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ORIGINAL ARTICLE

Determination of the position of mental foramen and frequency of anterior loop in Saudi population. A retrospective CBCT study

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Abstract *Objectives:* To determine the position of mental foramen (MF) and frequency of anterior loop (AL) using dental cone beam computed tomography (CBCT).

Materials and methods: The study involved the evaluation of 302 CBCT scans (196 males, 106 females). The position of MF was determined with respect to adjacent teeth, nearest root apex of adjacent teeth and mandibular borders. MF position was also assessed based on gender and age. In addition, prevalence of anterior loop was evaluated by categorizing the inferior alveolar canal (IAC) patterns into linear, perpendicular and anterior looping.

Results: The study revealed that the most common position of MF was below the apex of 2nd premolar accounting for a total of 52.8% of scans whereas, only 29.6% observed MF between 1st and 2nd premolar ($p > 0.05$). 38.7% of MF were located at a distance of 1–3 mm from the nearest root apex (2nd premolar), followed by a distance of less than 1 mm in 17.05 of cases. 63.2% of foramen on left side of the mandible were observed below the apex of 2nd premolar in females ($p = 0.023$). Statistically significant findings were observed with regards to position of MF in different age groups ($p < 0.05$). The most common IAC pattern observed was linear in nature which accounted for 46.2% of cases followed by perpendicular pattern (38.6%). AL was found only in 15.2% of cases.

Conclusions: Our sample population most commonly exhibited MF below the apex of 2nd premolar with linear IAC pattern. AL was regarded as the least common pattern in Saudi population.

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1. Introduction

Mental foramen (MF) is defined as a funnel-like opening of the mental canal onto the lateral surface of mandible (Phillips et al., 1990). The portion of inferior alveolar nerve present anteriorly to the mental foramen, prior to exiting the canal is

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referred to as the anterior loop (AL) of the inferior alveolar nerve (Apostolakis and Brown, 2012). Other patterns observed in addition to AL are categorized as straight (linear) and perpendicular (Iyengar et al., 2013). MF and AL are considered to be essential anatomical landmarks for the facilitation of giving local anesthesia, making incisions, implant placement, performing peri-apical surgeries and carrying out osteotomies in the region of MF (Greenstein and Tarnow, 2006; Von Arx et al., 2013). The evaluation of the position of MF and AL, if present, is clinically relevant for avoiding iatrogenic injury to the nerve. Mental nerve injury can lead to sensory dysfunction of lower lip or surrounding skin and mucosa (Greenstein and Tarnow, 2006; Ritter et al., 2012). Various studies have reported temporary and permanent sensory disturbances of peri-oral soft tissue after placement of mandibular implants (Wismeijer et al., 1997; Bartling et al., 1999; Walton, 2000). Therefore, to avoid injury of the MF and AL while performing various surgical procedures, it is necessary to determine the exact location of MF (Budhiraja et al., 2012).

MF position is important both from diagnostic and clinical point of view. Diagnostically, MF can be misdiagnosed as a radiolucent lesion near the apices of mandibular premolars. Clinically, inaccurate information regarding the position of nerve and presence/absence of AL can lead to injury of mental bundle leading to post-surgical neurovascular complications (Ngeow and Yuzawati, 2003). Most commonly, MF is located either below the apex of second premolar (Philips et al., 1992; Shankland, 1994; Fabian, 2007) or between the apices of first and second premolar (Al Jasser and Nwoku, 1998). Other variations also exist ranging from sub-canine to sub-molar region. The position of MF is directly influenced by racial group, age, gender, alveolar bone resorption and tooth loss (Igbigbi and Lebona, 2005). Literature suggests that the prevalence and length of AL also varies among different population groups (Lu et al., 2015; Chen et al., 2013; Apostolakis and Brown, 2012).

The accurate identification of MF position and AL can be very challenging. Various techniques have been applied for determining the precise position of MF and AL before performing surgical procedures. These techniques include, manual palpation, direct visualization during surgery, cadaveric dissection, panoramic radiographs, peri-apical radiographs, Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and Cone-Beam Computed Tomography (CBCT). Most techniques come with limitations such as cost, radiation exposure and magnification (Aminoshariae et al., 2014).

