Morphological and Morphometric Analysis of Stylomastoid Foramen in Dry Human Skulls and its Clinical Implications

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Authors’ contributions

This work was carried out in collaboration between both authors. Author BV carried out the study by collecting data and drafted the manuscript after performing the necessary statistical analysis and in the preparation of the manuscript. Author KGM aided in conception of the topic, designing the study and supervision of the study, correction and final approval of the manuscript. Both authors read and approved the final manuscript.

ABSTRACT

Introduction: Stylomastoid foramen present between two processes which are styloid process and mastoid process. Facial nerve and stylomastoid arteries are transmitted through the stylomastoid foramen. Facial canal gets terminated in the stylomastoid foramen. Stylomastoid foramen has a site for facial nerve block. Complications reduced by localization of foramen.

Aim: The aim of this study was to analyse the morphology and morphometry of stylomastoid foramen.

Materials and Methods: Damaged skulls were excluded and 60 dry human skulls without any damage were taken for this study. By using digital vernier caliper length and breadth of the stylomastoid foramen was measured. Then the statistical analysis was done using SPSS software and paired t-tests were done for comparison.

Results: The length and breadth of the right stylomastoid foramen was 2.39 ± 0.18 mm and 0.85 ± 0.12 mm and the left stylomastoid foramen was 2.18 ±0.33 mm and 1.13 ± 0.38 mm. From the

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paired t-tests it was very clear that the difference between the breath of right and left stylomastoid foramen was significant (p<0.05) and difference between the length of right and left stylomastoid foramen was not significant (p> 0.05).

**Conclusion:** The narrow size of stylomastoid foramen varied from individual skull to other. The accurate value for length and breadth, was measured to determine the variations of facial nerve emerging through it. The change in length and breadth of stylomastoid foramen can be correlated with its clinical aspects with reference to facial nerve.

**Keywords:** Styloid process; mastoid process; stylomastoid foramen; Facial nerve; base of skull; clinical implications.

1. **INTRODUCTION**

Stylomastoid foramen, a small opening present on the lower surface of the petrous part of the temporal bone [1,2]. This foramen is present between two processes which are the styloid process and the mastoid process [3]. The name stylomastoid foramen derived from Latin name ‘Foramen Stylomastoideum’ [4]. Facial canal which connects the internal auditory meatus to the base of the skull gets terminated in stylomastoid foramen [5]. Facial nerve and stylomastoid arteries are transmitted through the stylomastoid foramen [6]. Through this foramen the main motor position of the facial nerve passes [1]. For facial nerve stylomastoid foramen acts as an exit gateway [7].

The facial nerve trunk blockage is at risk of nerve injury and neurological complications at the position of the facial nerve passes [8]. The facial nerve blockage of stylomastoid foramen is also called a Nadbath block [9]. Complications reduced by localization of foramen [6]. Anatomical variation in stylomastoid foramen leads to nerve injury which is the major risk factor in Bell’s palsy (unilateral facial nerve paralysis) [8].

Bell’s Palsy means inflammation on the facial nerve at the portion where it passes through stylomastoid foramen [10]. Bell's palsy is the compression of a facial nerve in or just outside stylomastoid foramen due to inflammation and oedema of the nerve [11]. Infranuclear lesion of the facial nerve, at the stylomastoid foramen is known as Bell's palsy [12]. Muscles of, upper and lower quarters of the face on the same side get paralysed and loss of facial expression on the affected [13]. The face becomes asymmetrical and is drawn up to the normal side [14]. The affected side is motionless [15]. Result is asymmetry of corner of mouth, inability to close the eye and disappearance of nasolabial fold [16]. Articulation of labials is impaired [17].

