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Assessing the Prevalence and Morphological Characteristics of Bifid Mandibular Canal Using Cone-Beam Computed Tomography – A Retrospective Cross-Sectional Study

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ABSTRACT

Objectives: To evaluate the prevalence, location and configuration of bifid mandibular canals so as to avoid injury to the nerve and inadequate anesthesia during surgical procedures.

Materials and Methods: CBCT scan of 203 patients (125 males and 78 females) was evaluated for the presence and the type of the bifid mandibular canal. They were classified according to Nortje *et al*. The prevalence rates were determined according to gender, location, and type of bifid mandibular canal. Statistical analysis was performed using IBM SPSS software version 24.

Results: The prevalence rate of bifid mandibular canals was found to be 10.3% with 12.8% in males and 6.4% in females. The Chi-square test reveals there is a statistically significant difference between the different locations of bifid mandibular canals and most of the canals were present on the right side. The most frequent type of bifid mandibular canal observed was type II dental canal (38.1%), followed by type III forward canal (28.6%), type I retromolar canal (14.3%), and type IV buccolingual canal (14.3%).

Conclusion: CBCT is suggested for a detailed evaluation and identification of bifid mandibular canals before any surgical procedures to avoid post-operative complications.

Keywords: Cone-beam computed tomography, Bifid mandibular canal, Prevalence

INTRODUCTION

A bifid mandibular canal is an anatomical variation of the mandibular canal, which is divided into two branches and each separated branches might contain a neurovascular bundle.[1] The bifid mandibular canal variations can be visualized using various imaging modalities such as panoramic radiograph, computed tomography (CT), and cone-beam computed tomography (CBCT). Literature reveals that the prevalence rate of bifid mandibular canals was about 0.08–1.95% in panoramic radiographs and 3.4–65% in CBCT. The occurrence of the bifid mandibular canal has no correlation with the age of a patient. The radiographic appearance of mandibular canal is characterized by a radiolucent strip between two radiopaque lines as a single structure which is present inside the body of the mandible and occasionally duplicates in mediolateral directions as bifurcations and even as trifurcations.[2]

Until the advent of CBCT, the panoramic radiograph was used to identify bifid mandibular canals. Several studies done using orthopantomogram have shown lower prevalence rate than those with CBCT which is due to the lack of information in three-dimensional view. A panoramic radiograph can also produce false images by radiological osteocondensation caused by the insertion of the mylohyoid muscle into the internal mandibular surface. Moreover, ghost shadows produced by the opposing side of the mandible, the pharyngeal airway, the soft palate, and the uvula may hamper the localization of the mandibular canal using panoramic radiographs.[3]

CBCT is an advanced imaging modality which is superior to panoramic radiograph which provides high-resolution, superimposition-free, non-magnified, and undistorted three-dimensional images.[4] CBCT can also provide multiplanar images for identifying the bifid mandibular canal, without any errors such as ghost images and pseudo canals. The identification of the presence of the bifid mandibular canal is important during any mandibular surgical procedures to avoid post-operative complications.[5] The aim of the present study was to evaluate the accurate configuration and the presence of bifid mandibular canal using CBCT.

MATERIALS AND METHODS

This retrospective study was approved by the Institutional Ethical Committee. The study was performed on 203 CBCT images of patients who underwent pre-operative CBCT imaging for various dental purposes on a My Ray Sky View CBCT equipment. The CBCT images of patients aged above 15 years were included in the study. CBCT images that failed to show any part of the mandible and those that were of insufficient accuracy of region of the interest and with the presence of any cyst, tumors, bony malformation, or surgical procedures in the body or ramus of the mandible were excluded from the study.

Image evaluation using CBCT

The CBCT images were reformatted using NNT iRYS viewer software. The software allows viewing of axial, cross-sectional, panoramic, and 3D visualization of the jaw on the same screen. Both the left and right side of the mandible were studied. Axial, sagittal, coronal, and panoramic views were evaluated and the density and contrast of the images were adjusted to improve the visibility of inferior alveolar nerve course and modifications of the image were done with thickness slice of about 1 mm and distance of about 0.2 mm. Using the nerve marking tool, the course of the inferior alveolar nerve was traced using red and yellow colors. Red color marking was used to trace the main mandibular canal and yellow color was used for the bifid mandibular canal. The tracing was done in the panoramic view which could be viewed simultaneously in the axial, coronal, and cross-sectional views.

