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# Analysis of Buccal Cortical Plate Thickness for Placement of Mini-Implants – A CBCT Study

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**ABSTRACT**

*The purpose of this study was to quantitatively evaluate buccal cortical bone thickness in the maxilla and mandible so as to provide guidelines for mini-implant placement. Cone beam computed tomographic scans of thirty patients (Age 16-30 years) were collected from pre-orthodontic records. Each measurement area was coded with a number beginning in the maxillary right quadrant distal to the second molar with number 1 and ending in the mandibular right quadrant distal to the second molar with number 30. For analysis these measurement areas were also grouped as sextants. Three measurement points were then defined at 2 mm, 4 mm and 6 mm from the alveolar crest in each measurement. The measuring locations were recorded on the four quadrants, resulting in 90 locations in the buccal cortical plate of maxillary and mandibular arch. The region of interest was explored at each measuring location of the 30 sites using Galileos software. The optimal site for mini-implant placement in the anterior region is between the central and lateral incisors in the maxilla and between the lateral incisor and the canine in the mandible at the 6-mm level from the alveolar crest. At the buccal aspect of the posterior region of both jaws, the optimal sites are between between the first and second molars i.e. in the Maxillary arch at 4 mm level on the right side and left side and in the Mandibular arch at 6 mm level on the right side and left side.*

**Keywords:** Mini-implants, Buccal cortical plate , CBCT , Ideal site

## INTRODUCTION

Anchorage defined as resistance to unwanted tooth movement, is a pre-requisite for the orthodontic treatment of dental and skeletal malocclusion.

Controlling anchorage helps to avoid undesirable tooth movements. However even a small reactive force can cause undesirable tooth movements; so it is important to have absolute anchorage to avoid them. Absolute anchorage is defined as no movement of the anchorage unit as a consequence of the reactionary forces applied to the teeth [1].

For absolute anchorage, the use of orthodontic mini-implants (OMIs) as temporary anchorage devices has become increasingly common [2].

The important factors that should be considered when choosing mini-implant placement sites are soft-tissue anatomy, inter-radicular distance, sinus morphology, nerve location, buccolingual bone depth, and buccal and lingual cortical thickness [3].

Primary stability of skeletal anchorage is dependent on the quantity and quality of bone in the insertion site. Placing the implants in favourable bone thickness ensures better primary stability and long term success. The most used and easily accessible placement sites are the buccal aspect of the alveolar process in the maxilla and mandible as well as the palatal side of the maxillary alveolar process in the premolar and molar region. The thickness of human cortical bone in these areas has been assessed by conventional computed tomography (CT) and cone-beam computed tomography (CBCT) [4]

A detailed description of the alveolar process might provide the clinician with fundamental knowledge, increasing the success of orthodontic treatment with mini-implant anchorage. Knowledge of the buccal cortical plate thickness in various areas can guide clinicians in selecting the placement site and proper placement protocol [3]

Cone Beam Computed Tomography and its associated software provide the most effective radiographic modality in the diagnostic evaluation of the patients for mini-implant placement in orthodontics and permits the immediate formulation of a treatment plan [3]

Therefore, this study is conducted to evaluate buccal cortical bone thickness using Cone Beam Computed Tomography at every interdental site in both jaws to provide a guideline for implant site selection and placement.

## AIM OF THE STUDY

To identify the Buccal cortical plate thickness in the inter-radicular area in the maxillary and mandibular arches by using cone beam computed tomographic scans.

To identify the ideal site for placement of mini-implants in the maxillary and mandibular buccal cortical plate.

## MATERIALS AND METHODOLOGY

Thirty patients (19 females and 11 males) who were in the age group of 16-30 years volunteered to participate in this study and gave their informed consent. The subjects were selected from out patients at the Department of Orthodontics and Dentofacial Orthopaedics, D.A.P.M.R.V. Dental College and Hospital, Bangalore, with their informed consent.

There should be no more than 2 missing teeth per arch excluding third molars
Patients with supernumerary teeth, cleft palate, or previous orthodontic treatment were excluded from the study.

The Methodology was divided into three main steps;

1. CBCT scan for the maxillary and mandibular arch
2. Identification of the reference points
3. Measuring the cortical bone thickness.

**Cortical bone thickness**: *Buccally and lingually/ palatally, the distance between the internal and external aspects of the cortex in the middle of the interradicular distance between each two adjacent teeth was measured.*

Cone beam computed tomographic scans of thirty patients (Age 16-30 years) were collected from pre-orthodontic records. Each measurement area was coded with a number beginning in the maxillary right quadrant distal to the second molar with number 1 and ending in the mandibular right quadrant distal to the second molar with number 30. Three measurement points were then defined at 2 mm, 4 mm and 6 mm from the alveolar crest in each measurement. The measuring locations were recorded on the four quadrants, resulting in 90 locations in the buccal cortical plate of maxillary and mandibular arch. The measuring locations were described by the intersections of planes and distances.

