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Research Article

Anatomical Assessment of the Inferior Alveolar Canal and Anterior Loop and Measuring its Distance to Mental Foramen in Patients Referred to Radiology Clinics of Shiraz in 2017

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Abstract: Knowledge about inferior alveolar canal (IAC) position is very important in dental surgical procedures of the mandible. It has a close relation to mandibular molar teeth. Anatomic imaging of the mandibular canal prior to surgical procedures, such as implant placement and sagittal split osteotomy, is essential for the best result and minimal complications.

Purpose: The aim of this study is to determine normal variations of the mandibular canal and mental foramen in a selected population.

Material and methods: A total of 668 high qualities CBCT images of edentulous and dentate patients aged from 15 to 75 were evaluated. CBCT projections were analyzed in different planes (tangential, cross-sectional, and axial). Bifid mandibular canal, presence of anterior loop, the level of cortication and mental foramen variations were identified in cross-sectional and axial views.

Result: 668 images, 238 males and 430 females, were evaluated. Statistical analysis did not show a significant correlation between prevalence of bifid mandibular canal, anterior loop and mental foramen in both sides with age and sex ($p>0.05$). A significant relationship was seen between right mandibular canal cortication and age ($p=0.003$). Anterior loop was detected in 90.5% of cases, and its length was 3.34 ± 1.41 while accessory mandibular canal was observed in 4.6% of patients only.

Conclusion: This study showed that there are numerous anatomical variations of the mandibular canal, mental foramen and anterior loop. Dentists should be familiar with these variations in order to prevent treatment complications and success of mandibular related dental procedures.

Keywords: inferior alveolar canal; mandibular canal; mental foramen; anterior loop; CBCT
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Introduction

The inferior alveolar canal (IAC), sometimes called the inferior dental nerve, is a branch of the mandibular nerve which contains the inferior alveolar nerve, the inferior alveolar artery of the inferior alveolar system that moves diagonally downward and forward and then horizontally forward in the ramus which is located somewhere under the alveoli and the teeth are connected through small openings [1, 2]. Artery, vein and inferior alveolar nerve which is a branch of the third part of the trigeminal nerve moves through the mandible from the mandibular foramen to the mental foramen [3]. In the primary vertebral, the cartilage of the first bronchial arch (meckel's cartilage) forms maxilla [4]. Meckel's cartilage, which is an intermediate structure in the development of the embryonic mandible in mammals, disappears by undergoing different cell fates along the distal-proximal axis, with the majority (middle portion) undergoing degeneration and chondroblastic resorption [5]. In humans, this cartilage has a close proximity to the maxilla, but they do not form it [6]. As the evolution progress, meckel's cartilage is destroyed, except in two small parts which remain at its distal end, malleus and incus [7, 8]. Different types of bifid mandibular canals are described, which are classified according to anatomy and configuration using panoramic radiography [9, 10]. However, few studies have been used for this purpose using "Cone Beam Computed Tomography" (CBCT) or (C-armct) which is a medical imaging technic that consists of x-ray computer tomography and is formed as a cone [11, 12].

The results of previous anatomical and radiological studies indicate the significant changes in the mandibular canal pathway. Oliver found the IAC of only 60%. In other examples, the canal was less defined, and the nerves and vessels were placed inside the bone through the tunnel [13]. Nortje et al found the bifid mandibular canals [14]. Grover and Lorton were only able to find 0.08% of radiographs indicating a branch of bifid mandibular nerve as a possible cause of inadequate anesthesia in the mandible [15].

Materials and Methods

The aim of this study was to determine anatomical assessment of the IAC and anterior loop and measuring its distance to mental foramen in patients by CBCT. In this retrospective study, a total of 668 high quality CBCTs from edentulous and dentate patients aged between 15 and 75 years-old were reviewed after approval by the oversight board. All images of patients for diagnostic purposes were taken at the Oral and Maxillofacial and Radiography Clinics in Shiraz from 2012 to 2018 by the Mecapromax 3D MID software. CBCTs were analyzed by two inspectors (a senior student and a maxillofacial radiologist) on a LCD monitor (LG E2042C – Korea) and Sirona Galilco software. The required scan parameters were 90k VP and 14 mAp, depending on the size of patients. Exposure time was 14 seconds, the effective exposure time was 2 to 6 seconds, and the size of the voxel was 150 micrometers. The entry criteria were patients over 15 years-old whose bone growth was completed.

Surgical Steps

Exclusion criteria included patients under 15 years-old and the ones with mandibular pathologic lesions. CBCT predictions were analyzed at various levels such as tangential, cross-sectional and axial. The presence of bifid mandibular canal and anterior loop, corticalization level and incisive canal presence in transverse and axial dimensions, and canal dimensions were recorded. The ends of the teeth were referred as the anatomical index point.

