Original Article

Assessment of the anterior and caudal extent of inferior alveolar nerve canal, location of inferior alveolar canal and mental foramen, and the depth of submandibular fossa using computed tomography

ABSTRACT

Background: A well-versed knowledge of the precise location of various anatomical landmarks is necessary to avoid complications during surgery. The study was conducted for the assessment of the anterior and caudal extent of the inferior alveolar nerve canal, location of inferior alveolar canal and mental foramen, and the depth of the submandibular fossa using computed tomography (CT).

Materials and Methods: One hundred CT scans were randomly selected for this study accounting for 200 hemimandibles. Both axial and coronal images were obtained and evaluated concurrently. Results were subjected to statistical analysis for correct inferences.

Results: A total of 200 hemimandibles (n = 200) from 100 patients with a mean age was 23.89 ± 1.75 years ranging from 21 to 33 years were evaluated. The mean length of the anterior loop was 0.95 mm for all of the observation combined and measurement range from 0 to 5.1 mm. The total frequency of type I, type II, and type III of mental nerve was found as 71%, 4.5%, and 24.5%, respectively. At the level of the first molar, the mean distance from the center of the inferior alveolar canal to the external surface of the buccal cortex (Q) was 5.44 ± 1.38 mm ranging from 2.4 to 10.4 mm. Furthermore, there was no statistically significant difference in MF-IMB (mental foramen to the inferior border of mandible) between the right and left sides of the mandible. (P = 0.87).

Conclusion: Our study demonstrates that analyzing CT scans using the methods described in this study can be a useful tool in avoiding the iatrogenic injuries to inferior alveolar nerve and arteries during various maxillofacial surgical procedures.

Keywords: Computed tomography, inferior alveolar, injury, mental

INTRODUCTION

The knowledge and awareness about the precise location of various anatomical landmarks such as mandibular foramen, mandibular fossa, mandibular canal, and mental foramen and the course of the mandibular neurovascular bundle are mandatory to obtain the desired surgical output of the various procedures carried out at different levels of the mandible. Thus, the understanding of these mandibular landmarks helps Oral and Maxillofacial Surgeons to overcome various surgical complications.

Various methodologies employed in the literature includes dry skull studies, cadaveric studies, and two-dimensional (2D)

Deepak Kumar, Ramandeep Brar[1], Tahir Ahmad, Chintan Narad[1], S. P. S. Sodhi[1], Amandeep Kaur[1]

Department of Oral and Maxillofacial Surgery, Maharaja Ganga Singh Dental College and Research Center, Rajasthan, [1]Department of Oral and Maxillofacial Surgery, Dasmesh Institute of Research and Dental Science, Faridkot, Punjab, India

Address for correspondence: Dr. Tahir Ahmad, Department of Oral and Maxillofacial Surgery, Maharaja Ganga Singh Dental College and Research Center, Rajasthan, India. E-mail: t.a.tahir66@gmail.com

Received: 03 September 2020, **Revised:** 02 February 2021, **Accepted:** 14 June 2021, **Published:** 13 December 2021

Access this article online	
	Quick Response Code
Website: www.njms.in	
DOI: 10.4103/njms.NJMS_186_20	

How to cite this article: Kumar D, Brar R, Ahmad T, Narad C, Sodhi SP, Kaur A. Assessment of the anterior and caudal extent of inferior alveolar nerve canal, location of inferior alveolar canal and mental foramen, and the depth of submandibular fossa using computed tomography. Natl J Maxillofac Surg 2021;12:380-6.

radiographs. However, latest technologies like computed tomography (CT) (spiral/helical) have led to profound effect on surgical and medical practice by providing imaging in 3D. Multi-slice CT has become one of the gold standards among advanced imaging techniques for the preoperative evaluations, diagnosis, and treatment planning in oral and maxillofacial surgery for various surgical procedures.[1]

Taking into account, the inability of the clinical and common radiographic methods to give accurate information about the various important anatomical landmarks in the mandible, this study was conducted for the assessment of the anterior and caudal extent of inferior alveolar nerve canal, location of the inferior alveolar canal and mental foramen and the depth of submandibular fossa using CT.

Aims and objectives of the study

The aim of the study is to assess the CT to:

1. Evaluate the pattern of entry of mental nerve and length of the anterior loop if present
2. Evaluate the depth of submandibular fossa
3. Evaluate the location of mental foramen
4. Evaluate the location of the inferior alveolar nerve canal.