CBCT Machine: Sirona - Orthopos XG 3D model was used to take maxillary CBCT with FOV of 8×8 cm; images were reconstructed into Axial, Coronal & Sagittal planes with Galileos software of the maxillary and mandibular arches. The region of interest were explored at each measuring location extending 2mm, 4mm and 6 mm from the alveolar crest of each of the 30 sites using Galileos software. The bone depth at the measuring locations of the buccal cortical plate was mapped for their ability to host an implant. Statistical analysis was done to describe the bone depth available in the region of interest at each measuring location.

For analysis these measurement areas were also grouped as sextants (Fig 2). Three sextants each in maxillary and mandibular arches were defined:

Maxillary right (Max R),

Maxillary middle (Max M),

Maxillary left (Max L),

Mandibular right (Mand R),

Mandibular middle (Mand M),

Mandibular left (Mand L).

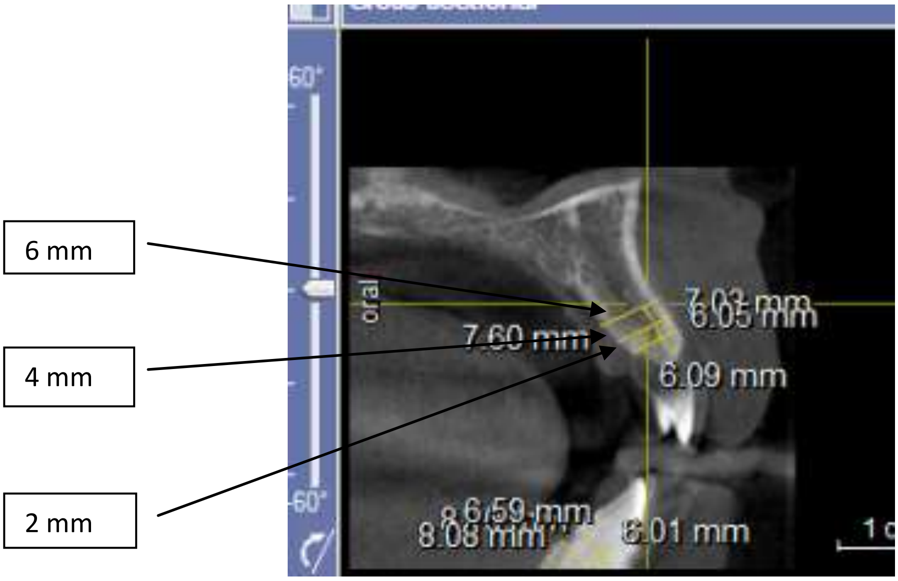


Figure 1 – CBCT Image showing measuring locations

**The mean bone depths in all the six sextants are compared with each other.**

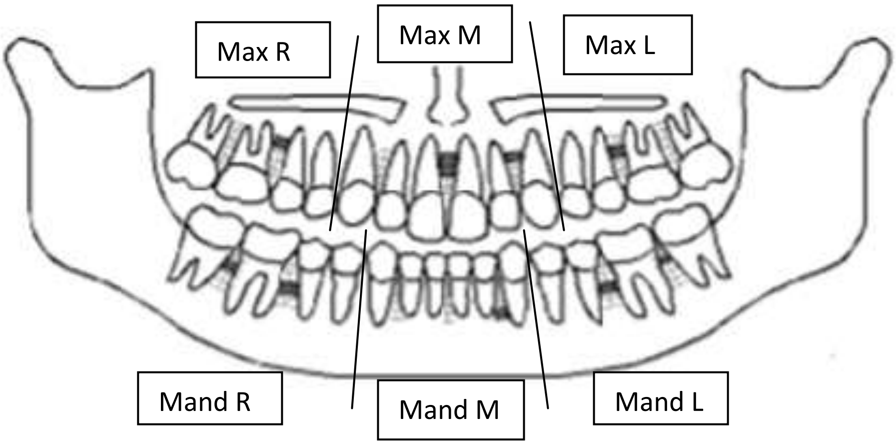


Fig. 2 – Representation of the sextants in the Maxillary and Mandibular arch

Fig 3 - Cone beam computed tomography scan of Maxilla

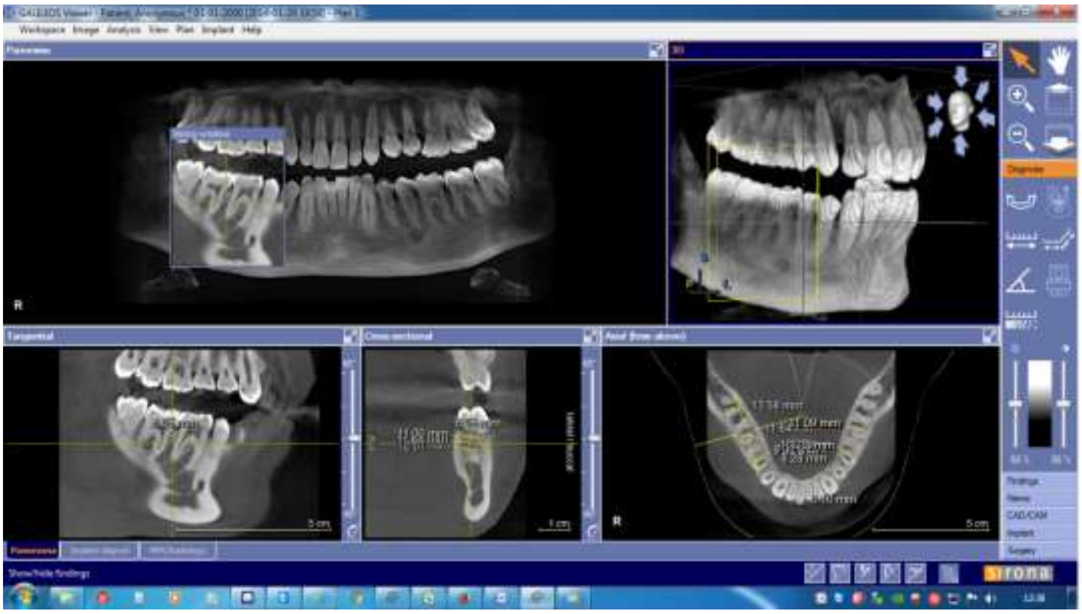

Fig 4- Cone beam computed tomography scan of Mandible

## STATISTICAL METHODS

Analysis of Variance (ANOVA test) and Tukeys' Post Hoc Analysis has been used to test for the differences in the cortical thickness and pair-wise comparisons.

**Statistical Interpretation (P-value):**

***Highly significant (≤ 0.001)

** Significant (≤ 0.05)

* Not significant (> 0.05)

The Statistical software namely SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate the tables etc.

**RESULTS**

The association of gender with the mean buccal cortical thickness at each of the locations showed no statistically significant values.

Statistical analysis showed that on average the buccal cortical bone was thicker in the mandible than in the maxilla.