The position of canal was evaluated in buccal, lingual and central form. Then the presence of anterior loop was determined and four positions were mentioned for that. Its absence on the right, left and both sides, and then the length of the anterior loop were calculated from the most anterior border mental foramen to the most anterior border loop (fig. 1). Then it was measured from the most anterior border mental foramen to the midline and the right anterior border mental foramen to its analogous left point (fig. 2). After that, the distance between the inferior mental foramen and the inferior mandibular border was measured (fig. 3). The length of the incisive canal (fig. 4) and its distance to the inferior mandibular border were also measured (fig. 5). Afterwards, we measured the distance between the buccal border of incisive canal and the buccal tablet, and between the lingual border and the lingual tablet (fig. 6). Also, the width of the lingual foramen and its distance to the inferior mandibular border were calculated accurately with other measurements by the software.

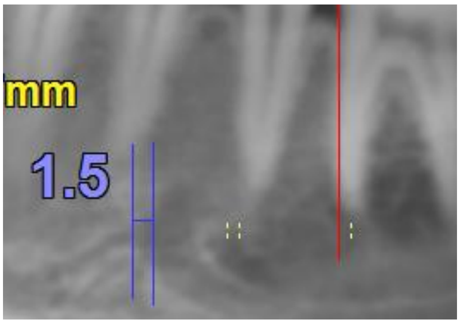

Fig. 1 Anterior loop

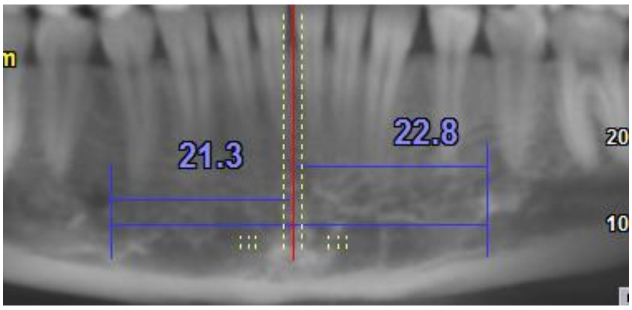

Fig. 2 The distance between mental foramen and midline

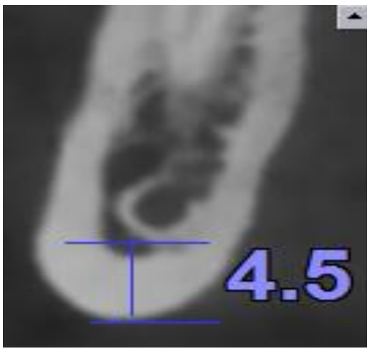

Fig. 3 The distance between the inferior mental foramen and the inferior mandibular border

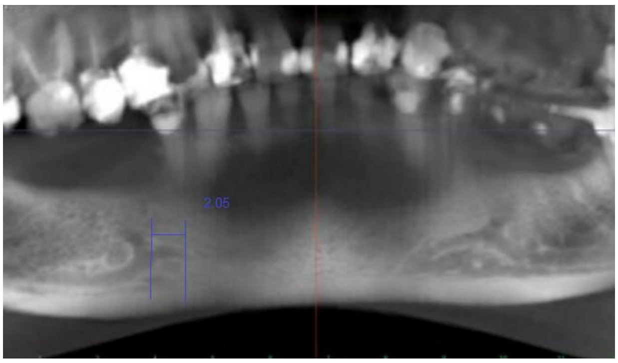

Fig. 4 The length of the incisive canal

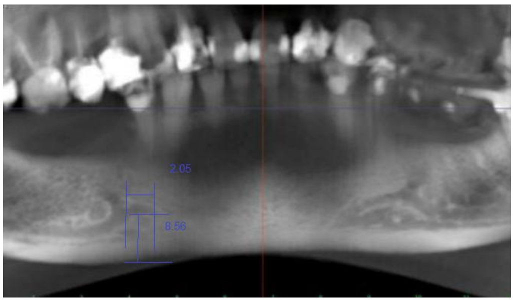

Fig. 5 The distance of incisive canal to the inferior mandibular border

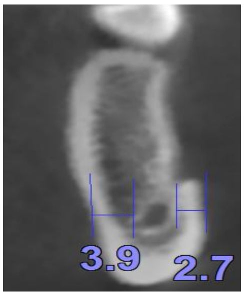

Fig. 6 The distance between the buccal border of incisive canal and the buccal tablet, and between the lingual border and the lingual tablet

Canal thickness was also classified in 5 categories:
0: Unknown cortex.
1: One of the lower or upper cortexes was found.
2: One of the lower or upper cortexes was correctly recognized.
3: Both the lower and upper cortexes were recognized.
4: Both the lower and upper cortexes were correctly recognized.