In the foetal skull/neonatal skull, stylomastoid foramen is exposed on the lateral surface of the skull because the mastoid portion is flat. Facial nerve -palsy in newborn: The mastoid process is absent in newborn and stylomastoid foramen is superficial. Manipulation of the baby's head during delivery may damage the VII nerve [18]. This leads to paralysis of facial muscles especially the buccinator, required for sucking the milk [19]. Our team has extensive knowledge and research experience that has translated into high quality publications [20–39]. The aim of this study was to analyse morphological and morphometrical measurements of stylomastoid foramen.

2. **MATERIALS AND METHODS**

By excluding the damaged skulls the study settings are done using sixty undamaged dry human skulls in the Department of Anatomy in Saveetha Dental college. By using a digital vernier caliper the length and breath of stylomastoid foramen on both right and left side were measured for all the 60 skulls. Then by using SPSS software mean value was obtained from descriptive statistics and significant value was obtained from paired t-test which was used to compare the means of the right and left sides of the foramina.

2.1 **Statistical Analysis**

From the above measurements mean, std deviation, correlation and significance were calculated. Statistical data analysis was done using SPSS software in which paired t-test was adopted for two indifferent means and p<0.05 was considered as statistically significant (95% Confidence Interval of the difference).

3. **RESULTS**

The minimum and maximum length of right stylomastoid foramen was 1.81mm and 3.16mm
Table 1. Shows the morphometric measurements of right and left stylomastoid foramen. The values are expressed as Mean ± SD

| Parameters       | Minimum | Maximum | Mean    | Std. Deviation |
|------------------|---------|---------|---------|---------------|
| Right length     | 1.81    | 3.16    | 2.3992  | 0.18336       |
| Right breath     | 0.40    | 1.51    | 0.8572  | 0.21664       |
| Left length      | 1.75    | 3.62    | 2.1863  | 0.33258       |
| Left Breath      | 0.50    | 1.98    | 1.1333  | 0.38631       |

Table 2. Shows the Pair 1 correlation of length of right and left stylomastoid foramen. Pair 2 shows the correlation of breadth of right and left stylomastoid foramen. p<0.05 was considered statistically significant

| Parameters       | N  | Correlation | Significance |
|------------------|----|-------------|--------------|
| Pair 1 - Right length & Left length | 60 | 0.171       | 0.190        |
| Pair 2 - Right breath & Left breath  | 60 | 0.279       | 0.031        |

respectively. The minimum and maximum breath of right stylomastoid foramen was 0.40mm and 1.51mm respectively. Minimum and maximum length of left stylomastoid foramen was 1.75mm and 3.62mm. Minimum and maximum breath of left stylomastoid foramen was 1.13mm and 1.98mm (Table 1). The mean length of the right and left stylomastoid foramen is 2.39 ± 0.18 mm and 2.18 ±0.33 mm. The mean breath of the right and left stylomastoid foramen is 0.85 ± 0.12 mm and 1.13 ± 0.38 mm. The paired sample correlation of right length and left length of stylomastoid foramen is 0.17 and the paired sample correlation of right breath and left breath of stylomastoid foramen is 0.27 (Table 2).

Significance value obtained from paired t-test of right and left length of stylomastoid foramen is 0.19 (p>0.05) this shows that the difference between the length is not significant. Significance value obtained from paired t-test of right and left breath of stylomastoid foramen is 0.03 (p<0.05) this shows that the difference between the breath is significant (Table 2).

4. DISCUSSION

In terms of shape stylomastoid foramen were observed to have 8 variations. Round, oval, square are commonly known variants whereas triangular, rectangular, serrated, bean and irregular are rare variants [9]. Wide variations have been observed between the distance from the center of stylomastoid foramen and the styloid process in several studies justifying the racial possibility behind it, this helps to determine the precise location of stylomastoid foramen with respect to various anatomical structures [40]. The distance from the center of stylomastoid foramen to the tip of the mastoid process on both the right and left sides were measured. This measurement will aid neurosurgeons in doing surgeries near the stylomastoid foramen [2].

