

**PREVALENCE OF BIFID MANDIBULAR CANALS IN A UNITED
STATES DENTAL SCHOOL POPULATION**

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by
Shamus Gartley, D.D.S
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Examining Committee Members:

Yueh Hsiao, DMD, MS, Thesis Advisor, Department of Periodontology and Oral
Implantology, Temple University Kornberg School of Dentistry
Susan M. Chialastri, DMD, MS, Department of Periodontology and Oral
Implantology, Temple University Kornberg School of Dentistry
Jie Yang, DMD, DDS, MS, MMed. SC, Oral and Maxillofacial Pathology,
Medicine and Surgery

ABSTRACT

Objective:

The mandibular canal, which houses the inferior alveolar neurovascular bundle, is a critical anatomic structure that needs to be accurately identified for mandibular dental procedures such as dental implant placement, extractions, and endodontic procedures. Damage to the mandibular neurovascular bundle can cause both neurologic damage and bleeding concerns. “Bifid” mandibular canals are a normal anatomic variation of mandibular canals. The purpose of this study is to identify the prevalence of bifid canals, use the Naitoh classification system to classify the bifid canals, and to measure the height of alveolar bone above the most superior portion of the mandibular canal. Other factors such as gender and ethnicity were evaluated for association with bifid canal prevalence.

Methods:

Retrospective analysis of 1,006 mandibular CBCT scans of patients treated at the Temple Kornberg School of dentistry were analyzed using Xelis software. Age, gender, ethnicity, and dentition status were recorded for each patient in the study. For each scan the right and left mandibular canals were identified as singular or bifid, and the height of alveolar bone above the most superior border of the mandibular canal at the right and left first molar position was recorded. Descriptive statistics, bivariate analyses, and multivariable regression analyses were performed using “R” statistical software.

Results:

After exclusion, 558 CBCT scans were included in the study. Of the 558 patients, 247 were male and 311 were female. Based on ethnicity: there were 170 African Americans, 53 Asians, 263 Caucasians, and 72 Hispanics. 76 of the patients had a

complete mandibular dentition, and 482 were missing at least 1 tooth in the mandible. The prevalence of bifid mandibular canals in the study population was 12.54%. There was no significant difference in the prevalence of bifid canals in relation to gender or ethnicity. The height of alveolar bone above the most superior border of the mandibular canal at the first molar position ranged from (2.2mm to 28.4mm) with an average of 15.25mm. There was a significantly greater height of alveolar bone in fully dentate compared to partially edentulous patients ($p < 0.001$), and there was a significant negative correlation between alveolar bone height above the mandibular canal and age ($p < 0.045$).

Conclusions:

Bifid mandibular canals are present in 12.54% of the population studied, and the prevalence does not vary by gender, or ethnicity as past studies have proposed. Further, alveolar height above the mandibular canal decreases with age and tooth loss. Therefore, it is critically important to obtain CBCT imaging of the mandible before performing implant, oral surgical, or endodontic procedures to prevent neurosensory and/or bleeding complications and improve patient care.

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CHAPTER 1

INTRODUCTION

CBCT imaging of the mandible is indicated for numerous dental treatments such as, identification of bony pathologies, implant planning, endodontic treatment, oral surgical procedures, and identification of critical anatomic structures like the mandibular canal . CBCT imaging allows for detailed analysis and measurements in the three-dimensions and provides information that traditional two-dimensional radiography cannot.

CBCT stands for Cone Beam Computerized tomography. It is based on a volumetric tomography, using a two-dimensional extended digital array providing an area detector in combination with a three-dimensional x-ray beam. CBCTs are taken with a single 360° scan. At certain degree intervals “basis” images are acquired. The series of basis projection images captured is called the projection data. Software programs then convert the projection data into a three-dimensional volumetric data set, which can be used to provide reconstruction images in 3 orthogonal planes: axial, sagittal, and coronal- this process is known as multiplanar reformation (MPR) (Scarfe et al., 2006).

CBCT has numerous advantages over both medical CT and intra-oral radiographs. CBCT provides detailed three-dimensional data with much greater resolution (0.125mm to 0.4mm) than any intra-oral radiograph can provide, it has a much smaller area of irradiation than CT due to collimation, and it has a rapid scan time, taking only 10-70 seconds. Further, the average dose of radiation from a CBCT ranges from 36.9-50.3 μ Sv which is reduced by up to 98% when compared to fan-beam CT. For comparison, a film

based periapical survey of a complete dentition ranges from 13-100 μSv and a panoramic radiograph ranges from 2.9-11 μSv (Scarfe et al., 2006).