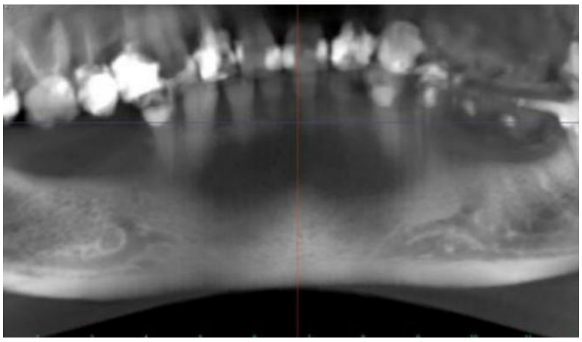

Fig. 7 Mandibular canal cortication

The maximum position and dimensions of the mandibular canal were measured between the mesial apexes of the second molar and the second premolar. Additional canals were divided into three types:
0: Without any canal.
1: With one additional canal.
2: More than one additional canal.

In these points, sagittal programs were evaluated and the largest diameter was mentioned as MC diameter. The shape of the canal was also classified as a circle or half crescent oval or unclassified. To open the mental foramen, it was rebuilt based on 3D CBCT images according to the categories like: poster superior, superior, mesial (anteriorly) and posterior labial.

Statistical Method

Statistical analysis was performed using SPSS 18 (SPSS, Chicago, IL, USA). Fischer's Test was used to determine the relationship between age and items recorded. Pearson Chi Square was used for statistical analysis of gender, localization and measurement. The significance level was set at p=0.05.

Results

A total of 668 images were surveyed in this study, among 238 males and 430 females. The anterior loop valves on the right side were seen in 606 (90.7%) cases and on the left side in 604 (90.4%). Statistical analysis did not show a significant difference between these two groups. In CBCT, 200 (29.9%) MC thickness was high and low on the right side. In 216 cases (33.8%) one thickness (up or down) and finally 46 (6.6%) of the images showed a degree of thickness in many sections. The thickness of the right canal was not seen in 196 cases (29.3%).

On the left, 218 (32.6%) of the CBCTs, the thickness of MC lower or upper cortexes was correctly seen. In 204 cases (30.5%), one (upper or lower) cortex was seen. In 64 (8.6%) of the images, they showed a degree of thickening. Left canal thickening was not found in 182 cases (27.2%). One single mental foramen was seen on the right side in 614 cases (93.4%). Double type was in 32 (4.3%) and more than 2 were in 12 pictures (1.8%). One solitary mental foramen was seen in 616 cases (93.7%) on the left. Double foramen was seen in 36 (4.5%) and more than 2 foramens were seen in 6 CBCTs (0.9%). The incidence of additional canals in the retro molar area on the right side was 32 cases (4.8%) and on the left side were 30 cases (4.5%).

Additional canals in the right molar area were 4 cases (0.6%) and in left side 6 cases (0.9%). At 612 CBCTs (94.6%), the frequency of additional canals was not found on both the right and the left side. The anterior loop valves on the right side were recognized in 214 men (89.9%) and 392 women (91.2%); and on its left side in 216 men (90.8%) and 388 women (90.2%). There was no significant relationship between gender and the presence of anterior loop on the right and left side. The average of the anterior loop length was 1041 ±3034 mm (mean: on the right 1.1 ±3.5 mm and on the left 1.4 ±2.9 mm). The mean of distance of the right mental foramen from the middle line was 4.9 ±24.9 mm and the left was 23.9 ±4.7 mm. So the distance between the two mental foramens was 48.8 mm. The mean of distance between the inferior mental foramen to inferior mandible was 2.28 ±5.05 mm (right 3.9 ±5.2 mm and left ±1.5 ±4.8 mm). The mean of incisive canal length was 0.70 ±1.49 mm; the left side was 0.48 ±1.44 mm and the total mean was 0.50 ±1.47 mm. The mean of incisive canal distance from the lingual mandibular border was 1.40 ±4.46 mm (right 1.50 ±4.58 mm and left 1.51 ±4.36 mm). The mean of incisive canal distance to buccal mandibular border was 1.17 ±3.48 mm (right 10.26 ±3.40 mm and left 1.48 ±3.48 mm). The mean of incisive canal distance to inferior mandibular border was 1.43 ±8.72 mm (right 1.98 ±8.98 mm and left 1.56 ±8.64 mm). The mean of the lingual canal foramen width was 0.09 ± 0.8 mm. The mean of distance between the lingual foramen and the inferior mandibular border was 2.99 ±8.85 mm (tab. 1).

