ORIGINAL RESEARCH

Determination of location of mandibular foramen of Sri Lankans with reference to nearer anatomic landmarks by using dry mandibles

K M Chandimal[1], K M W W Priyadarshani[1], D A S S Kumara[1], Amila Wickramarathna[1]

[1] *Department of Anatomy, Faculty of Medicine, Wayamba University of Sri Lanka*

Abstract

Objective: The mandibular foramen serves as a reference point in the inferior alveolar nerve block and is at risk in some maxillofacial surgeries. Therefore, it is crucial to localize the position of the mandibular foramen. Worldwide many studies have been conducted regarding this but in Sri Lanka, there aren't any recorded studies. The objective of this study was to determine the location of the mandibular foramen with reference to nearer anatomical landmarks of the Sri Lankans according to gender.

Methods: A total of 20 dry mandibles collected from the Department of Anatomy, Faculty of Medicine, Wayamba University Sri Lanka were included in this study. The distances from the mandibular foramen to 8 bony landmarks were measured using the digital vernier caliper. The data were analyzed using SPSS 23.0 Version. The mean distances were calculated and compared according to gender using the independent samples t-test. The differences in mean measurements between the right and left sides of the mandibles were compared according to gender using the paired samples t-test.

Results: There was a significant difference between male and female mandibles in mean distances from the posterior border of the mandibular ramus on the left side, and from the angle of the mandible bilaterally. There was no statistically significant difference between any of the measurements of the right and left sides of the male mandibles, but there was a statistically significant difference in some of the measurements between the right and left sides of the female mandibles. Out of the 40 mandibular foramina observed, there was only one accessory mandibular foramen.

Conclusions: According to the study it was proven that there's a difference in the location of mandibular foramen according to gender. The location of the mandibular foramen in the Sri Lankan population was different from the documented locations of the mandibular foramen of various populations around the globe.

Keywords: Mandible of foramen, Dry mandible, Morphometric analysis, Sri Lanka

DOI: https://doi.org/10.4038/slaj.v8i1.198

Sri Lanka Anatomy Journal 2024; 8(I): 55–63

Corresponding author
KM Chandimal
E-mail: kmchandimal@wyb.ac.lk

https://orcid.org/0009-0001-9470-5129

Introduction

A bony hole that forms the inner side of the mandibular ramus is called the mandibular foramen. It is situated immediately inferior to the mandibular notch. Its canal descends from its starting point inferior to the mandibular notch and ends slightly superior to the mandibular angle. The canal will bend in the direction of the anterior chin area at the point above the mandibular angle. The canal will proceed and terminate at the mental foramen, situated somewhat to the lateral side of the anterior chin region, after making this bend. The inferior alveolar artery a branch of the maxillary artery, inferior alveolar vein and the inferior alveolar branch of the trigeminal nerve are located in the mandibular foramen (1).

The mandibular foramen may have different s hapes depending on its content. The mandibular foramen opening can have a circular or even V shape in some individuals (2,3). The inferior alveolar nerve and artery influence the position, thickness, and length of the mandibular foramen (2,3) The age of an individual also affects the position of the mandibular foramen. It is situated at the more superior part of the ramus of the mandible in adults. On the other hand, in children, the mandibular foramen is situated lower in the ramus of the mandible (4). There may be an additional foramen closer to the mandibular foramen in certain circumstances. This is referred to as accessory mandibular foramen (5,6). This is very crucial in clinical practice as the accessory foramen contains a branch of the inferior alveolar nerve. The gross anatomy knowledge of the mandibular foramen is essential for dental and jaw surgery. To prevent unintended challenges, it is crucial to understand that the inferior alveolar nerve and vessels are housed in the mandibular foramen. For instance, when a third molar tooth is implanted or extracted, as well as lower jaw surgery the inferior alveolar nerve may sustain damage (11,12).

The clinical importance of the mandibular foramen comes into play for nerve blocks. The inferior alveolar nerve is commonly a target for blocking during dental procedures.(14,15) The location of the inferior alveolar nerve block is usually before it enters the mandibular foramen. The landmarks for the inferior alveolar nerve block are the pterygomandibular raphe and the coronoid notch (7). The local anesthetic is usually injected between these two structures to successfully numb the sensory territory of the inferior alveolar nerve. In nerve blocking of the inferior alveolar nerve, the clinician should account for the age of the patient due to the location variation of the nerve in adults and children (4). Also, it is important to account for the possible variations, such as multiple number of inferior alveolar nerve branches. The precise location of mandibular foramen plays a pivotal role which ensures a proper and successful nerve block that would anesthetize the entire region innervated by the inferior alveolar nerve.

