# MINI IMPLANTS -EFFECTIVE PLACEMENT & ANCHORING STRATEGIES

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**ABSTRACT:**

**Objectives:** The aim of this study is to provide a guide for the effective placement of mini- implants (TADs) in all three dimensions.

**Methods:** 3-D CT images were reconstructed for 20 patients. Cortical bone thicknesses were measured in the buccal and lingual regions mesial and distal to all the teeth right from incisor to last molar at 3 different levels.. Differences in cortical bone thickness at 4 angles (30°, 45°, 60 & 90°) were also assessed.

**KEY WORDS:** Anchorage, Mini-implants (TADs), Interradicular spaces, cortical bone thickness

## INTRODUCTION

Anchorage control is one of the most important aspects of orthodontic treatment. The importance of anchorage can best be described by the famous quote from the Greek philosopher Archimedes, "*Give me a place to stand and rest my lever on, and I can move the Earth*."

Anchorage preparation plays a key role in orthodontic treatment. The success of orthodontic treatment relies on the anchorage protocol planned for that particular case. Clinicians and researchers have tried to use implants as orthodontic anchorage units for over a half century[1-4]. Use of implants as a source of anchorage has a number of advantages, as compared to traditional anchorage such as no patient cooperation, ease of use, shortening of treatment time, good control on tooth movements.

Only a few studies have evaluated the quantity of bone for implant placement for orthodontic anchorage[12-14]. Schnelle[12] et al evaluated interradicular bone between the roots using panoramic radiographs. However, the thickness of the cortical bone could not be measured on panoramic or periapical radiographs. Although Gahleitner[13] et al evaluated bone volume using dental computed tomography (CT), they focused only on the hard palate for palatal implants. In a recent study, the depths of the hard and soft tissues of the oral cavity were measured by using volumetric CT[14]. However, the locations measured were different from the locations used for micro-screws (TADs) in clinics, and the

measurements were mainly performed bicortically instead of monocortically.

Hence, this study was done to quantitatively analyze the difference in cortical bone thickness in the maxilla and the mandible using three-dimensional (3D) CT and also to determine optimal locations and angulations for micro-implants (TADs), used as anchorage in orthodontic treatment.

## METHODOLOGY

In the present study, quantitative evaluation of cortical bone thickness in various locations in the maxilla and the mandible, the distances from inter cortical bone surface to root surface, and the distances between the roots of teeth , differences in cortical bone thickness at 4 angles (30°, 45°, 60 and 90°) was assessed using CT.

**SUBJECTS**:

The sample consisted of CT (Aquilion multi, 4DAS, Toshiba, Tokyo, Japan) images from 20 subjects who were volunteers from Sri Sai College Of Dental Surgery in Hyderabad, India. The average age of the subjects was 20-28 years with Skeletal Class I malocclusions and average mandibular plane angles. They all consented to participate in the study.

**Inclusion Criteria**: The subjects included were healthy individuals without any prior orthodontic treatment.

**Exclusion criteria**: Those who had congenital disorders, such as cleft lip and palate or general physical diseases were excluded from the sample.

**METHOD**:

The CT images were taken at 200-mm field of view, 120kV, 300 m, scanning time of 0.5 second/rotation, and slice thickness of 0.5 mm with a high-resolution mode.

To measure the thickness of cortical bone, the maxilla and the mandible were divided by the occlusal plane. Sagittal images were constructed mesial and distal to the incisors till the first molars, and distal to the second molars sectioning a line parallel to the long axis of the adjacent teeth. (Fig 1)

Figure 1

Differences in cortical bone thickness were measured in maxilla (Fig 2):

a) within 3 to 4mm (occlusal level) of the gingival margin (alveolar crest)

b) 6 to 7 mm of the gingival margin (apex level) and

c) 9-10 mm from gingival margin (apex level)

