).

Table 1. Criteria for selecting a technique for cholesteatoma surgery (modified according to Jahnke K et al., 1985).

Closed technique	Middle ear cholesteatoma	Open technique
Normal pneumatization		Poor pneumatization
Normal tubal function		Tubal dysfunction
Pediatric patient		Elderly patient
Second look possible		Poor compliance
	Extend of disease

Fig. 1. Intraoperative view – mastoid cavity obliteration with cartilage.

Fig. 2. Intraoperative view – mastoid cavity obliteration with Bone Paté.

Fig. 3. Intraoperative view – mastoid cavity obliteration with Bioactive glass S53P4.

Table 2. Materials used for mastoid cavity obliteration.

65 Obliteration from 155	All Cholesteatoma Operation	(41.94%)
26 Obliteration from 106	Initial Cholesteatoma Operation	(24.53%)
Bone		
	Bone Paté	16
	BonAlive	1
Cartilage		19
39 Obliteration from 49	Revision Cholesteatoma Operation	(79.59%)
Bone		
	Bone Paté	28
	Bioactive glass S53P4	15
Cartilage		29
Other materials:		
	Cartilage	68%
	Bone Paté	74%
	Bioactive glass S53P4	25%
	-16 Cases (15 revision; 1 primary by congenital cholesteatoma)	
	-2±4 ml (Mean 2.44; SD 0.57)	

Table 3. Complications after cholesteatoma surgery (follow-up period 1±48 months; mean follow-up 11.34 months; SD 13.10 months).

Infection	6
Granulation	4
Open vestibule with vertigo and SNHL (persistent)	6 (2)
Otoliquorrhoe requiring Reoperation	2
Temporally Facial Nerve Dysfunction	3

Some patient has two or three different complications (17; n=155); 1.29% has persistent complications (2; n=155).

References

- Jahnke K, Khatib M, Rau U (1985) Langzeitergebnisse nach Cholesteatomchirurgie. *Lar Rhinol Otol* 64: 238–242.
- Trinidad A, Skingsley A, Yung MW (2015) Mastoid obliteration surgery for cholesteatoma in 183 adult ears – a 5-year prospective cohort study: Our Experience. *Clinical Otolaryngology* 40: 715–736.
- Plester D, Hildmann H, Steinbach E. (1989) *Atlas der Ohrchirurgie*. Stuttgart: Kohlhammer p.84.
- Mosher HP. (1911) A method filling the excavated mastoid with a flap from the back of the auricle. *Laryngoscope* 21: 1158–1163.
- Mehrin S, Sumit K G, Sunil N D. (2018) The Forgotten Rambo Flap for Mastoid Cavity Obliteration. *Glob J Oto* 17(4): 61–63.
- Palva T. (1963) Surgery of chronic ear without cavity. *Archives of Otolaryngology* 570–580.
- Sarin J, Grenman R, Aitasalo K, Pulkkinen J. (2012) Bioactive Glass S53P4 in Mastoid Obliteration Surgery for Chronic Otitis Media and Cerebrospinal Fluid Leakage. *Annals of Otolology, Rhinology & Laryngology* 121: 563–569.
- Hildmann H, Sudhoff H, Jahnke K. (2004) Principles of an Individualized Approach to Cholesteatoma Surgery, Middle Ear Surgery. [In: *Current Topics in Otolaryngology – Head and Neck Surgery: Middle Ear Surgery – Recent Advances and Future Directions*, K. Jahnke (Ed.)], Georg Thieme Verlag pp. 73–93.
- Hildmann H. (1986) Mastoidhöhle und Gehörgangseingangsplastik. *Laryngol-Rhinol-Otol* 65: 684–687.
- Jussi Sarin, Reidar Grénman, Kalle Aitasalo, Jaakko Pulkkinen. (2012) Bioactive glass S53P4 in mastoid obliteration surgery for chronic otitis media and cerebrospinal fluid leakage. *Ann Otol Rhinol Laryngol* 121(9): 563–9.
- Stoor Patricia et al. (2001) Bioactive glass S53P4 in the filling of cavities in the mastoid cell area in surgery for chronic otitis media. *Annals of Otolology, Rhinology & Laryngology* 119(6): 377–382.
- Blayney AW, Erre J-P, Dhem A, Cazals Y. (1989) Experimental Mastoid Obliteration with Hydroxyapatite Tricalcium Phosphate (Zimmer/Xomed) and Fibrin Glue (Immuno-Austria). *Proceedings of the First International Conference on Interfaces in Medicine and Mechanics* pp. 204–214.
- Jang CH, Choi CH, Cho YB. (2016) Effect of BMP2-Platelet-rich Plasma-Biphasic Calcium Phosphate Scaffold on Accelerated Osteogenesis in Mastoid Obliteration. *In Vivo* 30(6): 835–839.
- Mirko Tos. (1997) *Manual of Middle Ear Surgery*, Vol. 2: Mastoid Surgery and Reconstructive Procedures pp. 310–314.
- Paparella et al. (1991) *Otolaryngology Volume II: Otolology and Neuro-Otolology*, Third Edition pp. 1432–5.
- Matthew Yung, Tetsuya Tono, Ewa Olszewska, Yutaka Yamamoto, Holger Sudhoff, Masafumi Sakagami, Jef Mulder, Hiromi Kojima, Armağan İncesulu, Franco Trabalzini, Nuri Özgür. (2017) EAONO/JOS Joint Consensus Statements on the Definitions, Classification and Staging of Middle Ear Cholesteatoma. *J Int Adv Otol* 13(1): 1–8.
- Peter MM, Li C, Eleni Linos, Richard K. Gurgel, Nancy J. Fischbein, Nikolas H. Blevins. (2013) Evaluating the utility of non-echo-planar diffusion-weighted imaging in the preoperative evaluation of cholesteatoma: A meta-analysis. *Laryngoscope* 123(5): 1247–50.
- Pai, Irume; Crossley, Eleanor; Lancer, Hannah; Dudau, Cristina; Connor, Stephen. (2019) Growth and Late Detection of Post-Operative Cholesteatoma on Long Term Follow-Up With Diffusion Weighted Magnetic Resonance Imaging (DWI MRI). *Otol Neurotol* 40(5): 638–644.

