

This is a provisional PDF only. Copyedited and fully formatted version will be made available soon.



ISSN: 0015-5659

e-ISSN: 1644-3284

Anatomical features of the mastoid segment of the facial canal

Authors: Angela Babuci, Laila Ashkar, Zinovia Zorina, Iliia Catereniuc, Mihail Gavriiliuc, Nicolae Chele, Sofia Lehtman, Gabriela Motelica, Ion Dabija

DOI: 10.5603/fm.100260

Article type: Original article

Submitted: 2024-04-15

Accepted: 2024-05-22

Published online: 2024-05-23

This article has been peer reviewed and published immediately upon acceptance. It is an open access article, which means that it can be downloaded, printed, and distributed freely, provided the work is properly cited.

Articles in "Folia Morphologica" are listed in PubMed.

Anatomical features of the mastoid segment of the facial canal

Angela Babuci et al., Mastoid segment of the facial canal

Angela Babuci¹, Laila Ashkar², Zinovia Zorina¹, Ilia Catereniuc¹, Mihail Gavriiuc³, Nicolae Chele⁴, Sofia Lehtman⁴, Gabriela Motelica⁴, Ion Dabija⁴

¹Department of Anatomy and Clinical Anatomy, *Nicolae Testemitanu* State University of Medicine and Pharmacy, Republic of Moldova

²Faculty of Medicine no. 2, *Nicolae Testemitanu* State University of Medicine and Pharmacy, Republic of Moldova

³Department of Neurology no. 1, *Nicolae Testemitanu* State University of Medicine and Pharmacy, Republic of Moldova

⁴*Arsenie Gutan* Department of Oral and Maxillofacial Surgery and Oral Implantology, *Nicolae Testemitanu* State University of Medicine and Pharmacy, Republic of Moldova

Address for correspondence: Angela Babuci, Department of anatomy and clinical anatomy, *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova Stefan cel Mare si Sfânt Bd., 192, Chisinau, MD-2004, Republic of Moldova, e-mail: angela.babuci@usmf.md, tel. + 373 22 205 349; + 373 22 205 235, fax: +373 22 242 411

ABSTRACT

Background: Considering the tortuous course of the facial canal that houses the facial nerve, the stylomastoid artery and the homonymous vein, its morphological features are of great clinical significance in otologic, maxillofacial, oncologic, reconstructive and plastic surgery of the head and neck. The aim of this paper was to determine the individual specific features of the mastoid segment of facial canal and of the stylomastoid foramen.

Material and methods: The study was carried out on 82 temporal bones (41 right/41 left), at the Department of anatomy and clinical anatomy of *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova. The morphometry of the mastoid segment of the facial canal and of the stylomastoid foramen was performed. The

morphometric parameters were statistically analyzed by descriptive and inferential statistics methods.

Results: The mastoid segment exited the facial canal by an obtuse, right and sharp angles, with a mean value of $113.1 \pm 21.80^\circ$ (right/left – $112.1 \pm 23.85^\circ/114.1 \pm 19.76^\circ$), $p = 0.701$. The mean length of the mastoid segment was 15.1 ± 3.78 mm (right/left – 15.7 ± 3.66 mm/ 14.5 ± 3.84 mm), $p = 0.153$. The longitudinal diameter of the stylomastoid foramen had a mean of 3.0 ± 0.93 mm (right/left – 3.3 ± 0.96 mm/ 2.7 ± 0.81 mm), $p = 0.007$. The transverse diameter had a mean of 2.6 ± 0.74 mm (right/left – 2.9 ± 0.80 mm/ 2.4 ± 0.60 mm), $p = 0.012$.

Conclusions: In otologic surgery and particularly in mastoidectomy, it should be taken into consideration that the mastoid segment of the facial canal could exit the temporal bone by a sharp, right and obtuse angles that along with high morphological variability of the stylomastoid foramen might be a predisposal factor for Bell's palsy.

Keywords: facial canal, facial nerve, anatomical variations, morphometry

INTRODUCTION

The facial nerve is one of the most susceptible cranial nerves to various exogenous and endogenous harmful factors, determined by its anatomical specific features. The facial nerve is the single cranial nerve that passes through a twisted bony canal, within which from its main trunk the greater petrosal nerve, the chorda tympani and the nerve to stapedius muscle derive. Taking into consideration the inestimable functional role of the facial nerve in a human being, both at the physiological and psychological levels, preservation of its functionality is the main aim in head and neck surgery.

Due to a heftier number of otologic surgeries, including mastoidectomy and stapedotomy that is highly efficient in otosclerosis [5], the interest in facial canal morphology has been increasing over the last decades. According to Hohman et al. [11] in mastoidectomy, parotidectomy and replacement of the temporomandibular joint there is a high risk of facial nerve lesions that may result in total hemifacial paresis. In mastoidectomy, along with well-known peculiarities of the mastoid segment, a surgeon should be aware of the variability of the tympanic sinus, that is located in a close vicinity to the mastoid segment of the facial canal [24, 32], increasing the risk of the facial nerve damage.

In acute mastoiditis, thrombosis of the sigmoid and transverse meningeal sinuses may occur, but in severe cases of mastoiditis the epidural and subdural empyema, and abscesses were reported [14]. An abnormality that might cause mastoiditis and otitis media, with

involvement of the facial nerve, is the Körner's septum [26]. In chronic otitis media and cholesteatoma due to the erosive defect of the bony wall, a dehiscence of the facial canal may form [6, 38], which might install a temporary facial nerve palsy in middle ear anesthesia [22]. Both benign and malignant tumors can appear at the level of the stylomastoid foramen, determining its deformation by the involvement of the facial nerve into the tumoral process [10].

In abnormal development of the temporal bone, the facial canal and even the facial nerve might present diverse congenital variants and malformations [23, 28, 37], increasing the risk of the facial nerve iatrogenic injury. The variation of the facial canal was reported by many papers [22, 23, 28, 37]. The most common abnormality of the facial canal is its dehiscence [14, 23, 28], with an incidence of up to 55% [23, 28].

