Evaluation of the Mastoid Emissary Canals with Computerized Tomography in Patients with Chronic Otitis Media

Ozkan Ozen¹ Caner Sahin²

¹Department of Radiology, Faculty of Medicine, Alanya Alaaddin Keykubat University, Antalya, Turkey

²Department of Ear Nose and Throat, Faculty of Medicine, Alanya Alaaddin Keykubat University, Antalya, Turkey

Address for correspondence Ozkan Ozen, MD, Department of Radiology, Faculty of Medicine, Alanya Alaaddin Keykubat University, Alanya Education and Research Hospital, Oba District, Alanya/Antalya, Turkey (e-mail: ozen@doctor.com).

J Neurol Surg B 2020;81:82–87.

Abstract

Background The mastoid emissary veins (MEVs) pass through the mastoid emissary canal-mastoid foramen (MEC-MF) in the mastoid region of the skull. MEVs can give rise to complications during surgical procedures. The purpose of our study was to investigate the morphological and morphometric characteristics of MECs of patients with clinical chronic otitis media (COM) using high-resolution computed tomography (HRCT).

Methods Patients diagnosed with COM and undergoing temporal HRCT were identified by retrospectively scanning our hospital's automation system. Patients undergoing temporal HRCT for reasons other than COM, infection or tinnitus were identified for the control group by scanning the PACS archive. Sixty-two mastoid regions were examined in 38 unilateral and 12 bilateral COM patients, and 100 mastoid regions in the 50 patients in the control group. The presence of an accessory MEC-MF and MEC-MF diameters was evaluated in both groups.

Results Main MEC diameters on the side of the ear with COM were 1.6 mm, and total accessory and main MEC diameters were 1.8 mm, both values being significantly higher than in the control group. Presence of accessory MEC on the side of the ear with COM was determined at 61.8%, significantly higher than in the control group.

Conclusion Preoperative awareness of cranial venous drainage abnormalities is important to reduce surgical complications. Our study shows that MECs may be wider in diameter in patients with COM. MECs in COM patients must be identified before surgery to the mastoid region.

Keywords

- ▶ computed tomography
- ▶ emissary vein
- ▶ mastoid emissary canal
- ▶ temporal bone
- ▶ otitis media

Introduction

The cranial emissary veins connect the intracranial and extracranial venous systems, independently of the arteries, by passing through small canals in the skull. The mastoid emissary vein (MEV) passes through the mastoid emissary canal (MEC). The MEC is generally present at the level of the mastoid part of the temporal bone. These veins connect the sigmoid sinus and the posterior auricular and occipital veins.^{1–3} In some individuals, the MEVs establish connections with intra-

diploic structures.^{1,4} Under normal conditions, blood flow in these emissary veins with valves is slow and generally from the intracranial system to the extracranial system.⁵

Chronic otitis media (COM) is a disease that causes ear membrane perforation and recurrent or continuous auricular discharge for more than 3 months.⁶ It is generally divided into two forms, with or without cholesteatoma. COM without cholesteatoma is further subdivided into active (with discharge) and inactive (dry ear) forms.⁷

received

June 27, 2019

accepted after revision

September 28, 2019

published online

October 28, 2019

© 2020 Georg Thieme Verlag KG
Stuttgart · New York

DOI <https://doi.org/10.1055/s-0039-3399518>.
ISSN 2193-6331.

It is important for these veins to be assessed using preoperative imaging techniques, because they may represent a source of bleeding and air embolism during surgery.^{8–10} However, many surgeons fail to pay these veins sufficient attention.¹¹

The number of radiological studies of the emissary veins is limited.^{12,13} Our review of the literature revealed no previous studies investigating the MEV and MEC in patients with COM. However, we did find one study evaluating the petrosquamosal sinus canal, one of the emissary veins.¹⁴

The purpose of our study was to investigate the morphological and morphometric characteristics of MECs through which MEVs pass in patients with clinically diagnosed COM using high-resolution computed tomography (HRCT).

