Anatomy & Physiology: Current Research
ISSN: 2161-0940

Anatomy & Physiology

Zhang et al., Anat Physiol 2015, 5:4
http://dx.doi.org/10.4172/2161-0940.1000182

Review Article | Open Access

Anatomic Relationship between Mental Foramen and Peripheral Structures Observed By Cone-Beam Computed Tomography

Lan Zhang[1,2], Qinghua Zheng[1], Xuedong Zhou[1,2], Yin Lu[1] and Dingming Huang[1,2]

[1]*Key Laboratory of Oral Diseases, Sichuan University, Chengdu, Sichuan and China*
[2]*Departments of Conservative Dentistry and Endodontics, West China College of Stomatology, Sichuan University, Chengdu, Sichuan, China*

Abstract

Backgroud: This study investigated the anatomic relationship between mental foramen and peripheral structures using cone-beam computed tomography.

Methods: In total, 172 cone-beam computed tomography images were evaluated. Mental foramen number, size, and form were recorded, and their three-dimensional relationships with mandibular premolar root apices were investigated. The percentile position of each mental foramen relative to bony reference points was measured, and distances from mental foramen to the cement enamel junctions of the mandibular premolars were determined. Data were analyzed and compared among groups defined by age and sex using one-way analysis of variance and Student's *t*-test, respectively (significance defined as $P<0.05$).

Results: Most of the subjects had a single mental foramen on each side; only 5.81% had double foramina. The mean horizontal and vertical MF diameters were 5.14 (1.10) mm and 3.85 (0.72) mm, respectively. 67% of mental foramen had an oval horizontal form and the others were round. Mean distances from mental foramen to the alveolar crest and inferior mandibular border were 11.88 (2.49) mm and 13.65 (1.75) mm, respectively. The cementoenamel junctions of mandibular premolars were ~14 mm superior to mental foramen were most commonly positioned in line with the longitudinal axis of the mandibular second premolar.

Conclusions: Most mental foramen were located in line with the longitudinal axis of the mandibular second premolar. The detailed information about the relationship between MF and peripheral structures obtained in this study will facilitate dental surgery in this oral and maxillofacial region.

Keywords: Mental foramen; Mandibular premolar; Cone-beam computed tomography; Anatomy

Abbreviations: MF: Mental Foramen; CBCT: Cone-beam Computed Tomography; CEJ: Cementoenamel Junction

Introduction

The mental foramen (MF) is a funnel-like opening located on the lateral aspect of the mandible. It is an important anatomical landmark through which the inferior alveolar nerve and vessel bundles pass. Once the nerve leaves the MF, it branches to innervate the anterior teeth and neighboring structures. The blood vessels supply the soft tissues of the lower jaw. Surgeons must establish the position of the MF accurately because any invasive procedure performed in this oral and maxillofacial region may damage the neurovascular bundles and cause serious sequelae, such as labiomandibular paresthesia or anesthesia [1,2]. Knowledge of the precise position of the MF would also facilitate a mental nerve block.

Although root canal therapy is the primary method to treat endodontic diseases, its rate of success is less than 100% and some patients require periapical surgery [3,4]. Because the MF is located near the root apices of the mandibular premolars, periapical surgery performed in this region may damage the neurovascular bundles. Thus, it is important to explore the precise position of the MF and its relationship with peripheral structures. However, previous studies of the MF, which were performed on human cadavers [5,6] or using panoramic radiographs [7,8], had some shortcomings. Sample sizes were relatively small, and the superimposition of structures on radiographs made it difficult to identify the three-dimensional (3D) relationships between the MF and root apices.

Recently, cone-beam computed tomography (CBCT) has been introduced to dental practice. It has shown several advantages, such as improved spatial resolution and reduced radiation dose. This technique has significantly improved the 3D imaging of osseous structures [9,10]. Due to these superiorities, CBCT has been utilized frequently in dental practice, such as for the diagnosis of endodontic diseases and the planning of periapical surgery and implant placement. A large CBCT database has thus accumulated, allowing the analysis of particular features in a large sample. CBCT also enables the visualization of 3D structures from different directions, and the ability to avoid superimposition allows the relationships between peripheral structures to be identified clearly. No significant difference in measurements of mandibular anatomy made with CBCT software or calipers has been found [11-13]. Hence, the exploration of the precise location of the MF could be facilitated by the use of CBCT images. The aim of this study was to investigate the position of the MF and its relationship to