It was reported that the location of mandibular foramen varies with gender, age, and with respect to population groups (2,3). There are no reported studies on location of mandibular foramen in Sri Lankans. Thus, this study aimed to determine the location of the mandibular foramen with respect to several bony

landmarks nearer to the mandibular foramen. Predetermination of precise localization of mandibular foramen in Sri Lankan adult population will minimize the complications that may arise in dental and jaw surgery.

Methods

The present study has been designed to locate the mandibular foremen from several nearer bony landmarks of male and female dry mandibles of Sri Lankans. The dry mandibles were collected from the Department of Anatomy, Faculty of Medicine, Wayamba University of Sri Lanka for the study. The fragmented mandibles and mandibles with abnormal morphologies were excluded from the study. A total of 20 mandibles were included in this study. The gender of the selected mandibles for the study was determined by assessing the morphological characteristics of the mandibles such as degree of alveolar resorptions and the attrition patterns of molar teeth reported by Williams et al., 2000. The age of each mandible was determined by following the methods described by Williams et al., 2000. The distance from the several bony landmarks (anatomical loci) to mandibular foramen (Figure 1) were measured using a digital vernier caliper.

All the measurements were taken thrice and the mean value of each distance of each mandible were taken, and mean value was taken for the analysis. The mean value of each measurement was taken for male and female mandibles separately to generate minimum distance from respective bony landmarks to the mandibular foramen. In addition, the presence of accessory mandibular foramina was also observed.

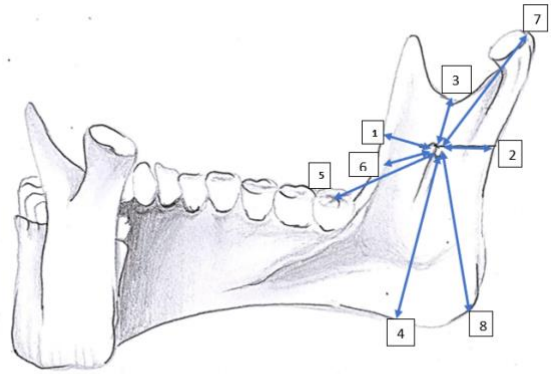

Figure 1: Mandibular foramen and bony landmarks
1. Anterior border of the ramus-MF, 2. Posterior border of the ramus-MF, 3. Mandibular notch-MF, 4. Base of the mandible-MF, 5. The third molar tooth-MF, 6. Apex of retromolar trigone-MF, 7. Mandibular condyle-MF, 8. Angle of the mandible-MF

Results

Forty mandibular foramina were observed in the 20 mandibles included in this study. According to the morphology, there were 11 male mandibles and 9 female mandibles. In terms of the degree of alveolar resorptions and the attrition pattern of their teeth, their ages varied from sixty to eighty. One left sided accessory mandibular foramen was observed in this study. It was the proportionately represented population (2.5%).

The data were analyzed using SPSS 23.0 version. The mean distance + standard deviation of mandibular foramina to various locations described in the methodology were calculated (Table 1 and 2).

Table 1: **Mean distance to the mandibular foramen from different anatomical locations (Right side) among gender**

Different anatomical loci from the mandibular foramen	Right side mean ± sd (mm)		P value
	Male	Female	
Anterior border of the ramus	17.69±2.46	16.54±2.39	P=0.305
Posterior border of the ramus	13.51±1.08	11.88±2.47	P=0.062
Mandibular notch	22.69±3.85	21.69±0.80	P=0.457
The base of the mandible	27.68±2.75	26.99±1.37	P=0.502
The third molar	27.74±4.56	28.34±3.69	P=0.754
Apex of retromolar trigone	14.99±2.13	14.47±1.73	P=0.567
Mandibular condyle	41.66±2.88	41.85±2.16	P=0.871
The angle of the mandible	24.48±2.72	19.92±3.13	P=0.003

Table 2: Mean distance to the mandibular foramen from different anatomical locations (Left side) among gender