Moreano et al. [22] pointed out that in only 30.7% of cases the facial canal is intact, but in other 69.3% of cases, dehiscences and microdehiscences are present. The authors have specified that dehiscence of the bony wall of the facial canal was more commonly found bilaterally, but microdehiscences had a unilateral prevalence. The dehiscences of the facial canal were revealed at the level of the geniculate ganglion, tympanic segment, oval window, second genu and mastoid segment [7, 33, 38]. The most common site of the facial canal dehiscence was reported to be the level of the oval window with a rate of 74.9% [22], followed by the dehiscence of the tympanic segment, which in cases of cholesteatomas reached a rate of 88.7% [35]. The incidence of the mastoid segment dehiscence varies from 1.6% [22] up to 2.8% [35], but in some studies, it reached a very high rate, up to 11.4%, with a statistically significant difference between the levels of the dehiscence location [7].

The duplication of the facial canal is characteristic to all its segments [12, 23, 28], and in many cases it is accompanied by duplication of the facial nerve [4, 8]. Kalaiarasi et al. [15] established a rate of 4% of the mastoid segment bifurcation. The malformations of the mastoid segment of the facial canal can influence the intratemporal course of the facial nerve, especially in rare abnormalities such as „persisting embryonic artery or vein” [13, p. 271], knowledge of which is of a substantial clinical impact in mastoidectomy and otologic surgery. Persistence of the lateral capital vein and of the embryonic stapedial artery were reported by some researchers [22, 23], and according to Moreano et al. [22], persistence of the stapedial artery has a rate of 0.48%. An anomalous enlargement of the facial canal, caused by presence of a bifurcated vein, which extended from the knee of the facial canal towards the stylomastoid foramen was revealed by Moonis et al. [21]. An uncommon path of the facial nerve within the mastoid segment, which did not open through the stylomastoid foramen, but

continued its course towards the mastoid process, traversing the mastoid antrum floor and subsequently forming a third sharp turn, after which it exited through the apex of the mastoid process was described by Rana et al. [29]. The anomalous course of the facial canal can lead to facial nerve impairments [25].

In clinical aspect, the data related to morphological specific features of the stylomastoid foramen are important for comprehension of the position, topography and variation of the facial nerve trunk. Only a few papers provide information about the anatomical variants of the stylomastoid foramen that can be of various shapes: round, oval, bean shape, triangular, rectangular, square, serrated and irregular [3, 20, 31, 36]. Meng et al. [20] pointed out the practical significance of the stylomastoid foramen in treatment of the parotid gland adenoid cystic carcinoma located at the level of that orifice. According to Vaishali et al. [36], a narrow stylomastoid foramen can correlate with the facial nerve impairments. Singh R. [31] mentioned that rare shapes of the stylomastoid foramen were mainly located unilaterally and the author assumed that uncommon shapes can be a predisposal factor for the development of the unilateral Bell's palsy.

In primary mastoidectomy the iatrogenic injuries of the facial nerve have a rate of 0.6–3.7%, and a twice higher rate of 4.0-10% is characteristic for the revision surgery [15]. Taking into consideration that on the premandibular segment the facial nerve trunk, along with the descending course, might have a horizontal and even an ascending path [1], we supposed that the direction of the facial nerve trunk might be dependent on the mastoid segment exit angle and on the shape of the stylomastoid foramen. Thus, our purpose was to study the individual specific features of the mastoid segment of the facial canal and of the stylomastoid foramen in order to supplement the anatomical knowledge.

MATERIALS AND METHODS

Our research was conducted at the Department of anatomy and clinical anatomy of *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova. A total number of 82 temporal bones (41 right and 41 left), of unknown age and gender, were included in the current study. The mastoid process and the stylomastoid foramen (SMF) of each temporal bone were thoroughly examined. The temporal bones were divided into two groups depending on laterality criterion (right and left), after which the morphometry of the mastoid segment of the facial canal and of the stylomastoid foramen was taken. The morphometric parameters were stored in an Excel 2019 database sheet and were statistically

analyzed using the predefined Excel functions such as CONFIDENCE, STDEV, SKEW and other functions of the descriptive and inferential statistics.

The following morphometric parameters of the mastoid segment and of the stylomastoid foramen were studied: the length of the mastoid segment of the facial canal (mm); the exit angle of the mastoid segment of the facial canal (°); the longitudinal and the transverse diameters of the stylomastoid foramen (mm).

Out of total number of temporal bones, for the measurement of the mastoid segment length only 75 temporal bones were eligible and the exit angle was measured on 73 temporal bones (in three temporal bones, the facial canal was partially or totally dissected, in five cases a double stylomastoid foramen was present and in one case the SMF was multiple). The measurements were taken with a surgical needle and a Vernier caliper. The needle was introduced through the stylomastoid foramen into the mastoid segment until it reached the second flexure of the facial canal, after which it was taken out, and that part of the needle that was inside the mastoid segment was measured by a Vernier caliper. The exit angle of the mastoid segment of the facial canal, represented by the angle formed between the surgical needle located within the mastoid segment and the vertical line traced through the posterior margin of the external acoustic meatus, was measured with a protractor.

Ahead of measurements, the morphological and number variants of the stylomastoid foramen were examined. For the measurement of the longitudinal and transverse diameters of the stylomastoid foramen were eligible 75 temporal bones (the temporal bones with the dissected SMF and those with double orifices were excluded). In cases of multiple stylomastoid foramen, only the parameters of the largest orifice were measured. Twice the same observers took all the measurements.

RESULTS

Under examination and morphometry of the mastoid segment of the facial canal some important morphological features were determined. Considering that the course of the facial nerve trunk on its premandibular segment is turned anteriorly, towards the parotid gland, there was supposed to be found a sharp exit angle of the mastoid segment of the facial canal, but unexpectedly its exit angle was variable (Fig. 1).

Three variants of the mastoid segment exit angle were revealed in the current study: a sharp angle, a right angle and an obtuse one. The sharp angle was determined in 5.3% of cases, the right angle — in 4.0%, and in 90.7% the exit angle of the mastoid segment of the facial canal was obtuse (Fig. 2).

The mean value of the exit angle of the mastoid segment was $113.1 \pm 21.80^\circ$ (max 168° — min 79°), on the right side the mean value was $112.1 \pm 23.85^\circ$ (max 168° — min 79°), and on the left side it was $114.1 \pm 19.76^\circ$ (max 160° — min 90°), $p = 0.701$. The mean length of the mastoid segment was 15.1 ± 3.78 mm (max 25.0 mm — min 5.0 mm). On the right side the mean value of the mastoid segment length was 15.7 ± 3.66 mm (max 23.0 mm — min 5.0 mm) and on the left side it was 14.5 ± 3.84 mm (max 25.0 mm — min 5.0 mm), $p = 0.153$ (Table 1).

