Inferior Alveolar Nerve Location to Determine Zone of Safety for Dental Implant Placement among Malaysian Population

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Abstract

Background: Zone of safety is a clinical method to assess a safe zone to insert posterior mandibular endosteal implant. Aim of this study is to determine the available bone height in different regions of posterior mandible among Malaysians to support the implants without fear of impingement on the inferior alveolar nerve.

Materials and Methods: Five hundred and fifty Orthopantomographies (OPGs) were observed. Line A was drawn parallel to the posterior plane of occlusion, at the level of the residual crest ridge. Line B was drawn at the most superior aspect of the mental foramen parallel to line A. Then, Line A and B are joined with a perpendicular line, which was named as Line C. The length of line C is the safe zone measurement to the mesial half of the first molar. Four lines were drawn tangent to line A at the position of mesial first molar, mid first molar, mesial second molar and mid second molar. The prevalence of the mandibular canal below the second line B was observed.

Results: According to our inclusion and exclusion criteria, 364 OPGs were selected and 657 samples were collected, including left and/or right side of the mandible. In Zone 1, the percentage of mandibular canal found inferior to line B in Chinese females and males were (n=112) 99.3% and (n=144) 100% respectively; in Malay females and males was 99.4% (n =174) and 100 % (n=123) respectively. While, in Indian females (n=43) and males (n=61) were 100%. In Zone 2, the percentage in Chinese females was 99.3% and 99.1% in males; Malay females was 97.1% and Malay males was 98.4%; whereas in Indian females was 96.7% and males was 95.3%. In Zone 3, the percentages in Chinese females and males were 86.8% and 89.3% respectively; Malay females was 92.4% and males was 85.4%; Indian females was 91.6% and males was 93.0%. In Zone 4, the percentages in Indian population were 67.2% (females) and 69.8% (males). Malay females and males were 40.8% and 56.1% respectively; 54.9% in Chinese females and 55.4% in Chinese males.

Conclusion: Overall, the percentage of mandibular canal below the safety zone was reducing from the region of mesial first molar to the distal second molar. There were no much variations in between the gender and races in relation to the position of the mandibular canal.

Keywords: Zone of Safety; Mental Foramen; Inferior Alveolar Dental Nerve; Dental Implant; Races

Introduction

The number of practitioners performing implant surgery has increased dramatically over the last decade. As confidence is gained, they tend to accept increasingly challenging cases and it is to be expected that the incidence of problems and complications will increase. The inferior alveolar nerve (IAN) injuries still remained a serious complication with incidence ranged from 0% to 40% [1].

Intrusion into the mandibular canal during placement of posterior endosteal implant is of great concern as this may result in increased risk of hemorrhage, visibility impairment, and increased risk of potential fibrous tissue formation at the surface of the implant.

Hence, knowing the location of the mental foramen is very important when considering placing implants in the foraminal region [2-4]. Nerve damage could result from the nerve being stretched, compressed, and partially or totally transected [5]. Paresthesia, hypoesthesia, hyperesthesia, dysesthesia, or anesthesis of the teeth, the lower lip, or surrounding skin and mucosa may be encountered during an osteotomy [6-10]. Measurement of zone of safety should be established prior to surgery so that the bone can safely support the implants without fear of impingement on the mandibular neurovascular bundle.

According to Carl E. Misch [11], zone of safety is defined as an area within the bone that can safely support implants without fear of impingement on the mandibular neurovascular bundle. It is Misch, who established a zone of safety for the placement of posterior mandibular endosteal implants in Year 1980 by the evaluation of 530 panoramic radiographs of partially edentulous patients. Later in 1989, Misch and Crawford confirmed this evaluation with an additional 324 consecutive panoramic radiographs [12].

It is used when the presence of adequate available bone height cannot be confirmed by a CT image. Hence, when the only diagnostic tools to assess available bone height turn out to be periapical or panoramic images and the height seems abundant, i.e., >15 mm.

Misch and Crawford stated in their studies that the zone of safety was observed 100% from mesial to the middle of the mandibular first molar [12]. It was very common to find that the mandibular canal was 2mm or more inferior to Line B among the 324 panoramic radiographs, which means the safety zone is above the mandibular canal. Hence, this allows a surgical safety zone that most often approximates 2mm. According to Misch [11], this clinical approach had been used successfully in thousands of surgery without paresthesia.

A perusal of data and records have revealed that there is no such studies has previously been done in a Malaysian population and hence, the present study would act as a pilot to lay down primary data on the mandibular zone of safety among Malay, Chinese and Indians.