For many dental procedures performed in the mandible, it is surgically important to appropriately identify and trace the mandibular canal in three-dimensions. The mandibular canal is a critical anatomic structure as it houses the Inferior Alveolar Nerve (IAN), the inferior alveolar artery and veins, autonomic nerve fibers, and lymphatic vessels. Damage to the mandibular canal can cause neurologic problems such as paresthesia, anesthesia, and hyperesthesia, as well as bleeding and hematoma formation (von Arx & Lozanoff, 2018).

The typical course of the mandibular canal through the mandible is from posterior to anterior and from lingual to buccal (von Arx & Lozanoff, 2018). The canal is usually single and bilaterally symmetrical, but anatomic variations of the canal do exist. “Bifid” mandibular canals are a normal anatomic variation in the structure of the mandibular canal. “Bifid” mandibular canals were first described in anatomical dissection by Carter and Keen in ((1971), but the term “bifid” was not coined until (1973) by Patterson and Funke who confirmed its panoramic existence. Bifid mandibular canals are described as dual or double canals within the mandibular body, and they can be bilateral or unilateral in nature (von Arx & Lozanoff, 2018).

Different types of bifid mandibular canals have been described by multiple authors throughout the years, and the prevalence of these canals have varied widely from study to study. In 1977 Nortje et al. used panoramic radiographs to classify and describe the frequency of bifid mandibular canals, and only found bifid canals to be present in 0.9% of patients. Other studies which also used 2D radiology, also found very low rates

of mandibular canals, <1% (Grover & Lorton, 1983; Langlais et al., 1985; Sanchis et al., 2003). However, more recent studies using highly detailed three-dimensional CBCT images have found much higher frequencies of bifid mandibular canals. In 2009 Naitoh et al. used CBCT evaluation to create a new classification system of bifid mandibular canals based on three-dimensional images and found the frequency of bifid canals in their study to be 65%. Naitoh et al. (2009) described four different types of bifid mandibular canals: (1) retromolar, (2) dental, (3) forward, and (4) buccolingual (Fig 1.).

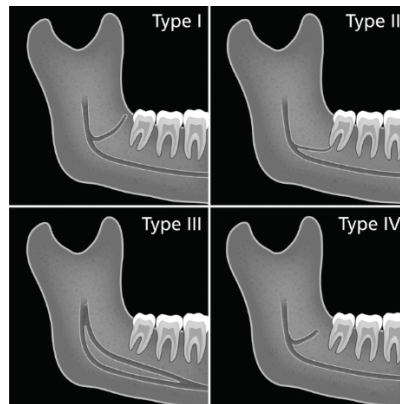


Figure 1. Naitoh et al. (2009) classification of bifid mandibular canals

Since Naitoh et al. (2009) introduced their classification system based on CBCT images, at least 12 studies have used it to label and detect the frequency of bifid mandibular canals in different specific populations (Ngeow & Chai, 2020).

In our PubMed search of the literature, we found 21 studies have used exclusively CBCT to determine the prevalence of bifid mandibular canals and these studies found a prevalence in the range of 0.05% to 82% (Ngeow & Chai, 2020). Although this still clearly shows a vast discrepancy in the reporting of prevalence, it does show that the more precise viewing allowed by CBCT does result in identifying more bifid mandibular canals. It has also been proposed by various authors that the reason for such wide

discrepancies between CBCT studies is due to the different ethnicities each study is based on (Elnadoury et al., 2022; Rashsuren et al., 2014; Zhou et al., 2020). Therefore, studies evaluating the effect of ethnicity on bifid canal prevalence are greatly needed.

When discussing differing anatomies of mandibular canals, it is also important to mention the height of alveolar bone that is present above the canal, as this is the space practitioners are most concerned. This is the space where implants are placed, teeth are extracted, and endodontic procedures are performed. Previous articles agree that the alveolar crest height is reduced in patients with poor oral hygiene (Schei et al., 1959), and as patients age (Schei et al., 1959; Streckfus et al., 1999). They also show that crest height is not influenced by gender (Streckfus et al., 1999). However, these studies evaluate changes in bone height by measuring distance from alveolar crest to CEJ and do not evaluate the height below the alveolar crest to the mandibular canal. Therefore, this study will also calculate the average height of alveolar bone from the most superior border of the mandibular canal to the alveolar crest at the right and left first molar position, and determine if there is any relationship between age, gender, ethnicity, or dentition status on crest height.

