Radiological Evaluation of the Dimensions of Lower MolarAlveoli

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Abstract

Aim: The aim of this study to analyze the alveolar bone morphology of the lower first and second molars. This analysisaims to evaluate the morphology of a hypothetical postextractive site in the lower molar area to diagnose the possibility of immediate postextraction implant placement using cone beamcomputed tomography (CBCT).

Materials and Methods: Conebeam CT scans of 45 patients were examined. The measurements were made using a dedicated 3D software. Reference points were identified to allow clear and repeatable measurements.

Results: The mean available bone height was **14.17 +/- 3.56** mm in lower first molars and **12.90 +/- 3.45** mm in lowersecond molars. The inter-radicular septum was present in 92% in first molar sites and in 70% in second molar sites.

Conclusions: Preoperative cone-beam scan and the knowledge of anatomical measurements fromthe present analysis are fundamental before planning immediate postextractive implants in the lower molar area.

Keywords: Dental alveoli, Human anatomy, Postextractive implant, Oral implantology, Cone beam CT

INTRODUCTION

Implant treatment is a common procedure in dental practice. Immediate or early placement approach increases the attractiveness of implant therapy. After extraction, the alveolar process undergoes marked alterations because of which alveolar bone width and height of buccal bone changes significantly.

Postextraction implant sites often require bone augmentation procedures to achieve and maintain successful osseointegration. Alveolar bone dimensions prior toextraction may be an important determinant of bone morphological changes that occur postextraction.[1]

The precise knowledge of the anatomical structures of dental alveolus appears useful when tooth extraction and subsequent immediate implant insertion are planned. [2] The outcome of implant therapy is no longer defined only by successful osseointegration. Rather, the success depends on a variety of factors that affect the implant-prosthetic complex, including the health and stability of peri-implant soft and hard tissues, esthetic outcomes, and patient satisfaction.

In the mandible, the first and second molars septum have 2 roots; mesial, and distal, that are similar in size and dimension, so the shape of interradicular septum is rhomboidal with a narrow mesiodistal dimension . The interradicular septum of the first and second teeth of maxillary molars is surrounded by 3 roots: bucco mesial, bucco distal, and palatal , which provides a triangular shape and wider dimensions of the septum. The average width of mandibular molars is 9 mm buccolingual and 9 mm mesiodistal, relative to maxillary 10 mm buccolingual and 8mm mesiodistal, which explains the triangular shape and wider interradicular septum.[3] The type of bone in the posterior mandible region (second premolar and molars) is described by Misch et al., and presents usually as D3 bone, while the posterior maxilla region (molar region) usually as D4 bone, still in cases of sinus grafting it may have D3 bone 6 months after grafting. "D3 bone describes fine trabecular bone surrounded by thin porous cortical bone **while** D4 boneis fine trabecular bone with almost no cortical bone". [4]

For a successful osseointegration, the main requisite is the primary stability of implant. It is achieved with some complications in molar alveoli sites due to some anatomical complexities like the inferior alveolar nerve canal. **Due to the presence of submandibular gland fossa, there is lingual bone concavity in mandibular posterior region which increase the complications.** Dental implants in the region, if not placed properly, can perforate the lingual bone or damage the lingual nerve leading to treatment failure.[4,5]

Watanabe et al. categorized the cross-sectional morphology of the mandible. Their data demonstrated that lingual concavity is prevalent in 36% to 39% of the study population. Although biomechanically it is best that bucco-lingualimplant inclination follows the long axis of the opposing tooth, ignoring the presence of a lingual undercut may lead to perforation of the lingual plate. On the same note, manually fabricated surgical guides following the ideal prosthetic position without considering underlying anatomic limitations may run the risk of lingual plate perforationthus leading to severe surgical complications. Furthermore, the residual gap between bone plates and implant neck, after immediate implant positioning, should be previously evaluated to understand the need for graft when standard diameter implants are used.[3,4,5]

