Radiographic evaluation of anatomical variables in maxilla and mandible in relation to dental implant placement

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ABSTRACT

Introduction: Oral rehabilitation using implants is rapidly replacing tooth supported prostheses. The success of implants is largely dependent on the quality and quantity of alveolar bone. In this study, we assessed the location of limiting anatomical structures and the amount of alveolar bone available for implant placement.

Materials and Method: Six hundred digital panoramic radiographs (300 males and 300 females) of dentate patients aged between 15-60 years were selected from the archives. The radiographs were subdivided into 3 groups with age interval of 15 years. Then the location of mental foramen, anterior loop, mandibular canal and maxillary sinus was determined. The amount of bone available was measured in both maxilla and mandible in the premolar and molar regions.

Results: The mental foramen was most commonly located at the apex of the second premolar in both the genders. The anterior loop was more readily visible in the younger age group. The amount of bone available in the premolar and molar region of the mandible is nearly the same, while more bone is available in the premolar region of the maxilla.

Conclusion: The location and morphology of anatomical structures of the jaws vary not only in different populations but also within the same population. The amount of bone available also showed variations in the same population and in the same individual on the right and left sides. The limiting anatomical structures govern the amount of bone available for possible implant placement.

Key words: Anterior loop, dental implants, mandibular canal, maxillary sinus, mental foramen, panoramic radiography

Loss of teeth leads to disuse atrophy of the alveolar bone due to lack of physiologic stimulation.[1] The bundle bone and marrow component of alveolar ridges undergo irreversible and persistent resorption. This results in a reduction of buccolingual and apicocoronal dimension and morphological changes.[1,2] Atrophy of residual alveolar bone is influenced by various factors such as gender, hormones, metabolism, and parafunctional habits.[1] The availability of residual bone is further reduced by limiting anatomical structures such as the nasal cavity, maxillary sinus, mandibular canal, and mental foramen. Dental implants have revolutionized oral rehabilitation and have replaced tooth-supported prostheses in rehabilitating the missing teeth.[3] It is very important to identify the structures. The success of dental implants also depends on the quantity and quality of jawbone.[4] Radiology plays an important role in assessing the quality and quantity of the bone, location of vital structures, and pathologies of the jaw bones.[3,5-7] Panoramic radiographs are the most commonly used imaging modality for implant planning.[8]

The location of anatomical structures and the amount of residual alveolar bone available vary among different populations. In our study, we assessed the location of various anatomic structures and bone available in both the jaws among Indian population using panoramic radiographs. The objectives of the study were as follows:

1. To determine the variations in the location of various anatomical structures in relation to age, gender, and laterality.

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2. To determine the amount of bone available in different regions of both maxilla and mandible for possible implant placement
3. To assess if any variations exist in the location of the anatomic structures of the jaws and the amount of bone available among different ethnic groups.

MATERIALS AND METHODS

Six hundred digital panoramic radiographs, 300 each of males and females in the age group of 15–60 years, were selected from the archives of data from the Department of Oral Medicine and Radiology, Rajarajeswari Dental College and Hospital, Bengaluru. The radiographs of complete dentate patients with full coverage of both the jaws were selected for the study. The radiographs of completely edentulous patients with pathologies of the jaw bones were excluded from the study. The radiographs were further grouped as Group I (15–30 years), Group II (31–45 years), and Group III (46–60 years). The anatomic structures identified were mental foramen and its location in relation to the premolars, presence or absence of anterior loop of mental foramen, mandibular canal, and floor of the maxillary sinus in relation to the maxillary premolars and molars.

The following measurements were made on the radiographs using the measuring tool on SIDEXIS XG (Version 2.61, Sirona Dental Systems GmbH, Bensheim, Germany) software as shown in Figure 1.
1. The angle of the anterior loop of the mental foramen
2. The distance between the alveolar crest and the superior margin of the mental foramen or the superior margin of the mandibular canal in the premolar and molar regions, respectively
3. The distance between the alveolar crest and the floor of the maxillary sinus in the premolar and molar regions in the maxilla.

RESULTS

The mental foramen was most commonly located at the apices of the second premolars (78.3%) followed by position between the premolars (13.7%) in both males and females [Table 1]. The anterior loop was present in 44 females (14.6%) and 69 (23%) males. In both males and females, the prevalence was observed to be more in younger age group with the greatest prevalence being in the age group of 15–30 years. As the age advanced, the prevalence rate was drastically low in the age group of 46–60 years. It was also noted that the anterior loop was most commonly present bilaterally followed by the right and then left side. On measuring the angle, it was found to be between 65.9° and 47.9° [Table 2]. The bone available for possible implant placement was measured in the premolar and molar regions of both the jaws. In the premolar region of the mandible, the mean bone available gradually decreased as the age advanced. There was no statistically significant difference between the right and left sides. In the molar region of the mandible, there was a significant difference in the bone available between the right and left sides with more bone available on the right side in the age groups of 15–30 years and 46–60 years [Table 3].