MATERIALS AND METHODS

Study design

This study based on CT was conducted in our Department of Oral and Maxillofacial Surgery for evaluation of the pattern of entry of mental nerve and length of the anterior loop, depth of submandibular fossa, location of mental foramen, and location of the inferior alveolar canal.

Study setting

A minimum of 100 CT scans were randomly selected for this study accounting for 200 hemimandibles. CT scans were obtained between July 2017 and October 2018 using SIEMENS SOMATOM PERSPECTIVE.

Multiplanar reconstructions including axial and coronal images were obtained and evaluated concurrently.

Participants

Inclusion criteria

The selected CTs met the following criteria:

- CTs taken for various clinical indications such as implant planning, trauma, assessment of impacted teeth, etc
- Images of adequate diagnostic quality.

Exclusion criteria

The CT scans were excluded based on the following criteria:

- Presence of any pathology in the mandible affects the position or obscuring the visibility of various structures/landmarks
- Poor quality with processing or exposure error and artifacts
- CTs of the patient below the age of 18 years
- CTs of the completely edentulous patient.

Ethics

Appropriate approval and permission for the study were taken from the Institutional Review Board and Ethical Committee. Written and informed consent was obtained from all the patients who underwent surgical procedures before enrolment.

Statistics

The data collected was compiled, tabulated, analyzed, and subjected to statistical tests. The data collected was evaluated using standardized statistical methods-Chi-square test, repeated ANOVA, independent *t*-test, and SPSS version 21 (Virginia, New York, US) to derive a logical conclusion. The level of significance was set at $P < 0.05$.

RESULTS

Anterior and caudal extent of inferior alveolar nerve

The coronal section of CT of 200 hemimandibles was carefully evaluated for anterior and caudal spread of the inferior alveolar nerve canal with respect to mental foramen and its entry pattern into the mental foramen. A total of 200 hemimandibles ($n = 200$) from 100 patients with a mean age was 23.89 ± 1.75 years ranging from 21 to 33 years were evaluated.

Tables 1 and 2 depict the prevalence of anterior loop and the anterior extent of the inferior alveolar nerve on right and left sides of the mandible. The mean length of the anterior loop was 0.95 mm for all of the observation combined and measurement range from 0 to 5.1 mm. The mean length of the anterior loop on the left side was 0.93 mm and on the right side was 0.96 mm.

Graph 1 depicts the observed length of the anterior loop. In 77 (54.2%) hemimandibles the length of anterior loop was 0.3-1 mm, whilst it was 1.1-2 mm in 59 (41.5%) hemimandibles. In 4 (2.8%) hemimandibles length of the

Table 1: Prevalence of anterior loop

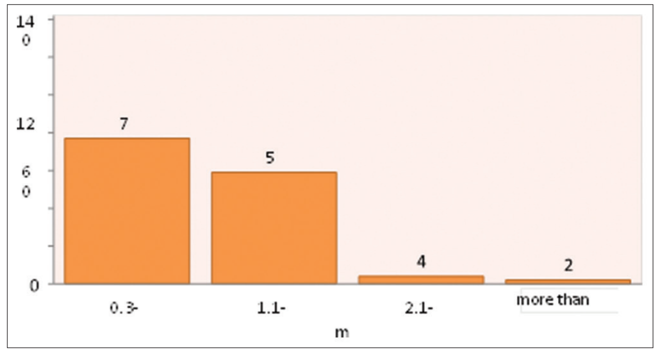
Prevalence of anterior loop	*n* (%)
Absence	58 (29)
Right side	10 (5)
Left side	16 (8)
Bilateral	58 (116 hemimandibles) (58)
Total	200 (100)

anterior loop was 2.1-3 mm and in 2 (1.4%) hemimandibles the anterior loop length (ALL) was more than 3.1 mm. The longest loop measured was 5.1 mm.