Statistical data based on Chi Square statistics did not show any meaningful relationship with age. Independent T-Test showed no difference in the distance between the incisive canal and mandibular border in both genders. Based on the Pearson Regression Test, no relationship was found between the length of the incisive canal and the age (p=0.707, p=0.887). The additional canal was seen in the right side in 12 men (5%) and 24 women (5.6%). CBCTs showed an additional canal on the left side in 8 males (3.4%) and 28 females (6.5%). There was also no significant relationship between gender and the presence of additional canals on the right and left side (p=0.22, p=0/834).

The upper and lower MC thickness were in 84 men (35.3%) and 116 women (27%). The upper thickness was recognized in 84 males (35.3%) and 142 females (33%), and the lower one in 14 males (5.9%) and 32 females (7.4%) in some cases. The upper and lower cortication on the left side were seen in 94 men (35.5%) and 124 women (28.8%). The lower or upper cortication were recognized in 68 men (26.8%) and 136 women (31.6%) and finally no thickness was recognized in 54 men (22.7%) and 128 women (29.8%). Statistical analysis showed no significant relationship between sex and mandibular canal thickness in both sides (p=0.228, p=0.223). The single right foramen was seen in 228 males (95.8%) and 396 females (92.1%). In 10 men (4.2%) and 34 women (9.9%), more than one foramen was recognized. The single left foramen was recognized in 216 men (90.8%) and 410 women (95.3%). More than one foramen was recognized in 22 men (9.2%) and 20 women (7.4%). The thickness of both left and right did not show any significant relationship (p=0.098, p=0.191).

As you can see in tab. 2, these anatomical changes are in total 608 patients between 15 to 45 years-old (group 1) and 60 (9%) over 45 years-old (group 2). An additional canal was seen in 456 patients (94.7%) in group 1 and 56 patients (93.3%) in group 2. No significant relationship was found between age and additional canals (p=0/745). 570 patients (93.1%) in group 1 and 58 patients (96.7%) in group 2 had a mental foramen on the right side. On the left, 570 images (93.8%) of group 1 and 56 (93.3%) of group 2 had a single mental foramen. Statistical analysis showed that there is no significant relationship between age and the presence of mental foramen on both sides (p=0/451, p=0/929).

On the right side, in group 1, 170 (28%) patients showed high and low mandibular canal thickness. 214 cases (35.2%) showed high or low thickness. 39 cases (5.9%) showed MC thickness in many sections, and eventually 188 (30.9%) did not show any thickness from the right side. In group 2, 15 patients (50%) showed high and low mandibular canal thickness, 12 cases (20%) showed high or low thickness, 10 cases (16.7%) showed the thickness of the mandibular canal in many parts, and finally, 8 cases (13.3%) did not show any thickness from the right side.

On the left side, in group 1, 188 patients (30.9%) showed high and low mandibular canal thickness. 192 cases (31.6%) showed high or low thickness. 58 cases (9.5%) showed the thickness of mandibular canal in many sections, and finally, 175 cases (28%) did not show any thickness. In group 2, 30 (50%) patients had high and low mandibular canal thickness, 12 (20%) showed high or low thickness, 6 (10%) in many sections showed MC thickness, and finally, 12 cases (20%) did not show any thickness from the left side.

The thickness of the right side of mandibular canal showed a significant correlation (p=0/003), but the left side in all the pictures did not show any meaningful relationship (p=0/180). Tab. 3 classified these changes in both right and left side in both age groups.

Table 1 Measure of the anterior loop length and the incisive canal in both sides

	Right	**Left**	**Mean**
anterior loop length	1.1 ±3.5	2.9 ±1.4	1.41 ±3.34
from anterior loop to mental foramen from the middle line	23.9 ±4.7	24.9 ±4.8	48.8
from inferior mental foramen to inferior mandible	5.2 ±3.9	4.8 ±1.5	5.05 ±2.28
incisive canal	1.49 ±0.70	1.44 ±0.48	1.47 ±0.50
from incisive canal to lingual mandible border	4.58 ±1.51	3.36 ±1.51	6.46 ±1.40
from incisive canal to buccal mandible border	3.40 ±1.26	3.48 ±1.25	3.48 ±1.17

from incisive canal to inferior mandible border	8.98 ±1.68	8.64 ±1.51	8.72 ±1.43
lingual canal foramen	–	–	0.80 ±0.09
from lingual canal foramen to inferior mandible border	–	–	8.85 ±2.99

Table 2 Relationship between age and presence of AL, MF and MC thickness and additional canals and anatomical changes of MC and MF based on age