In the maxilla, bone available is determined by measuring the distance between the alveolar crest and the floor of the sinus in the premolar and molar regions. The bone available was less in the molar region, as in the jaws, the existing bone decreases with age. In the premolar region, there was a significant difference in the bone available between the right and left sides with more bone available on the left side. In the molar region, there was more bone available on the left side in the age group of 15–30 years and 46–60 years [Table 4].

DISCUSSION

The mental foramen is defined as a funnel-like opening on the lateral surface of the mandible at the terminus of the mandibular canal. It transmits the mental nerve and vessels. The mental foramen is difficult to locate as there is no absolute anatomical landmark for reference. Hence, varied anatomical locations have been reported by different authors. Jasser and Nwoku put forward the categories for the location of the mental foramen in five positions: Anterior to the first premolar, below the first premolar, between the premolars, below the second premolars, and posterior to the second premolar.

| Position                                | Right | Left |
|-----------------------------------------|-------|------|
| At the first premolar                   | 15    | 11   |
| Between the premolars                   | 88    | 95   |
| At the second premolar                  | 465   | 473  |
| Between second premolar and molar       | 27    | 19   |
| At the first molar                      | 4     | 1    |

Figure 1: Measurements made on the digital panoramic radiographs using SIDEXIS software
Table 2: Prevalence of anterior loop

| Age group | Females | | Males | |
|-----------|---------|--------|--------|--------|
|           | Total   | Right  | Left   | Both   | Average angle on right | Average angle on left | Total   | Right  | Left   | Both   | Average angle on right | Average angle on left |
| 15-30 years | 24      | 8      | 5      | 11     | 65.9±2.44              | 47.9±2.91             | 34      | 12     | 7      | 15     | 53.4±2.43              | 59.7±2.38             |
| 31-45 years | 14      | 7      | 3      | 4      | 59.9±2.61              | 58.1±2.58             | 24      | 4      | 11     | 9      | 49.8±2.67              | 54.3±2.60             |
| 46-60 years | 6       | 2      | 1      | 3      | PV                   | PV                   | 11      | 8      | 1      | 2      | 58.4±2.43              | 58.4±2.32             |

SD=Standard deviation

Table 3: Bone available in the premolar and molar regions of the mandible

| Age group | Bone available in mandible | | Bone available in mandible | |
|-----------|----------------------------|--------|----------------------------|--------|
|           | Right Mean±SD | Left Mean±SD | P value | Right Mean±SD | Left Mean±SD | P value |
| 15-30 years | 15.1228±2.44 | 20.3181±2.72 | 0.893 | 15.8408±2.43 | 16.1459±2.88 | 0.014* |
| 31-45 years | 15.0214±2.61 | 14.8301±2.60 | 0.253 | 14.5356±2.94 | 14.3902±2.67 | 0.114 |
| 46-60 years | 14.5914±2.54 | 14.5608±2.52 | 0.594 | 14.2560±2.70 | 13.8599±2.91 | 0.031* |

SD=Standard deviation

Table 4: Bone available in the premolar and molar regions of the maxilla

| Age group | Bone available in maxilla | | Bone available in maxilla | |
|-----------|----------------------------|--------|----------------------------|--------|
|           | Right Mean±SD | Left Mean±SD | P value | Right Mean±SD | Left Mean±SD | P value |
| 15-30 years | 13.9762±4.14 | 14.0334±4.48 | 0.485 | 8.8847±2.53 | 8.7249±2.46 | 0.352 |
| 31-45 years | 13.7050±3.25 | 14.5502±3.69 | 0.013* | 8.4302±3.24 | 8.1800±3.19 | 0.348 |
| 46-60 years | 12.9223±3.84 | 13.1987±3.53 | 0.133 | 7.1913±2.70 | 7.6824±3.05 | 0.021* |

SD=Standard deviation

A number of studies have been done to determine the location of the mental foramen that show racial variation in relation to the position. In the present study, position 4 was the most common location with 78.3% of the mental foramen examined, followed by position 3 with 13.7%. It has been shown that position 4 is the most common location for the mental foramen. Interestingly, a study done in a South Asian population in 2014 showed position 3 to be the most common location. Studies done on different races have shown that the position of the mental foramen is highly variable even within the same race. Hence, it cannot be assumed that in a particular population the mental foramen is located at a specific location. In addition, Yosue and Brooks noticed that the actual position of the mental foramen was reflected ~50% in panoramic and periapical radiographs.