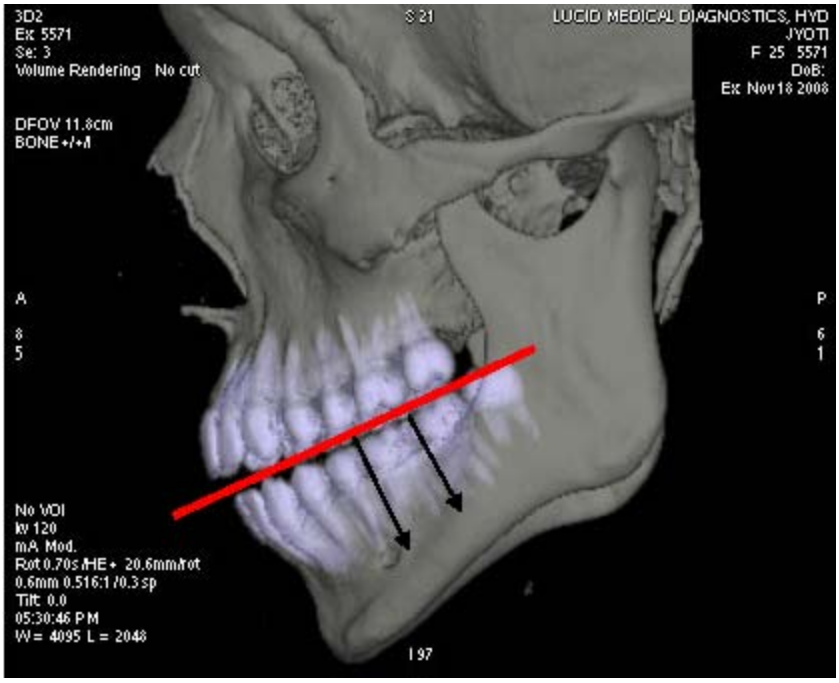



Figure:2

Differences in cortical bone thickness were measured in the mandible (Fig3):

a) Within 3 to 4mm (occlusal level) of the gingival margin (alveolar crest)

b) 6 to 7 mm of the gingival margin (apex level)