For clear visualization of the mandibular canal, the center of rotation of the reference line for multiplanar reconstruction was initially set at the mandibular canal. Then, the various sections were rotated horizontally and the center was moved buccolingually and anteroposteriorly by varying degrees to detect the bifid mandibular canal. The actual presence of bifid mandibular canal was established only if it was found on all reformatted images such as panoramic, coronal, and sagittal section. The bifid mandibular canals were further classified according to Naitoh *et al.*'s classification.[6]

- Type I (Retromolar canal type): The retromolar canal, which bifurcates from the mandibular canal in the mandibular ramus region, courses forward at the first, reaching the retromolar region [Figure 1a-c]
- Type II (Dental canal type): The dental canal, which bifurcates from the mandibular canal in the mandibular ramus region, courses forward, reaching the root of the molar [Figure 2a-c]
- Type III (Forward canal type): (a) Forward canal without confluence: The forward canal, which bifurcates from the mandibular canal in the mandibular ramus region, courses forward to the second molar region [Figure 3a-c]. Forward canal with confluence: The forward canal, which bifurcates from the mandibular canal in the mandibular ramus, courses anteriorly and then joins the main mandibular canal [Figure 3d-f]
- Type IV (Buccolingual canal type): (A) Buccal canal: The buccal canal, which bifurcates from the mandibular canal in the mandibular ramus, courses bucco-inferiorly [Figure 4a and b]. (B) Lingual canal: The lingual canal, which bifurcates from the mandibular canal in the mandibular ramus, courses lingually and then penetrates through the lingual cortical bone [Figure 4c and d].

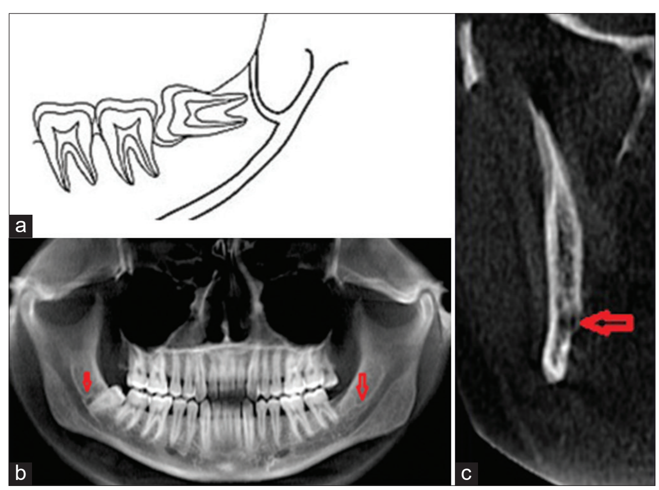

Figure 1: (a) Line diagram – Type I retromolar canal. (b) Bilateral type II Retromolar canal in a 21-year-old male patient shown on a recreated panoramic view (Red arrow shows bifurcation). (c) Cross-sectional view confirms the bifurcation (Red arrow shows bifurcation).

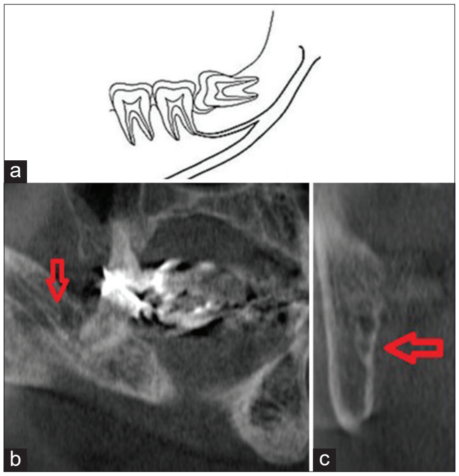

Figure 2: (a) Line diagram – Type II dental canal. (b) Type II dental canal in a 32 year male patient present unilaterally shown on a recreated panoramic view (Red arrow shows bifurcation). (c) Cross-sectional view confirms Type II Dental canal (Red arrow shows bifurcation).