Sicher’s Oral Anatomy describes the anterior loop as the mental canal which arises from the mandibular canal and runs outward and backward to open at the mental foramen. The mental neurovascular bundle crosses anterior to the mental foramen then doubles back to exit the mental foramen. Various diagnostic methods have been used to detect and measure the anterior loop which includes panoramic radiographs, periapical radiographs, computed tomography (CT) scans, and surgical cadaver dissections. There are wide variations in the prevalence, length, and angle of the anterior loop as noted by several studies. In the present study, the anterior loop was present more commonly bilaterally followed by the right and then left side. This is in accordance to a study done by Neiva et al. who found that the symmetry of the loops was a common finding. The novel finding of the study was that the loop was found to be more prevalent in the younger age group both in males and females. However, in older age group (46–60 years), the loop was found only in one-fourth of those present in younger age individuals.

Some authors have opined that the inability to visualize the loop on the panoramic radiograph does not mean that they are absent. The reason for poor visibility of the anterior loop in older individuals may be a result of reduced calcification of the canal walls, enlarged marrow spaces, disordered trabeculae, and increased porosity of the bones. Panoramic radiographs underestimate the prevalence of anterior loops when compared with spiral CT and anatomically identified loops. Radiographically, mandibular canal appears as a uniformly wide radiolucent line bounded by radiopaque walls. The vertical location and status of the canal can be detected using panoramic radiographs. The mandibular canal is closer to the apices of the mandibular third molar and it gradually descends down as it moves anteriorly, indicating that there is more residual bone available anterior to the third molar for possible implant placement.

The amount of bone available is influenced not only by the anatomic structures, but also by a number of factors such as gender, hormones, parafunctional habits, and race. In our study, the bone height was measured in different age...
groups of both males and females. The bone height was measured from the alveolar crest to the limiting anatomical structures in the premolar and molar regions bilaterally. In the mandible and maxilla, the bone height was progressively reduced as the age increased. In the older age group, there was a significant difference between the right and left sides of the molar regions of the maxilla and mandible. The dimensions of the vertical bone height in both the jaws were comparable to those studies done in edentulous jaws. However, the studies done in other populations showed lesser bone height.\(^1\)

Maxillary sinus is a pyramidal-shaped cavity in the facial skull with its floor in close approximation to the maxillary posterior teeth. The floor of the antrum in dentate adults is approximately 1 cm below the nasal floor. Anteriorly, the sinus extends to the canine premolar region. The convex sinus floor usually reaches its deepest point at the first molar region.\(^2\) The loss of teeth will cause the sinus floor to further dip down toward the alveolar crest. The degree of pneumatization increases as the period of edentulism increases. In the present study, the amount of bone available was measured from the floor of the sinus in both premolar and molar regions. There was a significant difference between the right and left sides in both premolar and molar regions in the older group. The amount of bone available in the molar region was comparable to a similar study done on Indian and Korean population.\(^1,2\) In the molar region, the vertical bone height was much less than a study done in Turkish edentulous population.\(^26\) The size of the maxillary sinus may be more in Indian population contributing to less bone available.