Fourteen morphological variants of the stylomastoid foramen were determined. The following variants of shape were distinguished: round orifices, longitudinal and transverse oval shapes, irregular, semilunar, quadrangular, rectangular, triangular and pentagonal ones. On some samples, a partial and total septum were revealed. Along with various shapes, numerical variants of the stylomastoid foramen such as double, pseudo-doubling and multiple stylomastoid foramens were marked out (Fig. 3).

The highest rate of 24.4% was characteristic for the round shape of the stylomastoid foramen. The longitudinal oval shape was present in 23.2% of cases and the transverse oval shape was determined in 11%. Each of the semilunar and irregular shapes had a rate of 7.3%. Both the quadrangular and rectangular variants were marked out in 3.7%, and the triangular shape was determined in 2.4%. The pentagonal shape was present in 1.2%. Partial septum of the stylomastoid foramen was revealed in 3.7% and a total septum in 1.2% of the samples. A double stylomastoid foramen was present in 6.1% and in 3.7% of the cases a pseudo-doubling foramen was determined. The multiple stylomastoid foramen was marked out in 1.2% of cases (Fig. 4).

The transverse diameter of the stylomastoid foramen had a mean value of 2.6 ± 0.74 mm (max 5.0 mm — min 1.5 mm). On the right side, the mean value was 2.9 ± 0.80 mm (max 5.0 mm — min 1.5 mm), and on the left temporal bones, it was 2.4 ± 0.60 mm (max 4.0 mm — min 1.5 mm). A statistically significant difference between the right and left stylomastoid foramens was established, $p = 0.012$. The longitudinal diameter of the stylomastoid foramen had a mean value of 3.0 ± 0.93 mm (max 6.0 mm — min 1.0 mm). On the right temporal bones, the mean was 3.3 ± 0.96 mm (max 6.0 — min 1.5 mm), and on the left ones — 2.7 ± 0.81 mm (max 4.0 mm — min 1.0 mm), with a statistically significant difference, $p = 0.007$ (Table 2).

DISCUSSION

The anatomical features, variants and abnormalities of the facial canal were reported in many scientific papers, according to which in facial canal dehiscence and other variants, the content of the facial canal, especially the facial nerve, is subjected to morphological changes [12, 14, 23, 25, 28, 29, 37].

Jatale et al. [13] stated that the length of the mastoid segment of the facial nerve varied from 12.0–16.0 mm, with a prevalence of cases in which the length was 13.1–14.0 mm (34%). In 24% of the cases, the length of the mastoid segment was 14.1–15.0 mm, in 20% it was 12.0–13.0 mm, in 12% it was 15.1–16.0 mm, and in 10% a length below 12.0 mm was determined.

Li et al. [18] reported a statistically significant difference, $p < 0.05$, of the length of the mastoid segment depending on laterality. In our study, the difference between the length of the right and left mastoid segments was not statistically significant, $p > 0.05$.

Vianna et al. [37] mentioned that in the majority of patients with Bell's palsy, the diameters of the tympanic and mastoid segments differed depending on laterality, but no differences of the labyrinthine segment diameters were determined.

The localization of the stylomastoid foramen is very important in facial nerve block and decompression, in various surgical procedures, including facial nerve repair in iatrogenic and traumatic injury [30, 34].

Ghosh et al. [3] described eight variants of the stylomastoid foramen shape among which were oval, round, serrated, square, rectangular, triangular, bean-shaped and irregular. The most common shapes of the named foramen were the round, oval and square orifices that exceeded 81% of cases, with a higher variation rate on the right side.

Singh R. [31] reported a prevalence of the round and oval stylomastoid foramina, and more rarely triangular orifices were determined, and in a few cases the stylomastoid orifices were located in close vicinity to the styloid process.

According to Ghosh et al. [3] in 45.95% of cases the stylomastoid foramina were associated with extensions. Double stylomastoid foramen was found in 18.2% of cases and in 2.7% orifices „interrupted by bony spur” [3, p. 97] were present.

In the current study, eleven variants of shape of the SMF were revealed, among which the most common were round and oval shapes. On some temporal bones, uncommon shapes of the SMF such as pseudo-doubling and stylomastoid orifices with partial and complete septa were found. Stylomastoid foramina without a clear anterior edge, connected in front to the posterior border of the styloid process were characteristic to some of our samples.

According to data reported by Vaishali et al. [36], the longitudinal diameter of the SMF on the right temporal bones was 2.39 ± 0.18 mm, and the transverse diameter had a mean of 0.85 ± 0.12 mm. On the left temporal bones, the longitudinal diameter of the stylomastoid foramen was 2.18 ± 0.33 mm and the transverse diameter was 1.13 ± 0.38 mm. A statistically significant difference, $p < 0.05$, between the longitudinal and transverse diameters of the right and left stylomastoid foramina was determined, but there was no difference between the right and left side similar diameters of the SMF, $p > 0.05$.

In the performed study, the mean of the longitudinal diameter was 3.0 ± 0.93 mm and the mean value of the transverse diameter was 2.6 ± 0.74 mm. On the right temporal bones, the mean value of the stylomastoid foramen longitudinal diameter was 3.3 ± 0.96 mm and on the left side — 2.7 ± 0.81 mm. The right transverse diameter presented a mean of 2.9 ± 0.80 mm and the left one had a mean of 2.4 ± 0.60 mm.

According to Karaca et al. [16] in patients with Bell's palsy, the affected facial nerve was more superficially located within the facial canal, with a mean depth of 32.9 ± 5.4 mm, compared to mean depth of 36.9 ± 5.1 mm of the healthy nerve and a statistically significant difference between the healthy and affected sides was established, $p = 0.007$.

A range of authors assumed that individual variability and abnormalities of the mastoid segment and of the stylomastoid foramen might have a negative impact on facial nerve, determining the metamorphoses characteristic of Bell's palsy [3, 16, 17, 37].

The etiology of Bell's palsy is still controversial, including „*a frigore*” cases [2], but its pathogenesis is mainly characterized by an inflammatory reaction of the facial nerve, followed by its compression within the facial canal [17]. At the histopathological level in Bell's palsy an injury of the myelin sheath and axons of the facial nerve with edema, compression and Wallerian degeneration occurs [9].