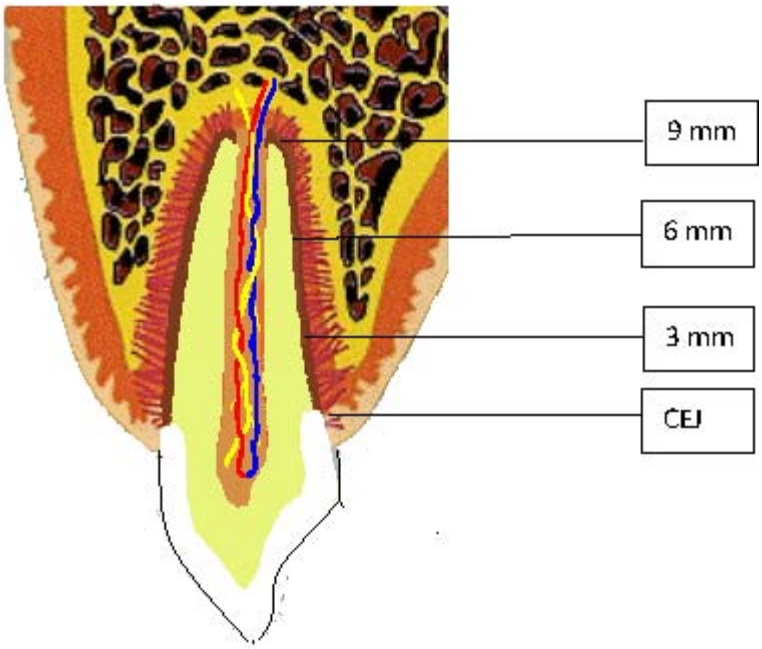
**Figure: 3**

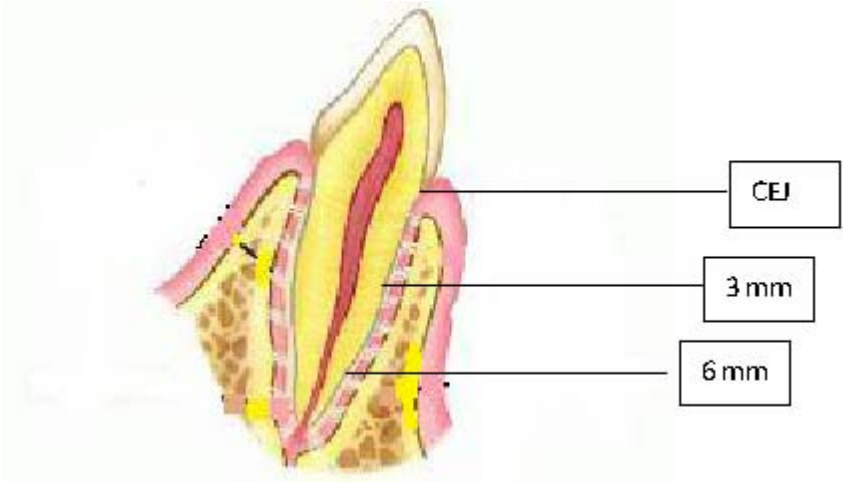
On the other hand, differences in cortical bone thickness between implant angulation were measured by 4 angulations (30°, 45°,60 and 90°) from the long axis of the maxillary and mandibular molars(fig 4). The total distance from inter-cortical bone surface to root surface was measured at these angles. Both cortical bone thickness and length from the root surface to the cortical bone should be measured to determine the acceptable length of the micro-implant (TAD).

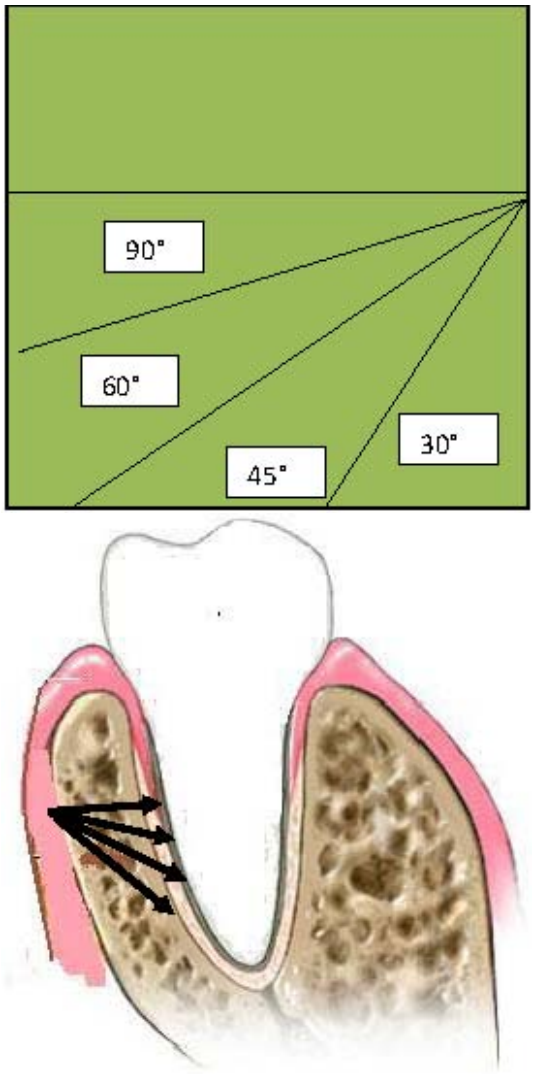
Figure 4

**c) Statistical Methods:**

Amount of bone available was determined for the maxilla and the mandible and expressed as mean and standard deviation.






## RESULTS

In the present study, the bone available for placement of mini-implants (TADs) was evaluated in different areas of the maxilla and the mandible. The sample had twenty subjects.

**Maxilla:**

In the maxilla at the level of 3mm from the CEJ, there was no significant amount of bone found among the different locations. On an average the available interradicular bone was 2mm and a standard deviation of 0.8mm was found (Table1, Graph 1).

At the level of 6mm from the CEJ, the amount of bone found between the first molar and second premolar is 2.5 with a standard deviation 0.79 first and second premolars is 2.5 with a standard deviation 0.71 lateral incisor and canine is 2.82 with a standard deviation 1.2 between two centrals is 2.7 with a standard deviation 1.1 (Table1, Graph 1).