									P value
Anterior loop	Right Side 606	Male 214	Female 392		Left Side 604	Male 216	Female 388		R S P=0.707. L S P=0.876
MC cortication	Upper & lower Cortication 200 (84 male, 116female)	Upper Or lower Cortication 226 (284 male, 142female)	Degree of Cortication 46 (12 male, 32female)	No Cortication 196	Upper & lower Cortication 200 (84 male, 116female)	Upper Or lower Cortication 204 (68 male, 136female)	Degree of Cortication 64	No Corticatio n 182 (54 male, 128 female)	R S P=0.232 L S P=0.228
Mental Foramen 228	Single 614 (228 male, 396 female)	Double 32	More 12 (10 male, 2 female)	Total 668	Single 626 (216 male, 410 female)	Double 36	More 6	Total 661	R S P=0.191 L S P=0.098
Accessory canals premolar	32				30				
Accessory canals molar	4		No canal 632		6			No canal 632	
Accessory canals	Male 12	Female 24			Male 8	Female 28			R S P=0.834 L S P=0.222

Table 3 The changes in both right and left side of mandibular canal in both age groups

	Age 15 – 45 (608 patient)	Age +45 (30 patients)	P
No Accessory canal	576	56	
Right Single mental foramen	570	58	P=0.451
Left Single mental foramen	570	56	P=0.929
Upper and lower MC Cortication	R=170 L=188	R=30 L=30	–
Upper or lower MC Cortication	R=214 L=192	R=12 L=12	–
MC Cortication in many sections	R=36 L=58	R=10 L=6	P=0.180
No cortication	R=188 L=170	R=8 L=12	–

Discussion

The mandibular canal, which carries the lower alveolar nerve and the vessels that transfer the mandibular teeth and adjacent structures, is an empty space surrounded by bone tissue and from the back to the forward of the mandibular foramen which extends to the front of the mental foramen [16, 17].

Knowing the exact position of the mandibular canal inside the mandible and identifying anatomical variations, such as the bifid mandibular canal or extra foramen and anterior loop to prevent potential complications during dental surgery are important, such as tooth extraction, implant installation, and periapical surgery [18, 19, 20]. Although it is generally considered that MC is a single structure. Since 1973, bifid and trifid changes from mandibular canal have been recognized by using panoramic radiography [21, 22]. However, the identification of bifid canals with panoramic radiography is difficult due to the presence of ghostly shadows which are due to the respiratory path, soft tissue, small tongue and the opposite of the mandible area [23, 24].

In 1973, Patterson described a case of one-way mandibular bifid canal with two mental foramens. He stated that, despite the many anatomical abnormalities described in the articles, there was no reference to the existence of this radiological image of a double dental nerve confirmed by a lateral projection radiograph from the skull [25]. In this study, we used high quality CBCTs to recognize the changes and the results showed that 86 patients had more than one mental foramen. Liete et al evaluated an example of 250 CBCT examinations (500 mandibular canals). An entrance criterion was mandibular CBCT examinations required for dental implant planning. Anatomical changes and lesions affecting the mandibular canal were evaluated in CBCT examinations. In addition, the buccal lingual position of the mandibular canal was investigated in the molar area and the ramus area. Large anatomical changes were recognized in mandibular incisive canal (51.6%), ramification (12%), and extra mental foramen (3.2%). There was no difference between anatomical variations in patients' age ($p > 0.05$) [26, 27]. These findings are in harmony with us, but we have not mentioned the diameter of the incisive canal.

The mandibular canal is divided into the mental and the incisive canal in the retro molar pad area, forming an anterior loop which passes in front of the mental foramen and then returns to the mental foramen [28]. The anterior loop can actually be described as extension of the mandibular canal that is smaller than the mental foramen [29]. Brown and Apostolakis examined 93 Brazilian patients with a Newtom VG device for various clinical symptoms in a retrospective study. By using some software platform capabilities of the device, the prevalence and the anterior loop length were investigated. The results of their study showed that the anterior loop could be identified in 48% of cases with an average length of 0.89 mm. They concluded that in almost half of the cases, there was an anterior mandible. Although in 95% of cases, the loop was less than 3 mm, 100% safety margin in the placement of an implant, anterior mandible in the absence of a CBCT, was only 6 mm between the anterior borders of the mental foramen and the more distal inter foramina implant texture [30, 31]. In this study, anterior loop was found in a large number of images reviewed by the authors (on the right of 303 and on the left of 302 patients).