A new approach in examining of Bell's palsy pathogenesis, using the diffusion tensor image on 3.0 T MR, was applied by Qin et al. [27], as a result of which a significant difference of the fractional anisotropy, of the mean and of the radial diffusivity, $p < 0.02$, and no difference of axial diffusivity was determined. Even if the most axons were intact, the authors concluded that Bell's palsy is mainly caused by injury to the myelin sheath of the intratemporal segments of the facial nerve.

The histopathological findings in Bell's palsy are characterized by diffuse infiltration of all the layers of the facial nerve with small, round inflammatory cells that are more prominent in the fibrous sheath of the nerve. The myelin sheath undergoes degeneration containing macrophages with products of myelin breakdown and increased interneuronal spaces,

characteristic for edema [19]. Thus, some authors pointed out that size, shape and rare variants of the mastoid segment and of the stylomastoid foramen could be a predisposal factor for Bell's palsy [3, 16, 17, 31, 37].

Considering the pathogenesis of Bell's palsy and the results of the current study, we suppose that an obtuse exit angle of the mastoid segment in association with the ascending facial nerve trunk [1], which on its outlet from the facial canal turns sharply towards the parotid gland, might be a trigger for Bell's palsy development. The inflammatory reaction of the facial nerve, under specific circumstances such as small size and bizarre shapes of the stylomastoid foramen, particularly in cases of irregular, pseudo-doubling, narrow orifices and those with septa, might cause compression, edema and degeneration of the motor fibers of the facial nerve resulting in Bell's palsy.

CONCLUSIONS

In mastoidectomy and other otologic surgical interventions, it should be taken into consideration that the mastoid segment of the facial canal could exit the temporal bone by a sharp, right and obtuse angles. The exit angle of the mastoid segment was higher on the left side, but the mastoid segment itself was longer on the right side. Fourteen morphological variants of the stylomastoid foramen, including three number variants (double, pseudo-doubling and multiple) were determined. Both diameters of the stylomastoid foramen, the longitudinal and the transverse one, were higher on the right side with a statistically significant difference on the laterality criterion. The variability of the mastoid segment exit angle along with morphological variants of the stylomastoid foramen might be a predisposal factor for Bell's palsy.

Article information and declarations

Data availability statement

The data reported in the article are available, if requested.

Ethics statement

The research project was approved by the Ethics Committee of *Nicolae Testemitanu* State University of Medicine and Pharmacy of the Republic of Moldova and it was conducted in full accordance with the Declaration of Helsinki.

Author contributions

All the authors contributed to the article. The contribution of each author is written in the Author Statement.

Funding

None.

Conflict of interest: No competing interests were involved in this study.

REFERENCES

1. Babuci A, Catereniuc I, Zorina Z, et al. Morphology and variability of the facial nerve trunk depending on the branching pattern, gender, anthropometric type and side of the head in Moldovan population. *Folia Morphol.* 2023; 82(4): 791–797, doi: [10.5603/FM.a2022.0088](https://doi.org/10.5603/FM.a2022.0088), indexed in Pubmed: [36254108](https://pubmed.ncbi.nlm.nih.gov/36254108/).
2. Gavriliuc M. Examenul neurologic. Universitatea De Stat De Medicină Și Farmacie „Nicolae Testemițanu”, Chișinău 2012.
3. Ghosh SK, Narayan RK. Variations in the morphology of stylomastoid foramen: a possible solution to the conundrum of unexplained cases of Bell's palsy. *Folia Morphol.* 2021; 80(1): 97–105, doi: [10.5603/FM.a2020.0019](https://doi.org/10.5603/FM.a2020.0019), indexed in Pubmed: [32073133](https://pubmed.ncbi.nlm.nih.gov/32073133/).
4. Glastonbury CM, Fischbein NJ, Harnsberger HR, et al. Congenital bifurcation of the intratemporal facial nerve. *AJNR Am J Neuroradiol.* 2003; 24(7): 1334–1337, indexed in Pubmed: [12917123](https://pubmed.ncbi.nlm.nih.gov/12917123/).
5. Gong Li, Feng Y, Tang X, et al. Variation of the stapes and its surrounding anatomical structures based on micro-computed tomography. *Folia Morphol.* 2023 [Epub ahead of print], doi: [10.5603/FM.a2023.0056](https://doi.org/10.5603/FM.a2023.0056), indexed in Pubmed: [37622391](https://pubmed.ncbi.nlm.nih.gov/37622391/).
6. Gulotta G, Pace A, Iannella G, et al. Facial nerve dehiscence and cholesteatoma: a comparison between decades. *J Int Adv Otol.* 2020; 16(3): 367–372, doi: [10.5152/iao.2020.8395](https://doi.org/10.5152/iao.2020.8395), indexed in Pubmed: [33136018](https://pubmed.ncbi.nlm.nih.gov/33136018/).
7. Gülüstan F, Aslan H, Songu M, et al. Relationships between facial canal dehiscence and other intraoperative findings in chronic otitis media with cholesteatoma. *Am J*