Methods

Following receipt of ethical committee approval, we identified 71 patients undergoing temporal HRCT with a diagnosis of COM between December 2016 and December 2018 via our hospital's automation system. Six patients who underwent surgical procedures, four patients aged under 18, and 11 patients with COM complications/cholesteatoma were excluded from the study. Date of definite diagnosis of COM could not be fully established. However, patients with symptoms of chronic otitis for at least the previous 6 months and diagnosed with COM were included in the study. For the control group, we identified 94 patients aged over 18 undergoing temporal HRCT for reasons other than infection or tinnitus through a scan of the radiology PACS (picture archiving and communication system) archive. Of these 94 patients, 50 subjects undergoing CT due to sudden hearing loss or trauma and with unremarkable physical examination and temporal HRCT findings were included in the study. The temporal CTs of 50 patients with COM and 50 normal patients were thus finally subjected to analysis.

CT examinations were performed using a 16-detector CT device (Toshiba Alexion/Advance, Toshiba Medical Systems Corporation Nashu, Japan), set to a 0.6-mm thickness in the axial plane, a 0.4-mm interval, 120 kV, 300 mA, 0.4 pitch, a 0.75-second rotation time, 16 × 0.75 collimation, a 512 × 512

matrix, and 200 × 200 mm FOV (field of view). All images were analyzed in three dimensions (3D) using multiplanar reformatted images and maximum intensity projections in 3D on a radiology workstation (Sectra Workstation IDS7, Linköping, Sweden).

MECs and numbers of accessory MECs, if present, were evaluated in this study. Mastoid foramen (MF, MEC's hole) diameter was measured from the intracranial part of the mastoid canal. Canal and foramen diameter was measured in the axial plane, and height in the sagittal or coronal planes, the images obtained being optimally magnified. The mean value of the measurements in the two planes was used in canal/foramen diameters, since these organs are ellipsoid in the majority of patients. The large diameter was evaluated as the main MEC in patients with an accessory canal (– Figs. 1–3). Evaluations were performed separately by a radiology specialist with 12 years' experience in the field of radiology and by a physician with 15 years' experience of ear, nose, and throat diseases. The patients who with differences were then assessed by the two specialists together, and a consensus was thus established.

Statistical Analysis

Descriptive data were expressed as number and percentage values for categorical data and as mean ± standard deviation and median interquartile range (25–75 percentile) values for continuous data. The chi square and Fisher's tests were used to compare categorical data. Normal distribution assumptions for measurement data were assessed using the Kolmogorov–Smirnov test. The Mann–Whitney U test was used to compare non-normally distributed measurement data, and the Kruskal Wallis test where appropriate. *p*-values <0.05 were regarded as statistically significant for all analyses. Post hoc analyses were performed in tables with multiple check-boxes, with Bonferroni correction for *p*-values. Analyses were performed on IBM © SPSS 15 software.

Results

Mean age was 49.5 (±12.8) years in the COM group and 47.2 (±15.8) years in the control group. No significant difference

Fig. 1 Images from a 60-year-old man with chronic otitis media for 6 years on the right and 5 years on the left; the CT image in the axial plane (A) represents the method by which mastoid emissary canal diameter was measured, while the CT image in the sagittal plane (B) is the method used to measure mastoid emissary canal height.

Fig. 2 Images from a 45-year-old woman with chronic otitis media for 4 years on the right; the CT image in the axial plane (a) represents the method by which mastoid foramen diameter was measured, while the CT image in the sagittal plane (b) is the method used to measure mastoid foramen height.

Fig. 3 Three-dimensional reformatted computerized tomography images in ►Fig. 3A,B show the main mastoid emissary canal and two accessory mastoid emissary canal orifices with smaller diameters around the right ear (black arrows), and the main mastoid emissary canal and one accessory mastoid emissary canal orifice with a smaller diameter around the left ear (black arrows).

was determined between the patient and control groups in terms of mean age or gender distribution ($p > 0.05$). Sixty-two ears with COM were present in the patient group, right-side in 19, left-side in 19, and bilateral in 12, while all 100 ears in the 50 patients in the control group were normal. No significant variation in terms of rates of presence of MEC was determined between patients with COM and the control group (all healthy ears) or with the healthy ears of patients with COM (unilateral healthy) ($p > 0.05$). Presence of acces-

sory MEC was significantly higher in patients with COM compared with the control group (all healthy ears) and the healthy ears of COM patients (unilateral healthy) ($p < 0.05$). These findings are also shown in ►Table 1. A bar chart for these findings is shown in ►Fig. 4.