Different loci from the mandibular foramen	Left side mean± sd (mm)		P Value
	Male	Female	
Anterior border of the ramus	17.96±1.52	16.38±2.28	P=0.078
Posterior border of the ramus	13.83±1.03	12.56±1.42	P=0.034
Mandibular notch	22.53±4.25	20.58±1.93	P=0.221
The base of the mandible	27.60±3.15	27.21±1.48	P=0.734
The third molar	27.61±4.86	27.83±3.42	P=0.911
Apex of retromolar trigone	14.53±2.66	14.15±1.53	P=0.704
Mandibular condyle	41.05±2.71	40.56±2.13	P=0.663
The angle of the mandible	24.50±3.31	20.24±1.73	P=0.003

The mean values of the measurements of male and female mandibles were compared using the independent sample t-test. The measurements of the right and left sides of males and females were compared separately using the paired samples t-test.

There were differences in the mean measurements between the male and female mandibles. Male values were higher than female values for the mean distance from the anterior border of the ramus, the posterior border of the ramus, the mandibular notch, the base of the mandible, the apex of the retromolar trigone, and the angle of the mandible to the mandibular foramen on both sides. The mean distances from the mandibular condyles on both sides and from the third molar on the left side to the mandibular foramen were greater in females than in males.

There was a significant difference ($p<0.05$) between male and female mandibles in mean distances from the posterior border of the mandibular ramus on the left side, and from the angle of the mandible bilaterally.

There was no statistically significant difference between any of the measurements of the right and left sides of the male mandibles. However, there was a statistically significant difference ($P<0.05$) between the distance from the mandibular notch and the mandibular condyle on the right and left sides of the female mandibles.

Discussion

Knowledge on the precise location of the mandibular foramen is important for various mandibular surgeries, including dental surgeries and general surgeries to the area such as vertical ramus osteotomy, inverted L osteotomy, and esthetic surgeries for dentofacial deformities. These procedures pose a higher risk to the inferior alveolar nerve. Additionally, the knowledge of the mandibular foramen location can assist in accurately performing a sagittal split of the mandibular ramus (20).

The present study examined the morphometrical characteristics of Sri Lankan male and female mandibles, specifically focusing on the distance of the mandibular foramen from various anatomical locations highlighted in Figure 1. In terms of the comparison between male and female mandibles, it was observed that male distance values were generally higher than female values for most measurements.

The results of this study were compared with the values obtained in number of previous studies form different populations to locate the mandibular foramen. A Turkish study by Oguz and Bozkir showed comparatively high distance to the posterior border of the ramus (14.09 mm on the right, and 14.37 mm on the left), comparatively low distance to the angle of the mandible (16.9 mm on the right and 16.78 mm on the left low), and approximately similar distance to the mandibular notch (22.37 mm on the right and 22.17 mm on the left) (21).

In contrast a Brazilian study by Ennes and Medeiros showed comparatively low distance to anterior border of the ramus (13.9mm in right side 14.3mm in left side), to the angle of the mandible angle of the mandible (13.18mm in right side and 13.1mm in left side) and to the posterior border of the ramus 10.6 mm in right side and 11.1 mm in left side (22).

In contrast to our results where there was statistically significant difference ($P<0.05$) between the distance from the mandibular notch and the mandibular condyle on the right and left sides of the female mandibles a Brazilian study by Prado et al. showed non statistically significant difference in left and right-side distance to mandibular notch and the mandibular condyle on the right and left sides. However, some of their findings were compatible with our results where the distance to anterior and posterior borders of the ramus showed no statistically significant difference (23).

In this study the mean distances from the anterior border of the ramus, posterior border of the ramus, mandibular notch, base of the mandible, apex of the retromolar trigone, and angle of the mandible to the mandibular foramen were all higher in male mandibles. On the other hand, the mean distances from the mandibular condyles on both sides and the third molar on the left side to the mandibular foramen were greater in female mandibles. These findings are compatible with two recent studies done on Turkish and Jordan populations (24,25).

To further investigate the differences between male and female mandibles, the mean values of the distance measurements were compared using the independent sample t-test. This analysis revealed a significant difference ($p<0.05$) between male and female mandibles in the mean distances from the posterior border of the mandibular ramus on the left side and from the angle of the mandible bilaterally.

Furthermore, the measurements of the right and left sides of male and female mandibles were compared separately using the paired samples t-test. The results indicated no statistically significant difference between any of the measurements of the right and left sides of male mandibles. However, for female mandibles, there was a statistically significant difference ($P<0.05$) between the distance from the mandibular notch and the mandibular condyle on the right and left sides.