Materials and Methods

Panoramic radiographs were obtained with the Siemen Orthophos (Sirona). All the images were taken under standardized protocol for patient positioning and magnification setting of 1.2. Images were obtained from 500 consecutive patients who were referred to the Oral Radiology Department of the Faculty of Dentistry, MAHSA College. However, only 364 images were being included into this study due to the following inclusion and exclusion criteria:
Inclusion criteria:

- Age of 18 and above.
- Malaysia ethnicity: Chinese, Malay, Indian.
- Presence of mandibular teeth, with the emphasis from the premolars to second molar.
- If there was no second molar in the mandibular jaw but the third molar was present, the third molar was taken into consideration.
- Film should show no radiographic exposure or processing artifacts.
- Film should be free from any radiolucent or radiopaque lesion in the mandibular arch.

Exclusion criteria:

- Age 17 and below.
- Other ethnics in Malaysia and foreigners.
- Blurred vision of OPG radiographs.
- Missing mandibular molars.
- Mixed dentition.
- Patient with previous or current orthodontic treatment.
- Patient with previous or current dental implant in mandibular arch.
- Patient with recent bone grafting.
- Radiographs in which the mental foramen and inferior alveolar canal could not be identified were excluded.

The visibility rating and dimensional measurements of all the images were performed by two examiners and the average results were being obtained. The mental foramen and inferior alveolar nerve were identified on the panoramic radiographs using an X-ray viewer. A sheet of transparent paper was superimposed on the film and stabilized with two stickers. The mental foramen was traced on the transparent paper by using a fine blue marker pen. Line A was drawn parallel to the posterior plane of occlusion, at the level of the residual crestal ridge. Line B was drawn at the most superior aspect of the mental foramen parallel to line A. Then, Line A and B are joined with a perpendicular line, which was named as Line C. The length of line C is the safe zone measurement to the mesial half of the first molar. Four lines were drawn tangent to line A at the position of mesial first molar, mid-first molar, mesial second molar and mid second molar. According to this we have 4 zones, zone 1 mesial first molar, zone 2 distal first molar, zone 3 mesial second molar and zone, 4 distal second molar. The prevalence of the mandibular canal below the line B was observed (Figure 1). The distance between Line A and B in the safe zone on radiograph to estimate the vertical bone height was measured [10]. The incorrect measurement due to magnification may be accomplished by using ratios of magnification 1.25 that obtained from the manufacturer. If the canal appears to remain at the same distance as the safety zone in the distal region of the first molar, the safety zone measurement is expanded to the second molars. If the canal appears to rise 2 mm or more in the mesial of the second molar region, the zone of safety measurement is reduced accordingly in this region. Percentage was calculated for each zone according to gender and race.

Results

Among 364 panoramic radiographs, 657 samples were collected, including left and/or right side of the mandible. The youngest patient involved in our study was 18 years old and the oldest one was 76 years old.

Of the 657 samples obtained, 256 samples were collected from Chinese populations, while 297 were from Malays and 104 were from the Indians. The Chinese females accounted for 144 samples, whereas the Malay females contributed to 174 samples. The Indian females had the least number of samples, which were 61.

There was not much variability in results regarding gender and races in Zone 1 (Figure 2). The percentage of mandibular canal found inferior to Line B in Chinese females and males were 99.3% and 100% respectively. In Malay populations, the percentage found in females was 99.4% and in males was 100%. While in Indian population, both females and males were found to have 100% of mandibular canal below Line B.

In Zone 2 (Figure 3) the percentage of mandibular canal found below Line B in Chinese females and males was slightly
decrease (females = 99.3% and males = 99.1%). There was not much differences in percentage found in Malay population when compared to Zone 1 as the percentage found in females was 97.1% and males was 98.4%. 96.7% of Indian females and 95.3% of Indian males were found to have mandibular canal inferior to Line B.

In Zone 3 (Figure 4) Chinese females and males populations, the percentage was 86.8% and 89.3% respectively; in Malay populations, the percentage in females was 92.4% and in males was 85.4%, which was the lowest among all the samples. Indian populations showed 91.6% in female and 93.0% in male.

In Zone 4 (Figure 5) Indian populations showed (67.2% of female and 69.8% of male) whereas the Malay populations showed 40.8% of female and 56.1% of male were shown to have inferior alveolar nerve below Line B. While in Chinese population, 54.9% in female and 55.4% in male was observed to have the ID canal within the safety zone.

Discussion

The aim of our study is to determine the zone of safety, which is an area within the bone that can safely support implants without fear of impingement on the mandibular neurovascular bundle, in Malaysian population.

Since dental implants are rarely inserted in the mandibular second or third molar region, our primary concern of placing the implants is in the first, second premolars and first molar region. The safety zone takes into account that the coronal aspect of the mental foramen is approximately 2 mm above the inferior alveolar/ mental nerve so as to decrease the risk of paresthesia by inadvertent violation of the main trunk or its branches [13,14]. Hence, for example, a 12 mm long implant requires 14 mm of available bone height and a 9 mm long implant requires 11 mm of bone height. Nevertheless, when there is an occurrence of great deal of bone resorption, these relationships may not be present. According to Carl E. Misch [11], the ideal length of an implant in the posterior regions is 12 mm or more; however, 9 mm has proven predictable when implant width, design and number are also considered.