The radiograph analyses are required diagnostics procedure in everyday dental practice, and also are used in the treatment plan and follow-up the results of therapy. **The conventional 2D radiographic techniques have multiple visual limitations like magnification, distortion, and superimpresion, which altogether may lead to misrepresentation of anatomical structures. The triumph of CBCT is its capability to gather patients** information of volumetric jaw bone imaging, which can be used for preoperative field review and treatment plan. The equipment that's included in CBCT is viewing software, containing 3D database, and a wide range of extensive tools that provide analysis of images. The software tools that are usually used in presurgical implant placement are: oblique slicing (nonorthogonal)- which creates 2D image at any angle by cutting across a set of axial images; curved slicing (panorama like view), cross-sectional (oblique coronal) view provide images in thickness and spacing, that's important for evaluation of morphometric characteristics of alveolar bone for immediate placement, and others like ray sum and volume rendering .[6,7] Using 3D CBCT in implantology, it is possible to fully integrate the preoperative transfer to the surgical field, virtual implants placement, and preoperative transfer to the surgical field with further prosthetic **rehabilitation.[7]**

Cone beam computed tomography (CBCT) is a promising diagnostic and prognostic tool in the implant therapy. It provides high resolution images of oral and maxillofacial region with lower radiation dose than conventional computed tomography. It provides the clinician with third dimension that makes it better than

two-dimensional imaging modalities such as intraoral periapical radiographs, orthopantomographs, etc. today, CBCT is preferred over CT, because this new technology offers better image quality and lower radiation exposure

The study by **R Pauwels et al in 2015** showed that CBCT is reliable in morphometric analyses of the anterior maxilla,to notice interconnections between the structure measures, and preliminary examination for implant **planning.[8]** Moreover, another studies using CBCT in anterior maxilla analyze that detection of various anatomic structures, may be useful in the prevention of complications during surgical intervention, as implant placement. Still, the morphological observed algorithms of the anterior maxilla may offer detailed information that can be used for planning orthodontic teeth movement. The justification of CBCT for preoperative implant plan is based on accurate information about vital structures, height, and width of bone, bone density, and alveoli profile. The European Association for Osseointegration in 2011, and the American Academy of Oral and Maxillofacial Radiology 2012, represented the guidelines of using CBCT in implant dentistry.[7,8]

According to the knowledge of CBCT usage, the study of Agostinelli et al. investigated the morphology of a hypothetical postextractive site in the upper molar area to diagnose the possibility of immediate postextraction implant placement and concluded that these alveolar sites do not present ideal conditions for immediate implant insertion in a correct position.[5]

Hence, it is imperative to evaluate bone dimensions of mandibular posterior teeth, such as buccal and lingual bone plate thickness, alveolar bone width, and distance from the inferior alveolar canal using CBCT. The radiographic evaluation of the alveolar bone morphology and sizes represents a key element to place and adequately stabilize the immediate implant in a predictable way.[8,9,10]

AIM & OBJECTIVE

- To analyze the **alveolar bone morphology** of the **mandibular first and second molars** in **hypothetically post extractive site** to diagnose the **possibility of immediate implant placement and its success.**

MATERIALS AND METHODS

This is a retrospective done from May 2018 to August 2018 in which CBCT scans of 45 patients reporting in Department of Periodontics, RUHS College of Dental Sciences, Jaipur were examined.

- Each "tooth site" was verified the presence of:
    i. Healthy or decayed tooth;
    ii. Endodontic injury or Osteolysis from periodontal disease and/or from root fracture
- The alveolar sites with the following criteria were excluded from the study:
    - Sites with large bone lesions like reactive bone diseases, fibro-osseous lesions, and giant cell lesions were notincluded in the study to exclude pathological condition that should influence the measurements in a significant way.
    - Teeth having periapical pathologies, like chronic periapical abscess, chronic apical periodontitis, apicalperiodontitis, perioendo lesion, infected periapical cyst, periapical cyst, and radicular cyst, which are indicated for apical surgery, were excluded from the study owing to the possible effects of periapical pathologies on alveolar bone dimensions at the analyzed sites.
    - Patients with systemic diseases were excluded from the study.
    - Due to varying anatomy, third molars were not considered in the study.
- Panorex, axial, and paraxial sections were analyzed (Figure 1) & the measurements in millimeters were made using the One Scan 3D software.
- To measure the bone available, there are series of some precise reference points for the alveoli thickness and size in CBCT scan which allow clear and repeatable measurements.

