J. Maxillofac. Oral Surg. (July–Sept 2019) 18(3):452–458
https://doi.org/10.1007/s12663-018-1167-3

ORIGINAL ARTICLE

Assessment of the Inferior Alveolar Nerve Canal Course Among Saudis by Cone Beam Computed Tomography (Pilot Study)

Shereen M. Shokry[1] · Sarah A. Alshaib[1] · Zahra Z. Al Mohaimeed[1] · Farah Ghanimah[1] · Malak M. Altyebe[1] · Mada A. Alenezi[1] · Fai Shadd[1] · Safa Z. Aldali[1] · May M. Alotaibi[1]

Received: 4 January 2018 / Accepted: 10 October 2018 / Published online: 17 October 2018

Abstract

Background The aim of this study was to identify the relative position and course of the inferior alveolar canal (IAC) in relation to the apices of the teeth in Saudi dentate subjects. Measurements were taken using cone beam computed tomography (CBCT).

Patient and Methods In this cross-sectional retrospective study, 124 cases were selected from the archived images in "Galileos" CBCT machine in Riyadh Colleges of Dentistry and Pharmacy. The sample included both males and females with their ages ranging from 15 to 61 years. The distance between the apices of the teeth from the first premolar till the second molar was measured. Also, the distance between the buccal and lingual alveolar plates and the inferior alveolar canal and the distance from the inferior border of the mandible to the alveolar canal were assessed utilizing the cross-sectional images.

Results The buccolingual linear measurements indicated a lingual course of the canal in both males and females. A significant difference existed between males and females regarding the vertical distance inferior to the IAC at first premolar on the right and left sides, On the right side in females the linear distance was (9.2 mm ± 1.03), and in males (10.9 mm ± 1.5), while on the left side in females the distance was (8.9 mm ± 1.7), while in males (11.3 mm ± 0.34). In 57% of the study group the mental foramen was found between the first and second premolars, while in 35% of the studied cases it was located below the second premolar.

Conclusion The inferior alveolar canal acquires a lingual course in this selected sample of the Saudi population detected by cone beam computed tomography.

Keywords Cone beam volumetric computed tomography · Mandibular canal course · Mental foramen

Abbreviations

IAC	Inferior alveolar canal
CBCT	Cone beam computed tomography
MC	Mandibular canal
V3	Mandibular division of trigeminal nerve
MF	Mental foramen
MM	Mandibular molar
RCsDP	Riyadh Colleges of Dentistry and Pharmacy

✉ Shereen M. Shokry
Shereen.shokry@georgebrown.ca

Sarah A. Alshaib
sara.a.alshaeb@student.riyadh.edu.sa

Zahra Z. Al Mohaimeed
zahra.z.almohaimeed@student.riyadh.edu.sa

Farah Ghanimah
farah.a.ghanimah@student.riyadh.edu.sa

Malak M. Altyebe
mlak.m.alotebe@student.riyadh.edu.sa

Mada A. Alenezi
Mada.a.al.enezi@student.riyadh.edu.sa

Fai Shadd
Fai.s.almajdi@student.riyadh.edu.sa

Safa Z. Aldali
safa.z.aldali@student.riyadh.edu.sa

May M. Alotaibi
may.m.alotaibi@student.riyadh.edu.sa

[1] Riyadh College of Dentistry and Pharmacy (RCsDP), 3866 Skyview, St., P.O. Box: L5M 8A1, Mississauga, ON, Canada

Introduction

The inferior alveolar canal (IAC) or the mandibular canal (MC) is an important osseous structure located in the mandible that permits the passage of the neurovascular bundle including the inferior alveolar nerve (IAN) and the mandibular division of the trigeminal nerve (V3). The (IAC) begins at the mandibular foramen in the middle third of the ascending ramus and ends in the mental foramen (MF) usually below the apex of the second premolar or between the first and second premolars [1].

Better understanding of the intrabony anatomy of the (IAC) and its relationship to mandibular molar (MM) anatomic landmarks, particularly with emphasis on the tooth, may aid to decrease the risk of inadvertent (IAN) injury associated with various surgical interventions in the area including sagittal split osteotomies or placement of fixation screws [2].

Periapical and panoramic radiographs are two-dimensional, conventional imaging techniques that have been used for the evaluation of surgical sites for the localization of critical anatomic structures [3, 4].