Sun Kyoung Yu et al studied on 19 Korean corpses (16 males and 3 females, with an average age of 44-54 years-old) by precise separation with surgical microscope. The position of the anterior loop, mandibular diameter, the incisive canal and the distances from the bone landmarks using digital caliber were measured. The anterior loop of the mandibular canal was 3.05 ± 1.15 mm ahead of the anterior mental foramen and was located 2.72 ± 1.41 mm below the upper margin of mental foramen with 4.34 ± 1.46 lengths. The anterior loop of mandibular canal was 1.3 mm taller and 7.2 mm lower than mental foramen and continued up and down to the mental canal and ended in the incisive canal [32, 33]. The present study did not only cover patient and body CBCTs. In this research, the mental foramen distance from the midline was 25 mm, while the Aardinger had a range of 2.9 to 0.48 mm [34].

On October 2012, Litter L, Neugebuuer et al. reviewed the implant placement in anesthetized mandibular anomalies, examined the age, sex, and extent of bone erosion on 1010 German cases of CBCT and found that the anterior loop was present in 1.3 individuals with the length of 7.6-6.7 mm [35].

On March 2015, Yusk Kim et al examined 26 Korean cases and measured the length, anterior loop diameter and its distance from the lower end of the mandible. They published the results and indicated that the mean was 3.1 mm [36]. In another study by Lautnern et al on October 2015, it was surveyed in 37 German cases in which the prevalence of the average and maximum length of the anterior loop was obtained, and ultimately the length of 2 mm was the safety length for the distance from mental foramen to implant placement [37].

In February 2016, Del Valle Lovato et al reviewed 55 Mexican samples and measured the mean length, the prevalence, the left and right side affinities, and the difference in the determination of the anterior loop. They acknowledged that the difference was on the right and left, there was no difference between male and female, and the average length of the anterior loop was 2.19 mm [38]. On March 2016, Panjnoush et al, in an article and during the study, 200 Iranian cases of CBCTs evaluated and determined the position of the mental foramen and incisive canal in which they found that the difference between the end of the canal and the buccal tablet and the lower mandibular lower extremity in women was less than that of the men. Age was also associated with a low incidence of anterior loop (59.5%) [39].

Powcharoen and Chinkrua performed a retrospective study of 49 patients referred for the third molar surgery with CBCT data. Coronal CBCT images were examined and exposure to IAN was recognized during the surgery. The predictor variables were the thickness and shape of the mandibular canal. All exposures to IAN showed that there was a lack of canal thickness. The mandibular canal shape (58.69%) was 27 dumbbells (26.08%) and oval (15.21%) tear drops. They concluded that the absence of mandibular canal thickness was high sensitivity and attributed to the prediction of exposure to IAN during molestation surgery [40, 41]. In this study, the thickness of the mandibular canal was most prominently found in most cases. MC thickness was not seen in the left side of 91 cases and in right side of 98 ones.

Yilkontiola et al conducted a study to determine the position of buccal lingual of mandibular canal in 20 patients. For osteotomy of the sagittal bilateral bifid, the mandibular canal position was evaluated by using the panoramic radiography, scan and CT [42]. Three imaging methods were compared for their ability to determine the position of the mandibular canal in the buccul lingual. They found that CT imaging from mandibular canal was better than scan [38]. The mandibular canal thickness in panoramic radiography is not a predictor of the proximity of the mandibular canal to the mandibular cortex [40]. We used CBCT images in this research and did not compare it with other images.

There were several reports of extra mandibular canals and foramina. This article could be divided into radiographic studies, anatomical studies (including anatomical examination of dry organs), and a combination of two cases and reporting of cases in a retrospective study of panoramic radiography. Further variation in the complementary mandibular canals was recognizable. The position of the entry of this new type into the mandible was through an additional foramen far from lingual.

In a panoramic radiography survey of 5000 cases at the age of 17 ± 26 years-old, four radiographies (0.08%) represented the mandibular canal. Anatomical changes in the mandible in the form of additional foramina and canals cannot be properly identified due to surgical complications. Surgical infiltration to anatomical structures may cause bleeding, reduce the sight of the surgeon and increase the potential for the formation of fibrous tissue at the site of contact with the implant. Most importantly, the patient may experience dysesthesia [40, 39].

Kaufman viewed a case of additional mandibular canals and foramina in CT and reviewed the related articles. He concluded that CT had more advantages than 2D radiographs of detecting anatomical changes in the mandible. Foramina at the end of the alveolar bone were relatively symmetric in the anterior mandible towards the ramus ascending of 1 to 2 mm in diameter [40]. We only used CBCT images to prevent extra radiation, and other images were not included. There are large variations in the size of the extra mandibular foramina. They may be as small as 0.1 mm or more than 1.5 mm wide, and are often of the same size as the main foramina [18]. Smaller foramina are rarely measured because they are not recognizable as a porous appearance [19]. In addition, there are changes in their number. Some of the mandibles may not have any of them; while in rare cases in a mandible up to 100 foramina also have been observed [20]. Differences in size and number may be explained by different input criteria for size and different assessment methods [40]. It is logical that the studies which conducted using dissection and examination of dry mandibles will provide more foramina [18]. Among the studies which performed on the basis of radiographic evaluation, many of the forums are not visible [41]. Most studies agree that most of the foramina are concentrated in the posterior area of the mandible and less in the symphysis, and in the interior, it is more frequent than the outer surface of the mandible [34]. In our study, there were no multiple foramina, but in some cases four foramina were observed.