PANOREX SECTIONS

- Apical-mesial point (AM)
- Apical-distal point (AD)
- Most coronal point at tooth furcation (F)

AXIAL SECTIONS

- P1 (distal point of mesial root)
- P2 (mesial point on distal root)
- Pm (mesial point on mesial root)

- Pd (distal point on distal wall)
- Pb (buccal point on the root)
- PI (lingual point on the root) Paraxial sections
- PCB (bone peak of buccal wall)
- PCL (bone peak of lingual wall)
- A (apical point)

Li (MANDIBULAR CANAL)

Parameters for Alveolar Dental Sites Measurements

- Average number of bony walls in each alveolus: The numbers of bony walls that surround the entire alveolar site (ie, the cortical lingual, cortical buccal, and mesial and distal cortical) wereevaluated in the axial sections and paraxial sections
- Mean height of useful bone from the mandibular canal: The measurement carried out on the paraxial section after establishing the alveolar reference site in the axial plane. Standard references are the mandibular canal (Li) and the coronal part of the alveolus (points PCB and PCL).
- Inter-radicular septum and extension of the Interseptal basis: The interradicular septum describesarea in the root furcation that separate alveoli of multi-rooted teeth. The shape and dimension depend of the topography of the extraction socket, the geometry of residual root and anatomy of molars alveoli. The clinical implications of this anatomic structure may be used in oral surgery resection procedures, periodontology and implantology. There is an opinion from the surgical and prosthodontic side that center of interradicular septum may be adequate place for immediate implantation. Presence of the septum observed in the axial and paraxial sections:
  - Present, it indicates when the septum is present and its thickness and height are measurable. The measurement is carried out on the Panorex section (distance between points F and AD and between F and AM) after having established the corresponding point on axial section.
  - Absent, it indicates that the roots are in close contact with each other, when the roots are open in the first section and converging at the apex otherwise the apex is affected by osteolytic disease. Width and height cannot be measured.
- Mean thickness of the lingual cortex: The measurement was made at the two most apical levels compared to the previous measurement. The average of the 3 measurements was then calculated (including the most coronal measurement).
- Mean thickness of the buccal cortex: The measurement was made at the two most apical levels compared to the previous measurement. The average of the 3 measurements (including the most coronal measurement) was then calculated.
- Buccal-lingual width of the dental alveolus: The measurement was evaluated on the paraxial section, after establishing the reference points on the corresponding axial section, in the most apical coronal bone peak (PCB-PCL). The mean distance between the measurements, both on the mesial and on the distal root, was calculated.
- Mesial-distal width of the dental alveolus: The measurement was made on axial section after establishing the point F on corresponding root furcation (in the Panorex section). The distance between the most distal point of distal alveolus (Pd) and the most mesial point of mesial alveolus (Pm) was calculated.

RESULT

- A total of 65 dental sites of first lower molar and 57 of second lower molars were examined. Tooth alveoli, surrounded by all 4 bone walls, were detected with a percentage of 72% in lower first molars (mean of 3.64 ± 0.53 mm bone plates) and in 82% of cases in lower second molars (mean of 3.70 ± 0.45 mm bone plates). The mean useful bone height measured was 14.17 ± 3.56 mm in firstmolar alveoli and 12.90 ± 3.45 mm in the second molar alveoli. (Figure 2)
- The inter-radicular septum was present in 92% in first molar sites and in 70% in second molar sites. This bone septum was 6.79 ± 2.66 mm thick in the first molar alveoli and 5.19 ± 1.88 mm in the second molar alveoli. The mean buccal-lingual alveolus width was 8.81 ± 0.67 mm in first molar alveoli and 8.80 ± 0.60 in second molar. The

mean mesio-distal alveolus width was 8.93 ± 0.84 mm in first molars and 8.98 ± 0.87 mm in second molars. All data about lower molars alveoli measurements are summarized in Table1.

DISCUSSION

Efforts have been taken to decrease overall treatment time and surgical interventions in implant therapy recently.[11] Alternative to conventional approach, immediate or early implant placement approaches have been proposed.