The main drawbacks of these imaging techniques are superimposition of overlying anatomy, distortion and magnification, the presence of acquisition and processing artifacts and lack of information in the third dimension [5].

Cone beam computed tomography (CBCT) is an excellent preoperative diagnostic tool for visualization of the (MC) and the collection of accurate measurements. CBCT allows the three-dimensional reconstruction of maxillofacial structures overcoming all limitations of two-dimensional imaging [6].

Aim

Owing to the absence of such (IAC) studies from this part of the world, this preliminary study was performed. The aim of this study was to identify the relative position of the inferior alveolar canal in relation to the apices of the teeth and its course variability in dentate Saudi subjects.

Materials and Methods

One hundred twenty-four cone beam computed tomographic (CBCT) images were randomly selected from saved cases in the Department of Oral Radiology, Riyadh Colleges of Dentistry and Pharmacy (RCsDP). From these cases 56 patients were males and 68 were females. Their ages range from 15 to 61 years. Ages were further classified into 4 groups from 15–25, 26–35, 36–45 to 46–61 years.

All patients were Saudi patients with full set of dentition excluding the third molar. The exclusion criteria included radiographs with one or more missing teeth, deeply impacted third molar, large pathological lesion or an obvious surgical procedure that could affect the course of the canal. The study was approved by the ethical committee of (RCsDP) under the number FIRP/2014/108.

All images were taken by the same trained personnel on the same machine. Images were obtained by Sirona, Galileos CBCT 3D Digital Imaging System, at 85 kV, 5–7 mA and 14 s, Germany. Images were displayed on a 3–9-in. LCD monitor with 1280 × 1024-pixel resolution.

The exact location of (IAN) was identified by utilizing the cross-sectional view where the following measurements in millimeter were taken, as shown in Figs. 1(1A, 1B) and 2.

Kappa value between observers was 0.98 for measured values. All the data were analyzed using descriptive analysis, ANOVA and Chi-square through SPSS software version 20.

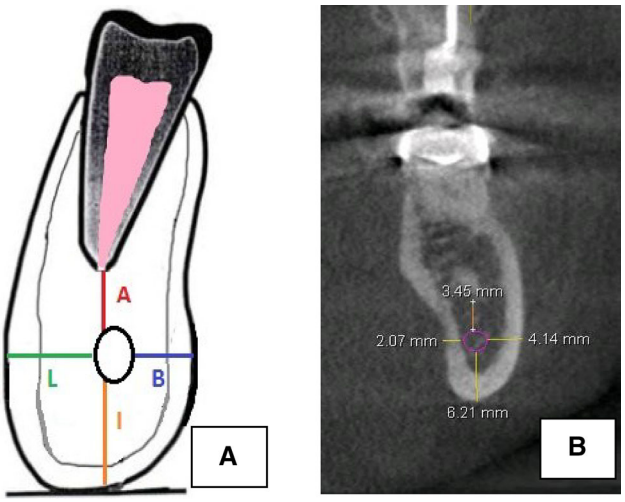

Fig. 1 (1A) Schematic diagram of various linear measurement parameters modified from Balaji et al. [6], where (A): distance between the root apex to the superior surface of IAN canal; (B): outer cortex of the buccal side to outer buccal surface of (IAN) canal; (L): outer cortex of the lingual side to outer lingual surface of (IAN) canal; and (D): outer cortex of the inferior side to outer inferior surface of (IAN) canal. (1B) Cross-sectional view, showing the measured distances using Galileos, Sirona software