Although it was previously discussed that entering the mandibular canal can lead to intra and post-operative sensory and bleeding complications, it is important to note what types of procedures bifid mandibular canals can effect. Implant placement in the posterior mandible without careful nerve tracing can result in neurovascular complications if a more coronal bifid canal is not identified (Ngeow & Chai, 2020). Bifid canals have been implicated in cases of incomplete anesthesia (Grover & Lorton, 1983; Lew & Townsen, 2006; Rood, 1977; Schejtman et al., 1967; Wadhvani et al.,

2008) and this failure of complete anesthesia can lead to abortion of procedures. Bifid mandibular canals, especially Type 1 and Type 3, need to be carefully mapped and avoided during third molar surgeries, as third molars can impinge on or be within the canal space. If care is not taken complications such as traumatic neuroma, hemorrhage, or paresthesia can occur. During endodontic treatment injury to accessory canals can result in hemorrhage or traumatic neuromas (Ngeow & Chai, 2020). Further, in a case series by Von Arx et al. (2011) 4 cases of endodontic apical surgery, in which a neurovascular bundle from an accessory mandibular canal was severed are reported. In one of the four cases the patient suffered paresthesia, highlighting the importance of detailed tracing of the mandibular canal for every case.

The purpose of this study is to identify the prevalence of bifid canals, use the Naitoh classification system to classify the bifid canals, and to measure the height of alveolar bone above the most superior portion of the mandibular canal. Other factors such as gender and ethnicity were evaluated for association with bifid canal prevalence.

CHAPTER 2

MATERIALS AND METHODS

This study was based on a retrospective evaluation of CBCT scans taken at the Temple University Kornberg School of Dentistry from January 2020 to July 2022. The Study received Temple University Office for Human Subjects Protections Institutional Review Board approval. 1,006 scans were screened initially. All scans were screened and analyzed by 4 calibrated postgraduate periodontal residents, and periodically reviewed by 1 calibrated board-certified periodontist. The CBCT scans were all performed using either the Planmeca Viso G7 or ProMax 3D Mid (PLANMECA USA INC., Charlotte, NC, USA) CBCT machines, using the following exposure settings: 100kV, 63mAs, and 24.4s at 0.3mm Voxel size. The following inclusion criteria were applied to each scan: 1. The patient had to be 18 years of age or older, 2. The patient needed to have a CBCT scan that included the entire mandible. The following exclusion criteria were applied to each scan: 1. Scans of pediatric patients under 18 years of age, 2. Limited field scans of the maxilla only, 3. Scans that were missing mandibular anatomic structures, 4. Scans presenting with high amounts of “scatter” that interfered with tracing of the mandibular canal. After exclusion 558 CBCT scans were used for this study. Each of the CBCT, images were viewed using Xelis viewing software (Infinit North America, Phillipsburg, NJ, USA), providing a panoramic reconstruction view module and an MPR screen module, that is, axial, sagittal, and coronal slides. All images were assessed under standardized conditions (Windows XP and Microsoft office Software). For each CBCT the right and left mandibular canal were traced and identified as single or bifid. Each bifid canal was then classified according to the Naitoh 2009 classification system (Fig.

2). The height of alveolar bone from the most superior border of the mandibular canal to the alveolar crest was recorded at the right and left first molar sites (Fig. 3).

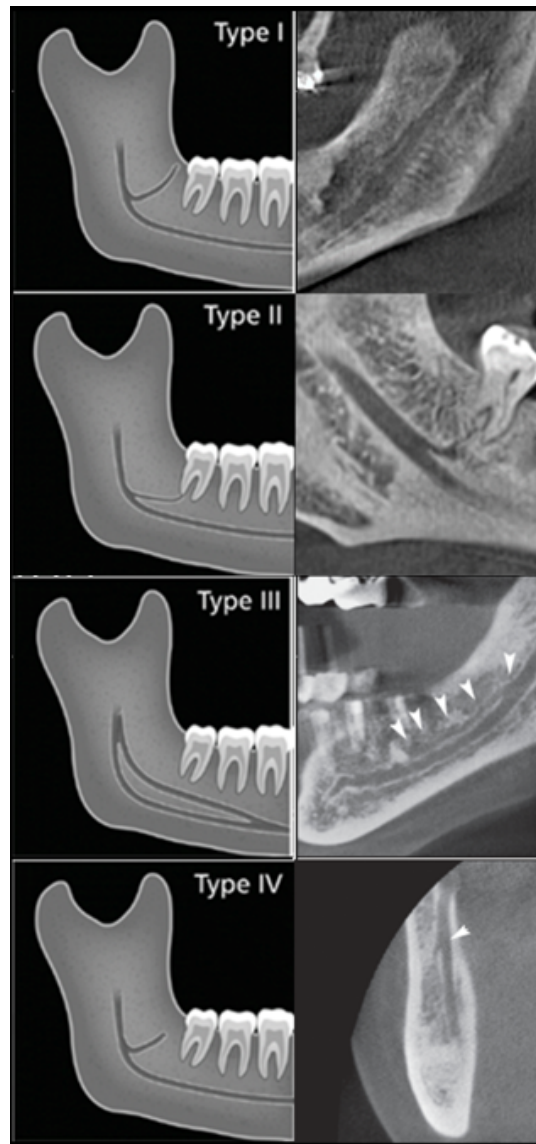


Figure 2. CBCT examples of the four types of bifid canals according to Naitoh 2009.