According to the survey of Swiss dental practitioners in 1994, most frequent indications for implant therapy were found to be completely edentulous mandible followed by edentulous posterior mandible. Knowledge of the exact location and course of the mandibular canal is of great importance to avoid neurosensory disturbances following placement of dental implants. Perforation of the lingual cortical plate during implant placement in the posterior mandible can be a severe surgical complication, and the presence of a lingual undercut is considered an importantanatomical risk factor.

Hence, **analysis of bone dimensions in posterior mandible for implant placement is important**.[12,13] **Tomasi et al[14]** stated that the thickness of the buccal bone wall is a key determinant of implant treatment success following extraction. The thickness of the buccal bone wall is associated with the degree of defect fill following implant placement. **Importance of analysis of bone dimensions before future implant placement is well documented in the literature.[14]**

Analysis of bone dimensions is a must before immediate implant placement to determine the need of bone augmentation and appropriate treatment planning. Inadequate amount of remaining bone following implant therapy can cause treatment failure. Following extraction, bony alterations are most commonly seen in the coronal portion of the alveolar ridge.[15,16]

Bone dimensions of the posterior mandible have been evaluated using different radiographic methods in several studies. However, in the majority of those studies imaging was not based on CBCT. Studies analyzing CBCT imagesof the posterior mandible were done either on fully dentate subjects or were cadaveric studies focusing mainly on theaccuracy of CBCT measurements.[17,18]

Lingual plate perforation is difficult to assess from radiographic images because of potential artifacts around implants. The beam-hardening effect of implants in CT or CBCT images complicates the establishment of a definitive diagnosis of lingual perforation, hindering investigations on the incidence of lingual perforations after implant placement. The beam-hardening effect is an inherent artifact resulting from the polychromatic absorption of low-energy x-ray photons by metallic objects resulting in an exiting x-ray beam that contains mainly high-energy x-ray photons (e.g., a harder beam). Although artifact reduction technique algorithms have been developed, they are computationally demanding and time consuming. Unless potential artifact caused by metallic objects (e.g., dental implants) can be resolved, the use of CT/CBCT for postoperative evaluation is not justifiable at this time.

Therefore, alveolar ridge dimensional changes after tooth extraction have been widely studied. A systematic review by Tan et al[15] reported that the mean amount of alveolar ridge resorption during the first 6 months following tooth extraction is 3.79 ± 0.23 mm in horizontal dimension and 1.24 ± 0.11 mm in vertical dimension. Another systematic review by Van der Weijden and colleagues[15] reported that a mean clinical loss of 3.87 ± 0.82 mm in horizontal dimension and 0.64 ± 0.19 mm in vertical dimension occurs following tooth extraction.

Data, emerging from the present study, similar to those provided by another **study (Agostinelli C et al. 2018)[5,6.]** The radiographic evaluation of the alveolar bone morphology and sizes represents a key element for the proper planning ofthe postextraction immediate implant treatment. **Proper clinical conditions, for scheduling a postextraction immediate implant placement surgery, inevitably involve the presence of 4 bone walls showing sufficient heightand width. Measurements of the present study clearly demonstrated that the postextraction alveolar site in lower molars alveoli could be too large to place a standard diameter implant with good primary stability with small peri-implant gap.**

It is demonstrated that the postextractive alveolar site has more osteogenetic potential than mature bone.[8] Bone defects, surrounding immediate post extractive implants, showed the tendency to be filled more easily and quickly than the same size defects surrounding implants inserted after 3 months from the extraction **(Esposito M et al. 2010)** [9] Peri-implant gap should be filled by graft materials rather than titanium, could prevent bone resorption if its size is more than 1.5 to 2 mm. **(Chen ST et al. 2005)** [10] The inter-radicular septum represents an usual ideal position during immediate postextractive dental implant insertion procedures. The presence of **thick inter-radicular septum** is an important **prognostic factor** to evaluate before planning an immediate implant. Thick bone septum was detected, in the present study, in 92% of first lower molars examined and only in 70% of cases in second lower molars.