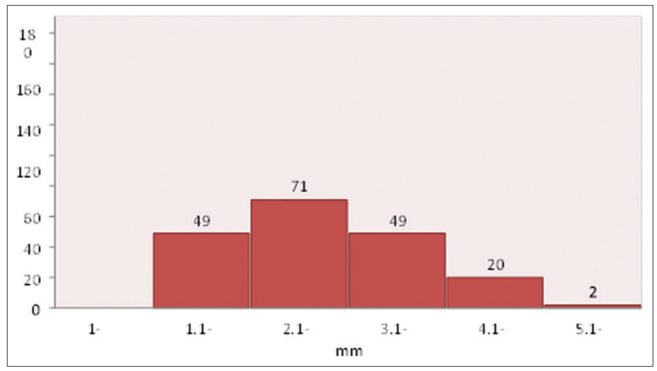
In 58 hemimandibles (28%), no formation of the anterior loop was identified. There was no formation of loop in 26 hemimandibles of the left side and 32 hemimandibles of right side. There was a statistical difference in the length of the anterior loop between the right and left sides of mandible ($P = 0.03$) with the anterior loop of right side being longer than the left side.

Tables 3 and 4 depict the prevalence of the caudal extension and caudal extension of the inferior alveolar nerve on right and left sides. The mean of caudal extension (vertical height, H) from the center of the maximum diameter of the mental foramen to the center of the mandibular canal was 2.62 ± 1.17 mm. The mean value of caudal extension on the left and right sides was 2.76 ± 1.13 mm and 2.48 ± 1.19 mm, respectively. In 191 (95.5%) hemimandibles, out of 200, the value of caudal extension (H) was present and ranges from 0.9–5.4 mm to in 9 hemimandibles, the value of caudal extension came out zero.

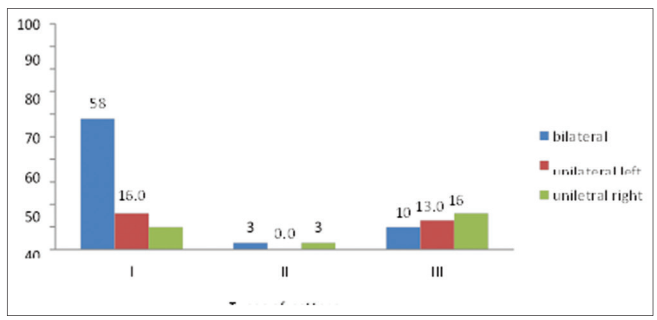
Graph 2 depicts the caudal extension of the inferior alveolar canal. In 49 (25.6%) hemimandibles, the caudal extension of inferior alveolar nerve was 1.1–2 mm. In 71 (37.1%) hemimandibles, value of caudal extension was 2.1–3 mm and in 49 (25.6%) hemimandibles, the caudal extension (H) was 3.1–4 mm. In 20 (10.4%) hemimandibles, the caudal extension was 4.1–5 mm and the value was between 5.1 and 6 in 2 hemimandibles (1.0%). The maximum value of caudal extension measured was 5.4 mm.



Graph 1: The observed length of the anterior loop



Graph 2: Caudal extension of inferior alveolar nerve



Graph 3: Type of pattern (I, II, III) in number of cases bilaterally and unilaterally

Prevalence of various patterns of formation of mental nerve

Based on the value of anterior extension (L) and caudal extension (H) recorded from 200 hemimandibles, the type of pattern was evaluated.

Table 5 depicts the pattern of formation of mental nerve bilaterally, right and left sides of mandibular. The total frequency of Type I, Type II, and Type III was as found 71%, 4.5%, and 24.5%, respectively. The distribution of Type I, Type II, and Type III on the right side were 68%, 6%, and 26% and on the left side were 74%, 3%, and 23%, respectively.

Graph 3 depicts the observed patterns of the anterior loop in number of cases bilaterally and unilaterally.

Out of 200 hemimandibles examined, Pattern I (Anterior loop) was recorded in 142 hemimandibles in which bilaterally it was recorded in 58 patients (116 hemimandibles). Unilaterally, on the left side pattern I was recorded in 10 hemimandibles and on the right-side pattern I (AL) was observed in 16 hemimandibles.

Pattern II (Straight) was observed in 9 hemimandibles out of which it was observed in 3 patients (6 hemimandibles), bilaterally and on the right side Pattern II was recorded in 3 hemimandibles unilaterally. On the left side pattern II was not observed unilaterally.

Pattern III (perpendicular) was observed in 48 hemimandibles out of which it was observed in 10 patients (20 hemimandibles), bilaterally. On the left side unilaterally pattern III was observed in 13 hemimandibles and on the right-side pattern III was observed in 16 hemimandibles, unilaterally.