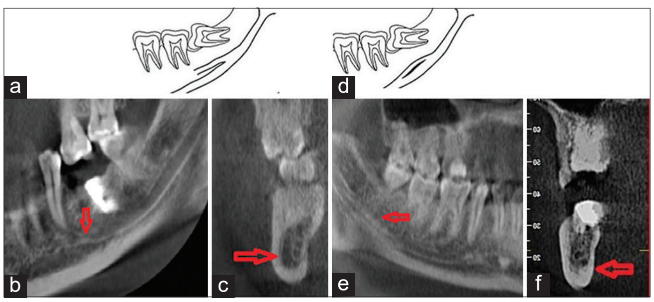

Figure 3: (a) Line diagram – Type III A forward canal without confluence. (b) Type III forward canal without confluence in a 51-year-old male patient shown on a recreated panoramic view (Red arrow shows the bifurcation). (c) Cross-sectional view confirms the bifurcation (Red arrow shows the bifurcation). (d) Line diagram – Type III B forward canal with confluence. (e) Type III B Forward canal with confluence in a 22-year-male patient shown on a recreated panoramic view (Red arrow shows bifurcation). (f) Cross-sectional view confirms the bifurcation (Red arrow shows the bifurcation).

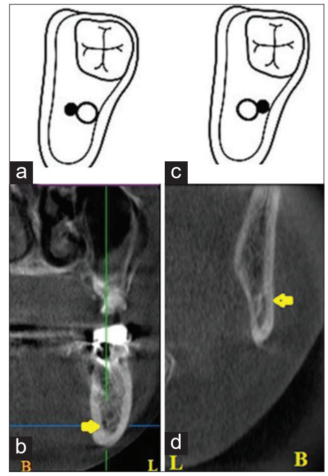

Figure 4: (a) Line diagram – Type IV buccal canal. (b) Type IV A buccal canal depicted in a 45-year-old male patient (Yellow arrow). (c) Line diagram – Type IV B lingual canal. (d) Type IV B lingual canal depicted in a 40-year-old female patient (Yellow arrow).

Statistical analysis

On a Microsoft Excel spreadsheet, the data such as image number, age, gender, presence of bifid mandibular canal (right or left), and type of bifid mandibular canal were documented. Statistical analysis was performed on IBM SPSS software (Version 24). The differences in the prevalence rate of the bifid mandibular canal according to gender, location (right or left) and types were evaluated using the Pearson's Chi-square test, Mann–Whitney U test, and Fisher's exact test.

RESULTS

Out of 203 CBCT images selected, 21 images showed the presence of bifid mandibular canals indicating the prevalence of the present study as 10.3%. The bifid mandibular canals were observed in 16 (12.8%) males and 5 (6.4%) females. No significant difference was found among genders statistically [Table 1]. Out of 21 (10.3%) bifid mandibular canals, ten (47.6%) canals were present on the right side, eight (38.1%) canals on the left side, and three (14.29%) canals bilaterally. Pearson's Chi-square test reveals there is a statistically significant difference between the different locations of bifid mandibular canals ($P < 0.001$) [Table 2]. Among the 16 CBCT from male patients with bifid mandibular canals, 6.4% (8) were located on the right side, 4% (5) on the left side and only 2.4% (3) bilaterally. Among five female's patients with bifid mandibular canals, 2.56% were located on the right side, and 3.85% (3) on the left side. No cases of bilateral canals were found among females. The Fisher's exact test reveals no statistically significant difference between the sides which implies that there is no preference for the side of occurrence of bifid mandibular canals between genders [Table 3].

Among the 21 bifid mandibular canals identified, the most frequent type of bifid mandibular canal observed was type II dental canal (9 cases – 38.1%), followed by type III forward canal (6 cases – 28.6%), type I retromolar canal (3 cases – 14.3%), and type IV buccolingual canal (3 cases – 14.3%). Of the six forward canals (Type III) identified, one (4.76%) occurred with confluence and five (23.8%) occurred without confluence. Of the three buccolingual canals (type IV) identified, one (4.76%) was a buccal canal and two (9.5%) was a lingual canal. The rest of the 18 canals were located along the course of the mandibular canal. The Chi-square test reveals $P = 0.49$ which is not statistically significant. Hence, the different types of bifid mandibular canals are distributed uniformly [Table 4].

Table 1: Prevalence of bifid mandibular canal according to gender.