**CONCLUSION**

The study concludes that the location of anatomical landmarks of the jaw was different in different populations. The anterior loop was more prevalent in the younger age and visibility markedly reduced in older individuals. In the mandible, the amount of bone available in the premolar and molar regions was similar. However, in the maxilla, the vertical bone height was markedly less in the molar region as compared to the premolar region. In addition, the amount of bone available also varies in the same population.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Liang XH, Kim YM, Cho IH. Residual bone height measured by panoramic radiography in older edentulous Korean patients. J Adv Prosthodont 2014;6:53-9.
2. Tonelli F, Duvinia M, Barbato I, Biondi E, Nuti N, Brancato L, et al. Bone regeneration in dentistry. Clin Cases Miner Bone Metab 2011;8:24-8.
3. Vishanti R, Rao G. Implant imaging. Int J Innov Res Dev 2013;2:285-9.
4. Juodzbalys G, Kubilius M. Clinical and radiological classification of the jawbone anatomy in endosseous dental implant treatment. J Oral Maxillofac Res 2013;4:e2.
5. McCrea SJ. Pre-operative radiographs for dental implants—are selection criteria being followed? Br Dent J 2008;204:675-82.
6. Bagchi P, Joshi N. Role of radiographic evaluation in treatment planning for dental implants: A review. J Dent Allied Sci 2012;1:21-5.
7. Lingam AS, Reddy L, Nimma V, Pradeep K. Dental implant radiology—Emerging concepts in planning implants. J Orofac Sci 2013;5:88-94.
8. Kim YK, Park JY, Kim SG, Kim JS, Kim JD. Magnification rate of digital panoramic radiograms and its effectiveness for pre-operative assessment of dental implants. Dentomaxillofac Radiol 2011;40:76-83.
9. Gada SK, Nagda SJ. Assessment of position and bilateral symmetry of occurrence of mental foramen in dentate Asian population. J Clin Diagn Res 2014;8:203-5.
10. Phillips JL, Weller RN, Kulild JC. The mental foramen: 1. Size, orientation, and positional relationship to the mandibular second premolar. J Endod 1990;16:221-3.
11. Loyal P, Butt F, Ogengo J. The surgical relevance of the anatomic position of the extraosseous mental nerve in a Kenyan population. Pan Afr Med J 2014;18:51.
12. Juodzbalys G, Wang HL, Sabalys G. Anatomy of mandibular vital structures. Part II: Mandibular incisive canal, mental foramen and associated neurovascular bundles in relation with dental implantology. J Oral Maxillofac Res 2010;1:e3.
13. Haghani Far, Sokouei M. Radiographic evaluation of the mental foramen in a selected Iranian population. Indian J Dent Res 2009;20:150-2.
14. Sankar DK, Bhanu SP, Susan PJ. Morphometrical and morphological study of mental foramen in dry dentulous mandibles of South Andhra population of India. Indian J Dent Res 2011;22:542-5.
15. Neiva RE, Gasperi R, Wang HL. Morphometric analysis of implant-related anatomy in Caucasian skulls. J Periodontol 2004;75:1061-7.
16. Yousef T, Brooks SL. The appearance of mental foramina on panoramic and periapical radiographs. II. Experimental evaluation. Oral Surg Oral Med Oral Pathol 1989;68:488-92.
17. Ngeow WC, Dionysius DD, Ishak H, Namibier P. A radiographic study on the visualization of the anterior loop in dentate subjects of different age groups. J Oral Sci 2009;51:231-7.
18. Greenstein G, Tarnow D. The mental foramen and nerve: Clinical and anatomical factors related to dental implant placement: A literature review. J Periodontol 2006;77:1933-43.
19. Kaya Y, Sencimen M, Sahin S, Okcu KM, Dogan N, Bahtecitapar M. Retrospective radiographic evaluation of the anterior loop of the mental nerve: Comparison between panoramic radiography and spiral computerized tomography. Int J Oral Maxillofac Implants 2008;23:919-25.
20. Kuzmanovic DV, Payne AG, Kieser JA, Dias CJ. Anterior loop of the mental nerve: A morphological and radiographic study. Clin Oral Implants Res 2003;14:464-71.
21. Xie Q, Wolf J, Tilvis R, Ainamo A. Resorption of mandibular canal wall in the edentulous aged population. J Prosthod Dent 1997;77:596-600.
22. Amorim MM, Borini CR, Lopes SL, Hairet-Neto F, Caria PH. Morphological description of mandibular canal in panoramic radiographs of Brazilian subjects: Association between anatomic characteristic and clinical procedures. Int J Morphol 2009;27:1243-8.
23. Güler AU, Sencimen M, Sahin S, Okcu KM, Dogan N, Bahcecitapar M. Anatomy of dental implant placement. Int J Morphol 2012;30:150-2.
24. Juodzbalys G, Wang HL, Sabalys G. Anatomy of mandibular vital structures. Part II: Mandibular incisive canal, mental foramen and associated neurovascular bundles in relation with dental implantology. J Oral Maxillofac Res 2010;1:e3.
25. Haghani Far, Sokouei M. Radiographic evaluation of the mental foramen in a selected Iranian population. Indian J Dent Res 2009;20:150-2.
26. Phillips JL, Weller RN, Kulild JC. The mental foramen: 1. Size, orientation, and positional relationship to the mandibular second premolar. J Endod 1990;16:221-3.
27. Loyal P, Butt F, Ogengo J. The surgical relevance of the anatomic position of the extraosseous mental nerve in a Kenyan population. Pan Afr Med J 2014;18:51.
28. Neiva RE, Gasperi R, Wang HL. Morphometric analysis of implant-related anatomy in Caucasian skulls. J Periodontol 2004;75:1061-7.
29. Yousef T, Brooks SL. The appearance of mental foramina on panoramic and periapical radiographs. II. Experimental evaluation. Oral Surg Oral Med Oral Pathol 1989;68:488-92.