Currently, high resolution CBCT is the most promising and accurate technology available for quantitatively determining the position of MF and presence of AL (Vujanovic-Eskenazi et al., 2015).

Little data are present in the literature regarding the position of MF and prevalence of AL in Saudi population using CBCT, therefore, the present study was undertaken to investigate the position of mental foramen, its distance from mandibular borders and adjacent teeth and prevalence of AL using CBCT in Saudi population.

2. Materials and methods

The study was retrospective in design. Following the ethical approval from the University ethics committee, a sample of 872 CBCT scans (120 kV, 5 mA, I-CATTM, 3-D imaging system, Imaging Sciences International Inc., Hatfield, PA, USA) was obtained from the data already available in the Department of Oral and Maxillofacial Surgery, from a period of January 2012 till January 2015. All scans consisted of a clinically standard resolution of 0.3 mm voxel, 8.9 s.

ICAT vision software (Q version 1.8.1.10, Imaging Science International, Hatfield, PA, USA) was used to study the position of MF and its relationship with adjacent structures. The CBCT images were evaluated in four views i.e. panoramic, sagittal, coronal and axial.

The following inclusion criteria were used:

- Sample should only consist of ethnic Saudi individuals.
- Presence of permanent dentition.
- All teeth should be present adjacent to MF, from canine to first molar, on both sides.

Exclusion criteria were:

- Presence of mixed dentition.
- Presence of any radiolucent or radio-opaque lesion, obscuring the MF region.

All the scans were assessed for eligibility against the selection criterion. Based on our evaluation 302 CBCT scans of 196 males and 106 females; mean age of 34.9 years (Age range; 16–68 years) fulfilled the inclusion criterion. Data were distributed among four groups with regard to age (Group A = 25 years or below, Group B = 26–40 years, Group C = 41–55 years, Group D = Above 55 years).

The anteroposterior position of MF was recorded as (a) below 2nd premolar, (b) between 1st and 2nd premolar, (c) below 1st premolar, (d) between 2nd premolar and 1st molar and (e) below 1st molar.

The distance between MF and nearest root apex of adjacent tooth, and mandibular borders was measured by viewing the panoramic, axial, sagittal and coronal cuts of the CBCT scan.

The prevalence of AL was assessed by classifying inferior alveolar canal (IAC) into three patterns; linear, perpendicular and anterior loop (Fig. 1a–c).

All CBCT scans were evaluated independently by two observers, one radiologist and one specialist in oral and maxillofacial surgery.

3. Statistical analyses

Data were analyzed using the Statistical Package for the Social Sciences (SPSS-19.0) software package (IBM, Chicago, USA).

Wilcoxon test was applied to check for inter-observer bias, as all scans were assessed by two observers, one radiologist and one oral and maxillofacial specialist.

Descriptive statistics was utilized for acquiring the position of MF, IAC pattern and distance between MF and nearest root apex and mandibular borders. It was also applied for frequency analysis of the distance between MF and nearest root apex, and mandibular borders.

The co-relation of position of mental foramen with regards to gender and age was also evaluated by applying Pearson chi-square test. Results showing $p < 0.05$ were considered as statistically significant.

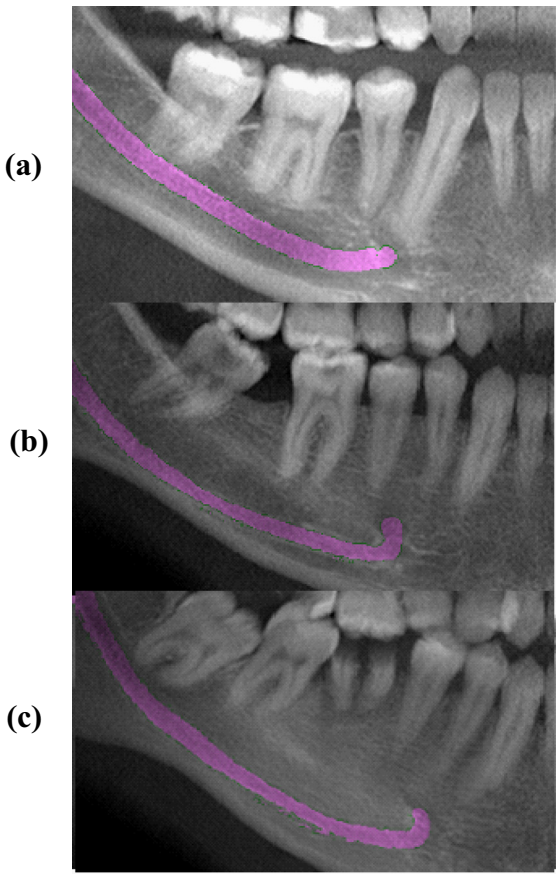

Fig. 1 Inferior alveolar canal patterns (a) linear pattern, (b) perpendicular pattern (c) anterior Loop.