According to research by Kilarkaje et al., the mandibular foramen exhibits bilateral symmetry in dry mandibles at all ages. But we could not observe bilateral symmetry of mandibular foramen from different mandibular ramus landmarks in females (26). The presence of accessory mandibular foramina (AMF) is an anatomical variation that can have implications for dental and surgical procedures. In this study, we observed a single left-sided accessory mandibular foramen, representing 2.5% of the studied population. A comparison of our findings with those reported in similar studies from diverse geographical regions, such as Brazil, Iran, and India, reveals notable variations in the prevalence and laterality of AMFs. The Brazilian study reported relatively higher frequencies of AMFs, with 27.93% and 43.24% of mandibles

presenting at least one mandibular accessory foramina (27).

On the other hand, the Iranian study reported a high frequency of AMFs, with a mean frequency of 88% in males and 80% in females (28). In contrast, the Indian study reported a prevalence of 12% on the right side and 4% on the left side of the mandible, showing a lower frequency of AMFs in the Indian population compared to the other studies mentioned (29).

In conclusion, the variations in the different morphometric distances to the mandibular foramen and the prevalence of AMFs and across different populations highlights the significance of considering population-specific anatomical variations in clinical practice. This study on Sri Lankan mandibles has provided valuable insights into the morphological characteristics and distances of the mandibular foramen from different anatomical landmarks. The results have shown significant differences between male and female mandibles, with male values generally being higher for most measurements. Overall, this knowledge can aid in the accurate performance of mandibular surgeries, ultimately improving patient outcomes.

References

1. Williams, P.L., Bannister, L.H., Berry, M.M., Collins, P., Dyson, M., Dussak, J.E., Ferguson, M.W.J. Gray's Anatomy: Skeletal System, 38th edition. 1995.
2. Al-Shayyab MH, Qabba'ah K, Alsoleihat F, Baqain ZH. Age and gender variations in the cone-beam computed tomographic location of mandibular canal. Implications for mandibular sagittal split osteotomy. Med Oral Patol Oral Cir Bucal. 2019; 01;24(4):e545-e554.
3. Friedrich RE, Matschke J, Wilczak W. Unilaterally Enlarged Mandibular Foramina and Canal Associated With Hyperplastic Lymphatic Tissue of Inferior Alveolar Nerve: Case Report and Short Literature Survey. Anticancer Res. 2019; 39(8):3991-4002.
4. TJ, Hsu SC, Huang QF, Guo MK. Age changes in location of mandibular foramen. Zhonghua Ya Yi Xue Hui Za Zhi. 1990; 9(3):98-103.
5. Predoiu M, Rusu MC, Chiriţă AL. A rare anatomic variation: Triple mental foramina. Morphologie. 2019; 103(341 Pt 2):110-115.
6. Lam M, Koong C, Kruger E, Tennant M. Prevalence of Accessory Mental Foramina: A Study of 4,000 CBCT Scans. Clin Anat. 2019; 32(8):1048-1052.
7. K, Kannan R, Kumar NS, Rethish E, Sabitha S, Sayeeganesh N. Significance of localization of mandibular foramen in an inferior alveolar nerve block. J Nat Sci Biol Med. 2012; 3(2):156-60.
8. Subramanian B, Anthony SN, Mubbunu L, Hachombwa C, Mlawa MS, Majambo MM, Sasi RM. Anthropometrics Analysis of Mental Foramen and Accessory Mental Foramen in Zambian Adult Human Mandibles. ScientificWorldJournal. 2019; 2019:9093474.
9. Kalabalik F, Aytuğar E. Localization of the Mandibular Canal in a Turkish Population: a

Retrospective Cone-Beam Computed Tomography Study. J Oral Maxillofac Res. 2019; 10(2):e2.

10. Costa ED, Peyneau PD, Visconti MA, Devito KL, Ambrosano GMB, Verner FS. Double mandibular canal and triple mental foramina: detection of multiple anatomical variations in a single patient. Gen Dent. 201; 67(5):46-49.

11. Qi W, Lei J, Liu YN, Li JN, Pan J, Yu GY. Evaluating the risk of post-extraction inferior alveolar nerve injury through the relative position of the lower third molar root and inferior alveolar canal. Int J Oral Maxillofac Surg. 2019; 48(12):1577-1583.