- Otolaryngol. 2014; 35(6): 791–795, doi: [10.1016/j.amjoto.2014.04.002](https://doi.org/10.1016/j.amjoto.2014.04.002), indexed in Pubmed: [25148712](https://pubmed.ncbi.nlm.nih.gov/25148712/).
8. Hafez M, Ghonim M, Razek AA, et al. Congenital duplication of mastoid segment of facial nerve in child candidate for Cochlear Implantation Surgery: a rare case report. *Minia J Med Res.* 2020; 31(2): 313–316, doi: [10.21608/mjmr.2022.221086](https://doi.org/10.21608/mjmr.2022.221086).
 9. Hervochon R, Madelain V, Seiller I, et al. CT and clinical prognostic factors in Bell's palsy: a study of 56 cases. *Clin Otolaryngol.* 2019; 44(5): 861–864, doi: [10.1111/coa.13392](https://doi.org/10.1111/coa.13392), indexed in Pubmed: [31220409](https://pubmed.ncbi.nlm.nih.gov/31220409/).
 10. Ho ML, Juliano A, Eisenberg RL, et al. Anatomy and pathology of the facial nerve. *AJR Am J Roentgenol.* 2015; 204(6): W612–W619, doi: [10.2214/AJR.14.13444](https://doi.org/10.2214/AJR.14.13444), indexed in Pubmed: [26001250](https://pubmed.ncbi.nlm.nih.gov/26001250/).
 11. Hohman MH, Bhama PK, Hadlock TA. Epidemiology of iatrogenic facial nerve injury: a decade of experience. *Laryngoscope.* 2014; 124(1): 260–265, doi: [10.1002/lary.24117](https://doi.org/10.1002/lary.24117), indexed in Pubmed: [23606475](https://pubmed.ncbi.nlm.nih.gov/23606475/).
 12. Jakkani RK, Ki R, Karnawat A, et al. Congenital duplication of mastoid segment of facial nerve: a rare case report. *Indian J Radiol Imaging.* 2013; 23(1): 35–37, doi: [10.4103/0971-3026.113618](https://doi.org/10.4103/0971-3026.113618), indexed in Pubmed: [23986616](https://pubmed.ncbi.nlm.nih.gov/23986616/).
 13. Jatale SP, Chintale SG, Kirdak VR, et al. Our experience of anatomical variations of facial nerve in cadaveric temporal bone dissection. *Indian J Otolaryngol Head Neck Surg.* 2021; 73(3): 271–275, doi: [10.1007/s12070-020-01969-9](https://doi.org/10.1007/s12070-020-01969-9), indexed in Pubmed: [34471613](https://pubmed.ncbi.nlm.nih.gov/34471613/).
 14. Juliano AF, Ginat DT, Moonis G. Imaging review of the temporal bone: part I. Anatomy and inflammatory and neoplastic processes. *Radiology.* 2013; 269(1): 17–33, doi: [10.1148/radiol.13120733](https://doi.org/10.1148/radiol.13120733), indexed in Pubmed: [24062560](https://pubmed.ncbi.nlm.nih.gov/24062560/).
 15. Kalaiarasi R, Kiran AS, Vijayakumar C, et al. Anatomical features of intratemporal course of facial nerve and its variations. *Cureus.* 2018; 10(8): e3085, doi: [10.7759/cureus.3085](https://doi.org/10.7759/cureus.3085), indexed in Pubmed: [30324041](https://pubmed.ncbi.nlm.nih.gov/30324041/).
 16. Karaca H, Soydan L, Yildiz S, et al. Measurement of the depth of facial nerve at the level of stylomastoid foramen using MR imaging in Bell's palsy. *Clin Imaging.* 2019; 58: 34–38, doi: [10.1016/j.clinimag.2019.06.008](https://doi.org/10.1016/j.clinimag.2019.06.008), indexed in Pubmed: [31228829](https://pubmed.ncbi.nlm.nih.gov/31228829/).

17. Kim J, Jung GH, Park SY, et al. Anatomical consideration of the temporal bone as a pathogenesis of Bell's palsy. *Med Hypotheses*. 2011; 77(5): 705–707, doi: [10.1016/j.mehy.2011.07.017](https://doi.org/10.1016/j.mehy.2011.07.017), indexed in Pubmed: [21864989](https://pubmed.ncbi.nlm.nih.gov/21864989/).
18. Li T, Lai ZC, Wang XuD, et al. Measurement and analysis of facial nerve on fully displayed multislice computed tomographic multiplanar reconstruction image. *J Craniofac Surg*. 2013; 24(4): 1411–1413, doi: [10.1097/SCS.0b013e3182903673](https://doi.org/10.1097/SCS.0b013e3182903673), indexed in Pubmed: [23851820](https://pubmed.ncbi.nlm.nih.gov/23851820/).
19. Liston SL, Kleid MS. Histopathology of Bell's palsy. *Laryngoscope*. 1989; 99(1): 23–26, doi: [10.1288/00005537-198901000-00006](https://doi.org/10.1288/00005537-198901000-00006), indexed in Pubmed: [2642582](https://pubmed.ncbi.nlm.nih.gov/2642582/).
20. Meng FH, Song Yu, Qiao Bo, et al. Image-guided, surgical robot-assisted percutaneous puncture of the foramen ovale and foramina stylomastoideum: a cadaveric study. *Chin Med J (Engl)*. 2021; 134(19): 2362–2364, doi: [10.1097/CM9.0000000000001783](https://doi.org/10.1097/CM9.0000000000001783), indexed in Pubmed: [34593697](https://pubmed.ncbi.nlm.nih.gov/34593697/).
21. Moonis G, Mani K, O'Malley J, et al. A venous cause for facial canal enlargement: multidetector row CT findings and histopathologic correlation. *AJNR Am J Neuroradiol*. 2011; 32(5): E83–E84, doi: [10.3174/ajnr.A2094](https://doi.org/10.3174/ajnr.A2094), indexed in Pubmed: [20395388](https://pubmed.ncbi.nlm.nih.gov/20395388/).
22. Moreano EH, Paparella MM, Zelterman D, et al. Prevalence of facial canal dehiscence and of persistent stapedia artery in the human middle ear: a report of 1000 temporal bones. *Laryngoscope*. 1994; 104(3 Pt 1): 309–320, doi: [10.1288/00005537-199403000-00012](https://doi.org/10.1288/00005537-199403000-00012), indexed in Pubmed: [8127188](https://pubmed.ncbi.nlm.nih.gov/8127188/).
23. Nager GT, Proctor B. Anatomic variations and anomalies involving the facial canal. *Otolaryngol Clin North Am*. 1991; 24(3): 531–553, indexed in Pubmed: [1762775](https://pubmed.ncbi.nlm.nih.gov/1762775/).
24. Nitek S, Wysocki J, Niemczyk K, et al. The anatomy of the tympanic sinus. *Folia Morphol*. 2006; 65(3): 195–199, indexed in Pubmed: [16988915](https://pubmed.ncbi.nlm.nih.gov/16988915/).
25. Ottaiano AC, Gomez GD, Freddi Td. The Facial Nerve: Anatomy and Pathology. *Semin Ultrasound CT MR*. 2023; 44(2): 71–80, doi: [10.1053/j.sult.2022.11.005](https://doi.org/10.1053/j.sult.2022.11.005), indexed in Pubmed: [37055142](https://pubmed.ncbi.nlm.nih.gov/37055142/).