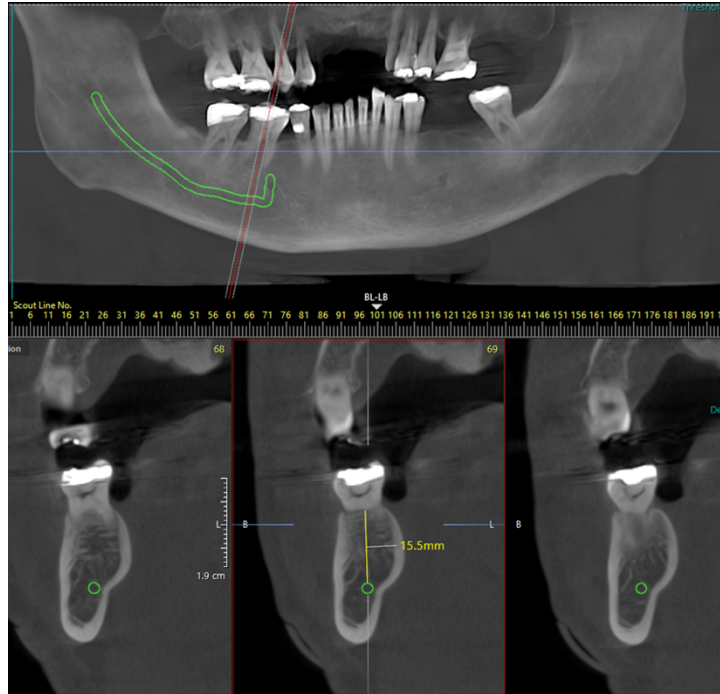


Figure 3. MPR view in Xelis viewing software showing how the height of alveolar bone above the mandibular canal was measured.

CBCT scans of 558 patients were included in the study. The mean age of patients at the time of the scan was 57. There were 247 males and 311 females. Based on ethnicity: there were 170 African Americans, 53 Asians, 263 Caucasians, and 72 Hispanics. 76 of the patients had complete mandibular dentition, and 482 were missing at least 1 tooth in the mandible.

A data table was created in Microsoft Excel (Table 1) and The R Project for Statistical Computing was used for analysis of the data. Descriptive statistics were run to determine the prevalence of bifid mandibular canals in the entire population studied and by gender and ethnicity.

Table 1. Example Data Collection Table

| Gender | Age | Ethnicity | Dentition | Right Crest Height (mm) | Right Canal | Right Classification | Left Crest Height (mm) | Left Canal | Left Classification |
|--------|-----|------------------|-----------|-------------------------|-------------|----------------------|------------------------|------------|---------------------|
| Female | 80 | Caucasian | P | 12 | 2 | I | 12 | 1 | |
| Female | 72 | Caucasian | P | 13 | 1 | | 13 | 1 | |
| Male | 78 | Caucasian | P | 16 | 1 | | 15 | 1 | |
| Male | 67 | African American | P | 20 | 1 | | 20 | 1 | |
| Male | 73 | Hispanic | P | 19 | 1 | | 18 | 1 | |
| Female | 70 | African American | P | 11 | 1 | | 14 | 1 | |
| Female | 73 | Caucasian | P | 20 | 1 | | 16 | 1 | |
| Female | 50 | African American | P | 12 | 1 | | 14 | 1 | |
| Female | 41 | Caucasian | P | 13 | 1 | | 13 | 1 | |

Bivariate analyses were also used to evaluate if there is an association between right and left crest height with age, gender, ethnicity, and dentition status. A linear regression was performed to compare right and left crest height to age, gender, ethnicity, and dentition.

CHAPTER 3

RESULTS

Of the 558 CBCT scans which were viewed, 488 of the 558 patients exhibited a singular mandibular canal morphology, and 70 exhibited a bifid mandibular canal morphology. This resulted in a 12.54% prevalence of bifid mandibular canals in the population studied. The remaining 87.46% presented with the more standard single canal morphology (Fig. 4).