Conclusion

This study showed that there are many anatomical changes in the mandibular canal, mental foramen and anterior loop. The results of this study indicate that mandibular canals and alterations in the mental foramen and anterior loop are present in a large part of the population, which are often unknown; even if they can be recorded in panoramic radiography. CBCT images provide the best information on the mandibular canal, which is very valuable.

Suggestions

Dentists should be familiar with these changes in order to prevent the side effects and mandibular dental procedures. Imaging technics help us to get the better results. Of these, CBCT is recommended because it provides the appropriate means for reviewing, identifying and approving such changes.

References

1. Greenstein G, Cavallaro J, Tarnow D. Practical application of anatomy the dental implant surgeon. ***J Perio***. 2008, 11: 837-839
2. Carter R B, Keen E N. The intra mandibular course of the inferior alveolar nerve. ***J Anat***. 1971, 108(3):433-440
3. Moiseiwitsch JRD. Position of the mental foramen in a North American, white population. ***Oral Surg Oral Med Oral Pathol Oral Radiol Endod***. 1998, 85(4):457-64
4. Wadu SG, Penhall B, Towsend GC. Morphological variabilitu of the human inferior alveolar nerve. ***Clin Anat.*** 1997, 10(2):82-87
5. Haveman CW, Tebo HG. Posterior accessory foramina of the human mandibular. ***J Prosthet Dent***. 1976, 35:462-468
6. Chavez ME, Mansilla J, Pompa JA*, et al.* The human mandibular canal arises from three separate canals innervating different tooth groups. ***J Dent Res***. 1996, 75:154-160
7. Langlais RP, Broadus R, Glass BJ. Bifid mandibular canals in radiographs. ***J Am Dent Assoc***. 1985, 110:923-926
8. Rouas P, delbos Y, Nancy J. Pseudo multiple and enlarged mandibular canals: the evidence-based response of cone beam computed tomography. ***Dentomaxillofac Radiol***. 2006, 217-218
9. Igarashi C, Kobayashi K, Yamamoto A, Morita Y, Tanaka M. Double mental foramina of the mandibular on computed tomography images: a case report. ***Oral Radiol***. 2004, 20:68-71
10. Auluck A, Pai K M. Trifid mandibular nerve canal. ***Dentomaxillofac Radiol.*** 2005, 34(4):259
11. Nortje CJ, Farman AG, de V Joubert JJ. The radiographic appearance of the inferior dental canal: an additional variation. ***Br J Oral Surg***. 1977, 15:171-172
12. Langlaiis RP, Broadus R, Glass BJ. Bifid mandibular canals in radiographs. ***J Am dent Assoc***. 1985, 110:990-992
13. Oliver E. Le canal dentairinferieuret son nerf chez ladulte. ***Ann Anat Pathol.*** 1927, 4:975-987
14. Nortje CJ, Farman AG, Grotepass FW. Variations in the normal anatomy of the inferior dental (mandibular) canal: a retrospective study of panoramic radiographs from 3612 routine dental patients. ***Br J Oral surg.*** 1977, 15:55-63
15. Grover PS, Lorton L. Bifid mandibular nerve as a possible cause of inadequate anesthesia in the mandibular. ***J Oral MaxillofacSurg***. 1983, 41:177-179
16. Sicher M, Bruls Du. Oral Anatomy. ***J Anat***. 1990, 169:266-277