In our research, the method we used to determine the mandibular safety zone was using a panoramic radiograph which was the same as the method used by Misch in Year 1989. The average height of bone in the zone of safety to the mid first molar region in Malaysian populations is 12 mm. This reading is much similar to the reading done by Misch, in which the height of zone of safety determined by him was 12 mm or more.

However, there were some differences in between the two studies. Like we compare and contrast the results of both the genders of each Malaysian race in each zone; while Misch study grouped both the genders and races together and gave data to each zone. Another difference is the location of mandibular canal in relation to safety zone in our study was classified into two types – Above and below the zone of safety; while in Misch's study, he classified the mandibular canal location in relation to safety zone as three types – within zone of safety, below zone of safety but not touching the canal, touching or below top of canal.

The results and the patterns of results obtained from each zone in our studies were much similar as Misch’s study. Apparently, the number of percentage indicating the mandibular canal below the zone of safety was decreasing from Zone 1 to Zone 4. This is because the angulation of the bone in the posterior mandible progressively evolves from almost vertical in the premolar region to 15° in the first molar region and 25° in the third molar region. Comparing the data of Zone 1 in our study with Misch's study, 100% of zone of safety was observed in both of the studies, except in Chinese males and Malay females’ population; but this only accounted for 1/143 and 1/173 respectively.

Coming to Zone 2, the results collected in both studies were almost the same, which was approximately 97% of mandibular canal was still below Line B. However in Zone 3 and 4, there was a marked difference in the data collected in between Malaysian populations and American populations. In Misch’s study, the mandibular canal in Zone 3 was below Line B in 43% of the radiographs, but in Malaysian populations, the safety zone found was ranging from 85.4% to 93.0%; whereas in Zone 4, American populations only accounted for 5.5% of having zone of safety, and approximately 55.3% of Malaysian populations having their mandibular canal below Line B, with the Indian populations having the highest percentage 67.2% and 69.8% in females and males respectively. The possible reasons behind this significant difference of data might be owing to the difference in the magnification power of the panoramic radiograph and the available mandibular bone height in Americans is shorter.

The imprecision in marginal cases is often due to no uniform magnification rate in panoramic radiographs. Besides, an alteration in the magnification by as much as 55% will occur due to patient’s head position [15].

As the x-ray beam of a panoramic radiograph originates from below the patient’s mandible, the location of the inferior alveolar canal in reference to the crest of the ridge is dependent on the buccolingual position of the mandibular canal [15]. For example, if the ID nerve proceeds along the lingual aspect of the mandibular body, the canal will be projected more superior toward the crest; however, if the nerve proceeds along the buccal aspect of the mandibular body, the canal projected will be more inferior toward the crest [16]. Usually, the mandibular canal in the first molar region is difficult to be identified in the Orthopantomograph due to the
cortical lining of the canal is not always present in the molar region and even when it presents; it may be confused with a vascular region surrounded by trabecular bone [15]. Therefore, when the diagnosis is unclear; CT scan and the reformatted images into a computer software package can be used as a considerable advancement in diagnostics for the mandibular canal location [17-21].

According to the study done by Sonick et al [22], about comparison of the location of mandibular canal with panoramic and CT radiographs of a cadaver mandible, the average distortion on the panoramic radiographs was shown to be 3.0 mm (range from 0.5 to 7.5 mm), while the CT average error was 0.2 mm (range from 0 to 0.5 mm). Hence, the panoramic method of mandibular nerve location would be limited to obvious extremes of abundant or inadequate bone. Using a CT scan is most indicated when a questionable bone height is present or the panoramic radiograph gives an uncertain answer relative to the availability of adequate bone height in the particular region [23-24].

The incorrect measurement due to magnification may be accomplished by calibrated balls or wires and using ratios of magnification or an arbitrary 25% magnification. Treatment plan is developed according to the approximation of the available bone height. Though the implant height is initially determined, it will be different when the safe zone is measured at the time of surgery due to osteoplasty or incorrect magnification allowance. The comparison of the cone-beam CT (CBCT) with Periapical radiograph shows the superiority of the CBCT [13]. While Accuracy of cone-beam CT was comparable to that of digital caliper measurements [14]. Bigger sample size or using cone beam CT to confirm the finding of this study is recommended.

Conclusion

With the limitation of this study, the percentage of mandibular canal below the safety zone was reducing from the region of mesial first molar to the distal second molar. There were not much variations in between the gender and races in relation to the position of the mandibular canal.

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References