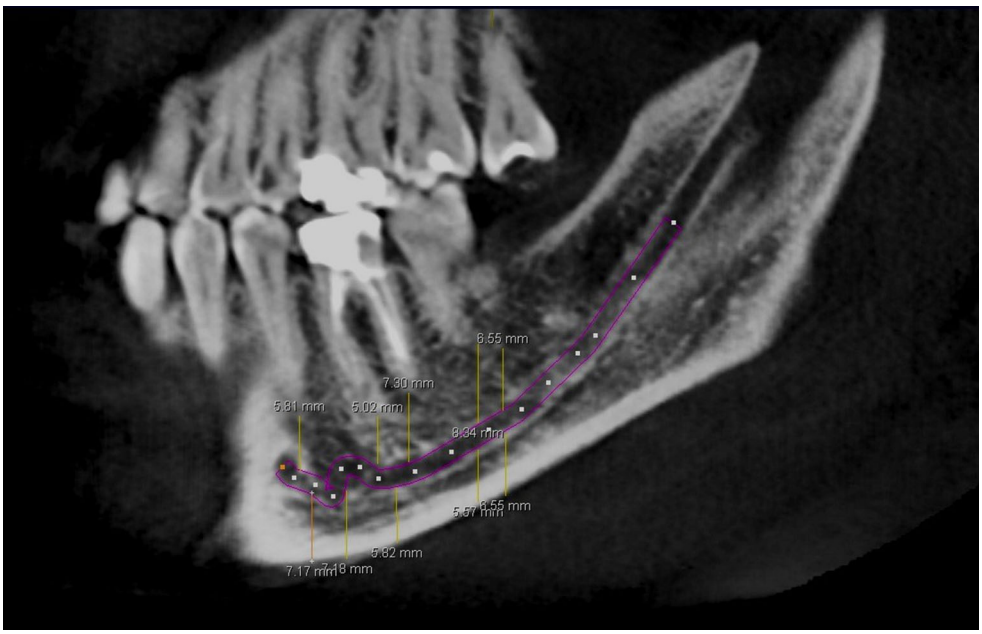

Fig. 2 A tangential view demonstrating all measured distances

Results

Regarding the apical position of the canal in relation to second molar, first molar, second premolar and first premolar, it was found that the closest apical distance to the IAC was related to the distal root of the second molar, while the farthest location is below the apex of the first premolar. The closest to the buccal cortex was the relation of the IAC and the first and second premolar. On the other hand, the farthest inferior distance was in relation to the first and second premolars, as represented in Fig. 3.

The IAC was located more lingually in the mandibles of Saudi males and in females. In males there was not any significant difference between the right side and the left sides of the jaws regarding the course of the IAC at $p < 0.05$. On the other hand, in females there was a significant difference in the course of the IAC between the right and left side of the mandible in relation to the first molar's mesial and distal roots at $p = 0.04$ and $p = 0.001$, respectively. The IAC tended to shift more lingually on the right side of the jaw at the mesial root (2.9 mm ± 1.5) than the same root on the left side of the jaw (3.6 mm ± 1.41)

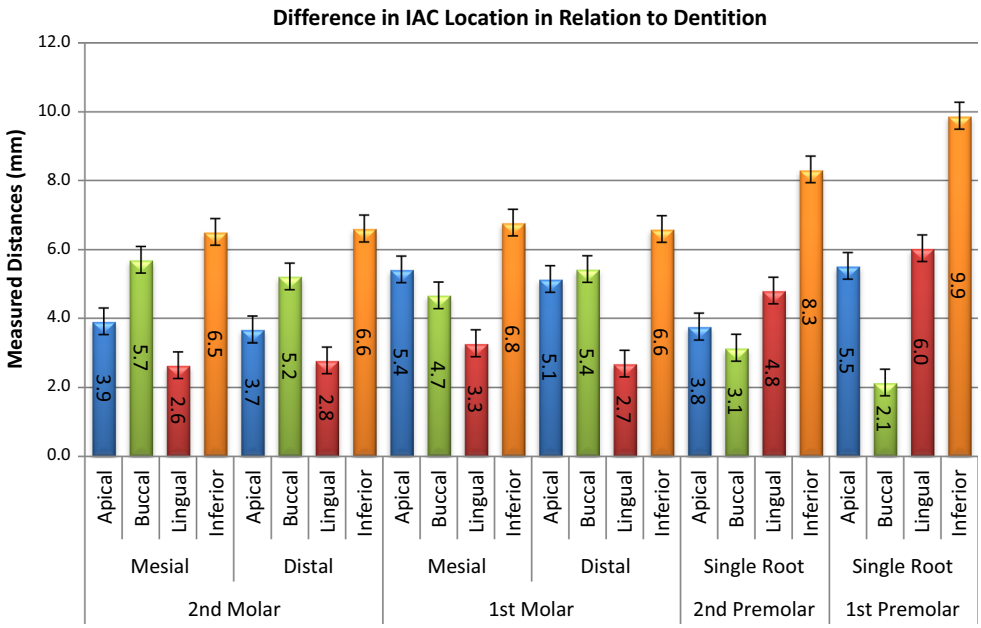

Fig. 3 The correlations between different measured variable in relation to first premolar, second premolar, first molar and second molar

and at the distal root (2.2 mm ± 1.5) on the right side than on the left side (2.9 mm ± 1.3).