***Corresponding author:** Dingming Huang, Key Laboratory of Oral Diseases, Sichuan University, Chengdu, China; and Departments of Conservative Dentistry and Endodontics, West China College of Stomatology, Sichuan University, Chengdu, Sichuan, China, 610041, Tel:+86-28-85501481; Fax: +86-28-85582167; E-mail: dingminghuang@163.com, 249557997@qq.com

Received August 22, 2015; **Accepted** September 30, 2015; **Published** October 07, 2015

Citation: Zhang L, Zheng Q, Zhou X, Lu Y, Huang D (2015) Anatomic Relationship between Mental Foramen and Peripheral Structures Observed By Cone-Beam Computed Tomography. Anat Physiol 5: 182. doi:10.4172/2161-0940.1000182

peripheral structures using CBCT imaging and measurements made with the corresponding software.

Materials and Methods

Patient selection

This study was approved by the Ethics Committee of West China College of Stomatology, Chengdu, Sichuan, China. Patients enrolled in the study had received CBCT scans between November 2009 and February 2011 for a variety of reasons at West China Hospital of Stomatology. The CBCT images were selected according to the following criteria: 1) the mandibular first and second premolars and MF were visible; 2) no lesion was present in the cervical area of the premolars; 3) the premolars were oriented upright; and 4) no bone resorption had occurred in the superior bony crest.

A total of 172 patients (68 females, 104 males) were included in the study. The mean age of the patients was 36.8 (range, 12-75) years. The patients were divided into three age groups [14]: group I, <18 years of age, group II, 18-49 years of age, and group III, >49 years of age.

Evaluation of CBCT images

All CBCT images were obtained using a 3D Accuitomo unit (Morita Co., Tokyo, Japan) at 80 kV and 5.0 mA, with a voxel size 0.125-0.25 mm and an exposure time of 17.5 s. Data were reconstructed with slices at 1-mm intervals. All images were analyzed using specialized computer software (i-Dixel One Volume Viewer, ver. 1.5.0; J. Morita Mfg. Corp., Kyoto, Japan). To enable the identification of the MF and the exploration of its relationship to peripheral structures, CBCT scans were oriented according to the following criteria: 1) the longitudinal axes of both mandibular premolars were oriented perpendicular to the *Z* cursor line; and 2) the *X* cursor line was tangent to the outline of the MF in an axial slice (Figure 1A).

After orientation, the horizontal and vertical diameters of each MF were determined, and the ratio of these two diameters (H:V) was calculated. H:V was used to classify the form of each MF into one of three types[15]: type I, oval horizontal form, H:V>1.24; type II, oval vertical form, H:V<0.76; and type III, round form, 0.76 ≤ H:V ≤ 1.24.

To establish the precise position of each MF, its horizontal relationships with the mandibular first and second premolars were classified into one of three types. In type A, the root apex of the premolar was located mesial to the MF, and the horizontal distance between the root apex and the mesial margin of the MF (HDM) was measured. In type B, the root apex was located distal to the MF, and the horizontal distance between the apex and the distal margin (HDD) was measured. In type C, the root apex was located between the mesial and distal margins of the MF, and the horizontal distances from the apex to both of these margins were measured.

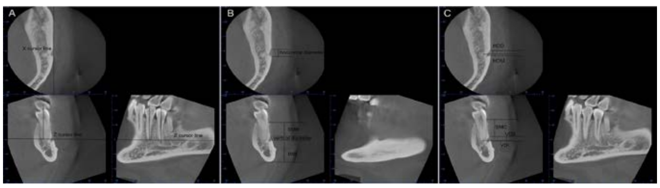

Figure 1: Measurement diagram. A. Criteria used to orient cone-beam computed tomography images: 1) the longitudinal axis of the mandibular premolar was perpendicular to the *Z* cursor line, and 2) the *X* cursor line was tangent to the outline of the mental foramen (MF) in an axial slice. B and C. Illustrations of the measurements used to determine the relationships between the MF and peripheral structures. SMB, the distance from the superior margin of the MF to the superior bony crest; IMB, the distance from the inferior margin of the MF to the inferior border of mandible; HDM, the horizontal distance between the root apex and the mesial margin of the MF; HDD, the horizontal distance between the apex and the distal margin of the MF; VDS, the vertical distance between the apex and the superior margin of the MF; VDI, the vertical distance between the apex and the inferior margin of the MF; SMC, the distance from the cementoenamel junction of the first or second mandibular premolar to the superior margin of the MF.