Previous research done on this topic indicates the variation in shape of the stylomastoid foramen, the precise location of stylomastoid foramen with respect to various anatomical structures and measurement which helps the surgeons in doing surgeries. But in no other research length and breath of stylomastoid foramen were measured so I measured the length and breath of stylomastoid foramen and by using paired t-test we came to know that the difference of right and left breath of stylomastoid foramen is significant (p<0.05). Less sample size seems to be the limitation of the study. Future studies with large sample sizes can be encouraged for more reliable results.

5. CONCLUSION

The parameters of this study are useful for anesthetists to accurately locate the facial nerves because its exit gateway is stylomastoid foramen. This study may also be useful for trunk surgeons to prevent injury by identifying the facial nerves. The narrow size of stylomastoid foramen varied from individual skull to other. The accurate value for length and breadth, was measured to determine the variations of facial nerve emerging through it. The change in length and breadth of stylomastoid foramen can be correlated with its clinical aspects with reference to facial nerve.
CONSENT
It is not applicable.

ETHICAL APPROVAL
It is not applicable.

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COMPETING INTERESTS
Authors have declared that no competing interests exist.

REFERENCES
1. El-Sherbini KB. Injection of prednisolone trimethylacetate in the stylomastoid foramen in bell’s palsy [Internet]. Vol. 10, Rheumatology. 1969:121–9. Available: http://dx.doi.org/10.1093/rheumatology/10.3.121
2. V HRN. Morphometric Analysis of stylomastoid foramen location and its clinical importance [Internet]. Bioscience Biotechnology Research Communications. 2020;13:108–11. Available: http://dx.doi.org/10.21786/bbrc/13.8/120
3. Hermans R. Stylomastoid foramen- Necrotizing external otitis [Internet]. Radiology Intelligent Assistant. Available: http://dx.doi.org/10.5832/m182-1-118-0
4. D’Souza AR, Fenton JE, O’Dwyer TP. Pleomorphic adenoma involving the stylomastoid foramen [Internet]. The Journal of Laryngology & Otology. 2000;114:641–2. Available: http://dx.doi.org/10.1258/0022215001906381
5. Nakamura K, Sakamaki K, Sizuku H, Koike Y. Determining the pathway of the blink reflex through transcutaneous electrical stimulation of the facial nerve over the stylomastoid foramen [Internet]. ORL. 1999;61:350–4. Available: http://dx.doi.org/10.1159/000027698
6. Hampi M, Kachlik D, Kikalova K, Riemer R, Halaj M, Novak V, et al. Mastoid foramen, mastoid emissary vein and clinical implications in neurosurgery. Acta Neurochir. 2018 Jul;160(7):1473–82.
7. Curtin HD, Wolfe P, Snyderman N. The facial nerve between the stylomastoid foramen and the parotid: Computed tomographic imaging [Internet]. Radiology. 1983;149:165–9. Available: http://dx.doi.org/10.1148/radiology.149.1.6611924
8. Ghosh SK, Narayan RK. Variations in the morphology of stylomastoid foramen: A possible solution to the conundrum of unexplained cases of Bell’s palsy [Internet]. Folia Morphologica; 2020. Available: http://dx.doi.org/10.5603/fm.a202.0.0019
9. Kilic C, Kirici Y, Kocaoglu M. Double Facial Nerve Trunk Emerged from the Stylomastoid Foramen and Petrotympanic Fissure: A Case Report [Internet]. Journal of Korean Medical Science. 2010;25:1228. Available: http://dx.doi.org/10.3346/jkms.2010.25.8.1228
10. Karaca H, Soydan L, Yildiz S, Toros SZ. Measurement of the depth of facial nerve at the level of stylomastoid foramen using MR imaging in Bell’s palsy [Internet]. Clinical Imaging. 2019;58:34–8. Available: http://dx.doi.org/10.1016/j.clinimag.2019.06.008
11. Rowe A. Facial nerve palsy audit: referral of facial nerve palsy to specialist care according to NICE Guidelines [Internet]; 2012. Available: http://dx.doi.org/10.26226/morresor.5af5cdae738ab1001baf50df
12. Deweese DD. Facial nerve problems. Including Remarks on Bell’s Palsy [Internet]. The Laryngoscope. 1962;72:693????707.
13. Eviston TJ, Croxson GR, Kennedy PG, Hadlock T, Krishnan AV. Bell's palsy: Aetiology, clinical features and multidisciplinary care. J Neurol Neurosurg Psychiatry. 2015 Dec;86(12):1356-61. DOI: 10.1136/jnnp-2014-309563 Epub 2015 Apr 9. PMID: 25857657.
14. Dhinakaran N, Ent MS, And HOD, Dept of ENT, Madurai Medical College, Madurai. Analytical study of facial nerve injury in traumatic facial nerve palsy [Internet]. International Journal of Advanced Research. 2018;6:487–9. Available: http://dx.doi.org/10.21474/ijar01/6463
15. Filfel ME, Belal T, Abou Elmaaty AA. Bell's palsy: Clinical and neurophysiologic predictors of recovery [Internet]. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery. 2020;56. Available: http://dx.doi.org/10.1186/s41983-020-00171-6