Location of inferior alveolar nerve canal

Table 6 depicts the mean value and standard deviation (SD) of P, Q, and R at the level of the first and second molars. At the level of the first molar, the mean distance from the center of the inferior alveolar canal to the external surface of the buccal cortex (Q) was 5.44 ± 1.38 mm ranging from 2.4 to 10.4 mm. The mean distance from the center of the inferior alveolar canal to the external surface of the lingual cortex (P) was 3.34 ± 1.59 mm ranging from 2 to 6.01 mm.

At the level of the first molar, the mean value of the distance from the center of the inferior alveolar canal to the inferior border of the mandible (R) was 9.98 ± 1.75 mm ranging from 3.8-12.3 mm.

At the level of the second molar, the mean distance from the center of the inferior alveolar nerve canal to the external surface of the buccal cortex (Q) was 8.35 ± 1.47 mm (range 4.7-12.6 mm). The mean value of the distance from the center of the inferior alveolar nerve canal to the external surface of the lingual cortex was 2.75 ± 1.13 mm ranging from 2.3-5.1 mm. The mean value of the distance from the center of the inferior alveolar nerve canal to the inferior border of the mandible (R) at the level of the second molar was 8.81 ± 1.58 mm ranging from 3.8-12.3 mm.

Location of mental foramen

Table 7 depicts the mean and SD of the location of mental foramen on the right and left sides. The mean distance from center of mental foramen (maximum diameter) to the inferior border of mandible(Y) was 14.15 mm. The mean distance from the center of the mental foramen to inferior border of the mandible on the right side was 13.72 mm (SD ± 1.94) and on the left side was 14.59 mm (SD ± 1.87). The result showed that there was no statistically significant difference in MF-IMB (mental foramen to the inferior border of mandible) between the right and left sides of mandible ($P = 0.87$).

The mean distance from the center of mental foramen (maximum diameter) to the lingual cortex (X) was 13.66 mm (SD ± 1.98). The mean distance from the center of the mental foramen to the lingual cortex on the right side was 14.03 mm (SD ± 2.17) and on the left side was 13.30 mm (SD ± 1.72). There was no statistically significant difference in MF-LC (Mental foramen to lingual cortex) between the right and left side of the mandible ($P = 0.73$).

Depth of submandibular fossa

Table 8 depicts the mean and SD of the depth of submandibular fossa at the first and second molars.

Table 2: Anterior extent of inferior alveolar nerve on right side and left side of mandible

Group	Anterior loop length (mm) (L)			
	Range	Mean	Median	SD
Right side (74 hemimandibles)	0.3–4	0.96	0.6	0.86
Left side (68 hemimandibles)	0.6–5.1	0.93	0.9	0.74

SD: Standard deviation

Table 3: Prevalence of caudal extension

Prevalence of caudal extension	*n* (%)
Absence	9 (4.5)
Right side	94 (47)
Left side	97 (48.5)
Total	200 (100)

Table 4: Caudal extension of inferior alveolar nerve on right and left sides

Group	Range	Mean±SD
Right side (94 hemimandibles)	0.9–5.1	2.48±1.19
Left side (97 hemimandibles)	0.9–5.4	2.76±1.14

SD: Standard deviation

Table 5: Pattern of formation of mental nerve bilaterally, right and left side of mandible

Variables	Type of pattern	*n* (%)
All (*n*=200 hemimandibles)	I	142 (71)
	II	9 (4.5)
	III	49 (24.5)
Right side (*n*=100)	I	68 (68)
	II	6 (6)
	III	26 (26)
Left side (*n*=100)	I	74 (74)
	II	3 (3)
	III	23 (23)

Table 6: The mean value and standard deviation of *P*, *Q* and *R* at level of first and second molars

Teeth	Sides	Mean±SD		
		BCP (Q)	LCP (P)	IBM (R)
First molar	All	5.44±1.38	3.34±1.59	9.98±1.75
	Left	5.43±1.37	2.92±1.47	10.08±1.70
	Right	5.45±1.41	3.50±1.67	9.18±1.77
Second molar	All	8.35±1.47	2.75±1.13	8.81±1.58
	Left	8.28±1.36	2.13±1.10	8.54±1.45
	Right	8.42±1.58	2.96±1.11	9.10±1.69

SD: Standard deviation, BCP: Buccal cortical plate, LCP: Linqual cortical plate, IBM: IBM-inferior border of mandible

Table 7: Mean and standard deviation of location of mental foramen on right and left side

