Safe zone in anterior mandible related to the genial tubercle for implant osteotomy in a Chinese-Malaysian population: A CBCT study

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The inferior alveolar or mental nerve can be injured during implant osteotomy, especially for implant-retained mandibular overdentures. In the edentulous mandible, identifiable anatomic landmarks which can be used to plan implant osteotomy sites predictably are lacking. A diagnostic stent with radiopaque markers in the region of planned implant osteotomy sites is often made before making a panoramic radiograph or a computed tomography (CT) scan.

The interforaminal area is part of the anterior body of the mandible located between the mental foramina on the left and right sides where the inferior alveolar nerve exits as the mental nerve. Careful planning is necessary to avoid injuring these nerves during implant surgery. The position of the radiopaque markers in the diagnostic stent is usually determined by the clinician’s judgment. However, this is not always a reliable and predictable method.

ABSTRACT

Statement of problem. The genial tubercle is a clinically palpable landmark in the mandible and can be identified in cone beam computed tomography (CBCT). Its location can be used to measure the safe zone in the interforaminal region of the mandible. These measurements may be helpful for implant treatment planning in patients with complete edentulism.

Purpose. The purpose of this clinical study was to evaluate the safe distance in the interforaminal region of the mandible measured from the genial tubercle level for implant osteotomy in a Chinese-Malaysian population.

Material and methods. A total of 201 Digital Imaging and Communications in Medicine (DICOM) files were selected for the study from the CBCTs of dentate or edentulous Chinese-Malaysian adult patients with ongoing or completed treatments. Measurements were made with implant planning software. The anatomy of the whole mandible was assessed in the coronal cross-sectional, horizontal view and in panoramic view. Measurements were obtained in millimeters on one side by locating and marking a genial tubercle and then marking the mesial margin of the mental foramen and the anterior loop of the inferior alveolar nerve. The corresponding points of these landmarks were identified on the crest of the mandibular ridge to measure the linear distances. All the measurement steps were repeated on the other side. The linear distance of 2 mm was deducted from the total distance between the genial tubercle and the anterior loop separately for left and right side measurements to identify the safe zone. The mixed 2-way analysis of variance (ANOVA) test was used to analyze side and sex-related variations.

Results. The mean safe zone measured at the crestal level from the genial tubercle site on the left side of the mandible was 21.12 mm and 21.67 mm on the right side. A statistically significant (P<.05) difference was found between the left and right sides of the safe zone measurements in both men and women. No statistically significant differences were found in the safe zone between men and women on either the left or right side (P=.655). The minimum distance from the genial tubercle to the right side safe zone in women was 12.82 mm and 14.99 mm in men; however, on the left side, the minimum distance was observed to be 14.81 mm in women and 15.54 mm in men.

Conclusions. The safe zone related to the genial tubercle was 21.12 mm on the left side and 21.67 mm on the right side, with no significant sex-related variations. Within the same individuals, a significant difference was found in the safe zone between the left and right side. (J Prosthet Dent 2018;119:568-73)
Clinical Implications
The genial tubercle, a clinically palpable landmark, can be used as a cone beam computed tomography (CBCT) landmark to estimate the safe zone in the interfornal region of the mandible. The safe zone measurements in relation to the genial tubercle obtained from the CBCTs can help clinicians determine implant locations in patients with complete edentulism.

Frequently, the planned position of the radiopaque markers needs to be changed, leading to an additional radiograph or CT scan with more radiation exposure to the patient. In such situations, palpation of the genial tubercle can provide a point of reference in the mandible from which measurements can be made to determine the marker locations. However, a point corresponding to the genial tubercle location first needs to be marked on the crest of the ridge to facilitate such measurements.

Lu et al identified the anterior loop of the mental nerve in 85.2% of individuals and found the mean anterior loop length of 366 participants (732 hemimandibles) to be 1.46 ±1.25 mm with no statistically significant differences between right and left sides or different sexes. The safe zone for bone harvesting from the interfornal region of the mandible in a Malaysian population was studied by Omar Al-Ani et al. Sokhn et al studied the course of the incisive canal in the interfornal region of the human mandible and observed the incisive canal in 97.5% of the images. The CBCT or panoramic radiograph studies were carried out considering different reference points, for example, the premolar teeth.