26. Przewoźny TT, Kosiński A, Markiet K, et al. Körner's septum (petrosquamosal lamina): the anatomical variant or clinical problem? *Folia Morphol.* 2020; 79(2): 205–210, doi: [10.5603/FM.a2019.0079](https://doi.org/10.5603/FM.a2019.0079), indexed in Pubmed: [31448811](https://pubmed.ncbi.nlm.nih.gov/31448811/).
27. Qin Yi, Liu J, Zhang X, et al. To explore the pathogenesis of Bell's palsy using diffusion tensor image. *Sci Rep.* 2023; 13(1): 15298, doi: [10.1038/s41598-023-42570-8](https://doi.org/10.1038/s41598-023-42570-8), indexed in Pubmed: [37714930](https://pubmed.ncbi.nlm.nih.gov/37714930/).
28. Somayaji K, Rajeshwary A, Goutham MK. Dehiscent mastoid segment of the facial nerve. *Arch Med Health Sci.* 2018; 6(1): 187, doi: [10.4103/amhs.amhs_56_18](https://doi.org/10.4103/amhs.amhs_56_18).
29. Rana A, Khan M, Parab S. A rare case of aberrant facial nerve course in the mastoid segment. *Pol Otorhino Rev.* 2021; 10(2): 30–33, doi: [10.5604/01.3001.0014.8691](https://doi.org/10.5604/01.3001.0014.8691).
30. Sharma N, Varshney R. Morphometry of stylomastoid foramen and its clinical application in facial nerve block. *Saudi J Anaesth.* 2015; 9(1): 60–63, doi: [10.4103/1658-354X.146314](https://doi.org/10.4103/1658-354X.146314), indexed in Pubmed: [25558201](https://pubmed.ncbi.nlm.nih.gov/25558201/).
31. Singh R. Morphological Study of Stylomastoid Foramen at the Base of Skull and its Role in Facial Nerve Palsy. *J Craniofac Surg.* 2023; 34(5): 1584–1586, doi: [10.1097/SCS.00000000000009355](https://doi.org/10.1097/SCS.00000000000009355), indexed in Pubmed: [37253242](https://pubmed.ncbi.nlm.nih.gov/37253242/).
32. Skrzat J, Kozerska M, Zarzecki M, et al. A micro-computed tomography study of the sinus tympani variation in humans. *Folia Morphol.* 2023; 82(4): 898–908, doi: [10.5603/FM.a2022.0094](https://doi.org/10.5603/FM.a2022.0094), indexed in Pubmed: [36385425](https://pubmed.ncbi.nlm.nih.gov/36385425/).
33. TanrivermiŞ Sayit A, Gunbey HP, Sağlam D, et al. Association between facial nerve second genu angle and facial canal dehiscence in patients with cholesteatoma: evaluation with temporal multidetector computed tomography and surgical findings. *Braz J Otorhinolaryngol.* 2019; 85(3): 365–370, doi: [10.1016/j.bjorl.2018.03.005](https://doi.org/10.1016/j.bjorl.2018.03.005), indexed in Pubmed: [29699880](https://pubmed.ncbi.nlm.nih.gov/29699880/).
34. Tewari S, Gupta C, Palimar V. A morphometric study of stylomastoid foramen with its clinical applications. *J Neurol Surg B Skull Base.* 2022; 83(1): 33–36, doi: [10.1055/s-0040-1716674](https://doi.org/10.1055/s-0040-1716674), indexed in Pubmed: [35155067](https://pubmed.ncbi.nlm.nih.gov/35155067/).
35. Topaloglu I, Yaslikaya S, Berkiten G. Facial canal dehiscence in patients undergoing surgery for chronic otitis media: analysis of 850 patients. *Otolaryngol Pol.* 2022; 77(1): 1–5, doi: [10.5604/01.3001.0016.1772](https://doi.org/10.5604/01.3001.0016.1772), indexed in Pubmed: [36805516](https://pubmed.ncbi.nlm.nih.gov/36805516/).

36. Vaishali B, Mohanraj K. Morphological and morphometric analysis of stylomastoid foramen in dry human skulls and its clinical implications. *J Pharm Res Int.* 2021; 33(60B): 1659–1664, doi: [10.9734/jpri/2021/v33i60b34791](https://doi.org/10.9734/jpri/2021/v33i60b34791).
37. Vianna M, Adams M, Schachern P, et al. Differences in the diameter of facial nerve and facial canal in bell's palsy — a 3-dimensional temporal bone study. *Otol Neurotol.* 2014; 35(3): 514–518, doi: [10.1097/MAO.0000000000000240](https://doi.org/10.1097/MAO.0000000000000240), indexed in Pubmed: [24518410](https://pubmed.ncbi.nlm.nih.gov/24518410/).
38. Yetiser S. The dehiscent facial nerve canal. *Int J Otolaryngol.* 2012; 2012: 679708, doi: [10.1155/2012/679708](https://doi.org/10.1155/2012/679708), indexed in Pubmed: [22518159](https://pubmed.ncbi.nlm.nih.gov/22518159/).

Table 1. The morphometric parameters of the mastoid segment of the facial canal

MSFC		Length of the MSFC	Exit angle of the MSFC
All samples	Number of cases	75	73
	Mean value ± SD	15.1 ± 3.78 mm	113.1 ± 21.80°
	Maximal value	25.0 mm	168°
	Minimal value	5.0 mm	79°
Right side	Mean value ± SD	15.7 ± 3.66 mm	112.1 ± 23.85°
	Maximal value	23.0 mm	168°
	Minimal value	5.0 mm	79°
Left side	Mean value ± SD	14.5 ± 3.84 mm	114.1 ± 19.76°
	Maximal value	25.0 mm	160°
	Minimal value	5.0 mm	90°
Difference		1.3	-0.2
p-value		0.153	0.701
Standard error		0.44	2.55
Dispersion		14.27	475.18
Kurt Excess		1.00	-0.46
Skew Asymmetry		-0.19	0.68
Coefficient of variation [%]		25.03%	19.27%

MSFC — mastoid segment of the facial canal, SD — standard deviation

Table 2. The morphometric parameters of the stylomastoid foramen

Stylomastoid foramen		Transverse diameter of the SMF	Longitudinal diameter of the SMF
	Number of cases	75	75
	Mean value ± SD	2.6 ± 0.74 mm	3.0 ± 0.93 mm

Right side	Maximal value	5.0 mm	6.0 mm
	Minimal value	1.5 mm	1.0 mm
Left side	Mean value \pm SD	2.9 \pm 0.80 mm	3.3 \pm 0.96 mm
	Maximal value	5.0 mm	6.0 mm
	Minimal value	1.5 mm	1.5 mm
Difference	Mean value \pm SD	2.4 \pm 0.60 mm	2.7 \pm 0.81 mm
	Maximal value	4.0 mm	4.0 mm
	Minimal value	1.5 mm	1.0 mm
Difference	0.4	0.6	
p-value	0.012	0.007	
Standard error	0.09	0.11	
Dispersion	0.55	0.87	
Kurt Excess	0.18	0.05	
Skew Asymmetry	0.64	0.23	
Coefficient of variation [%]	27.91%	31.39%	

SMF — stylomastoid foramen, SD — standard deviation.

