

Bone Density Assessment to Determine Ideal Site of Orthodontic Mini-implant Placement in Maxillary Anterior Region

A Retrospective CBCT Study

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Abstract

Introduction: Mini implants were introduced as a means of effecting absolute anchorage in enhancing non-compliance treatment modalities and have redefined the limits of non-surgical treatment protocol quite radically. Failure rates for mini-implants range from 10%-30%. Quality of the bone at site of implant placement is perhaps most important in determining primary stability and success of mini-implants.

Aim & Objectives: The present study aims at sourcing the ideal site for mini implant placement in maxillary anterior region based on bone density in labial cortical region between inter-radicular areas for adjacent teeth as measured in Hounsfield Unit (HU) on CBCT.

Methodology: The Sample size for the study was of 50 patients, age group 18-32 years, comprising of 25 males and 25 females. CBCT Images were taken with same machine following standard guidelines. Areas under study included labial cortical plate at each inter-radicular region between canine to canine in maxillary arch at 6 mm & 8 mm height from cemento-enamel junction (CEJ).

Results: Results obtained were statistically evaluated. Bone density at labial cortical plate between canine and lateral incisor was found to be 759.29HU and 779.36HU at 6mm and 8mm respectively. While bone density between lateral incisors and central incisor was found to be 851.35HU and 863.29HU at 6mm and 8mm respectively and bone density between central incisors it was observed to be 730.43HU and 744.03HU at 6mm and 8mm respectively

Conclusion: Bone density was found to be maximum at labial cortical plate between lateral incisor and central incisor. This was followed by labial cortical

plate between canine and lateral incisors while between central incisors it was observed to be the least.

Keyword: Bone Density, CBCT, Maxillary Anterior, Mini-implant, Retrospective.

Introduction

Anchorage is defined as 'resistance to unwanted tooth movement'¹. It is one of the important factors affecting treatment plan and treatment results. Absolute anchorage was a theoretical terminology till mini implant came in use. Mini screws originally used for bone fixation have been used widely as auxiliary anchorage devices for tooth movement without a great compliance requirement for orthodontic patients². Recently, mini implants have gained popularity among orthodontist due to its low cost, good stability, ease of placement and removal. Among the factors affecting mini-implant stability, alveolar bone thickness, bone density, placement angle, and location appear to be critical for success of mini implant.

Bone density appears to be a key determinant for the stability of mini-implants in sites with inadequate cortical bone thickness because primary retention of mini-implants is achieved by mechanical means rather than through Osseointegration³. Bone density influences amount of bone contacting implant surface, thus distributing functional forces along increased amount of bone.

In recent years, cone beam computed tomography (CBCT) has been widely used in dentistry and orthodontics. Cone-beam CT (CBCT), which offers clear 3-dimensional (3D) images with small voxel size, used in implant dentistry for accurate surgical guidance of implant placement and is a reliable tool to objectively determine site-specific bone density. The objective of present study was to determine bone

density of inter-radicular labial cortical plate present in maxillary anterior region.

Materials and Methods

The CBCT images of 50 adults (25 male, 25 females; average age, 25±8.5 years) were taken. Inclusion criterion were adults with no craniofacial deformity or systemic disease, Indians, having permanent dentition. Exclusion criterion were adults with missing anterior teeth, with tumors or cancerous lesion and blurred scans. All scans were taken using a CBCT apparatus at 90 kV and 0.09 mA. The CBCT images were formatted into standard DICOM images and reconstructed into continuous slices at 0.200-mm thickness each. Planmeca Romexis viewer 4.4.1 R software was used to perform CBCT analyses. The CBCT images of the maxilla were not distorted or magnified and were displayed simultaneously with their coronal, axial, and sagittal slices so that the maxillary anterior teeth regions could be accurately measured in 3 dimensions. To measure the bone density at labial cortical plate in inter radicular region of maxillary anteriors, the axial images were reoriented to the occlusal plane (Fig 1), and then sequential axial plane images of 6mm and 8mm from the cement enamel junction (CEJ) apical and parallel to the occlusal plane were constructed.

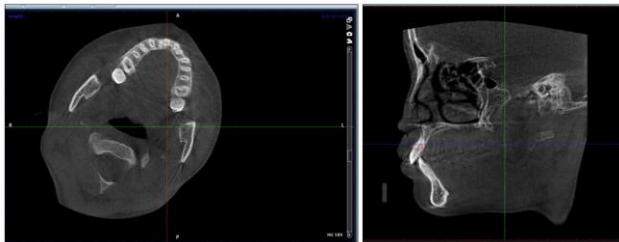


Figure 1: Orientation of axial images to occlusal plane

Misch and Kircos⁴ classified bone density into 5 types based on Hounsfield units (HU): D1, more than 1250 HU; D2, 1250 to 850 HU; D3, 850 to 350 HU; D4, 350 to 150 HU; and D5, less than 150HU. Of these D2 is considered ideal for implant placement. Bone density measurements were done in Hounsfield Unit (HU) on CBCT. Measurements were done at labial cortical plate between canine and lateral incisor; between lateral incisor and central incisor; between both central incisor on both right and left side at 6mm height from CEJ (Fig 2). Similarly, measurements were done at 8mm height from CEJ (Fig 3).