The vertical relationships between each MF and the root apices of the mandibular first and second premolars were also classified into one of three types. In type A, the root apex was located superior to the MF, and the vertical distance between the apex and the superior margin of the MF (VDS) was measured. In type B, the root apex was located inferior to the MF, and the vertical distance between the apex and the inferior margin of the MF (VDI) was measured. In type C, the root apex was located between the superior and inferior margins of the MF, and the vertical distances from the apex to both of these margins were measured.

The percentile position of each MF between the superior bony crest and the inferior mandibular border was also determined. This position was defined as the ratio between the distance from the superior margin of the MF to the superior bony crest (SMB) and that from the inferior margin of the MF to the inferior border of the mandible (IMB). The distances from the cementoenamel junctions (CEJs) of both mandibular premolars to the superior margin of the MF (SMC1 and SMC2) were also determined.

All images were evaluated by an experienced endodontist. For calibration and the evaluation of intra-examiner reliability, the horizontal diameters of 40 randomly selected MF were measured twice on two different days, resulting in a mean difference of 0.15 mm per image. For the final analysis, each measurement was performed twice. If the difference between the two values was ≥0.2 mm, a third measurement was made. Mean values were then calculated [14-16].

Statistical analysis

Data were presented as the mean (SD). The difference in the distribution of sex among age groups was first analyzed using the chi-squared test. The position and size of the MF were then analyzed among groups defined by age and sex using one-way analysis of variance (ANOVA) and Student's *t*-test separately. Data were considered significant at $P<0.05$.

Results

Size and form of the MF

Most patients had a single MF on each side, except for 10 (5.81%) patients with double MF (Figure 2) who were excluded from further analysis. Among the remaining patients, a chi-squared test found no significant difference in sex distribution among the three age groups (Table 1).

The mean horizontal and vertical diameters of the MF were 5.14 (1.10) mm and 3.85 (0.72) mm, respectively; and the mean H:V was 1.35 (0.24). Among the measurements of MF size, age affected only horizontal diameters, which differed significantly between patients aged <18 years and those aged 18–49 years ($P<0.05$; Table 2). The MFs of male patients were larger than those of female patients, reflected in significant differences in horizontal and vertical diameters ($P<0.05$; Table 2).

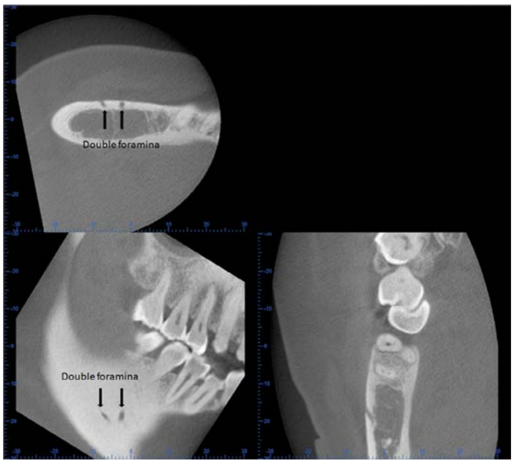

Figure 2: Examples of double foramina.

Age group (years)	Sex		Total
	Male	Female	
<18	8	1	9
18–49	70	50	120
>49	19	14	33
Total	97	65	162

Table 1: The patient sample classified by age and sex.

The classification of MF form using H:V revealed that most (67%) MF had an oval horizontal form (Figure 3A) and the others (33%) were round (Figure 3B). No MF had an oval vertical form. The MF form did not differ significantly among age groups or between sex groups (P>0.05, chi-squared tests; Table 2).

Position of the MF

The mean SMB and IMB were 11.88 (2.49) mm and 13.65 (1.75) mm, respectively. The mean ratio of these two distances, which was used to define the percentile position of the MF, was 0.88 (0.23). ANOVA found no significant difference in these three values among age groups (P > 0.05; Table 2), but Student's t-tests showed that SMB and IMB were significantly larger in male subjects than in female subjects (P<0.05; Table 2).

Mean SMC1 and SMC2 were 14.61 (2.45) mm and 14.26 (2.42) mm, respectively. Like SMB and IMB, these values were larger in male subjects than in female subjects (P<0.05; Table 2).