4. Results

Among the sample, the results assessed by two observers showed statistically insignificant inter-observer bias ($p > 0.05$) with regard to position of MF and presence of anterior loop.

Table 1 illustrates the positioning of mental foramen with reference to the adjacent teeth on right side of the mandible. 53% of MF were located below the apex of 2nd premolar (Male = 51%%, Female = 56.6%), whereas, only 31.5% observed MF between 1st and 2nd premolar. No cases showed position of MF below apex of 1st molar. Statistically, no significant findings were observed ($p = 0.226$).

Table 2 illustrates the positioning of mental foramen with regards to the adjacent teeth on left side of the mandible. 52.6% of cases showed MF below apex of 2nd premolar (Male = 46.9%, Female = 63.2%), where only 27.8% of cases observed positioning of the MF between 1st and 2nd premolar, whereas only 2.6% cases exhibited MF below apex of 1st molar. The association of MF with regard to gender on the left side was found to be statistically significant ($p = 0.023$).

According to Table 3, overall 52.8% cases showed MF below apex of 2nd premolar with respect to adjacent teeth on both sides of the mandible, whereas, 29.6% exhibited MF between 1st and 2nd premolar. In 10.3% cases, it was located below the apex of 1st premolar and 6% were detected between the 2nd premolar and 1st molar. Only 1.3% were observed below the apex of 1st molar. Statistically, no significant findings were observed ($p < 0.05$).

Table 4 illustrates the position of MF on left side with regard to age. 61.1% of cases showed MF below apex of 2nd premolar in Group B (26–40 years of age), followed by 52.4% in Group A. Only 2.8% cases observed MF below apex of 1st molar in Group B. Statistically significant findings were observed ($p < 0.05$).

Table 5 illustrates the position of MF on right side with regards to age. MF was most commonly present below apex of 2nd premolar in group B (63.9%), whereas Group C most commonly showed MF between 1st and 2nd premolar (50%). Statistically significant findings were observed with regard to age on right side ($p < 0.05$).

Table 6 demonstrates the distance of MF from the nearest adjacent root apex in sagittal plane using frequency analysis, where 0 mm meant that the MF was in contact with the adjacent root apex. Majority of MF were located at a distance of 1–3 mm (38.74%), followed by 3.1–5 mm (29.8%). 17.05% were located at a distance of less than 1 mm, and 14.4% MF were observed at a distance of more than 5 mm.

According to Table 7, the superior margin of MF was observed at an average of 14.3 mm from the alveolar crest (Range: 9.1–19.2 mm). The inferior margin of MF was found to be located at a mean distance of 13.8 mm (Range: 8.75–16.6 mm) from the lower border of the mandible.

According to Table 8, the most commonly observed IAC pattern was linear (46.2%), followed by perpendicular pattern (38.6%). AL was observed in only 15.2% of cases. The IAC pattern on left and right sides was coincident in 79.1% cases.

Table 1 Position of mental foramen with respect to gender and adjacent teeth on right side of mandible.

		Gender (*n* (%))		Total (*n* (%))
		Male	Female	
Position of mental foramen (right side)	Between 1st and 2nd premolar	64	31	95
		32.7%	29.2%	31.5%
	Below apex of 2nd premolar	100	60	160
		51.0%	56.6%	**53.0%** *
	Below apex of 1st premolar	24	7	31
		12.2%	6.6%	10.3%
	Between 1st molar and 2nd Premolar	8	8	16
		4.1%	7.5%	5.3%
	Below apex of 1st molar	0	0	0
		0%	0%	0%
Total		196	106	302
		100.0%	100.0%	100.0%

* $P = 0.226$ (not significant).

Table 2 Position of mental foramen with respect to gender and adjacent teeth on left side of mandible.