Variables	*n*	Mean±SD (MF-IMB)	Mean±SD (MF-LC)
All	200	14.15±1.95	13.66±1.98
Right side	100	13.72±1.94	14.03±2.17
Left side	100	14.59±1.87	13.30±1.72

SD: Standard deviation, MF-IMB: Mental foramen to inferior border of mandible, MF-LC: MF to lingual cortex

Table 8: Mean and standard deviation of depth of submandibular fossa at first and second molars

Variables	Level	Mean±SD	Minimum (mm)	Maximum (mm)
All (*n*=200 hemimandibles)	First molar	1.69±0.67	0.3	3.4
	Second molar	2.56±0.79	0.9	4.7
Right side (*n*=100)	First molar	1.77±0.65	0.4	3.4
	Second molar	2.57±0.78	0.9	4.3
Left side (*n*=100)	First molar	1.61±0.68	0.3	3.2
	Second molar	2.55±0.81	0.9	4.7

SD: Standard deviation

In this study, the depth of the submandibular fossa was taken at the level of the first and second molars.

At the level of the first molar, the mean of the depth of the submandibular fossa was 1.69 mm. The mean of maximum depth on the left side was 1.61 mm and on the right side was 1.77 mm.

At the level of the second molar, the mean of maximum depth of submandibular fossa was 2.56 mm. The mean of depth on the left side was 2.55 mm and on the right side was 2.57 mm.

DISCUSSION

With the advent of newer modalities of imaging, the surgeon can visualize real-time images which hitherto was not possible. The precise knowledge of the location of the various mandibular anatomical landmark is highly valuable to overcome various surgical complications like iatrogenic injuries to the inferior alveolar nerve (while performing third molar surgery, implant placement), injury to arteries, especially on the floor of the mouth.

CT had led to intellectual effects on the surgical and medical fields as it provides 3-D images and because of this property, CT has become one of the gold standards among advanced imaging techniques in oral and maxillofacial surgery for preoperative and postoperative evaluation.[2,3]

The present study was undertaken to assess the anterior extent that is the prevalence of the anterior loop and also the caudal extent of inferior alveolar nerve canal, prevalence of pattern of entry of mental nerve, location of inferior alveolar nerve canal, and mental foramen and the depth of submandibular fossa using CT.

A total of 100 CT scans from 100 patients were randomly selected from the outpatient department of Oral and maxillofacial Surgery.

Patients were selected irrespective of age, gender, caste, and socioeconomic status. Patients were selected according to the inclusive and exclusive criteria of this study.

These selected coronal section of CT scans taken from 100 patients were examined and values were recorded for each parameter on right and left sides of the mandible.

In the current study, based on the evaluation of the anterior and caudal extension of the inferior alveolar nerve canal various patterns were depicted, in this study the anterior loop (pattern I) was seen in 71% of cases, straight (pattern II) was seen in 4.5 and perpendicular (pattern III) was seen in 24.5% of cases. The same results were reported by Uchida *et al*.[4] who compared the accuracy of CT to that of direct measurement made on cadavers. Panjnoush *et al*.[5] reported the incidence of the anterior loop around 59.5% in their topographic study. Kaya *et al*.[6] in their CT scan reported the incidence of the anterior loop in 34% of the cases. Arzouman *et al*.[7] reported a 100% incidence of the anterior loop. According to a study conducted by Arzu Demir *et al*.,[8] the distribution of pattern I, II, and III were noted in 59.5%, 8.6%, and 31.9%, respectively, which are consistent with our results that the most common pattern is the anterior loop.

The mean length of the anterior loop in this study was 0.95 mm which is consistent with the study of Apostolakis *et al*.[9] who reported 0.89 mm as the mean length of anterior loop. In this study, the longest loop reported was 5.1 which was almost close to the longest length of anterior loop (5.7 mm) reported by Apostolakis *et al*.[9] Since the longest loop identified in our study was 5.1 mm and in 1.4% of the case the anterior loop was more than 3 mm, there is always the possibility that a long anterior loop may be encountered during various surgical procedures.

In the present study, the average distance from the center of the mandibular canal to the buccal cortex is 5.4 ± 1.38 mm at the level of the first molar and 8.35 ± 1.47 at the level of the second molar. Nagadia *et al*.[10] reported that the mandibular canal was farthest from the buccal cortex at the second molar region with a mean of 6.79 mm. In the first molar region, the mean distance was 5.44 mm. The results of this study are almost consistent with our study.