In most cases (98.71%), the MF was found to be located distal to the root apex of the mandibular first premolar (Figure 4A), of which 62.09% were inferior and 1.96% were superior to the apex. The others were in the same horizontal plane as the apex. The average distance from the root apex of the first premolar to the mesial margin of the MF was 5.29 (1.94) mm (Table 3).

The mandibular second premolar was also evaluated as an important reference point. Most (74.67%) MF were in line with the longitudinal axis of the second premolar (Figure 4B), whereas 14% were distal and 11.33% were mesial to the root apex. Among the MF located in line with the longitudinal axis of the second premolar, 36.61% were superimposed on the root apex of the second premolar (Fig. 5A), 56.25% were a mean of 2.34 (1.77) mm inferior to the root apex (Figure 5B), and 7.14% were a mean of 1.73 (1.68) mm superior to the apex (Figure 5C).

Discussion

The MF is usually single; any additional foramen present in this area is called accessory mental foramen (AMF). The presence of an AMF has been suggested to result from the branching of the mental nerve before it exits the MF. Ignoring the presence of an AMF may cause unexpected damage to the neurovascular bundles or lead to the failure of a mental nerve block. In the present study, AMF were found in 5.81% of patients, which was similar to the 5% incidence reported in a previous study in a Chinese population [5]. The incidence of AMF appears to vary among ethnic groups; Mwaniki et al. reported multiple foramina in 4.5% of an African population [17], Kalender et al. observed AMF in 6.5% of a Turkish population [18], and incidences of 6.68% and 7% were found in Greek [19] and Japanese [20] populations, respectively. In adult Sri Lankan [6] and Indian [21] populations, the incidence of AMF was found to be 3.92% and 8.9%, respectively.

The mean horizontal (5.14 (1.10) mm) and vertical (3.85 (0.72) mm) MF diameters observed in the present study were larger than those reported in a Sri Lankan population (horizontal diameter: 3.31 (0.76) mm; vertical diameter: 2.50 (0.61) mm) [6]. The distribution of MF forms (67% oval horizontal, 33% round) was similar to those

Subgroup		MF size			MF form (type)			Position relative to bony structures			Position relative to CEJs of mandibular premolars	
		Horizontal diameter*& (mm)	Vertical diameter* (mm)	H:V	I	II	III	SMB* (mm)	IMB* (mm)	SMB:IMB	SMC1*& (mm)	SMC2* (mm)
Age (years)	<18	6.06 ± 1.09 (4.23–7.34)	4.05 ± 0.70 (2.81–5.24)	1.50 ± 0.11	9	0	0	11.76 ± 1.03 (9.54–12.81)	13.47 ± 2.03 (11.17–15.00)	0.86 ± 0.18	13.48 ± 1.76 (12.17–17.93)	13.17 ± 2.10 (11.75–18.33)
	18–49	5.04 ± 1.04 (2.75–7.73)	3.81 ± 0.69 (2.25–6.39)	1.34 ± 0.24	79	0	41	12.03 ± 2.58 (6.25–19.35)	13.69 ± 1.69 (9.73–17.25)	0.88 ± 0.23	14.47 ± 2.47 (8.5–22.38)	14.19 ± 2.34 (10.00–21.00)
	>49	5.27 ± 1.20 (2.60–8.31)	3.93 ± 0.82 (2.32–5.84)	1.35 ± 0.25	20	0	13	11.37 ± 2.41 (5.75–16.25)	13.51 ± 1.99 (9.50–18.26)	0.87 ± 0.25	15.54 ± 2.37 (10.00–20.03)	15.01 ± 2.75 (10.45–20.58)
Sex	Male	5.31 ± 1.11 (2.60–8.31)	3.98 ± 0.69 (2.25–5.84)	1.35 ± 0.24	65	0	32	12.25 ± 2.35 (5.75–19.35)	14.37 ± 1.55 (10.30–18.26)	0.86 ± 0.22	15.00 ± 2.34 (10.20–22.38)	14.62 ± 2.52 (10.00–21.00)
	Female	4.89 ± 1.04 (2.75–7.73)	3.65 ± 0.71 (2.38–6.39)	1.35 ± 0.24	43	0	22	11.34 ± 2.60 (6.25–17.03)	12.65 ± 1.51 (9.50–16.22)	0.91 ± 0.25	13.97 ± 2.52 (8.5–19.04)	13.61 ± 2.10 (10.25–18.25)

H:V, the ratio of horizontal diameter to vertical diameter of the mental foramen (MF); SMB, the distance from the superior margin of the MF to the superior bony crest; IMB, the distance from the inferior margin of the MF to the inferior border of the mandible; SMC1: the distance from the cementoenamel junction of the mandibular first premolar to the superior margin of the MF; SMC2: the distance from the cementoenamel junction of the mandibular second premolar to the superior margin of the MF. The form of the MF was classified into three types: type I, oval horizontal form; type II, oval vertical form; type III, round form. *Significant difference between sexes; &significant differences among age groups. The numerical values in parentheses indicate ranges.