Mean MEC diameters were 1.6 mm in the 62 ears with COM and 0.7 mm in the control group. Mean MEC diameter was significantly higher in the ears with COM ($p < 0.05$). In addition, total main MEC diameters, MF diameters, and

Table 1 Presence of mastoid emissary canal (MEC) and accessory MEC on the side with chronic otitis media (COM) in patients, on the healthy side in COM patients (unilateral healthy) and in the control group

		COM		Unilateral healthy		Control		p^a
		<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	
MEC	Yes	54	(87.1)	33	(86.8)	80	(80.0)	0.411
	No	8	(12.9)	5	(13.2)	20	(20.0)	
Accessory MEC	Yes	34	(61.8)	6	(18.2)	25	(31.3)	< 0.001 ^b
	No	21	(38.2)	27	(81.8)	55	(68.8)	

^aChi-square test.

^bSignificant two-way comparisons with the COM group.

Fig. 4 Bar chart showing the distribution of mastoid emissary canals (MEC) and presence (+) or absence of (-) accessory MEC in the chronic otitis media, unilateral healthy and control groups.

Table 2 Evaluation of mastoid emissary canal (MEC), mastoid foramen (MF), and total accessory MEC, where applicable, and main MEC diameters in patients with chronic otitis media (COM) and the control group

	COM		Control		p^a
	Median (mm)	IQR	Median (mm)	IQR	
MEC diameters	1.6	(1.0–2.0)	0.7	(0.5–1.0)	<0.001
MF diameters	1.8	(1.2–2.2)	0.8	(0.6–1.3)	<0.001
Total main MEC and accessory MEC diameters	1.8	(1.1–2.3)	0.7	(0.4–1.2)	<0.001

Abbreviation: IQR, interquartile range.

^aMann-Whitney U test. mm, millimeter.

accessory MEC diameters, where present, were significantly higher compared with the control group ($p < 0.05$). The findings are summarized in ►Table 2. A bar chart showing patient and control group MEC and MF diameters and total accessory MEC, where applicable, and main MEC diameters is shown in ►Fig. 5.

Ad hoc analysis of COM cases classified as unilateral and bilateral revealed no significant differences between the two groups in terms of MEC diameters, total main MEC and accessory MEC (where applicable) diameters, and MF diameters. However, MEC diameters, total main MEC and accessory MEC (where applicable) diameters, and MF diameters were significantly higher in cases of both bilateral and unilateral COM compared with the control group. The findings are summarized in ►Table 3.

Discussion

Mastoid emissary canal-mastoid foramen (MEC-MF) diameters and presence of accessory MECs were higher in the patients with COM in our study than in the normal control group. These findings are important in surgery.

Under conditions in which the cranial venous drainage pathways are normal, the role of the emissary veins is limited.

However, the emissary veins may represent a primary outflow route in patients with intracranial hypertension, high flow vascular malformation, obstruction in the internal jugular veins, or hypoplasia/aplasia.^{3,12,13} The emissary veins prevent increases in intracranial pressure by providing cerebral venous drainage in patients with pathologies of the neck or base of the skull or with internal jugular vein occlusion.^{15–17} Calibration of the emissary vein canals can increase under conditions of high vascular pressure or hypoplasia or aplasia of the jugular vein that may accompany states such as craniosynostosis.¹⁸ In our review of the literature; we did not find information concerning an increase in MEC-MF diameter in patients with otitis.

Previous studies have reported that there may be more than one MEC/MEV with differing diameters.^{3,12,13,19} However, MEVs or MECs have not been investigated in patients with otitis. Our review of the literature revealed one previous study assessing the petrosquamosal sinus (PSS), a rare emissary vein, using HRCT in patients with otitis. PSS rates were higher in the otitis group in that study.¹⁴ In their magnetic resonance imaging (MRI) study, Shah et al²⁰ detected noninfectious inflammation-fluid findings in mastoid air cells in posterior fossa acute cranial venous sinus thromboses. They emphasized that these findings derived from mastoid venous drainage obstruction. We do not think that it is possible for the MEVs not

Fig. 5 Bar chart showing mastoid emissary canal (MEC) diameters, total main MEC, and accessory MEC (in those cases applicable) diameters, and mastoid foramen (MF) diameters in the chronic otitis media, unilateral healthy and control groups.