The measurements of alveolus bone dimensions appear fundamental to correctly plan a hypothetical postextractive implant. For this reason, the radiological evaluation of human molar alveoli bone dimensions could act as a preoperative guide able to integrate clinical and radiological data before planning immediate postextractive implants.

CONCLUSION

The present retrospective radiological study analyzed human mandibular molar alveoli by measuring the cone beam computed tomography (CBCT) scans. **The measurements made described the bone anatomy of lower molar alveoli before a hypothetical tooth extraction. The accurate knowledge of alveolus bone morphology in mandibular molars could be an important guide in planning immediate postextractive implant insertion to avoid potential failures due to non-ideal anatomical features to fixture stabilization. Careful CBCT analysis of each single case, however, is highly recommended before planning immediate postextractive implants in mandibular molar sites.**

Data from the present study demonstrated **that lower molar alveoli have typical anatomical features different from anterior or premolar teeth. These differences should be cautiously evaluated during the case planning toadjust the surgical approach to the alveolus anatomy and morphology. From a clinical point of view, the bone anatomy of lower molar sites does not allow an easy immediate postextractive implant insertion with sufficient primary stability, especially when the inter-root septum is thin or absent.**

Inadequate bone may result in implant failure. To prevent this, bone augmentation procedures are required. Currently, there is insufficient data regarding preoperative bone dimension analysis of mandibular posterior teeth. As CBCT is the preferred imaging modality for oral and maxillofacial structures, careful preoperative analysis of alveolar bone dimensions may determine the need for bone augmentation. Thus, it will significantly increase the success rate of immediate implant treatment in the mandibular posterior teeth.

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TABLES

Table1: Measured Parameters in Mandibular Molar Alveoli

	First Lower Molars		Second Lower Molars	
	Mean	**SD**	**Mean**	**SD**
No. examined alveoli	65	--	57	--
Average no. bone walls ineach alveolus	3.64	0.53	3.70	0.45
Mean available bone heightvalue (mm) from the mandibular canal	14.17	3.56	12.90	3.45
Mean height (mm) of inter- radicular septum (if present)	6.79	2.66	5.19	1.88
Mean bucco-lingual dimension (mm) of wholedental alveolus	8.81	0.67	8.80	0.60
Mean mesio-distal dimension(mm) of whole dental alveolus	8.93	0.84	8.98	0.87

FIGURES

Fig 1. a) Panorex Section; b) Axial Section; c) Paraxial Sections

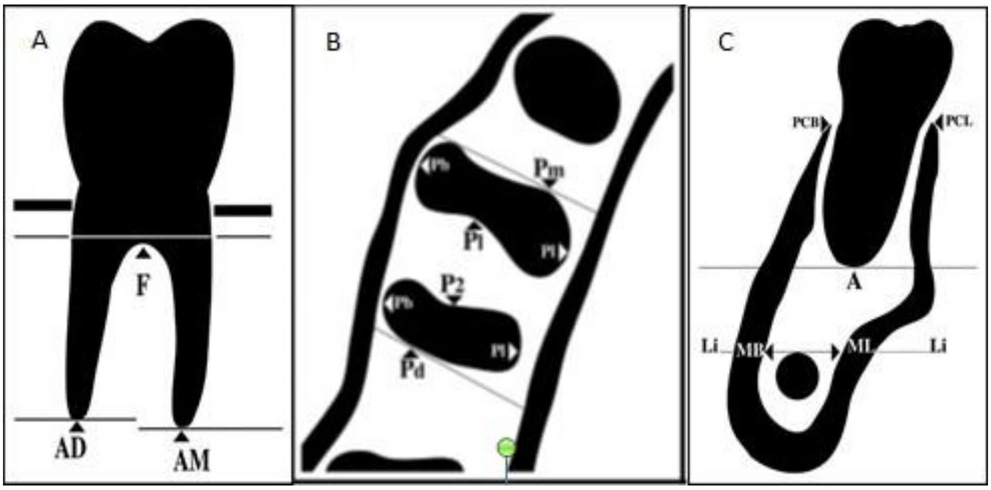

Fig 2. Mean available bone height in first molars & second molars