At the level of 9mm from the CEJ, the amount of bone found between the first molar and second

premolar is 3.4with a standard deviation 0.89 first and second premolars is 3.09 with a standard deviation 0.99 lateral incisor and canine is 2.82 with a standard deviation 0.9 between two centrals is 4.6 with a standard deviation 1.7 (Table1, Graph 1).

In the maxilla, the greatest amount of mesiodistal bone was on the palatal side between the first molar and the second premolar which is 6.2mm; the least amount of bone was at the tuberosity 0.2 mm SD 1.2. Less mesiodistal space is available on the buccal side than on the palatal side. This indicates that more sites for a safe screw insertion are available on the palatal side than on the buccal side (Table 1, Graph 1). In 70% of the measured maxillae, the sinus or impacted wisdom teeth were present in the tuberosity, thus explaining the limited amount of bone found in this area.

In the maxilla at 9mm depth, both the buccopalatal and the mesiodistal values are low because of the frequent presence of the maxillary sinus. Once again, this result has a fundamental clinical application, showing that areas between the maxillary posterior teeth more than eight mm apical to the alveolar crest are off limits for any kind of implantation.

In the buccal region of the maxilla, average cortical thicknesses were 2.3mm, 3.8mm, 6.3mm at 60°, 45°, and 30°, respectively (Table 3,Graph 3). Significantly more cortical thickness was observed at 30° than at 45° ($P \leq .0001$) and 90° ($P \leq .0001$).There was also a significant difference between the measurements at 45° and 60° ($P \leq .01$)

**Mandible:**

In the mandible at the level of 3mm from the CEJ, the amount of bone found between the first molar and second premolar is 2.3650 with a standard deviation 0.72 first and second premolars is 2.6 with a standard deviation 0.42 ,lateral incisor and canine is 2.1with a standard deviation 1.3(Table-2,graph 2)

At the level of 6mm from the CEJ, the amount of bone found between the first and second molars 2.662 with a standard deviation 1.6 first molar and second premolar is 2.950 with a standard deviation 0.8 first and second premolars is 2.5 with a standard deviation 1.12 lateral incisor and canine is 2.4 with a standard deviation 1.4 central and lateral incisors is2.38with a standard deviation 1.3 (Table-2, Graph 2)

In the mandible, average cortical thicknesses were 3.2 ±0.8 mm, 4.8 ± 0.6 mm, and 7.345 ± 0.5 mm at 60°, 45°, and 30°, respectively (Table 4,Graph 4). Significantly greater cortical thickness was observed at 30° than at 45° ($P \leq .0001$) and 90° ($P \leq .0001$). There was also a significant difference between the measurements at 45° and 60° ($P \leq 001$).

Another significant finding is the availability of bone within the roots of molars. On an average, there is 1.75, 1.74 and1.611 available within the roots of first, second& third molars respectively. Maximum bone available is 3, 2.8, 3 between the roots of the first, second& third molars respectively (Graph 5).

**DISCUSSION**

This study analyzes the interradicular spaces in the maxillary and mandibular arches, anterior and posterior region for safe miniscrew insertion with the help of CT data. The potential of high resolution computed tomography (CT) as a quantitative tool for obtaining linear and area measurements of skeletal tissue has been investigated.

It is generally thought that CT images tend to provide inaccurate measurements because structures are blurred at boundaries, and it may be difficult to decide where to place a measurement point, this was due to the slice thickness which was used. However, Tsunori et al[17] and Spoor et al[18] measured bone thickness using CT and concluded that the CT images could be used as a means to measure linear and area measurements. In the present study we are using 64 slice CT with a slice thickness of 0.5 mm, so accurate measurements can be made.

Minimal data is available on how much bone is necessary between the miniscrews (TADs) and the dental roots for both periodontal health and miniscrew stability and almost no study has been done on the Indian population.

The CT images at the level of the 3 ,6 ,9 mm apical to the alveolar crest were selected for the measurements, because the apical portion of the micro-implant will be positioned within this level clinically[20]

Bone thickness in 3 different locations by the distances from the CEJ at the occlusal and apical levels was analyzed. There was significant difference in the availability of bone measured at these sites (2.1,2.4 and 3,1mm respectively at 3,6,9 mm from CEJ in the maxilla). This is not in accord with another study of CT done by Deguchi etal[21], in which it was concluded that there is no significant difference between the cortical bone thickness in different locations they have studied, but the bone thickness is almost similar in the mandible at different levels.