This purpose of this study was to determine the crestal level measurements in the anterior mandible based on CBCT measurements in a selected population so that implant osteotomy sites could be planned predictably in the interfornal region. This implant placement location can be considered a safe zone in the anterior mandible. The study evaluated the genial tubercle as a point of reference for measuring the distances in the interfornal region of the mandible when implant osteotomy sites are planned based on CBCT images already made for other diagnostic purposes. To the authors’ knowledge, published information is not available for any population.

MATERIAL AND METHODS
Institutional ethical committee approval was obtained for the study. A total of 201 CBCT-Digital Imaging and Communications in Medicine (DICOM) files of Chinese-Malaysian dental patients (81 men and 120 women) were identified from the available pool of CBCTs at the dental clinic of the authors’ institute. The sample size (n=201) was calculated, with a 5% margin of error and a 95% confidence level from a total of 420 CBCTs (of Chinese patients available in the clinic), using an online sample size calculator (Raosoft Inc). The CBCT-DICOM files were selected based upon the following inclusion and exclusion criteria. Dentate or edentulous healthy Chinese-Malaysian patients ranging between 18 and 80 years of age were included. Patients with congenital or developmental deformities, any syndrome affecting the mandible, traumatic injury, or pathologic changes in the mandible such as cysts and tumors were excluded from the study. Distorted or blurred CBCT images were also excluded.

To ensure consistency, the measurements were made a technician (Y.S.V.) who was trained in interpreting oral and maxillofacial CBCT imaging. The DICOM image data obtained were imported into software (i-CATVision; Imaging Sciences Intl, LLC). The software allowed coronal cross-sectional, horizontal sectional, and panoramic views on the same screen. The anatomy of the whole mandible was assessed first in all 3 views. The visible genial tubercle, mental foramina, and anterior loop of the mandibular nerve image were marked. All these key landmarks were identified first in cross-section, and a reference point was marked on the crest of the ridge. All values shown in Figure 1 were measured from the reference points marked on the crest of the ridge. A total of 12 selected images were reviewed again after 2 weeks by the same researcher to determine reliability. The Cronbach alpha test was used to evaluate the reliability between the first and second readings of the selected images.

Details of the measurements are indicated in a schematic diagram (Fig. 1). A perpendicular distance between the mesial margin of the right and left mental forams (Fig. 1, F-left to F-right) was marked. A perpendicular distance was then marked between the mesial margin of the anterior loop of the right and left mental nerve (Fig. 1, L-left to L-right). Perpendicular
distances were marked between the center of the genial tubercle (Fig. 1, G) and the mesial margin of the left mental foramen (Fig. 1, G to F-left) and between G and the mesial margin of the right mental foramen (Fig. 1, G to F-right). Then perpendicular distances were marked between G and the mesial margin of the loop of the left mental nerve (Fig. 1, G to L-left) and between G and the mesial margin of the loop of the right mental nerve (Fig. 1, G to L-right).

The safe zone (S) was calculated by using the following formula: 
\[ S = \text{distance between 2 mm mesial to L-Left (L-2 Left) and 2 mm mesial to L-right (L-2 right)} \]. The relationship of the genial tubercle to the safe zone (GS) was calculated by using the following formula: 
\[ GS = GS\text{ left} + GS\text{ right} \], where GS left = distance between G and (L-2 left); GS right = distance between G and (L-2 right).

Screenshots of the software for the step-by-step measurements are indicated in Figures 2-4B. The genial tubercle was assessed and located from the axial and panoramic views. The location of the genial tubercle was marked in the horizontal view (Fig. 2). The mental foramen was first located in the cross-sectional views,
and the mesial margin of the mental foramen was marked in the horizontal view (Fig. 3A). The mesial margin of the anterior loop was located and marked in the coronal cross-sectional view (Fig. 3B). The crest of the ridge was identified at the genial tubercle level (Fig. 4A), and all markings were transferred to the crestal level to measure the distances (Fig. 4B). The distance from the genial tubercle to the mesial margin of the anterior loop (safe zone) was measured on the left and right side at the crest of the mandible in the horizontal view (Fig. 4B).