Table 3 MEC diameters, total main mastoid emissary canal (MEC) and accessory MEC (where present) diameters, and mastoid foramen (MF) diameters in unilateral-bilateral chronic otitis media and healthy ears

	Unilateral COM		Bilateral COM		Control		<i>p</i> ^a
	Median (mm)	IQR	Median (mm)	IQR	Median (mm)	IQR	
MEC diameters	1.5	(1.0–2.0)	1.7	(1.3–2.1)	0.7	(0.5–1.0)	< 0.001 ^b
MF diameters	1.8	(1.1–2.2)	1.9	(1.4–2.2)	0.8	(0.6–1.3)	< 0.001 ^b
Total main MEC and accessory MEC widths	1.7	(1.0–2.2)	2.0	(1.2–2.5)	0.7	(0.4–1.2)	< 0.001 ^b

Abbreviations: COM, chronic otitis media; IQR, interquartile range.
^aKruskal Wallis test.
^bSignificant two-way comparisons with the control group, mm, millimeters.

to be affected in patients with COM. We think that it is due to blood flow change in veins.

Multiple detector computed tomography (MDCT) is a valuable technique for assessing the base of the skull and cranial foramens. Even very small emissary veins can also be identified using MDCT. Disadvantage of CT is radiation exposure. These veins can be examined by MRI.^{3,13}

Demirpolat et al¹² investigated the temporal CTs of 248 patients (496 ears) and reported MEC at a rate of 83.5% and two or three channels in 25.2% of subjects. Whether the patients in these studies had aural pathologies is unclear. In the present study, we also evaluated 100 ears of 50 patients with no aural problems at physical examination or history of such problems as a control group. MEC was present in 80% of the control group and 87.1% of the COM group, while accessory MECs were present in 31.3% of the control group and 61.8% of the COM group. The prevalence of accessory MECs was higher in the COM group than in the control group.

Demirpolat et al¹² reported mean mastoid canal diameters of 1.58 ± 0.86 mm on the right and 1.48 ± 0.79 mm on the left. Mean MEC diameters in our study were 0.7 mm (IQR 0.5–1.0) in the control group and 1.6 mm (IQR 1.0–2.0) in the COM group. The reason why some of our findings are not in agreement with those of Demirpolat et al¹² may be that we evaluated patients with aural pathologies, as well as differences in measurement methods. No statistically significant difference was determined in our study between healthy side values in the COM group and the control group.

The presence of the MEV and mastoid canal diameters is important. The presence and size of the MEV must be assessed using thin-slice bone window CT scanning before surgical procedures concerning the posterior fossa and mastoid region. An MEV diameter greater than 3.5 mm is clinically significant.^{3,12} Excessive bleeding deriving from a wide MEV during modified radical mastoidectomy was reported in a patient with cholesteatoma. The MEV was missed at preoperative

imaging in that study.¹⁰ MRI is inadequate for visualizing emissary veins. HRCT shows the emissary veins better, permitting more reliable approaches.³

In the light of our study findings and the information set out above, importance must be attached to MEV/MECs in the preoperative imaging of patients with otitis. Due to the low number of subjects with COM with cholesteatoma, these were excluded from the study. We think that studying MEV/MECs in subjects with COM with cholesteatoma will contribute to the literature.

The principal limitation of our study is that it involved only temporal CTs without contrast. However, previous studies have regarded MEC and MEVs as synonymous at CT angiography.¹³ It has also been reported that these veins can be shown better with thin slice CT than MRI in routine clinical examinations.^{3,13} Another limitation is that due to the retrospective nature of the study, it was unclear how long COM had been present.

In conclusion, to reduce complications, identification of all cranial emissary veins before mastoid and posterior fossa surgery is very important in all patients. HRCT is quite successful in showing MEV/MECs. Operations to be performed on this region are probably more common in patients with COM. Considering that these canals are wider in patients with COM, these veins must be identified before posterior fossa, mastoid region, and ear surgery.

Funding

This study has no funding.