The insertion of TADs in the maxillary molar region above 7-8 mm from the alveolar crest has to be avoided with any type of screw because of the presence of the sinus. Some of the clinical reports present in the literature seem to overlook this anatomical observation (Paolo Maria)[78]. Another area that is generally not suitable for screw implantation is the tuberosity, where the amount of bone is very limited by the presence of wisdom teeth.

There was also a significant difference between the maxillary and mandibular cortical bone thickness at the apical level in between the roots of incisors .The availability of bone was greater between the maxillary central incisors at the level of 6mm as compared to 3mm level (2.74mm at the level of 6mm compared to none available at 3mm level). The amount of bone available here(2.74mm) can be compared to that available between the maxillary lateral & canine (2.8mm).In one subject the maximum amount of bone available in this region is 4mm, which is really a significant finding.

In the maxilla, at the level of 9mm, the amount of bone available is maximum ie; 4.06mm which is more than the bone available at all the corresponding sites at that level. These findings point out the fact that TADs can be successfully placed in these areas mainly for the purpose of intrusion of incisors & also in Class II, Div 2 cases for correction of the retroclination as well as the deep bite. This particular finding has not been evaluated, to our knowledge, in any other study.

If the screw is inserted perpendicular to the dental axis, it might reach the narrowest interradicular space earlier than when inserted at an oblique angle and, according to findings of Paolo Mario Poggio et al[25], it should be embedded for no more than 6–8 mm of bone depth.

It is speculated that there might be an increase of cortical bone contact by changing the angulation of the TAD. In this study, there was a significant difference in the thickness of cortical bone

at 3 angulations. The smaller the angle, the more cortical bone is in contact with the TADs, in both jaws. Compared with placing implants perpendicular to the long axis of the teeth, angling the implant at approximately 30° would increase the contact by as much as 1.5 times more cortical bone. Thus, an angle of approximately 30° to the long axis of the tooth is recommended to increase the stability of these miniscrews.

In the mandible, the safest sites are between the first and second molars and between the first and second premolars, at all depths investigated. Between the first and second molars, and because of the shape of the first molar's mesial root, there is a safe zone for the insertion of 1.2- to 1.5-mm diameter screws only at 6mm depth. Between the first premolar and canine, because of the root proximity, the values are suitable for the safest TAD insertion over 6 mm from the alveolar crest. Because of the limited amount of interradicular space, miniscrew stability under mechanical loading such as an orthodontic force is an important clinical issue .Also, in this study, it was found that safe areas of insertion of miniscrews is found even in between the roots of first and second mandibular molars, which is a significant finding and this reading was not observed in any of the previous studies.

Many factors could play a key role in implant stability, such as the type and direction of the applied force, the loading period, bone quality, and the quantity of bone at the insertion site. These questions should be open for future research.

## SUMMARY AND CONCLUSION

By measuring CT images from 20 subjects, anatomical data was obtained and this data can be used a guide to determine the location for implantation of mini-implants.

The safe sites available in the interradicular spaces of the posterior maxilla are as follows:

- On the palatal side, the interradicular space between the maxillary first molar and second

premolar, from 3-9mm from the CEJ

• On the palatal side, the interradicular space between the maxillary second and first molars, from 3-6 mm from the CEJ

• Both on buccal or palatal side between the second and first premolar, between 6 and 9 mm from the CEJ

• Both on buccal or palatal side between the first premolar and canine, between 6 and 9 mm from the CEJ

• On the buccal side, in the interradicular space between the first molar and second premolar, from 6 to 9 mm from the CEJ

• On the buccal side, in the interradicular space between the first premolar and canine, from 6 to 9 mm from the CEJ.

• On the buccal side, in the interradicular space between the lateral and canine, from 3 to 9 mm from the CEJ

• Interradicular spaces between central incisors beyond 6mm from the CEJ

• In the maxilla, the more anterior and the more apical, the safer the location becomes.