16. Rubin LR. The Paralyzed Face. Mosby Incorporated. 1991;278.

17. Shehata G, El-Tallawy H, Farghaly W, Badry R, Hassan M, Hamed M, et al. Incidence and clinical predictors of outcome of Bell's palsy, Al-Quseir City, Red Sea Governorate, Egypt [Internet]. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery. 2016;53:70. Available: http://dx.doi.org/10.4103/1110-1083.183405

18. Orobello P. Congenital and Acquired Facial Nerve Paralysis in Children [Internet]. Vol. 24, Otolaryngologic Clinics of North America. 1991;647–52. Available: http://dx.doi.org/10.1016/s0030-6665(20)31119-1

19. Krmpotić Nemenić J, Vinter I, Ehrenfreund T, Marusić A. Postnatal changes in the styloid process, vagina processus styloidei, and stylomastoid foramen in relation to the function of muscles originating from the styloid process. Surg Radiol Anat. 2009 Jun;31(5):343–8.

20. Sekar D, Lakshmanan G, Mani P, Biruntha M. Methylation-dependent circulating microRNA 510 in preeclampsia patients. Hypertens Res. 2019 Oct;42(10):1647–8.

21. Princeton B, Santhakumar P, Prathap L. Awareness on Preventive Measures taken by Health Care Professionals Attending COVID-19 Patients among Dental Students. Eur J Dent. 2020 Dec;14(S 01):S105–9.

22. Logeshwari R, Rama Parvathy L. Generating logistic chaotic sequence using geometric pattern to decompose and recombine the pixel values. Multimed Tools Appl. 2020 Aug;79(31-32):22375–88.

23. Johnson J, Lakshmanan G, M B, R M V, Kalimuthu K, Sekar D. Computational identification of MiRNA-7110 from pulmonary arterial hypertension (PAH) ESTs: A new microRNA that links diabetes and PAH. Hypertens Res. 2020 Apr;43(4):360–2.

24. Paramasivam A, Priyadharsini JV, Raghunandhakumar S, Elumalai P. A novel COVID-19 and its effects on cardiovascular disease. Hypertens Res. 2020 Jul;43(7):729–30.

25. Pujari GRS, Subramanian V, Rao SR. Effects of Celastrus paniculatus Willd. and Sida cordifolia Linn. in Kainic Acid Induced Hippocampus Damage in Rats. Ind J Pharm Educ. 2019 Jul;3:53(3):537–44.

26. Rajkumar KV, Lakshmanan G, Sekar D. Identification of miR-802-5p and its involvement in type 2 diabetes mellitus. World J Diabetes. 2020 Dec 15;11(12):567–71.

27. Ravisankar R, Jayaprakash P, Eswaran P, Mohanraj K, Vinitha G, Pichumani M. Synthesis, growth, optical and third-order nonlinear optical properties of glycine sodium nitrate single crystal for photonic device applications. J Mater Sci: Mater Electron. 2020 Oct;31(20):17320–31.