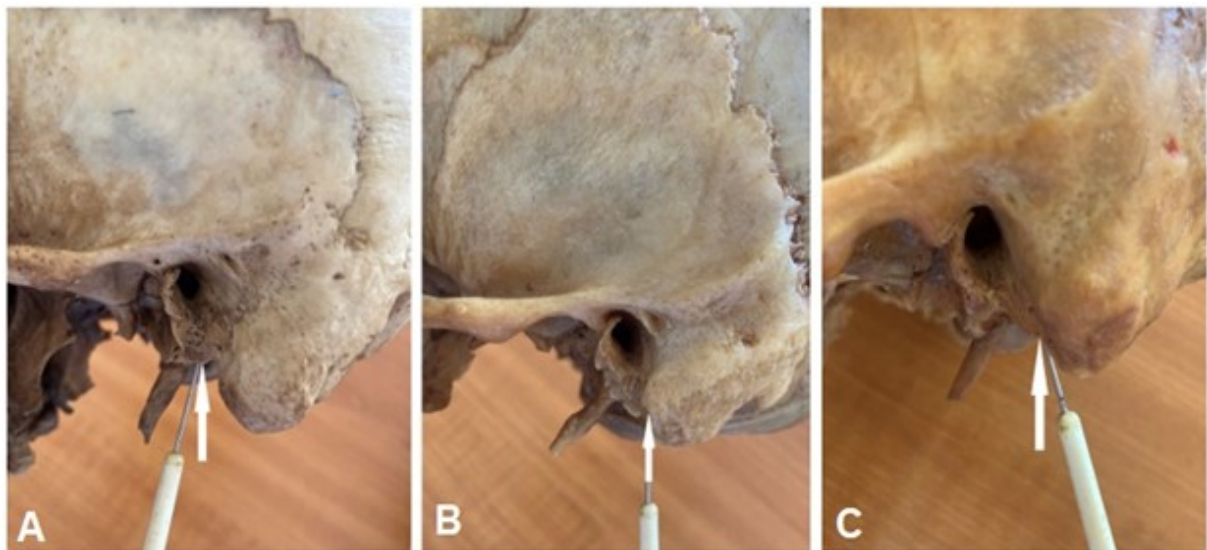


Figure 1. The exit angle of the mastoid segment of the facial canal. **A.** Sharp angle; **B.** Right angle; **C.** Obtuse angle.