A significant relation existed on the left side of the mandible ($p = 0.04$) at the mesial root of the first molar buccally, where in males (5.2 mm ± 1.6), while in females (4.2 mm ± 1.4). Moreover, a significant difference existed between males and females regarding the vertical distance inferior to the IAC at first premolar on the right and left sides at ($p = 0.01$). On the right side in females the linear distance was (9.2 mm ± 1.03), and in males (10.9 mm ± 1.5), while on the left side in females the distance was (8.9 mm ± 1.7), while in males (11.3 mm ± 0.34) (Figs. 3, 4, 5).

In the relationship between different age categories and different measured variables, a significant relation ($p = 0.02$) was found between ages 36–45 and ages 46–61 regarding the buccal aspect of the distal root of the second molar where mean distances were (5.4 mm ± 1.5) and (6.02 mm ± 1.7), respectively. Moreover, a significant correlation was found ($p = 0.02$) regarding the lingual aspect of the mesial root of the first molar between ages 15–25 and ages 36–45 where means of measured distances were (3.7 mm ± 1.7) and (2.7 mm ± 1.2), respectively. Regarding the distribution of different mental foramen location among Saudis, see Figs. 6, 7, 8.

The distribution of mental foramen location in relation to gender is shown in Fig. 6.

Discussion

The inferior alveolar canal (IAC) shows variety of patterns in its course both in vertical and in buccolingual dimension, resulting in an increased incidence of unintentional injury to IAN (inferior alveolar nerve) during treatment procedures like implant placement and mandibular osteotomy. This makes the **k**nowledge of the anatomy of the mandibular canal and its related structures crucial [7] where according to Gerlach et al. [8] IAC damage may cause sensory deficits up to 8.3%.

Cone beam computed tomography (CBCT), a relatively new imaging modality in dentistry, produces high-resolution, superimposition-free, artifact-free, non-magnified and undistorted 3D images of the maxillofacial anatomy that can be reformatted in any desired plane for interactive viewing and image manipulation [9].

