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.\(^{[3]}\) 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).
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 | 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].

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
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.\[13\] 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.\[1\] 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 Iretromolar 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%).\[15\] 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.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Nithya J, Aswath N. Assessing the prevalence of bifid mandibular canal using CBCT.