17. Scarf WC, Farman AG, Sukovic P. Technical Description of CBCT from University of Manchester: Clinical applications of cone-beam computed tomography in dental practice. ***Journal of the Canadian Dental Association***. 2006, 72(1):75-80
18. Hatcher DC. Operational principles for cone-beam computed tomography. ***Journal of the American Dental Association***. 2010, 3:3S-6S
19. Orth RC, Wallace MJ, Kuo MD. C-arm cone-beam CT: general principles and technical considerations for use in interventional radiology. ***Journal of Vascular and Interventional Radiology***. 2008, 19(6):814-20
20. Mah JK, Huang JC, Choo H. Practical applications of cone-beam computed tomography in orthodontics. ***Journal of the American Dental Association***. 2010, 141(3):7S-13S
21. Nikzad S,Azari A, Sabouri S. Double mandibular foramina and canal: report a case with interactive CT-based planning software. ***Iran J Radiol***. 2008, 5(2):83-86
22. Norton MR, Gamble C. Bone classification: an objective scale of bone density using the computerized tomography scan. ***Clinical Oral Implants*** Research. 2010, 12(1):79-84
23. Mah P, Reeves TE, McDavid WD. Deriving Hounsfield Units using grey levels in cone beam computed tomography. ***Dentomaxillofacial Radiology***. 2011, 39(6):323-35
24. Zografos J, Kolokoudias M, Papadakis E. The types of mandibular canal. ***Hell Period Stomat Gnathopathoprosopike Cheir.*** 1999, 5:17-18
25. Patterson JE. Bifid inferior alveolar canal. ***Oral Surg Oral Med Oral Pathol.*** 1973, 36-39
26. Leite GM, Lana JP, de Carvalho Machado V , Manzi FR, Souza PE, HortaMC. Anatomic variations and lesions of the mandibular canal detected by cone beam computed tompography. ***SurgRadiol Anat***. 2014, 36(8):795-804
27. Leite GM, Lana JP, Carvalho Machado V, Manzi FR, Souza PE, Horta MC. Anatomic variations and lesions of the mandibular canal detected by cone beam computed tompography. ***SurgRadiol Anat***. 2014, 36(8):795-804
28. Sanchis JM, Penarrocha Miguel, Soler F. Bifid Mandibular Canal. ***J Oral Maxillofac Surg***. 2003, 61:422-424
29. Kim MS Yoon SG, Park HW, Kang JH, Yang SY, *et al*. A false presence of bifid mandibular canals in panoramic radiographs. ***Dentomaxillofac Radiol***. 2011, 40(7):434-438
30. Apostolakis D, Brown JE. The anterior loop of the inferior alveolar nerve: prevalence, measurement of its length and a recommendation for interforaminal implant installation based on cone beam CT imaging. ***Clin Oral Implants Res***. 2012, 23:1022-1030
31. Kaufman E, Serman NJ, Wang PD. Bilateral mandibular accessory formina and canals: a case report and review of the literature. ***Dentomaxillofac Radiol***. 2000, 29(3):170-175
32. Su Kyoung Yu, Seog Kim, Shin Gu Kang, Jae Hyuk Kim, *et al*. Morphological assessment of the anterior loop of the mandibular canal in Koreans. ***Anat Cell Biol***. 2015, 48(1):75-80
33. Koutouzis T, Wennstrom JL. Bone level changes at axial and non-axial positioned implants supporting fixed partial dentures; a 5-year retrospective longitudinal study. ***Clinical oral implants research.*** 2007, 18(5):585-90
34. Capote TS, Goncalves MA, Campos DB. Retromolar canal associated with age, side, sex, bifid mandibular canal, and accessory mental foramen in Brazilians panoramic radiographs. ***Anatomy Research International***. 2015, 8:43-48
35. KarbasiKheir M, Hekmatian E. Cone-beam computed tomography evaluation of mental foramen variations; a preliminary study. ***Radiology Research and Practice.*** 2015, 4:36-47

36. Fabian M. Position, shape and direction of opening of the mental foramen in dry mandibulars of Tanzanian adult black males. ***Italian Journal of Anatomy and Embryology***. 2007, 112(3):169-177
37. Ossenberg NS. Retromolarforamen of the human mandibule. ***Am J Phys Anthropol***. 1987, 73:119-128
38. Powcharoen W, Chinkrua C. Cone-beam computed tomographic assessment of mandibular canal as predictors of intraoperative nerve exposure after third molar surgery. ***Anatomy Research International***. 2015, 1654-1701
39. Panjnoush M, Mirzaey M, Tari M. Pre-implant linear tomography using film-screenand photostimulable phosphor plate in mandible. ***Journal of Dental Medicine***. 2010, 23(2):128-133
40. Elias CN, Meirelles L. Improving osseointegration of dental implants. ***Expert review of medical devices***. 2010, 7(2):241-256
41. Dubey RK, Gupta DK, Singh AK. Dental implant survival in diabetic patients; review and recommendations. ***National Journalof Maxillofacial Surgery***. 2013, 4(2):142-150
42. Ylikontiola L, Moberg K, Huumonen S, Soikkonen K, Oikarinen K. Comparison of three radiographic methods used to locate the mandibular canal in the buccolingual direction before bilateral sagittal split osteotomy. ***Oral Surg Oral Med Oral Pathol Oral Radiol Endod***. 2002, 93(6):736-742