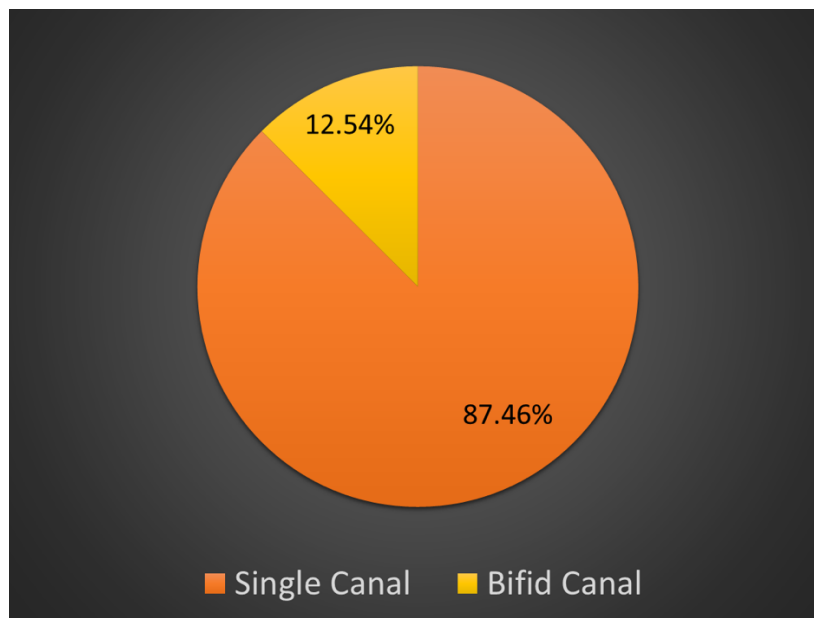


Figure 4. Prevalence of bifid mandibular canals in the study population

Bifid mandibular canals were then categorized using the Naitoh 2009 classification system. Of the 70 patients that had bifid canal morphology 42 had Naitoh Type 1, 16 had Naitoh Type 2, 7 had Naitoh Type 3, and 3 had Naitoh Type 4 canals. 2 patients had mandibular canal morphology that was not clearly distinct and remained unclassified. Therefore, of the 70 patients that had a bifid canal morphology, the prevalence of Naitoh

Type 1 canals was 58.33%, prevalence of Type 2 canals was 22.86%, prevalence of Type 3 canals was 10.00%, and Type 4 canals was 4.29% (Fig. 5).

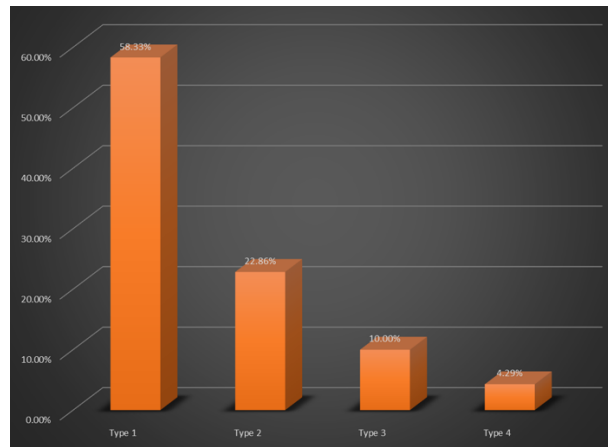


Figure 5. Prevalence of each Naitoh 2009 type among patients with bifid mandibular canals.

When examining left and right canal morphology based on patient demographics, there is no significant relation between left canal morphology and ethnicity (chi-squared = 6.8974; p-value = 0.07524). Similarly, there is no significant relation between right canal morphology and ethnicity (chi-squared = 1.9307; p-value = 0.5869)

When the study population is further broken down by gender, 37 of the 247 men exhibited bifid mandibular canal morphology, resulting in a prevalence of 14.98%. In women, 33 of the 311 patients exhibited bifid mandibular canal morphology, resulting in a prevalence of 10.61%. For both right and left mandibular canals, there was not significant relationship between canal morphology and gender (chi-squared = 2.395; p-value = 0.1217/ chi-squared = 2.6136; p-value = 0.1.59 respectively) (Fig. 6).

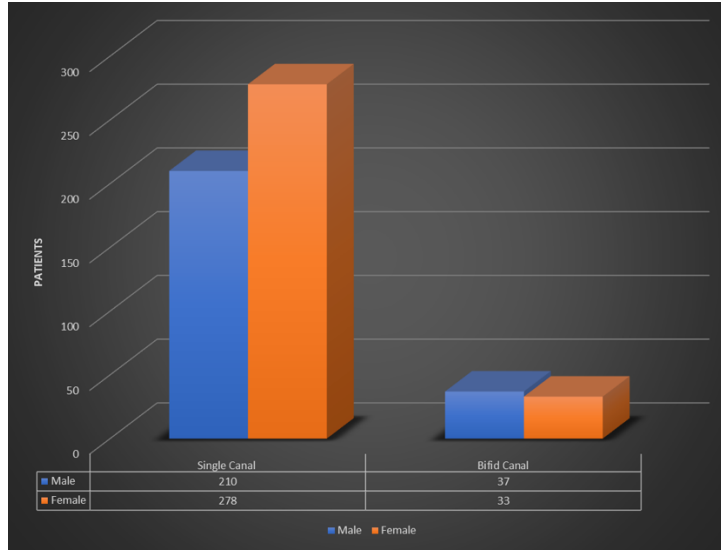


Figure 6. Prevalence of bifid mandibular canal morphology by gender.