28. Wu S, Rajeshkumar S, Madasamy M, Mahendran V. Green synthesis of copper nanoparticles using Cissus vitiginea and its antioxidant and antibacterial activity against urinary tract infection pathogens. Artif Cells Nanomed Biotechnol. 2020 Dec;48(1):1153–8.

29. Vikneshan M, Saravanakumar R, Mangaiyarkarasi R, Rajeshkumar S, Samuel SR, Suganya M, et al. Algal biomass as a source for novel oral nano-antimicrobial agent. Saudi J Biol Sci. 2020 Dec;27(12):3753–8.

30. Alharbi KS, Fuloria NK, Fuloria S, Rahman SB, Al-Malki WH, Javed Shaikh MA, et al. Nuclear factor-kappa B and its role in inflammatory lung disease. Chem Biol Interact. 2021 Aug 25;345:109568.

31. Rao SK, Kalai Priya A, Manjunath Kamath S, Karthick P, Renganathan B, Anuraj S, et al. Unequivocal evidence of enhanced room temperature sensing properties of clad modified Nd doped mullite Bi2Fe4O9 in fiber optic gas sensor [Internet]. Journal of Alloys and Compounds. 2020;838:155603. Available: http://dx.doi.org/10.1016/j.jallcom.2020.155603

32. Bhavikatti SK, Karobari MI, Zainuddin SLA, Marya A, Nadaf SJ, Sawant VJ, et al. Investigating the antioxidant and cytocompatibility of mimusops elengi linn extract over human gingival fibroblast cells. Int J Environ Res Public Health [Internet]. 2021 Jul 4;18(13). Available: http://dx.doi.org/10.3390/ijerph18131762

33. Marya A, Karobari MI, Selvaraj S, Adil AH,
Assiry AA, Rabaan AA, et al. Risk perception of SARS-CoV-2 infection and implementation of various protective measures by dentists across various countries. Int J Environ Res Public Health [Internet]. 2021 May 29;18(11). Available: http://dx.doi.org/10.3390/ijerph18115848

34. Barma MD, Muthupandiyan I, Samuel SR, Amaechi BT. Inhibition of Streptococcus mutans, antioxidant property and cytotoxicity of novel nano-zinc oxide varnish. Arch Oral Biol. 2021 Jun;126:105132.

35. Vijayashree Priyadharsini J. In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens. J Periodontol. 2019 Dec;90(12):1441–8.

36. Priyadharsini JV, Vijayashree Priyadharsini J, Smiline Girija AS, Paramasivam A. In silico analysis of virulence genes in an emerging dental pathogen A. baumannii and related species [Internet]. Archives of Oral Biology. 2018;94:93–8.

Available: http://dx.doi.org/10.1016/j.archoralbio.2018.07.001

37. Uma Maheswari TN, Niveditha MS, Ramani P. Expression profile of salivary micro RNA-21 and 31 in oral potentially malignant disorders. Braz Oral Res. 2020 Feb 10;34:e002.

38. Gudipaneni RK, Alam MK, Patil SR, Karobari MI. Measurement of the Maximum Occlusal Bite Force and its Relation to the Caries Spectrum of First Permanent Molars in Early Permanent Dentition. J Clin Pediatr Dent. 2020 Dec 1;44(6):423–8.

39. Chaturvedula BB, Muthukrishnan A, Bhuvaraghan A, Sandler J, Thiruvenkatachari B. Dens invaginatus: A review and orthodontic implications. Br Dent J. 2021 Mar;230(6):345–50.

40. Tewari S, Gupta C, Palimar V. A morphometric study of stylomastoid foramen with its clinical applications [Internet]. Journal of Neurological Surgery Part B: Skull Base; 2020. Available: http://dx.doi.org/10.1055/s-0040-1716674