19. Lingam R, Singh A. (2015) Detecting postoperative cholesteatoma with diffusion weighted magnetic resonance imaging. *ENT & Audiology News* 23(2): 56–57.
20. Kartush JM. (1994) Ossicular chain reconstruction. Capitulum to malleus. *Otolaryngol Clin North Am* 27: 689–715.
21. Csakanyi Zsuzsanna, Katona Gabor, Konya Denes, Mohos Ferenc, Sziklai Istvan. (2014) Middle Ear Gas Pressure Regulation: The Relevance of Mastoid Obliteration. *Otol Neurotol* 35(6): 944–953.
22. James L. Sheehy, Derald E. Brackmann, Malcolm D. Graham. (1977) Cholesteatoma Surgery: Residual and Recurrent Disease: A Review Of 1,024 Cases. *Annals of Otology, Rhinology & Laryngology* 86(4): 451–462.
23. Tarabichi M. (1997) Endoscopic management of acquired cholesteatoma. *Am J Otol.* 18(5): 544–9.
24. James L. Sheehy, Derald E. Brackmann, Malcolm D. Graham. Cholesteatoma Surgery: Residual and Recurrent Disease: A Review Of 1,024 Cases, *Annals of Otology, Rhinology & Laryngology* 86(4): 451–462.
25. Roberson Joseph B Jr, Mason Theodore P, Stidham Katrina R. (2003) Mastoid Obliteration: Autogenous Cranial Bone Paté Reconstruction. *Otology & Neurotology* 24(2): 132–140.
26. Yung M, Jacobsen NL, Vowler SL. (2007) A 5-year observational study of the outcome in pediatric cholesteatoma surgery. *Otol Neurotol* 28: 1038–40.
27. Martin Bremke, Karl-Bernd Hüttenbrink, Dirk Beutner. (2011) The sandwich cartilage shoe technique for ossicular reconstruction in a case of an unsecure stapes footplate. *The Laryngoscope* 121(9): 1950–1952.
28. Linder Thomas, Shankar Shah, Aline Silveira Martha, Christof Roosli, Susan D. (2018) Emmett. Introducing the “CHOLE” Classification and Its Comparison to the EAONO/JOS Consensus Classification for Cholesteatoma Staging. *Otology & Neurotology* 40: 63–72.

Correspondence to:

Petar Rouev,

ENT Dept., Trakia Hospital Stara Zagora,

84 Patriarch Evtimiy Street, Stara Zagora, BG-6000, Bulgaria,

E-mail: petar.rouev@mail.bg