Gender	Present		Absent		Mann–Whitney U test: *P* value
	n	%	*n*	%	
Male	16	12.8	109	87.2	0.964
Female	5	6.4	73	93.58	
Total	21	10.3	182	89.6	

Table 2: Prevalence of bifid mandibular canals according to different location.

Location	Present (%)	Absent (%)	Value	*P* value
Right side	10 (47.6)	11 (52.4)	453.099	<0.001**
Left side	8 (38.1)	13 (61.9)		
Bilateral	3 (14.29)	18 (85.7)		

Table 3: Different locations of bifid mandibular canals according to gender.

Location		Gender				Fisher's exact test	
		Male		Female			
		n	%	*n*	%	Chi-square value	*P* value
Unilateral-right	Present	8	6.40	2	2.56	1.509	0.323
	Absent	117	93.60	76	97.44		
Unilateral-left	Present	5	4.00	3	3.85	0.003	1.000
	Absent	120	96.00	75	96.15		
Bilateral	Present	3	2.40	0	0.00	1.900	0.287
	Absent	122	97.60	78	100.00		

Out of 16 bifid mandibular canals identified in males, nine cases of bifid mandibular canal identified were Type II (Dental canal) followed by four cases of Type III B (Forward canal without confluence), two cases of type IV B (Lingual canal), and one case of type I (retromolar canal), type III A (Forward canal with confluence), and type IV A (buccal canal). When the different types of canals were statistically analyzed, $P = 0.006$ was obtained which implies that the different types of bifid mandibular canals were not uniformly distributed among males. Nearly 50% of males have only type II dental canal which is significantly higher when compared with other types [Table 5].

Out of five bifid mandibular canals identified in females, two canals were present as type I (retromolar canal) and type IV (Lingual canal), one canal as type III B (forward canal without confluence) and no cases of type II (dental canal), and type III (forward canal with confluence) or type IVA (buccal canal) were found. When the different types of canals among females were statistically analyzed, $P = 0.819$ was obtained which implies that the prevalence of bifid mandibular canal is uniformly distributed among females in the present study [Table 5].

Table 4: Frequency of various types of bifid mandibular canals among the 21 bifid cases.

Classification of bifid canals	No	Rate (%)	Chi-square value	*P* value
Type I - Retromolar canal	3	14.29	12.667	0.49
Type II - Dental canal	9	42.8		
Type III - Forward canal				
With confluence A	1	4.76		
Without confluence B	5	23.8		
Type 1 V - Buccolingual canal				
Buccal canal A	1	4.76		
Lingual canal B	2	9.5		

DISCUSSION

The mandibular nerve is a complex pathway which is located within the ramus and body of the mandible. It pathway begins at the mandibular foramen and exists at mental foramen.[7] In an anthropological study done by Chavez *et al*. suggested that during embryologic development three different mandibular canals occurred in each hemi mandible and from each canal three different inferior dental nerves originated and innervated the three mandibular region. During prenatal growth phase of bone remodeling and apposition, these three canals fuse to form single canal. Incomplete fusion of these three canals results in an anatomical variation such as bifurcation or trifurcation.[8]

One case of bifid mandibular canal was reported by Patterson and Funke who had illustrated little information regarding this entity till then.[9] Seeman *et al*. reported a double mandibular foramina in seven cases in 79 dry mandible studies and also reported no cases with more than two mandibular foramina in his study.[10] Rood *et al*. observed a case of failure to achieve mandibular anesthesia due to anatomical variation such as supplementary foramen which acts as escape route for the impulse to transmit pain.[11] Some authors have also reported cases of failure in achieving mandibular anesthesia and also radiological assessment the presence of bifid mandibular canal.

However, vast majority of dentist have little or no knowledge regarding the anatomical variation of mandibular canal. When bifid mandibular canal gets injured during any mandibular surgical procedures such as impacted third molar extraction, placement of dental implants, and sagittal split osteotomy it might result in complications such as traumatic neuroma, paresthesia, anesthesia, and bleeding. With regard to the different types of bifid mandibular canals, the most common retromolar canal type may open at the

Table 5: Frequency of different types of bifid mandibular canal based on gender.