In the present study, the average distance from center of the mandibular canal to the lingual cortex is 3.34 ± 1.5 mm at first molar region and 2.13 ± 1.13 mm at level of second molar. The findings of this study are nearly in agreement with the results of Edrees *et al*.[11] who concluded that the mandibular canal runs from the mandibular foramen obliquely not only in the downward and forward direction but also in the buccolingual dimension that is the mandibular canal in the molar area is close to the lingual cortex than in the premolar area.

In the vertical dimension, our study shows that on average, the mandibular canal runs almost 1 cm above the inferior border of the body of the mandible in the molar region (in the first molar region its mean value is 9.98 ± 1.25 mm and in the second molar region its mean value is 8.81 ± 1.5 mm). Our results are in agreement with 2 cadaveric studies conducted by Rajchel *et al.*[12] and Mbajiorgu *et al.*[13] where the inferior alveolar nerve was found to be situated almost 1 cm above the mandibular inferior border.

Mental foramen position is important from the diagnostic and clinical point of view. Since the alveolar bone can undergo resorption following periodontitis or extraction; therefore, more stable landmark for measuring the mental foramen position is the basal cortical bone that is the lower border of the mandible.

In the present study, the mean distance from the center of mental foramen (maximum diameter) to the inferior border of the mandible was 14.15 ± 1.95 mm and the mean distance from the center of mental foramen (maximum diameter) to the lingual cortex was 13.6 ± 1.98 mm. Our results are consistent with the tomographic study conducted by Al-Mahalway *et al*.[14] they have recorded the mean distance of 13.8 mm (8.7-16.6 mm) between the inferior margin of mental foramen and the lower mandibular border.

However, Saito *et al*.[15] in the tomographic study reported the average distance of mental foramen to lingual cortex around 3.1 mm and from the lower margin of mandible around 7.25 mm. Their results were smaller than those of the present study as they measured from the lower edge of mental foramen and not from the center of the mental foramen.

Afkhami *et al*.[16] reported in the panoramic radiographic study that mental foramen is present, on average, 10.72 mm above the lower border of the mandible. Chen *et al*.[17] using CBCT in American and Taiwanese, revealed no statistically significant difference in the distance from the mental foramen to the lower edge of the mandible between American (9.84 mm) and Taiwanese (10.13 mm).

In the current study, the mean values of submandibular fossa depth at the level of first and second molars were 1.69 ± 0.67 mm and 2.56 ± 0.79 mm, respectively. The deepest part of the fossa was observed in the second molar area. Similar results were seen in a study conducted by Bayrak *et al*.[18] Parnia *et al*.[19] conducted the tomographic evaluation and stated that the maximum depth of submandibular fossa is present in the 2^{nd} molar region and is more than 2 mm in 80% of the study population. The results of this study are in consistent with our study. de Sauza *et al*.[20] evaluated depth of submandibular fossa among 100 CBCT scans and observed a significant correlation between fossa depth and bone thickness. They suggested, although favorable, greater attention for thick ridges may be associated with deeper submandibular fossa.

CONCLUSION

In this study, after evaluating 100 CT scans, it can be summarized that because of the wide range of the ALL (0.3–5.1 mm) observed in our study, no fixed distance mesially or anteriorly from the mental foramen should be considered to be a "safe" distance without the use of 3D imaging.

Furthermore, mandibular canal runs on an average almost 1 cm above the inferior border of the body of the mandible in the molar region. The mandibular canal not only runs in the downward and forward direction but also runs in the buccolingual dimension, i.e., the mandibular canal in the molar area is close to the lingual cortex than in the premolar area. The deepest part of the mandibular fossa was observed in the second molar region. Therefore, when deep undercut is present, the lingual plate may be perforated resulting in hemorrhage, particularly during implant surgeries. Therefore, analyzing CT scans using the methods described in this study can be a useful tool in avoiding iatrogenic injuries to inferior alveolar nerve and arteries during various maxillofacial surgical procedures.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Quereshy FA, Savell TA, Palomo JM. Application of cone beam computed tomography in the practice of oral and maxillofacial surgery.