		Gender (*n* (%))		Total (*n* (%))
		Male	Female	
Position of mental foramen (left side)	Between 1st and 2nd Premolar	60	24	84
		30.6%	22.6%	27.8%
	Below apex of 2nd premolar	92	67	159
		46.9%	**63.2%***	52.6%
	Below apex of 1st premolar	20	11	31
		10.2%	10.4%	10.3%
	Between 1st molar and 2nd premolar	16	4	20
		8.2%	3.8%	6.6%
	Below apex of 1st molar	8	0	8
		4.1%	0.0%	2.6%
Total		196	106	302
		100.0%	100.0%	100.0%

* P value = 0.023 (significant).

Table 3 Position of mental foramen with respect to adjacent teeth on both sides of mandible.

Position of mental foramen	Below apex of 2nd premolar	Between 1st and 2nd premolar	Below apex of 1st premolar	Between 1st molar and 2nd premolar	Below apex of 1st molar
Right mental foramen	160	95	31	16	0
Left mental foramen	159	84	31	20	8
Total	319(52.8%)	179(29.6%)	62(10.3%)	36(6%)	8(1.3%)

$P > 0.05$ (not significant).

Table 4 Position of mental foramen with respect to age and adjacent teeth on left side of mandible.

		Age groups (years) (*n* (%))				Total (*n* (%))
		25 or below (Group A)	26–40 (Group B)	41–55 (Group C)	>55 (Group D)	
Position of mental foramen (left side)	Between 1st and 2nd premolar	24	32	28	0	84
		29.3%	22.2%	50.0%	0.0%	27.8%
	Below apex of 2nd premolar	43	88	20	8	159
		52.4%	**61.1%***	35.7%	40.0%	52.6%
	Below apex of 1st premolar	11	16	0	4	31
		13.4%	11.1%	0.0%	20.0%	10.3%
	Below apex of 1st molar	0	4	4	0	8
		0.0%	2.8%	7.1%	0.0%	2.6%
	Between 1st molar and 2nd premolar	4	4	4	8	20
		4.9%	2.8%	7.1%	40.0%	6.6%
Total		82	144	56	20	302
		100.0%	100.0%	100.0%	100.0%	100.0%

* $P < 0.05$ (significant).

5. Discussion

The present study focused on assessing the position of MF and presence of anterior loop by using CBCT technology in Saudi population. The precise identification of MF and AL is considered to be an important factor while administering mental nerve block and performing surgical procedures in the specified area. Since little is available in literature which assessed the presence of AL in Saudi population, this parameter can only be compared with similar studies carried out in different population groups. However, one of the limitations of the present study was the small sample size.

Variations exist in the position of MF among different racial groups. According to some studies MF is most commonly located between 1st and 2nd premolars (Gungor et al., 2006; Von Arx et al., 2013; Verma et al., 2015; Currie et al., 2015). Another study carried out in Saudi population using panoramic radiography showed that in female patients,

Table 5 Position of mental foramen with respect to age and adjacent teeth on right side of mandible.

		Age groups (years)				Total (*n* (%))
		25 or below (Group A)	26–40 (Group B)	41–55 (Group C)	> 55 (Group D)	
Position of mental foramen (right side)	Between 1st and 2nd premolar	23	40	28	4	95
		28.0%	27.8%	50.0%	20.0%	31.5%
	Below apex of 2nd premolar	40	92	16	12	160
		48.8%	**63.9%** *	28.6%	60.0%	53.0%
	Below apex of 1st premolar	11	12	4	4	31
		13.4%	8.3%	7.1%	20.0%	10.3%
	Between 1st molar & 2nd premolar	8	0	8	0	16
		9.8%	0.0%	14.3%	0.0%	5.3%
Total		82	144	56	20	302
		100.0%	100.0%	100.0%	100.0%	100.0%

* $P < 0.05$ (significant).

Table 6 Frequency analysis of mental foramen (MF) from nearest adjacent root apex (2nd Premolar).

Distance of MF from adjacent root apex (2nd Premolar)	Number of cases (%)
< 1 mm	103(17.05%)
1–3 mm	234(38.74%)
3.1–5 mm	180(29.8%)
> 5 mm	87(14.4%)
Total	604 (100%)

Table 7 Linear distance of mental foramen (MF) mandibular borders.