Classification of bifid canals	Total	Total *P* value	Males	*P* value for males	Females	*P* value for males
Type I - Retromolar canal	3 (14.29%)		1 (6.2%)		2 (12.5%)	
Type II - Dental canal	9 (42.8%)		9 (56.2%)		0 (0%)	
Type III - Forward canal		0.49		0.006		0.819
With confluence A	1 (4.76%)		1 (6.2%)		0 (0%)	
Without confluence B	5 (23.8%)		4 (25%)			
Type 1 V - Buccolingual canal					1 (6.25%)	
Buccal canal A	1 (4.76%)		1 (6.2%)		0 (0%)	
Lingual canal B	2 (9.5%)		2 (12.5%)		2 (12.5%)	

bony surface of the retromolar region, contain neurovascular bundle, and supply third molar and the mucosa of the retromolar area. Injury to this canal during any surgical procedures may lead to excessive bleeding or post-operative anesthesia.[12]

Irrespective of the type, the presence of a bifid mandibular canal itself can cause certain complications. Inadequate anesthesia in the mandible is the most common problem encountered in patients with a bifid mandibular canal. The position of bifurcation in the mandibular ramus is often superior to the most commonly administered injection point.[13] Thus, Gow-Gates technique or the Akinosi technique can be used to perform local anesthesia where the anesthetic solution is injected at a slightly higher level before the bifurcation of mandibular nerve.[14] In case of trauma, all mandibular fractures should be handled with care to ensure precise alignment to avoid impingement when the fracture is reduced. Alignment of fragments becomes considerably more difficult in the case when a second neurovascular bundle is located in a different plane.[13]

Bifid mandibular canals may also cause pain and discomfort in patients with mandibular prostheses due to additional pressure placed on the neurovascular bundle. Any prosthetic restoration or implants located distal to the retromolar area can also lead to paresthesia and pain. Shen *et al.* reported that 32.4% of bifid mandibular canals were located in the potential position for dental implant placement.[15] Hence, insight regarding the prevalence, preferential location and configuration of the bifid mandibular canal are highly important.

The previous studies have reported that the prevalence of bifid mandibular canal identified using CBCT was considerably higher than that obtained using panoramic radiography. Tantanapornkul *et al.* compared panoramic radiograph and CBCT in the detection of mandibular canal and reported that CBCT has 93% of sensitivity and 77% of specificity. Hence, he concluded that CBCT can be used for more accurate visualization of mandibular nerve.[16] Neves *et al.* assessed the presence of bifid mandibular canal using panoramic radiograph and CBCT and reported 2.4% higher prevalence of bifid mandibular canal observed through CBCT.[17]

In the present study, the prevalence rate of bifid mandibular canal was found to be 10.3% using CBCT imaging. In comparison to the studies in the literature, the difference in the prevalence rate of bifid mandibular canal in the present study was due to variation in sample size, methodological difference, and geographical variations. Some authors have reported a slightly higher incidence of bifid mandibular canals among women,[18,19] but the present study showed no significant difference in the prevalence of bifid mandibular canals between men and women.

In the present study, most of the canals were present on the right. There is no preference for the side of occurrence of bifid mandibular canals between genders. This corroborated with the study done by Orhan *et al.*[3] and De Freitas *et al.*[2] who also reported a higher prevalence of bifid mandibular canal on the right side.

From reviewing the literature, several classifications were given by authors for classifying mandibular canal according to the anatomical location and configuration. Carter and Keen classified the inferior alveolar nerve arrangement in human dry mandible.[20] Nortje *et al.*[21] and Langlais *et al.*[18] classified the bifid mandibular canal using panoramic radiograph. Naitoh *et al.*[6] classified using CBCT imaging since his criteria included buccal and lingual canal, which can only be viewed in three-dimensional imaging and this classification has been used in the present study. In our study, the most frequently observed type of bifid mandibular canal was type II dental canal (38.1%), followed by type III forward canal (28.6%), type I retromolar canal (14.3%), and type IV buccolingual canal (14.3%). Orhan *et al.* used the same classification for a Turkish population and reported that the most frequent type observed was the forward canal type (29.8%) and least common type observed was the dental canal (8.3%).[3] Abbas *et al.* also used the same classification and found forward canal as the most frequent type (1.2%) and retromolar canal type as the least common (0.14%).[1] The reported prevalence rates of each type of bifid mandibular canal were not exactly consistent between various authors due to variation in study sample size, methodological difference, and geographical variations.