Conflict of Interest

All authors declare no conflict of interest.

References

- 1 Reis CV, Deshmukh V, Zabramski JM, et al. Anatomy of the mastoid emissary vein and venous system of the posterior neck region: neurosurgical implications. *Neurosurgery* 2007;61(05, Suppl 2):193–200, discussion 200–201
- 2 El Kettani C, Badaoui R, Fikri M, Jeanjean P, Montpellier D, Tchaoussoff J. Pulmonary oedema after venous air embolism during craniotomy. *Eur J Anaesthesiol* 2002;19(11):846–848
- 3 Hampl M, Kachlik D, Kikalova K, et al. Mastoid foramen, mastoid emissary vein and clinical implications in neurosurgery. *Acta Neurochir (Wien)* 2018;160(07):1473–1482
- 4 Murlimanju BV, Prabhu LV, Pai MM, et al. Occipital emissary foramina in human skulls: an anatomical investigation with reference to surgical anatomy of emissary veins. *Turk Neurosurg* 2011;21(01):36–38
- 5 Braun JP, Tournade A. Venous drainage in the craniocervical region. *Neuroradiology* 1977;13(03):155–158
- 6 Acuin J. Chronic suppurative otitis media. *BMJ Clin Evid* 2007; 2007:0507
- 7 Wallis S, Atkinson H, Coatesworth AP. Chronic otitis media. *Postgrad Med* 2015;127(04):391–395
- 8 Marsot-Dupuch K, Gayet-Delacroix M, Elmaleh-Bergès M, Bonneville F, Lasjaunias P. The petrosquamosal sinus: CT and MR findings of a rare emissary vein. *AJNR Am J Neuroradiol* 2001; 22(06):1186–1193
- 9 An YH, Wee JH, Han KH, Kim YH. Two cases of petrosquamosal sinus in the temporal bone presented as perioperative finding. *Laryngoscope* 2011;121(02):381–384
- 10 Ahmad R, Ali I, Naikoo GM, Choo NA, Jan F. Giant mastoid emissary vein: source of profuse bleeding during mastoid surgery. *Indian J Otolaryngol Head Neck Surg* 2011;63(Suppl 1):102–103
- 11 Kim LK, Ahn CS, Fernandes AE. Mastoid emissary vein: anatomy and clinical relevance in plastic & reconstructive surgery. *J Plast Reconstr Aesthet Surg* 2014;67(06):775–780
- 12 Demirpolat G, Bulbul E, Yanik B. The prevalence and morphometric features of mastoid emissary vein on multidetector computed tomography. *Folia Morphol (Warsz)* 2016;75(04):448–453
- 13 Pekcevik Y, Sahin H, Pekcevik R. Prevalence of clinically important posterior fossa emissary veins on CT angiography. *J Neurosci Rural Pract* 2014;5(02):135–138
- 14 Božek P, Kluczevska E, Misiotek M, Ścierański W, Lisowska G. The prevalence of persistent petrosquamosal sinus and other temporal bone anatomical variations on high-resolution temporal bone computed tomography. *Med Sci Monit* 2016;22:4177–4185
- 15 Ginsberg LE. The posterior condylar canal. *AJNR Am J Neuroradiol* 1994;15(05):969–972
- 16 Forte V, Turner A, Liu P. Objective tinnitus associated with abnormal mastoid emissary vein. *J Otolaryngol* 1989;18(05): 232–235
- 17 Falk D. Evolution of cranial blood drainage in hominids: enlarged occipital/marginal sinuses and emissary foramina. *Am J Phys Anthropol* 1986;70(03):311–324
- 18 Jeevan DS, Anisow P, Jayamohan J. Abnormal venous drainage in syndromic craniosynostosis and the role of CT venography. *Childs Nerv Syst* 2008;24(12):1413–1420
- 19 Tsutsumi S, Ono H, Yasumoto Y. The mastoid emissary vein: an anatomic study with magnetic resonance imaging. *Surg Radiol Anat* 2017;39(04):351–356
- 20 Shah LM, Khaleel ZL, Harnsberger HR, Wiggins RH. Mastoid findings secondary to posterior fossa dural venous sinus thrombosis. *AJR Am J Roentgenol* 2013;201(02):406–411