Table 2: Size, form, and position of the mental foramen analyzed by age and sex.

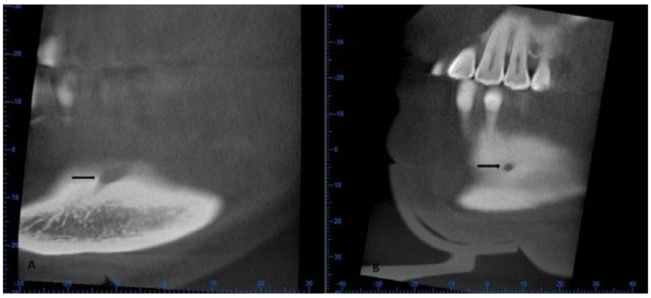

Figure 3: Forms of the mental foramen. A. Type I, oval horizontal form. B. Type III, round form.

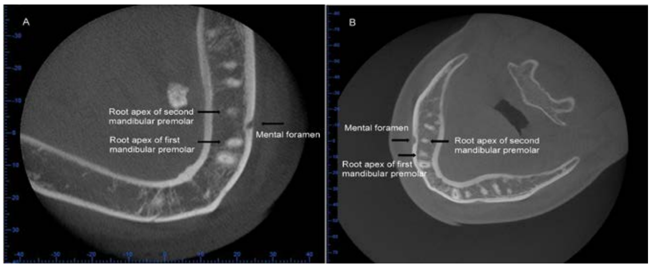

Figure 4: Horizontal relationships between the mental foramen (MF) and the root apices of the mandibular premolars. A. The MF is located between the first and second mandibular premolars. B. The MF is located in line with the longitudinal axis of the mandibular second premolar.

reported in most previous studies [6,15]. However, Sankar [21] found that the round MF form was most common in an Indian population.

In the present study, horizontal and vertical MF diameters were larger in male patients than in female patients, as were SMB, IMB, and SMCs. This sex difference was consistent with previous reports [22,23] and can be attributed to the relatively smaller size of mandibles in females versus males [18]. Mean IMB (13.65 (1.75) mm) values obtained in the present study corresponded with the results of Gupta (IMB: 13 mm) [24], but were smaller than those observed by Ozturk (IMB: 16 mm) [25] and Guo (IMB: 15.56 (1.74) mm) [5].

Given that periodontal disease frequently causes bone resorption at the alveolar crest, the CEJs of the mandibular premolars provide better reference points for the location of the MF. The present study found that the MF was generally located about 14 mm inferior to the CEJs. However, when these data are used in dental surgery, some prerequisites should be considered: the premolars should be oriented upright and no lesion should be present in the cervical area of the teeth.

Although the relationships between the MF and bony structures or CEJs of the mandibular premolars aid in understanding the precise position of the MF, the most important factor for periapical surgery is the spatial relationship between the MF and the root apices of the mandibular premolars. These relationships are used to determine the safe range of surgery performed in this region, so that damage to the neurovascular bundles exiting the MF can be avoided. The results of the present study indicate that periapical surgery performed in the root apex of the first premolar has a relatively low risk of causing damage to the mental nerve because most MF are located distal to this apex. However, surgery in the root apex of the second premolar should be performed very carefully, as 74.67% of MF in the present study were in line with the longitudinal axis of the second premolar, located in the range from 2.34 (1.77) mm inferior to 1.73 (1.68) mm superior to the root apex. In addition, 36.61% of MF were superimposed over the root apex of the second premolar. Thus, the surgical entry should be designed properly to avoid damage to the neurovascular bundles. These findings are consistent with those of some previous studies. In a Chinese population, the MF was most commonly located in line with

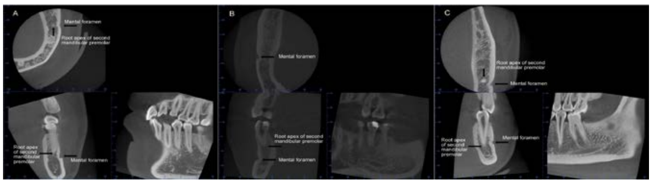

Figure 5: Three-dimensional relationship between the mental foramen (MF) and the root apex of the mandibular second premolar. In all three images, the MF is in line with the longitudinal axis of the mandibular second premolar. A. The MF is superimposed over the root apex. B. The MF lies inferior to the root apex. C. The root apex is just inferior to the MF.