12. Kang F, Sah MK, Fei G. Determining the risk relationship associated with inferior alveolar nerve injury following removal of mandibular third molar teeth: A systematic review. J Stomatol Oral Maxillofac Surg. 2020; 121(1):63-69.

13. Shen H, Wang S, Zhi Y, Si J, Shi J. Effects of inferior alveolar nerve rupture on bone remodeling of the mandible: A preliminary study. Medicine (Baltimore). 2019; 98(35):e16897.

14. Kommineni M, Kuchimanchi PK, Koneru G, Sanikommu S. A Simplified Single-Penetration Technique of IANB (MK Technique) for Mandibular Anesthesia. J Maxillofac Oral Surg. 2019; 18(3):459-465.

15. Kojima Y, Murouchi T, Akiba M, Oka T. Ultrasound-guided inferior alveolar nerve block for postoperative analgesia after mandibular sequestrectomy: A single-center retrospective study. J Clin Anesth. 2020; 60:39-40.

16. Soares AL, Simon S, Gebrim LH, Nazário ACP, Lazaretti-Castro M. Prevalence and risk factors of medication-related osteonecrosis of the jaw in osteoporotic and breast cancer patients: a cross-sectional study. Support Care Cancer. 2020; 28(5):2265-2271.

17. Brijs K, Miclotte I, Vermeire S, Darche V, Politis C. Osteonecrosis of the jaw in patients with inflammatory bowel disease treated with tumour necrosis factor alpha inhibitors. Int J Oral Maxillofac Surg. 2020; 49(3):317-324.

18. Fujita M, Hirokawa Y, Naito K, Tagashira N, Yajin K, Wada T. Recurrent lower gingival squamous cell carcinoma spreading along the pathway of the inferior alveolar nerve. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995; 80(3):369-75.

19. A, Goh BS, Rajaran JR, Nazimi AJ. Numb chin syndrome: an ominous sign of mandibular metastasis. BMJ Case Rep. 2018; 2018 doi:10.1136/bcr-2017-223586

20. Daw Jr JL, de la Paz MG, Aitken ME, Patel PK. The Mandibular Foramen: An Anatomic Study and Its Relevance to the Sagittal Ramus Osteotomy. Journal of Craniofacial Surgery. 1999; 10(6):475-9.

21. Oguz O, Bozkir MG. Evaluation of location of mandibular and mental foramina in dry, young, adult human male, dentulous mandibles. The West Indian Medical Journal. 2002; 51(1):14-6.

22. Ennes JP, Medeiros RM. Localization of mandibular foramen and clinical implications. International Journal of Morphology. 2009; 27(4). doi:10.4067/s0717-95022009000400053

23. Prado FB, Groppo FC, Volpato MC, Caria PH. Morphological changes in the position of the mandibular foramen in dentate and edentate Brazilian subjects. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the British Association of Clinical Anatomists. 2010; 23(4):394-8.

24. Direk F, Uysal II, Kivrak AS, Dogan NU, Fazliogullari Z, Karabulut AK. Reevaluation of mandibular morphometry according to age, gender, and side. Journal of Craniofacial Surgery. 2018; 29(4):1054-9.

25. -Shamout R, Ammoush M, Alrbata R, Al-Habahbah A. Age and gender differences in gonial angle, ramus height and bigonial width in dentate subjects. Pakistan Oral & Dental Journal. 2012; 32(1).

26. Kilarkaje N, Nayak SR, Narayan P, Prabhu LV. The location of the mandibular foramen maintains absolute bilateral symmetry in mandibles of different age-groups. Hong Kong Dent J. 2005; 2:35-7.

27. Freire AR, Rossi AC, Prado FB, Caria PH, Botacin PR. Incidence of the mandibular accessory foramina in Brazilian population. Journal of Morphological Sciences. 2017 ,16;29(3):0.

28. Vahdani N, Ghobadi F, Bijani A, Haghanifar S. Prevalence of mandibular accessory foramina using CBCT in a selected iranian population. Caspian Journal of Dental Research. 2019; 8(1):31-6.

29. Asdullah M, Ansari AA, Khan MH, Salati NA, Khawja KJ, Sachdev AS. Morphological variations of lingula and prevalence of accessory mandibular foramina in mandibles: A study. National journal of maxillofacial surgery. 2018; 9(2):129.