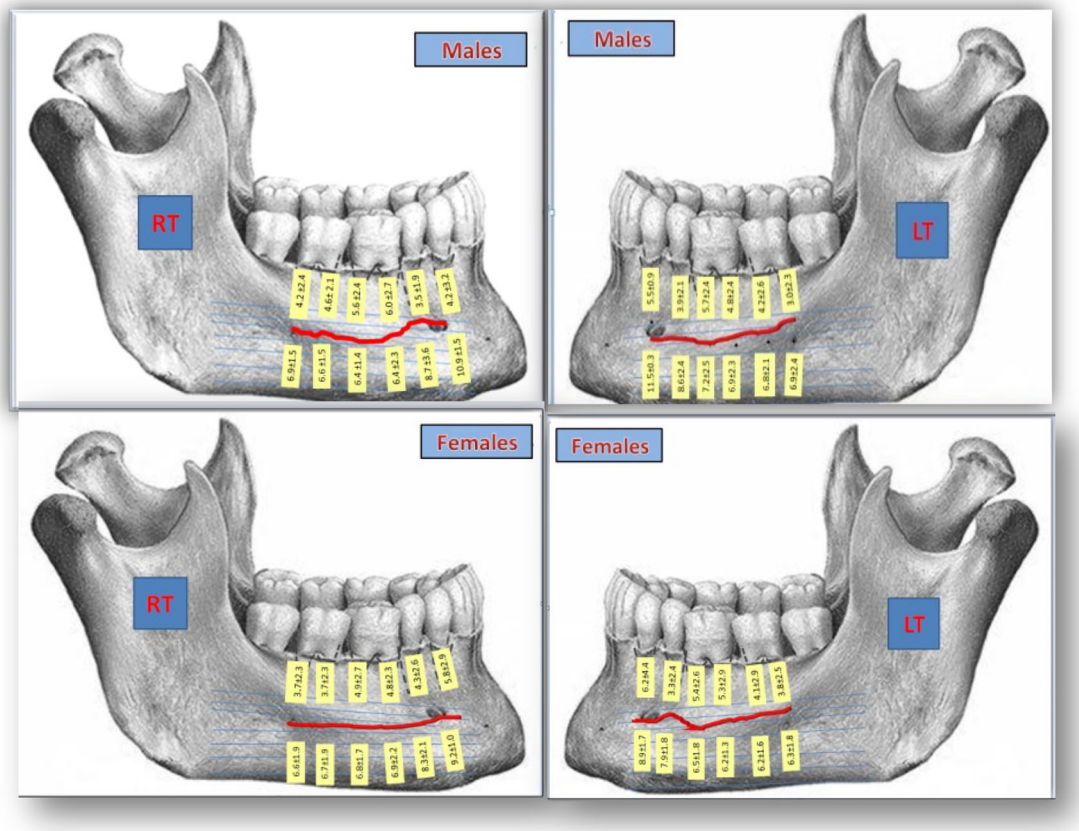

Fig. 4 Schematic presentation of the course of the IAC in both right and left sides of the jaw in males and females in apical to dentition

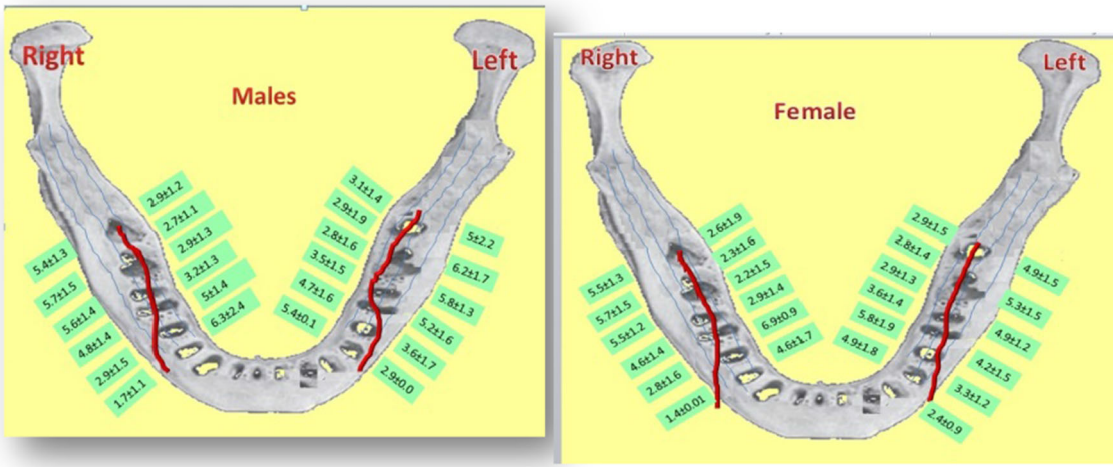

Fig. 5 Schematic presentation of the course of the IAC in both right and left sides of the jaw in males and females in buccolingual relation to dentition

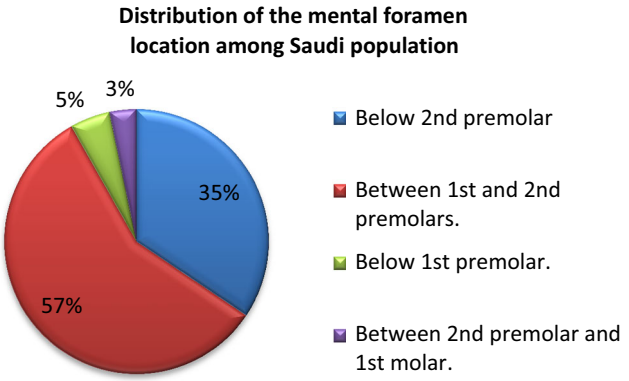

Fig. 6 The distribution of mental foramen location among Saudi population

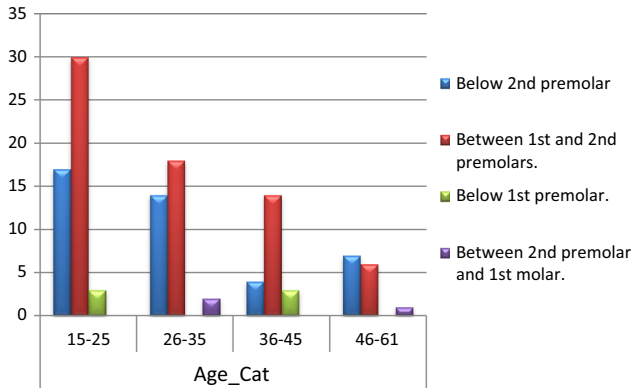

Fig. 7 The distribution of different mental foramen locations among different age categories