When looking at left and right canals individually, 70 of the 558 patients exhibited a right bifid mandibular canal and 55 of the 558 patients exhibited a left bifid mandibular canal. Resulting in a prevalence of 12.54% and 9.86% respectively. Further, there is a significant relation between the right canal and left canal morphology (chi-squared = 201.43; $p < 2.2 \times 10^{-16}$) (Fig. 7).

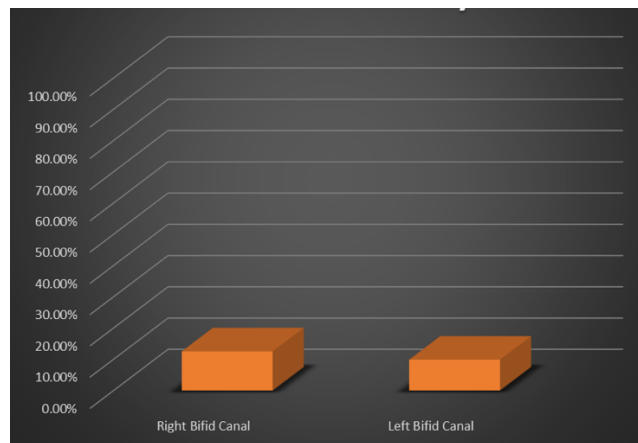


Figure 7. Prevalence of bifid mandibular canals by side.

The height from the superior border of the mandibular canal to the alveolar crest at the first molar position ranged from 2.2 mm to 22.4 mm, and the average height was 15.25 mm. The average height for the right alveolar crest was 15.50 mm, and the average height for the left alveolar crest was 15.00 mm. There is a significant positive correlation between right and left alveolar crest height ($r = 0.56$; $p = 0$) (Fig. 8).

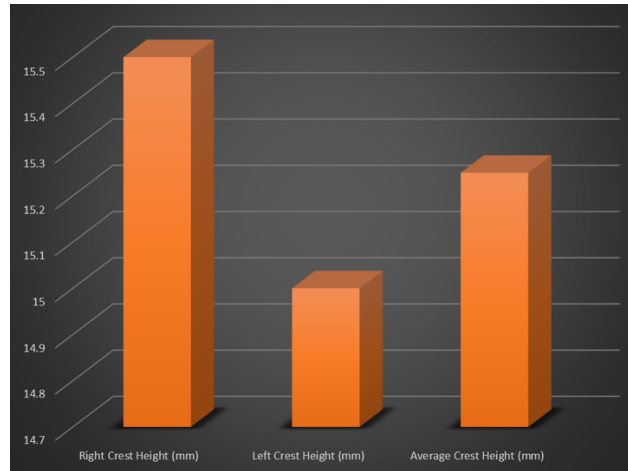


Figure 8. Mean alveolar crest height above the mandibular canal.

There is a significant negative correlation between both left and right alveolar crest height above the mandibular canal and age ($r = -0.1$; p -value = 0.02/ $r = -0.12$; $p = 0.00$ respectively). There was a significant difference in mean left alveolar crest height between the complete dentition and partially edentulous group (15.73 mm vs 14.76 mm respectively; $p = 0.00473$). There was also a significant difference in mean right alveolar crest height between the complete and partially edentulous groups (17.04 mm vs 15.15 mm respectively; $p = 0.0000003536$). There was no significant difference in left or right alveolar crest height above the mandibular canal based on ethnicity. There was a significant difference in mean right alveolar crest height above the mandibular canal for

men compared to women (15.81 mm vs 15.08 mm respectively; $p = 0.013$), however, there was no significant difference for the left side.

A linear regression analysis was performed to look at crest height regarding age, gender and dentition. It was found that for every increase in age of 1 year, there was a decrease in left alveolar crest height of 0.02 mm when gender, ethnicity, and dentition variables are constant ($p = 0.0474$). Therefore, left alveolar crest height is significantly associated with change in patient age. It was also found that for every increase in age of 1 year, there was a decrease in right alveolar crest height of 0.02 mm when gender, ethnicity, and dentition variables are constant ($p = 0.02873$). Therefore, right alveolar crest height is significantly associated with change in patient age.