Distance		Horizontal relationship (mm)			Vertical relationship (mm)		
		A	B	C	A	B	C
First mandibular premolar	HDM	5.29 ± 1.94 (1.14–11.45)		0.53 ± 0.40 (0.25–0.81)			
	HDD			5.35 ± 0.49 (5–5.75)			
	VDS				2.79 ± 1.77 (0–7.00)		1.82 ± 0.96 (0.41–4.25)
	VDI					1.84 ± 1.45 (0.64–4.64)	1.93 ± 1.17 (0.18–4.75)
Second mandibular premolar	HDM	1.36 ± 1.47 (0–5.25)		2.99 ± 1.73 (0.25–7.33)			
	HDD		2.43 ± 2.26 (0.14–6.52)	2.43 ± 1.76 (0–7.1)			
	VDS				2.48 ± 1.80 (0–8.75)		1.77 ± 0.96 (0.14–3.87)
	VDI					0.91 ± 0.47 (0.32–1.82)	2.10 ± 1.43 (0–7.13)

HDM, the horizontal distance between the root apex and the mesial margin of the MF; HDD, the horizontal distance between the apex and the distal margin of the MF; VDS, the vertical distance between the apex and the superior margin of the MF; VDI, the vertical distance between the apex and the inferior margin of the MF. The numerical values in parentheses indicate ranges.

Table 3: Mean distances (and ranges) from the MF to the root apices of the premolars.

the longitudinal axis of the second premolar [26,27]. The same position was also observed to be most common in Saudi [28], Nigerian [29], Kenyan [17], Sri Lankan [6], and Kurdish [7] populations. However, other studies suggested that most MF were located between the first and second premolars [8,15,30]. Thus, the location of the MF appears to show racial differences [31].

In conclusion, this study investigated the anatomic relationship between the MF and peripheral structures using CBCT, and found that the MF was most commonly located in line with the longitudinal axis of the second premolar. This detailed information about the position of the MF will facilitate dental surgery or nerve block in this oral and maxillofacial region.

Acknowledgements

This study is supported by funds from National Natural Science Foundation of China (11272226, 81300876).