Distance between MF and mandibular borders	Minimum (mm)	Maximum (mm)	Mean (mm)
Distance to the upper border of Mandible	9.1	19.2	14.3
Distance to the lower border of Mandible	8.75	16.6	13.8

Table 8 Prevalence of inferior alveolar canal patterns.

Inferior alveolar Canal patterns	Linear	Perpendicular	Anterior loop
Right	142	110	50
Left	137	123	42
Total	279(46.2%)	233(38.6%)	92(15.2%)

mental foramen was located more frequently apical to the mandibular 2nd premolar, whereas, in male patients it existed commonly between the 1st and 2nd premolars (Al-Khateeb et al., 1993). Our study indicated that the most common position of MF was below the apex of 2nd premolar (52.8%) both in male and female patients, which was coincident with a similar study carried out in selected Saudi population using panoramic radiographs (Al Jasser and Nwoku, 1998), thereby, supporting the data presented in the current study. As our study was carried out using CBCT scans, it gives much more precise information concerning the position of MF compared with panoramic radiography.

In our study, significant differences were observed in MF position with regards to age. This difference might have resulted because of small sample size. Hence, a larger sample size is required in future to study the position of MF with regard to age and gender more accurately.

The distance between the MF and the apex of nearest adjacent root is an important factor for consideration while carrying out certain surgical procedures, such as apicoectomy and genioplasty. A surgeon must be aware of the accurate distance of MF from the roots to avoid damage of neurovascular bundle exiting the MF. Our study showed that the MF was located most commonly at a distance of 1–3 mm (Mean: 3.1 mm) from the nearest adjacent root apex (38.7%), hence, increasing the chances of nerve injury if operator is not aware of the accurate distance. Similar studies in different population groups showed variations when compared with our study. Von Arx et al., (2013) showed that the MF was located more than 5 mm away from the nearest adjacent root apex.

In the current study, a distance of MF from upper border of mandible or alveolar crest was present at a range of 9.1–19.2 mm (Mean: 14.3 mm). The mean value (14.3 mm) of our study was coincident with the findings suggested by Haktanir et al. (2010), which showed a mean distance of 14.2 mm (Range: 10.7–29.8 mm) of MF from alveolar crest using multi-detector CT. The reason for a wide variation existed maybe because of alveolar bone loss. For nullifying the variations created by alveolar bone resorption, some authors suggested using cemento-enamal junction of adjacent teeth as a reliable reference point instead of alveolar bone (Neiva et al., 2004).

The mean distance between the inferior margin of MF and lower mandibular border was 13.8 mm (Range: 8.7–16.6 mm), whereas according to Von Arx et al., (2013) and Kalender et al., (2012), the average distance was 13.2 mm and 12.4 mm, respectively. No significant variation was detected among gender.

The clinical implications associated with the location of MF in relation to upper and lower borders of mandible and adjacent teeth include avoidance of mental nerve injury while performing osteotomies in the region (genioplasty), apical curettage at mandibular premolar area, surgical extractions, mandibular fracture fixation and periodontal surgeries. Addi-

tionally, information concerning the location of mental foramen can lead to a more precise local anesthetic technique, and mental nerve injury can be avoided during implant placement.

The IAC pattern in the present study was categorized into linear, perpendicular and anterior loop patterns. The identification of AL is important for preventing neurosensory alterations during various surgical procedures, especially during the placement of endosseous implants in the MF region (Iyengar et al., 2013). In our study AL was present in only 15.2% of cases, whereas, the most common pattern detected was linear in nature (46.2%). The IAC patterns on the left side were coincident with those of the right side in 79.1% of cases. Variations exist between different studies with regard to the most common pattern. Iyengar et al. (2013) also suggested that linear/straight pattern was most commonly observed (79%), whereas according to Hu et al. (2007)) and Apostolakis and Brown (2012), AL constituted 61.5% and 48% of cases respectively.

6. Conclusion

The sample population most commonly exhibited MF below the apex of 2nd premolar with linear IAC pattern. AL was regarded as the least common pattern in Saudi population.

Conflict of interest

We have no conflict of interest to declare.

Ethical statement

The authors confirm that this study has been conducted following ethical approval from relevant body and approval has been acknowledged within the manuscript.

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