The following are the safe sites available in the interradicular spaces of the posterior mandible:

• Interradicular spaces between the second and first molar beyond 6 mm from CEJ. In between the roots of first molar and second pre molar beyond 3 and 6 mm from CEJ Interradicular spaces between the second and first premolar beyond 6mm from CEJ Interradicular spaces between the first premolar and canine 3 to 9 mm from the CEJ Interradicular spaces between central & lateral incisors beyond 3 mm from CEJ

• Between the centrals only beyond 6mm.

• In the mandible, the more apical, the safer the location becomes.

These findings are statistical evaluations of data coming from a group of untreated patients. They represent a guide for clinicians but does not eliminate the need for a radiographic evaluation in each individual case before miniscrew insertion.

| Teeth | N | Maxilla 3MM Mean | Maxilla 3MM Std. Deviation | Maxilla 6MM Mean | Maxilla 6MM Std. Deviation | Maxilla 9MM Mean | Maxilla 9MM Std. Deviation |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1st&2ndmolars | 20 | 2.0400 | .94167 | 2.1900 | .94529 | 3.0600 | 1.28816 |
| 1st M & 2nd PM | 20 | 2.2650 | .89105 | 2.5050 | .79503 | 3.4250 | .82963 |
| 1st & 2nd PM | | 2.40 | .86297 | 2. | .71486 | 3. | .99814 |
| 1st PM & Canine | 20 | 2.1900 | .85649 | 2.3350 | .58963 | 2.9500 | 1.07825 |
| Canine& LI | 20 | 2.4900 | .88906 | 2.8250 | .90372 | 2.8250 | 1.34981 |
| LI & CI | 20 | 2.2525 | .70347 | 2.1500 | .77765 | 2.3200 | 1.50179 |
| CI&CI | 20 | 2.2222 | .60345 | 2.7400 | 1.13897 | 4.0600 | 1.34493 |
| Total | 140 | 2.2779 | .83615 | 2.4643 | .86898 | 3.1050 | 1.29239 |

**Table 1: MAXILLA –Availability of cortical bone**

**Table 2: Mandible –Availability of cortical bone**

| 20 Teeth | 55N | Mandible 3mm Mean | Mandible 3mm 5050Std. Deviation | Mandible 6mm Mean | Mandible 6mm 0950Std. Deviation |
|---|---|---|---|---|---|
| 1st&2ndmolars | 20 | 2.1600 | 1.06692 | 2.6211 | 1.64269 |
| 1st M & 2nd PM | 20 | 2.3650 | .72058 | 2.9500 | .88109 |
| 1st & 2nd PM | 20 | 2.6000 | .42550 | 2.5950 | 1.09615 |
| 1st PM & | 20 | 2.6300 | .72917 | 2.6450 | 1.22064 |

| | | | | | |
|---|---|---|---|---|---|
| Canine | | | | | |
| Canine& LI | 20 | 2.1100 | 1.03461 | 2.4750 | 1.42011 |
| LI & CI | 20 | 2.1250 | 1.12384 | 2.3850 | 1.31280 |
| CI&CI | 20 | 1.6750 | .28996 | 1.6350 | .36168 |
| Total | 140 | 2.2379 | .86511 | 2.4712 | 1.22789 |

**Table3 : MAXILLA –Availability of cortical bone when implant is angulated**

| Angulation | N | Mean | Maximum | Minimum | Standard Deviation |
|---|---|---|---|---|---|
| 60 | 20 | 2.3 | 3.3 | 1.5 | 0.8 |
| 45 | 20 | 3.825 | 5 | 2.4 | 0.6 |
| 30 | 20 | 6.32 | 8.2 | 4.2 | 0.5 |

**Table 4: MANDIBLE- Availability of cortical bone when implant is angulated**

| Angulation | N | Mean | Maximum | Minimum | Standard deviation |
|---|---|---|---|---|---|
| 60 | 20 | 3.2 | 4.1 | 1.8 | 0.7 |
| 45 | 20 | 4.8 | 6.1 | 2.6 | 0.6 |
| 30 | 20 | 7.345 | 9.3 | 4.7 | 0.4 |

**Graph5 : Interradicular distance between the roots of mandibular molars**

Amount

of

bone

available

in mm

Teeth : 1-1st molar;2- 2nd molar:3-3rd molar

## BIBLIOGRAPHY

1. Roberts WE, Nelsen CL, Goodacre CJ. Rigid implant anchorage to close a mandibular first molar extraction site. J Clin Orthod 1994; 38: 693-704.