References

1. Gambarini G, Plotino G, Grande NM, Testarelli L, Prencipe M, et al. (2011) Differential diagnosis of endodontic-related inferior alveolar nerve paraesthesia with cone beam computed tomography: a case report. Int Endod J 44: 176-181.
2. González-Martín M1, Torres-Lagares D, Gutiérrez-Pérez JL, Segura-Egea JJ (2010) Inferior alveolar nerve paresthesia after overfilling of endodontic sealer into the mandibular canal. J Endod 36: 1419-1421.
3. Allen RK, Newton CW, Brown CE Jr (1989) A statistical analysis of surgical and nonsurgical endodontic retreatment cases. J Endod 15: 261-266.
4. Sjogren U, Hagglund B, Sundqvist G, Wing K (1990) Factors affecting the long-term results of endodontic treatment. J Endod 16: 498-504.
5. Guo JL, Su L, Zhao JL, Yang L, Lv DL, et al. (2009) Location of mental foramen based on soft- and hard-tissue landmarks in a chinese population. J Craniofac Surg 20: 2235-2237.
6. Ilayperuma I, Nanayakkara G, Palahepitiya N (2009) Morphometric analysis of the mental foramen in adult Sri Lankan mandibles. Int J Morphol 27: 1019-1024.
7. Al Talabani N, Gatta IS, Jaff K (2008) Precise computer-based localization of the mental foramen on panoramic radiographs in a Kurdish population. Oral Radiol 24: 59-63.
8. Amorim NM, Borini CB, Lopez SLPD, Haiter-Neto F, Caria PHF (2009) Morphological description of mandibular canal in panoramic radiographs of Brazilian subjects: association between anatomic characterisitic and clinical procedures. Int J Morphol 27: 1243-1248.
9. De Greef S, Willems G (2005) Three-dimensional cranio-facial reconstruction in forensic identification: latest progress and new tendencies in the 21st century. J Forensic Sci 50: 12-17.
10. Scarfe WC, Farman AG (2008) What is cone-beam CT and how does it work? Dent Clin North Am 52: 707-730, v.
11. Kamburo AY, Kili AC, Ozen T, Yaksel SP (2009) Measurements of mandibular canal region obtained by cone-beam computed tomography: a cadaveric study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 107: e34-42.
12. Kim TS, Caruso JM, Christensen H, Torabinejad M (2010) A comparison of cone-beam computed tomography and direct measurement in the examination of the mandibular canal and adjacent structures. J Endod 36: 1191-1194.
13. Ludlow JB, Laster WS, See M, Bailey LJ, Hershey HG (2007) Accuracy of measurements of mandibular anatomy in cone beam computed tomography images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 103: 534-542.
14. Kovisto T, Ahmad M, Bowles WR (2011) Proximity of the mandibular canal to the tooth apex. J Endod 37: 311-315.
15. Oliveira Junior EM, Araújo ALD, Da Silva CMF, Sousa-Rodrigues CF, Lima FJC (2009) Morphological and morphometric study of the mental foramen on the M-CP-18 Jiachenjang point. Int J Morphol 27: 231-238.
16. Bornstein MM, Lauber R, Sendi P, Von Arx T (2011) Comparison of periapical radiography and limited cone-beam computed tomography in mandibular molars for analysis of anatomical landmarks before apical surgery. J Endod 37: 151-157.
17. Mwaniki DL, Hassanali J (1992) The position of mandibular and mental foramina in Kenyan African mandibles. East Afr Med J 69: 210-213.
18. Kalender A, Orhan K, Aksoy U (2012) Evaluation of the mental foramen and accessory mental foramen in Turkish patients using cone-beam computed tomography images reconstructed from a volumetric rendering program. Clin Anat 25: 584-592.
19. Zografos J, Mutzuri A (1989) [Incidence of double mental foramen in a sample of Greek population]. Odontostomatol Proodos 43: 521-523.
20. Naitoh M, Hiraiwa Y, Aimiya H, Gotoh K, Ariji E (2009) Accessory mental foramen assessment using cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 107: 289-294.
21. Sankar DK, Bhanu SP, Susan PJ (2011) Morphometrical and morphological study of mental foramen in dry dentulous mandibles of South Andhra population of India. Indian J Dent Res 22: 542-546.
22. Amorim MM, Prado FB, Borini CB, Bittar TO, Volpato MC, et al (2008) The mental foramen position in dentate and edentulous Brazilian's mandible. Int J Morphol 26: 981-987.
23. Haktanir A, Ilgaz K, Turhan-Haktanir N (2010) Evaluation of mental foramina in adult living crania with MDCT. Surg Radiol Anat 32: 351-356.
24. Gupta T (2008) Localization of important facial foramina encountered in maxillo-facial surgery. Clin Anat 21: 633-640.
25. Ozturk A, Potluri A, Vieira AR (2012) Position and course of the mandibular canal in skulls. Oral Surg Oral Med Oral Pathol Oral Radiol 113: 453-458.
26. Santini A, Land M (1990) A comparison of the position of the mental foramen in Chinese and British mandibles. Acta Anat (Basel) 137: 208-212.
27. Wang TM, Shih C, Liu JC, Kuo KJ (1986) A clinical and anatomical study of the location of the mental foramen in adult Chinese mandibles. Acta Anat (Basel) 126: 29-33.
28. Al Jasser NM, Nwoku AL (1998) Radiographic study of the mental foramen in a selected Saudi population. Dentomaxillofac Radiol 27: 341-343.
29. Kekere-Ekun TA (1989) Antero-posterior location of the mental foramen in Nigerians. Afr Dent J 3: 2-8.
30. Kqiku L, Sivic E, Weiglein A, Städtler P (2011) Position of the mental foramen: an anatomical study. Wien Med Wochenschr 161: 272-273.
31. Green RM (1987) The position of the mental foramen: a comparison between the southern (Hong Kong) Chinese and other ethnic and racial groups. Oral Surg Oral Med Oral Pathol 63: 287-290.

Citation: Zhang L, Zheng Q, Zhou X, Lu Y, Huang D (2015) Anatomic Relationship between Mental Foramen and Peripheral Structures Observed By Cone-Beam Computed Tomography. Anat Physiol 5: 182. doi:10.4172/2161-0940.1000182