In this study the course of the IAC in Saudi population was studied using CBCT imaging, where it was found that the linear distance from the buccal cortical plate to the IAC

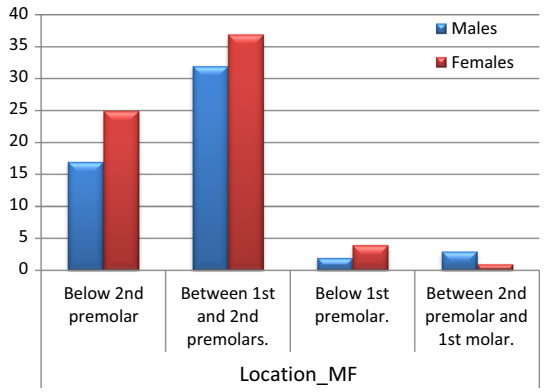

Fig. 8 The frequency of different mental foramen locations in relation to gender

is more than the linear distance from the lingual cortical plate to the IAC, indicating a lingual course of the canal.

This finding is consistent with the finding of Tae et al. [10], where they found that alveolar canal followed the lingual cortical plate at the mandibular body and ramus. This type of buccolingual course was considered favorable in implant placement without causing any damage to inferior alveolar canal.

Moreover, it was also found that the closest distance was related to the mesial root of the second molar, while the farthest lingual distance was related to the first premolar region due to tendency of the inferior alveolar nerve to emerge through the mental foramen. This finding was confirmed by the findings of other investigators who dissected the mandibles of cadavers [11].

The closest apical distance was related to the apex of the distal root of the second molar with mean apical distance 3.7 mm. This finding is similar to the finding of Abdullah,

2008, in his study where he found that the closest apical distance was related to the apices of the distal and mesial roots of the second molar, but with lesser mean apical distances (2.3 mm) for the distal root [12].

Regarding the inferior distance from the inferior border of the mandible to the IAC, the highest vertical distance was related to the first premolar due to the ascending course of the canal in this region toward the mental foramen.

Comparing between the different studied parameters in relation to gender, it was found that no significant difference was found in males between the right and the left sides of the jaw, while in females a significant difference existed between the right and left sides, where the canal had a more lingual course on the right side of the mandible below the first molar than the left side. This finding is related to previous findings where the right and left halves are not entirely symmetrical. The right halves value is noted to be always higher than the left values which is consistent with reports from the literature [13]. On the other hand, when comparing between males and females, there was a significant increase in the buccal distance in relation to the mesial root of the first molar in males more than in females. Also, there was a significant increase in the vertical distance in males at the first premolar region than in females, which may be attributed to increase in the overall vertical dimension in the mandible in males more than in females.

When comparing different age categories to measured parameters, there was a significant difference between 36–45 years and 46–61 years in the area of the distal root of second molar buccally where the distance increased by age, shifting the canal more lingually by age. At the same time the lingual distance increases in relation to the mesial root of first molar in the age 15–25 than 36–45 year.

The location of the mental foramen varies from being between the first and second premolars, which constituted 57% of the population, or below the second premolar constituting 35% of the population. This finding is contrary to the finding of Ngeow et al. [14] in his study indicating the most common position for the MF was in line with the longitudinal axis of the second premolar (69.2%) followed by a location between the first and second premolar (19.6%).

When relating the location to gender prevalence, it was found that females surpass males in the prevalence of the two common locations, while males surpass the females in the location between the second premolar and first molar.

Regarding different age categories, the common location in different age categories is between the first and second premolars, while the location below the second premolar is more prevalent in the oldest age category between 46 and 61 age categories.