Table 2. Bivariate Analyses and P-values.

| Variables | | Type of analysis | Test statistics | p-value |
|------------------------|-------------------|----------------------------|---|----------|
| Left crest height | Age | Correlation test | r=-0.1 | 0.02 |
| | Gender | t-test | Mean: Males – 15.15 Females – 14.69 | 0.1128 |
| | Ethnicity | Anova | F=0.299 | 0.826 |
| | Dentition | t-test | Mean: Group C – 15.73 Group P – 14.76 | 0.00473 |
| Right crest height | Age | Correlation test | r=-0.12 | 0 |
| | Gender | t-test | Mean: Males – 15.81 Females – 15.08 | 0.013 |
| | Ethnicity | Anova | F=1.365 | 0.253 |
| | Dentition | t-test | Mean: Group C –17.04 Group P – 15.15 | 3.563e-7 |
| Right crest height | Left crest height | Correlation test | r=0.56 | 0 |
| Right canal | Left canal | Chi-square test | Chi-square = 201.43 | 2.2e-16 |
| Left canal morphology | Age | Simple logistic regression | OR = 0.99 | 0.50 |
| | Gender | Chi-square test | Chi-squared = 2.6136 | 0.1059 |
| | Ethnicity | Chi-square test | Chi-squared = 6.8974 | 0.07524 |
| Right Canal morphology | Age | Simple logistic regression | OR = 0.99 | 0.95 |
| | Gender | Chi-square test | Chi-squared = 2.395 | 0.1217 |
| | Ethnicity | Chi-square test | Chi-squared = 1.9307 | 0.5869 |

CHAPTER 4

DISCUSSION

Previous studies on various populations have reported variations in the prevalence of bifid canals ranging from 0.04% to 82%. When exclusively looking at the prevalence of bifid mandibular canals from studies using two-dimensional panoramic imaging the percentage is lower, between 0.04% to 30.6%. When evaluating the prevalence of bifid mandibular canals from studies using three-dimensional CT/CBCT scanning the prevalence is higher from 0.05% to 82% (Ngeow & Chai, 2020). These results show that although there is still a wide discrepancy on the prevalence of bifid mandibular canals in the literature, they may be more common than previously thought, and CBCT imaging is a more sensitive imaging modality to identify them than panoramic imaging. In this study, the prevalence of bifid mandibular canals was 12.54%, which falls into the middle to lower third of the wide range of bifid mandibular canal prevalence reported in the literature. Some reasons for this wide range may be differing resolutions of CBCT units, differences in imaging software, differences between examiners, and uncalibrated radiology technicians. Further, a previous study by Kim et al. reported that a bifid mandibular canal identified by CBCT can be trabecular pattern when subjected to direct stereoscopy and histologic examination (Kim et al., 2011). This shows that CBCT evaluation may overestimate the true prevalence of bifid mandibular canals due to false positive identifications.

Two other modalities have also been used in the literature to evaluate the prevalence of bifid mandibular canals, dry mandible studies and MRI studies. Only one study by Bogden et al. (2006) checked for bifid mandibular canals using dry mandibles

and reported the prevalence to be 17.4%. There is also only one study which utilized MRI. Wamasing et al. (2019) used MRI to identify bifid mandibular canals and found the prevalence to be 6.80%. The prevalence reported in these studies, while not the same, is similar to the prevalence of 12.54% reported in this study. Especially when compared to a prevalence of less than 1% reported by Nortje et al. (1977), which used panoramic imaging known to underestimate the prevalence of bifid canals; or when compared to a prevalence of 65% reported by Naitoh et al. (2009), which can be an overestimate due to false positives.

Naitoh et al. (2009) classified bifid mandibular canals into 4 categories: (1) retromolar, (2) dental, (3) forward, (4) buccolingual, and reported the prevalence of each. They found that in patients with bifid mandibular canals: 29.8% had type 1, 8.8% had type 2, 59.6% had type 3, and 1.8% had type 4. However, in this study 58.33% had type 1, 22.86% had type 2, 10.00% had type 3, and 4.29% had type 4. In other studies, using the Naitoh 2009 classification system, there is no consensus as to which type is the most prevalent (Elnadoury et al., 2022; Rashsuren et al., 2014; Zhou et al., 2020). In fact, there is a very broad range in the prevalence of each canal type reported in the literature, but at least 4 other studies have also found type 1 to be the most prevalent (Ngeow & Chai, 2020).