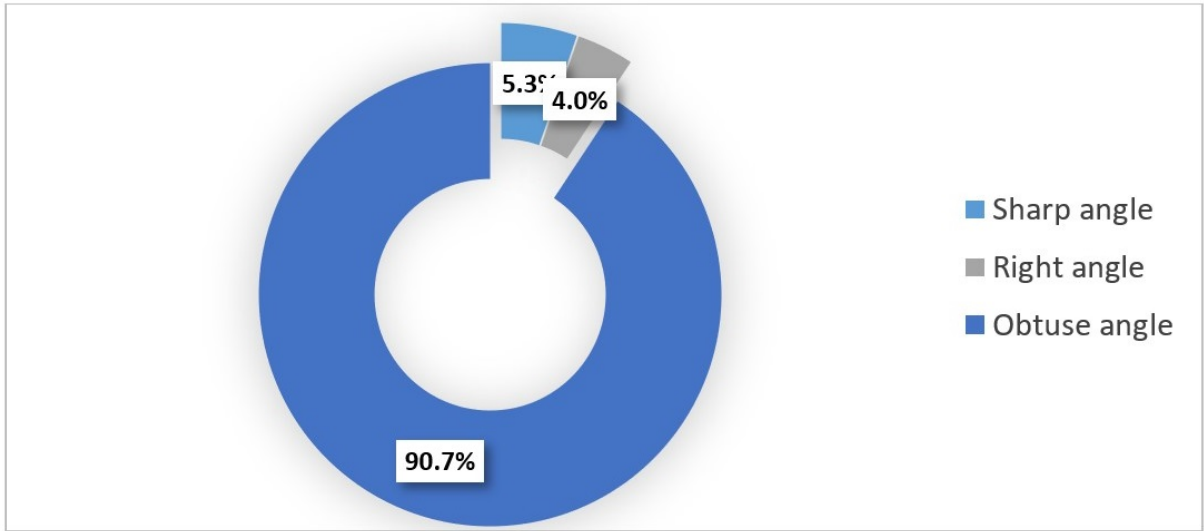


Figure 2. The rate of the exit angle of the mastoid segment

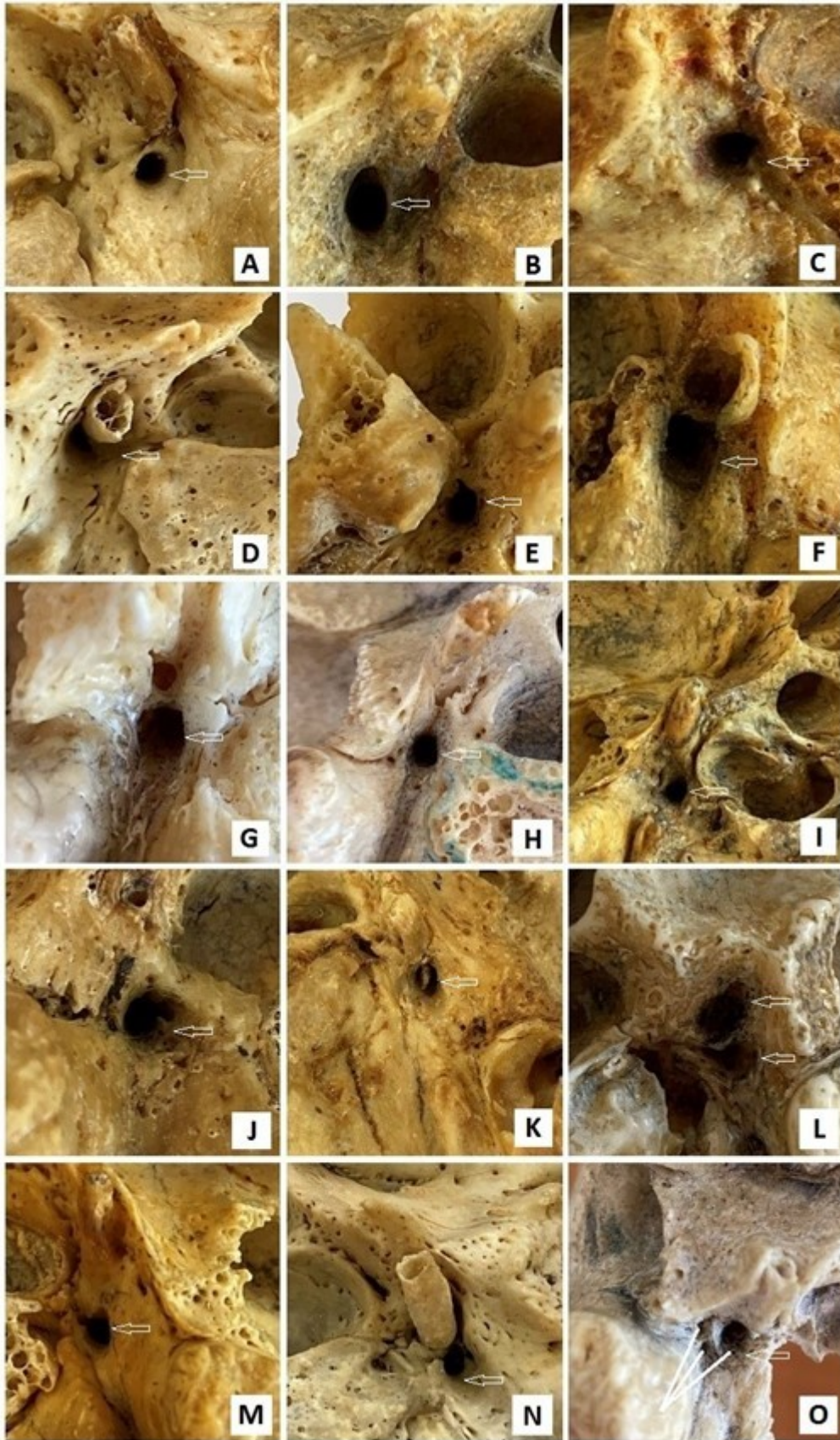


Figure 3. Variants of the stylomastoid foramen. **A.** Round orifice; **B.** Longitudinal oval; **C.** Transverse oval; **D.** Semilunar; **E.** Irregular; **F.** Rectangular; **G.** Quadrangular; **H.** Triangular;

I. Pentagonal; J. Partial septum; K. Total septum; L. Double orifice; M. Pseudo-doubling orifice; N. Pseudo-doubling orifice with a lateral extension around the stylomastoid process; O. Multiple stylomastoid foramen.

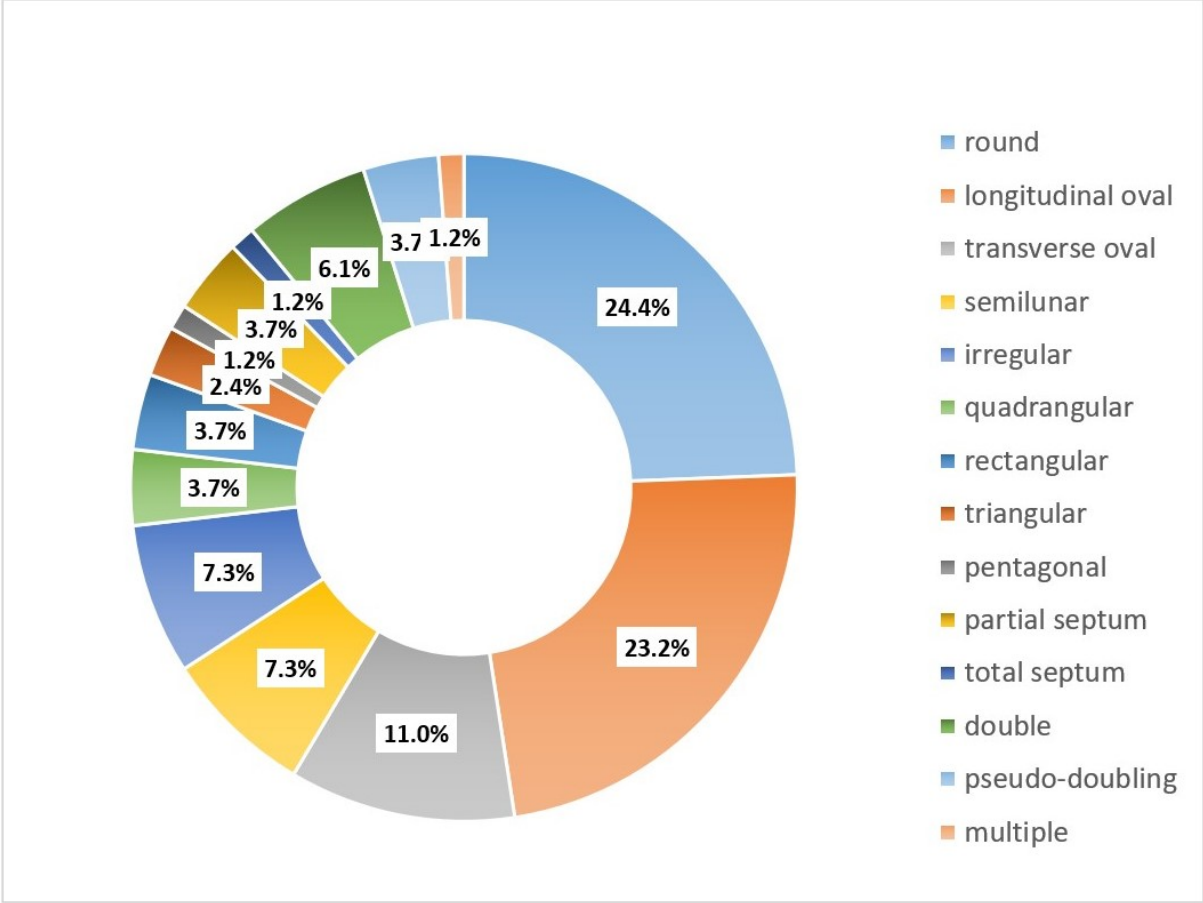


Figure 4. The rate of the stylomastoid foramen variants