2. Umemori M, Sugawara J, Mitani H, Nagasaka H, Kawamura H. Skeletal anchorage system for open-bite correction. Am J Orthod Dentofacial Orthop 1999; 115 :166-74.

3. Kuroda S, Katayama A, Takano-Yamamoto T. Severe anterior open-bite case treated using titanium screw anchorage. Angle Orthod 2004;74 :558-67.

4. Park HS, Kwon DG, Sung JH. Nonextraction treatment with microscrew implant. Angle Orthod 2004;74:539-49

5. Kanomi R. Mini-implant for orthodontic anchorage. J Clin Orthod 1997;31:763-7.

6. Antonio Costa, Giulio Pasta, and Giovanni Bergamaschi. Intraoral Hard and Soft Tissue Depths for Temporary Anchorage Devices. Semin Orthod:2005 11:10-15

7. Kyung HM, Park HS, Bae SM, et al: Development of orthodontic microimplants of intraoral anchorage. J Clin Orthod 37:321-328, 2003

8. Albrektsson T, Branemark PI, Hansson HA, Lindstrom J. Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. Acta Orthop Scand 1981;52:155-70.

9. Roberts WE, Smith RK, Zilberman Y, Mozsary PG, Smith RS.Osseous adaptation to continuous loading of rigid endosseous implants. Am J Orthod 1984;86:95-111.

10. Adell R, Lekholm U, Rockler B, Branemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387-416.

11. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T,Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop 2003; 124 :373-8.

12. Schnelle MA, Beck FM, Jaynes RM, Huja SS. A radiographic evaluation of the availability of bone for placement of miniscrews. Angle Orthod 2004; 74: 832-7.

13. Gahleitner A, Podesser B, Schick S, Watzek G, Imhof H. Dental CT and orthodontic implants: imaging technique and assessment of available bone volume in the hard palate. Eur J Radiol 2004;51: 257-62.

14. Costa A, Pasta G, Bergamaschi G. Intraoral hard and soft tissue depths for temporary anchorage devices. Semin Orthod 2005;11 :10-5.

15. Gainsforth BL, Higley LB. A study of orthodontic anchorage possibilities in basal bone. Am J Orthod Oral Surg 1945; 31:406-17.

16. Linkow LI. The endosseous blade implant and its use in orthodontics. Int J Orthod 1969; 18:149-54.

17. Tsunori M,Mashita M,and Kasai K.Relationship between facial types and tooth and bone characterestics of mandible obtained by CT scanning.Angle O rthod 1998:68(6):557-62

18. Spoor CF,Zonneveld W,and Macho GA.Linear measurements of cortical bone and dental

enamel by computed tomography:applications and problems,Am J Phys Anthropol 1993:91:469-84.

19. Costa A, Raffainl M, Melsen B. Miniscrews as orthodontic anchorage: a preliminary report. Int J Adult Orthod Orthognath Surg 1998;13:201-9

20. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T,Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop 2003;124

21. Toru Deguchi, Miho Nasu, Kaoru Murakami, Toshinori Yabuuchi, Hiroshi Kamioka, and Teruko Takano-Yamamotoc: Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants: Am J Orthod Dentofacial Orthop 2006;129:721.e7-721.e12

22. Hobos S, Ichida E, Garcia LT. Osseointegration and occlusal rehabilitation. London: Quintessence; 1989. p. 33-54.

23. Lindhe Jan. Textbook of Clinical Periodontology. Copenhagen, Denmark: Munksgaard; 1984:28.

24. Park HS. An anatomical study using CT images for the implantation of micro-implants. Korean J Orthod. 2002; 32:435–441.

25. Paola Maria Poggio;Cristina Incorvati; Stefano Velo; Aldo Carano “Safe Zones”: A Guide for Miniscrew Positioning in the Maxillary and Mandibular Arch The Angle Orthod: Vol. 76, No. 2, pp. 191–197.