All data are mean values for statistical evaluation. However, to avoid the influence of extreme measurements and to estimate a comparison with the mean values, the median values are also indicated in Table 1.
Statistical analysis was performed using a mixed 2-way analysis of variance (ANOVA) test to evaluate sex- and side-related variations, using statistical software (IBM SPSS Statistics v24; IBM Corp). The correlation between the left and right sides within the same individual was calculated using the intraclass correlation value.

RESULTS

The linear distances between the genial tubercle to the mental foramen, the mesial margin of the anterior loop of the inferior alveolar nerve, and the safe zone were measured at the ridge crest of the mandible (Table 1) (Fig. 5). The Cronbach alpha value of .907 (> .7) indicated the reliability of the readings for the same researcher at 2 different time points for the 12 selected images. The mean safe zone value for women was 20.79 mm on the left side and 21.32 mm on the right side. The mean safe zone value for men was 21.60 mm on the left side and 22.18 mm on the right side. The minimum distance from the genial tubercle to the right side safe zone was observed to be 12.82 mm in women and 14.99 mm in men; however, on the left side, the minimum distances were observed to be 14.81 mm in women and 15.54 mm in men. The overall mean safe zone distance measured from the genial tubercle on the left side was 21.12 mm and 21.67 mm on the right side. No statistically significant differences in left side measurements were observed between men and women nor in right side measurements between men and women (P=.655) (Fig. 6, Table 2). However, a statistically significant difference was observed between the right and left sides in both women and men (P<.05) (Fig. 6). A strong correlation (with intraclass correlation value of .972) was observed between the left and right sides in the same individual.

DISCUSSION

Dental implant restorations must not only satisfy esthetic and functional criteria, but also implant placement...
should be a safe dental treatment with no risk of injury to the surrounding anatomic structures. Selection of the optimal implant site is essential to prevent injury.\textsuperscript{3} The results of this study may facilitate the initial planning of dental implant locations in the interforaminal region of the mandible.

Wei et al\textsuperscript{5} studied the location of the mental foramina in a Malay population and found it to be located most commonly (69.2\%) close to the longitudinal axis of the second premolar, followed by a location between the first and second premolar (19.6\%). From the present research, the mean value of all participants was 21.12 mm for the safe zone on the left side and 21.67 mm for the safe zone on the right side. Once the clinician is aware of the baseline information for the mandible, this will be a valuable guideline to initiate the planning of implant osteotomy sites and can provide a provisional guideline for planning the location of the implant osteotomy in the interforaminal region of the mandible. The clinician should first mark the left and right safe zones from the genial tubercle (based on available population data) and then the number and location of the implants to be placed (Fig. 7).

This guideline is useful when dental implants are placed without the aid of a CBCT scan. These results can be used to compare safe zones in different populations. The CBCT scans and CAD-CAM facility is not always available in dental clinics. Therefore, CBCT scans are an important source for obtaining preliminary measurements in a selected population that can help in implant planning as adjunct information in the same population. All bony landmarks used for the measurements do not change significantly in horizontal direction due to tooth/teeth loss.\textsuperscript{6} Hence measurements were made from dentate or partially or completely edentulous mandibles.

The study has limitations. The crestal level may not be at the same horizontal level at the genial tubercle and anterior loop sites. However, the discrepancy of these measurements should be minimal and not cause significant differences in the clinical measurements. The measurements were made at the bony crestal level and not at the mucosal level, which may differ from the clinical scenario. However, this difference should also be minimal.

CONCLUSIONS

Based on the findings of this clinical study, the following conclusions were drawn:

1. The safe zone related to the genial tubercle on the left side was 21.12 mm and 21.67 mm on the right side with no significant sex-related variations.

2. In the same individuals, a significant difference was found in the safe zone between the left and right side.

3. The genial tubercle, a clinically palpable landmark, can also be used as a CBCT landmark to estimate the safe zone in the interforaminal region of the mandible.

REFERENCES


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