J Oral Maxillofac Surg 2008;66:791-6.
2. Misch CE, Crawford EA. Predictable mandibular nerve location – A clinical zone of safety. Int J Oral Implantol 1990;7:37-40.
3. Wismeijer D, van Waas MA, Vermeeren JI, Kalk W. Patients' perception of sensory disturbances of the mental nerve before and after implant surgery: A prospective study of 110 patients. Br J Oral Maxillofac Surg 1997;35:254-9.
4. Uchida Y, Noguchi N, Goto M, Yamashita Y, Hanihara T, Takamori H, *et al*. Measurement of anterior loop length for the mandibular canal and diameter of the mandibular incisive canal to avoid nerve damage when installing endosseous implants in the interforaminal region: A second attempt introducing cone beam compute tomography. J Oral Maxillofac Surg 2009;67:744-50.
5. Panjnoush M, Rabiee ZS, Kheirandish Y. Assessment of location and anatomical characteristics of mental foramen, anterior loop and mandibular incisive canal using cone beam computed tomography. J Dent (Tehran, Iran) 2016;13:126.
6. Kaya Y, Seincimen M, Sachin S, Okcu KM, Dogan N, Bahcecitapar M. Retrospective radiographic evaluation of the anterior loop of the mental nerve: Comparision between panoramic radiography and spiral computerized tomography. Int J Oral Maxillofac Implants 2008;23:919-25.
7. Arzouman MJ, Otis L, Kipnis V, Levine D. Observations of the anterior loop of the inferior alveolar canal. Int J Oral Maxillofac Implants 1993;8:295-300.
8. Demir A, Izgi E, Pekiner FN. Anterior loop of the mental foramen in a Turkish subpopulation with dentate patients: A cone beam computed tomography study. Clin Exp Health Sci 2015;5:231.
9. Apostolakis D, Brown JE. The anterior loop of the inferior alveolar nerve: Prevalence, measurement of its length and a recommendation for inter foraminal implant installation based on cone beam CT imaging. Clin Oral Implants Res 2012;23:1022-30.
10. Nagadia R, Tay AB, Chan LL, Chan ES. The spatial location of the mandibular canal in Chinese: A CT study. Int J Oral Maxillofac Surg 2011;40:1401-5.
11. Abdallah Edrees MF, Moustafa Attia A, Abd Elsattar MF, Fahmy Gobran HG, Ahmed AI. Course and topographic relationships of mandibular canal: A cone beam computed tomography study. Int J Dent Oral Sci 2017;4:444-9.
12. Rajchel J, Ellis E 3rd, Fonseca RJ. The anatomical location of the mandibular canal: Its relationship to the sagittal ramus osteotomy. Int J Adult Orthodon Orthognath Surg 1986;1:37-47.
13. Mbajiorgu EF, Mawera G, Asala SA, Zivanoic S. Position of mental foramen in adult black Zimbawean mandibles: A clinical anatomical study. Cent Afr J Med 1998;44:24-30.
14. Al-Mahalawy H, Al-Aithan H, Al-Kari B, Al-Jandan B, Shujaat S. Determination of the position of mental foramen and frequency of anterior loop in Saudi population. A retrospective CBCT study. Saudi Dent J 2017;29:29-35.
15. Saito K, Araujo NS, Saito MT, Pinheiro JD, Carvalho PL. Analysis of the mental foramen using cone beam computerized tomography. Rev Odontol UNESP 2015;44:226-31.
16. Afkhami F, Haraji A, Boostani HR. Radiographic localization of the mental foramen and mandibular canal. J Dent (Tehran) 2013;10:436-42.
17. Chen JC, Lin LM, Geist JR, Chen JY, Chen CH, Chen YK. A retrospective comparison of the location and diameter of the inferior alveolar canal at the mental foramen and length of the anterior loop between American and Taiwanese cohorts using CBCT. Surg Radiol Anat 2013;35:11-8.
18. Bayrak S, Demirturk-Kocasarac H, Yaprak E, Ustaoglu G, Noujeim M. Correlation between the visibility of submandibular fossa and mandibular canal cortication on panoramic radiographs and submandibular fossa depth on CBCT. Med Oral Patol Oral Cir Bucal 2018;23:e105-11.
19. Parnia F, Fard EM, Mahboub F, Hafezeqoran A, Gavgani FE. Tomographic volume evaluation of submandibular fossa in patients requiring dental implants. Oral Surg Oral Med Oral Pathol Oral Radiol Endodontol 2010;109:e32-6.
20. de Souza LA, Souza Picorelli Assis NM, Ribeiro RA, Pires Carvalho AC, Devito KL. Assessment of mandibular posterior regional landmarks using cone-beam computed tomography in dental implant surgery. Ann Anat 2016;205:53-9.