Due to the wide range of bifid mandibular canal prevalence that is reported in the literature, some authors believe that geographic or ethnic differences may be a reason for such inconsistencies in prevalence (Elnadoury et al., 2022; Rashsuren et al., 2014; Zhou et al., 2020). This study evaluated if ethnicity had a relationship with bifid mandibular canal morphology for African American, Asian, Caucasian, and Hispanic populations

within the dental school. By evaluating prevalence based on ethnicity in a single study population, sources of error when comparing the prevalence between studies such as different CBCT units used, different viewing software used, and different examiner calibration can be kept constant. No significant relationship was found between left bifid canal morphology and ethnicity (chi-squared = 6.8974; p-value = 0.07524), and similarly no significant relationship was found between right bifid canal morphology and ethnicity (chi-squared = 1.9307; p-value = 0.5869). In the population studied African American, Asian, Caucasian, and Hispanic ethnicity had no significant relationship with bifid canal morphology rates. Further studies, utilizing larger study sizes and different ethnicities are still needed.

This study also found that there is no relationship between gender and bifid canal morphology for both the right and left mandibular canals (chi-squared = 2.395; p-value = 0.1217/ chi-squared = 2.6136; p-value = 0.1.59 respectively). This is consistent with past studies which also found no significant relationship between gender and prevalence of bifid mandibular canals (Elnadoury et al., 2022; Okumuş & Dumlu, 2019; Rashsuren et al., 2014; Zhou et al., 2020).

The final data point analyzed in the study was the height of alveolar bone from the most superior portion of the mandibular canal to the alveolar crest. This is a very important measurement, as it is how neurosensory and bleeding complications are avoided during implant surgery. The first molar position was used to standardize the measurement for all patients. The average height of the alveolar bone above the mandibular canal for the right side was 15.5mm, and the average height for the left side

was 15mm. There is a significant positive correlation between right and left alveolar crest height ($r = 0.56$; $p = 0$), meaning patients have a similar amount of bone above the mandibular canal on both sides of the mandible. There is also a significant difference in height of bone above the mandibular canal between the complete dentition and partially edentulous group for both the right and left sides of the mandible, where there is a significant decrease in height from the complete dentition group to the partially edentulous group. This finding agrees with the classic literature showing loss of alveolar height and width after tooth extraction (Tan et al., 2012).

No significant relationship was found between crest height above the mandibular canal and ethnicity, and no significant relationship was found for mean crest height above the mandibular canal and gender for the left side. However, there was a significant difference in right alveolar crest height above the mandibular canal between genders. The mean height for the right crest in males was 15.81 mm and in females was 15.08 mm (p -value = 0.013). Although our analysis deems this difference as statistically significant, an average difference of 0.73mm is most likely not clinically significant for this measurement. Therefore, the significance of this result likely does not translate into clinical practice.

When alveolar crest height above the mandibular canal was evaluated in terms of age, a significant negative correlation was found between alveolar crest height and age for both the right and left sides (p -value = 0.00, p -value = 0.02 respectively). This result suggests that as patients increase in age the height of the alveolar crest above the mandibular canal decreases, limiting space for future implant placement. These results agree with past articles by Schei et al. (1959) who stated that loss of alveolar bone

increase with age, and with Streckfus et al. (1999) who showed a significant relationship between alveolar bone loss and age, while race and gender did not, using multiple linear regression analysis.

Finally, multiple linear regression analysis showed that for both the left and right side; when gender, ethnicity, and dentition are constant; for every one-year mean patient age increased, the mean alveolar height above the mandibular canal decreased by 0.02mm ($p = 0.0474$ for the left, $p = 0.02873$ for the right). As previously stated, this finding agrees with the previous literature that alveolar bone loss does increase with age (Schei et al., 1959; Streckfus et al., 1999).

CHAPTER 5

CONCLUSION

Bifid mandibular canals are a normal anatomic variation that are being identified in patients more regularly with advanced imaging modalities like CBCT. If impinged upon or severed during mandibular implant, oral surgical, or endodontic procedures, neurosensory and bleeding complications can occur intra or post-operatively.

This study determined that the height of available bone above the mandibular canal decreases with both tooth loss and age, making identification of bifid canals very important in edentulous and elderly patients. The prevalence of bifid mandibular canals in an American dental school population was determined to be 12.54%, and of the patients with bifid mandibular canals the most common was a Naitoh type 1 (retromolar). The prevalence of bifid mandibular canals was not related to patient gender. The prevalence was also not related to patient ethnicity, as has been speculated in previous CBCT studies conducted within a single ethnicity. In conclusion, bifid mandibular canals are encountered in the American population; therefore, precise mandibular canal tracing utilizing CBCT imaging is needed to avoid intra and post-operative neurovascular complications. This will reduce patient morbidity and improve overall patient outcomes.

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