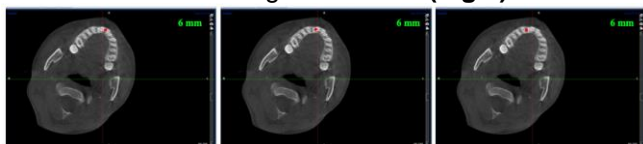


Figure 2: 6 mm from CEJ

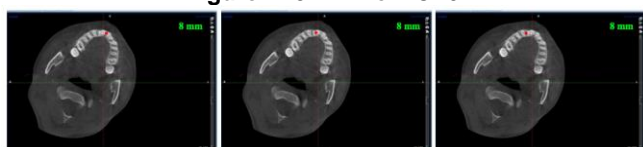


Figure 3: 8 mm from CEJ

This procedure was repeated for each individual. Measurements and analyses of the data were carried out randomly by 1 researcher (C.S.). Same date was measured twice at an interval of 2 weeks by the same person. When assessed with the intra class correlation coefficient, no statistical difference was found between repeated measurements; the results showed that the measurements were reliable (P <0.05).

Statistical Analysis

The data was analyzed using one-way ANOVA test applied to values obtained at 6mm from CEJ and at 8 mm from CEJ. The statistical significance was determined at p value <0.05. Analysis performed indicate that there are significant differences in bone density, as observed, between canine and lateral incisor, between lateral incisor and central incisor, between two central incisors at 6mm height from CEJ with p value 0.03 and also at 8mm height from CEJ with p value 0.034.

Results

The mean and standard deviation of bone density at labial cortical plate measured at different heights. There is significant difference between canine and lateral incisor, between lateral incisor and central incisor, between two central incisors at 6mm height from CEJ with p value 0.03 and also at 8 mm height from CEJ with p value 0.034.

Results suggest that at 6mm height from CEJ, the maximum bone density was observed between lateral incisor and central incisor (mean= 851.35HU) followed by between canine and lateral incisor (mean= 781.29HU) with minimum bone density observed between central incisors (mean= 730.43HU). At 8 mm height from CEJ, the maximum bone density was observed between lateral incisor and central incisor (mean= 863.29HU) followed by between canine and lateral incisor (mean= 807.86HU) with minimum bone density observed between central incisors (mean= 744.03HU). They have been tabulated (Table 1).

It was observed that there is no significant difference between bone densities measured values on right and left side of arch.

Sr. No.		Between canine and lateral incisor	Between lateral incisors and central incisor	Between central incisors	Between lateral incisor and central incisor	Between canine and lateral incisor
		Right			Left	
At 6 mm	Mean (HU)	806.96	900.7	730.43	896.6	800.63
	SD	191.04	197.99	168.353	186.018	156.049
At 8 mm	Mean (HU)	814.96	901.76	744.03	893.78	816.76
	SD	172.20	153.73	135.97	165.65	177.60

Table 1: Hounsfield Unit (HU) values

Sr. No.		Between canine and lateral incisor	Between lateral incisor and central incisor	Between central incisors
At 6mm	Mean (HU)	781.29	851.35	730.43
At 8mm	Mean (HU)	807.86	863.29	744.03
One-way ANOVA: P value <0.05; p= 0.03 at 6 mm				
One-way ANOVA: P value <0.05; p= 0.034 at 8 mm				

Table 2: Mean Hounsfield Unit (HU) values

Discussion

CBCT system was first made available for use in head and neck imaging in April 2001 (NewTom, Verona, Italy)⁵. CBCT has gained popularity as diagnostic imaging technique due to low radiation exposure, shorter scanning time and high definition⁶⁻⁸. With variety of recent software's available, bone density can now be measured with accuracy on CBCT.

Many factors could affect the success rates and effectiveness of mini-implants used for establishing skeletal orthodontic anchorage. Some of these factors are implant related (type, diameter, and length of the implant), patient related (sex, age, physical status, oral hygiene), surgical related (direction of mini-implant placement and placement torque), orthodontic related (magnitude and timing of force), site related (peri-implant bone quantity, cortical bone thickness, keratinized versus oral mucosa), and implant-maintenance related⁹. Of these, bone density is considered to be one of the important ones affecting success of mini implants. Factors other than bone can be modified by operator, bone quality and quantity are patient dependent. Adequate knowledge of bone density before starting with treatment will help us in reducing failures.

Most studies on mini implant studies have aimed to determine the safest sites for mini-screw placement by focusing on the posterior region of the jaws^{10, 11}. Study done by Fayed MM¹² suggests that in maxilla, the highest buccolingual thickness existed between first and second molars. The highest buccal cortical thickness was between the first and second premolars. The highest palatal cortical thickness was between central and lateral incisors. There are very few studies done anterior region for mini implant placement. However, the fact that mini-implants are often useful in the anterior region for space closure or correction of overbite problems necessitated the evaluation of the anterior region as well. In recent times, many case reports show use of mini implants in anterior region for intrusion and retraction purpose. The present study was designed to determine ideal site for mini implant placement in maxillary anterior region depending on bone density.

Conclusion

Results of the study suggests that minimum bone density was observed between central incisors (**Table 2**). This is probably due to presence of incisive canal

between central incisors¹⁴. Radiolucency of incisive canal reducing bone density. Maximum bone density was observed at inter-radicular bone between lateral incisor and central incisor. Based on bone density optimal site for mini implant placement in maxillary anterior region is inter-radicular space between central incisor and lateral incisor. Based on bone density least favorable site for mini implant placement in maxillary anterior region is inter-radicular space between central incisors.

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