CONCLUSION

The identification and configuration of the bifid mandibular canals are essential to avoid post-surgical and anesthetic complications. CBCT is suggested for detailed evaluation of the bifid mandibular canal since studies have reported higher sensitivity and specificity. More studies on a larger sample should be done.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Abbas S, Sepideh F, Yousefi A, Setareh S, Payam A. Prevalence and characteristics of bifid mandibular canal by using cone-beam computed tomography. Int J Pharm Technol 2017;9:28132-9.
2. Freitas D, de Freitas Silva GB, Alessandra M, Alexandre FS, da Silva MB, Gomes TC. Incidence and classification of bifid mandibular canals using cone beam computed tomography. Braz J Oral Sci 2015;14:294-8.
3. Orhan K, Aksoy S, Bilecenoglu B, Sakul BU, Paksoy CS. Evaluation of bifid mandibular canals with cone-beam computed tomography in a Turkish adult population: A retrospective study Surg Radiol Anat 2011;33:501-7.
4. Kuribayashi A, Watanabe H, Imaizumi A, Tantanapornkul W, Katakami K, Kurabayashi T. Bifid mandibular canals: Cone beam computed tomography evaluation. Dentomaxillofac Radiol 2010;39:235-9.
5. Kang JH, Lee KS, Oh MG. The incidence and configuration of the bifid mandibular canal in Koreans by using cone-beam computed tomography. Imaging Sci Dent 2014;44:53-60.
6. Naitoh M, Hiraiwa Y, Aimiya H, Ariji E. Observation of bifid mandibular canal using cone-beam computerized tomography. Int J Oral Maxillofac Implants 2009;24:155-9.
7. Sanchis JM, Penarrocha M, Soler F. Bifid mandibular canal. J Oral Maxillofac Surg 2003;61:422-4.
8. Chavez ME, Mansilla J, Pompa JA, Kjaer I. The human mandibularcanal arises from three separate canals innervating different tooth groups. J Dent Res 1996;75:1540-4.
9. Patterson JE. Funke FW: Bifid inferior alveolar canal. Oral Surg 1973;36:287-8.
10. Serman NJ. An Osteo-radiographic Study of the Mandibular Canal. M.S. Thesis. South Africa: University of Stellenbosch; 1982. p. 77-108.
11. Rood JP. The analgesia and innervation of mandibular teeth. Br Dent J 1976;140:237-9.
12. Bilecenoglu B, Tuncer N. Clinical and anatomical study of retromolar foramen and canal. J Oral Maxillofac Surg 2006;64:1493-7.
13. Lee HW, Kim YG, Lee BS, Kwon YD, Choi BJ, Kim YR. Bifid mandibular canal: Radiographic observation and clinical relevance a case report. J Korean Dent Soc Anesthesiol 2009;9:24-9.
14. Auluck A, Pai KM, Mupparapu M. Multiple mandibular nerve canals: Radiographic observations and clinical relevance. Report of 6 cases. Quintessence Int 2007;38:781-7.
15. Shen EC, Fu E, Fu MM, Peng M. Configuration and corticalization of the mandibular bifid canal in a Taiwanese adult population: A computed tomography study. Int J Oral Maxillofac Implants 2014;29:893-7.
16. Tantanapornkul W, Okouchi K, Fujiwara Y, Yamashiro M, Maruoka Y, Ohbayashi N, *et al*. A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:253-9.
17. Neves FS, Nascimento MC, Oliveira ML, Almeida SM, Boscolo FN. Comparative analysis of mandibular anatomical variations between panoramic radiography and cone beam computed tomography. J Oral Maxillofac Surg 2014;18:419-24.
18. Langlais RP, Broadus R, Glass BJ. Bifid mandibular canals in panoramic radiographs. J Am Dent Assoc 1985;110:923-6.
19. Das S, Suri RK. An anatomico-radiological study of an accessory mandibular foramen on the medial mandibular surface. Folia Morphol (Warsz) 2004;63:511-3.
20. Carter RB, Keen EN. The intramandibular course of the inferior alveolar nerve. J Anat 1971;108:433-40.
21. 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;15:55-6.

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