Conclusion

The identification of the location of the IAC using CBCT is crucial for avoidance of IAC injury during implant placement or other surgeries such as sagittal split osteotomy. According to the current study of a sample of the Saudi population, it was found that the linear distance from the buccal cortical plate to the IAC is more than the linear distance from the lingual cortical plate to the IAC, indicating a lingual course of the canal.

The location of the mental foramen varies from being between the first and second premolars, which constituted 57% of the population, or below the second premolar constituting 35% of the population.

Acknowledgements All authors like to thank all radiology technicians working in the department of oral maxillofacial radiology for their kind assistance and cooperation.

Authors' Contributions SS planned the research idea, selected cases, wrote the manuscript and performed the statistical analysis, while SAS, Z ZAM, FG, MMA, MAA, FS, SZA, M.M.A all worked in the practical part of the research as they performed all the required measurements. This research was a requirement for the study group graduation. Furthermore, M.M. A travelled from Riyadh City to Makkah City to present the article in the form of a poster in the 12th International Dental Conference in Makkah, Saudi Arabia, 2015. The poster was awarded the best poster award. All authors read and approved the final manuscript.

Funding This research is self-funded and did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics Approval and Consent to Participate The study was approved by the ethical committee of (RCsDP) under the number FIRP/2014/108.

References

1. Pria CM, Masood F, Beckerley JM, Carson RE (2011) Study of the inferior alveolar canal and mental foramen on digital panoramic images. J Contemp Dent Pract 12(4):265–271
2. Juodzbalys G, Wang H, Sabalys G (2010) Mandibular vital structures. Part I: mandibular canal and inferior alveolar neurovascular bundle in relation with dental implantology. J Maxillofac Res 1(1):e2 p1
3. Simonton JD, Azevedo B, Schindler WG, Hargreaves KM (2009) Age- and gender-related differences in the position of the inferior alveolar nerve by using cone beam computed tomography. J Endod 35:944–949
4. Nair UP, Yazdi MH, Nayar GM, Parry H, Katkar RA, Nair MK (2013) Configuration of the inferior alveolar canal as detected by cone beam computed tomography. J Conserv Dent 16(6):518–521

5. Huumonen S, Kvist T, Gröndahl K, Molander A (2006) Diagnostic value of computed tomography in re-treatment of root fillings in maxillary molars. Int Endod J 39:827–833
6. Balaji SM, krishnaswamy NR, Kumar SM, Rooban T (2014) Anatomy of inferior alveolar nerve canal position among south Indians: a cone beam computed tomographic pilot study. Ann Maxillofac Surg 25:51–55
7. Littner MM, Kaffe I, Tames A, Dicapua P (1986) Relationship between the apices of the lower molars and mandibular canal a radiographic study. Oral Surg Oral Med Oral Pathol 62(50):595–602
8. Gerlach NL, Meijer GJ, Mall TJ, Mulder J, Rangel FA, Borstlap WA et al (2010) Reproducibility of 3 different tracing methods based on cone beam computed tomography in determining the anatomical position of the mandibular canal. J Oral Maxillofac Surg 68:811–817
9. Patel S, Dawood A, Ford TP, Whaites E (2007) The potential applications of cone beam computed tomography in the management of endodontic problems. Int Endod J 40:818–830
10. Tae K, Kyung Seok H, Wu Ched S, Minpkyu K, Hu-Jin K (2009) Location of the mandibular canal and the topography of its neurovascular structures. J Craniofac Surg 20:936–939
11. Denio D, Torabinejad M, Bakland LK (1992) Anatomical relationship of the mandibular canal to its surrounding structures in mature mandibles. J Endod 18:161–165
12. Abdullah AG (2008) Relationship of inferior alveolar canal to the apices of lower molar teeth Radiographically. Tikrit Med J 14(1):124–126
13. Humphries SM (2007) Comparison of cortical bone thickness between second premolars and first molars in the maxilla and mandible in four ethnic groups. Dissertation submitted to the Faculty of the Graduate School University of Southern California for the Degree MASTER OF SCIENCE (Craniofacial Biology), pp 57–58
14. Ngeow WC, Dionysius DD, Ishak H, Nambiar P (2009) A radiographic study on the visualization of the anterior loop in dentate subjects of different age groups. J Oral Sci 51:231–237