The buccal sextants of both the jaws maxilla left [MaxL], maxilla right [MaxR] , mandible left [MandL], mandible right[MandR] had greater cortical bone thickness than the anterior sextants ,i.e. .maxilla middle [MaxM] and mandible middle [MandM] (Table 2).

When the means of the measurement levels ( 2 , 4 and 6 mm ) were compared in each sextant ,the differences were not significant in the entire maxilla [MaxL , MaxR , MaxM] and mandibular right and middle quadrant[MandR , MandM] but was significant in the mandibular left sextant [MandL] (Table 2).

In the maxillary anterior sextant [MaxM], the buccal cortical plate thickness increased with increasing distance from the alveolar crest being thinnest at 2 mm level and thickest at 6 mm level. Whereas in the maxillary right and left sextants ,i.e. in MaxR and MaxL , the cortical bone was thinnest at 2 mm level and thickest at 4 mm level.

The mandibular anterior sextant [MandM] was similar to its maxillary counterpart cortical thickness increasing away from the alveolar crest. In the mandibular buccal sextant [MandR and MandL] the same trend was observed.

Cortical bone thickness increased in both jaws with the increasing distance from the midsagittal plane except distal to the maxillary right second molars where it decreased (Table 4).

In the posterior maxillary right buccal sextant [MaxR] the maximum buccolingual thickness was found at the 4-mm level between the first and second molars (Q1S2D4) 13.23 mm (Table 4).

In the anterior maxillary sextant [MaxM] the maximum buccolingual thickness was found between the right central and lateral incisor at the 6mm level (Q1S7D6) 7.51 mm followed by between left central and lateral incisor at 6 mm level (Q2S9D6) 7.45 mm.

In the posterior maxillary left buccal sextant [MaxL] the maximum buccolingual thickness was found at the 4-mm level between the first and second molars (Q2S14D4) 13.20 mm.

In the posterior mandibular right buccal sextant[MandR] the maximum buccolingual thickness was found at the 4-mm level between the distal to second molars (Q4S30D4) 15.12 mm. Mesial to second molar the maximum buccolingual thickness was found between 1$^{st}$ and 2$^{nd}$ molar at 6 mm level (Q1S29D6) 12.83 mm.

In the posterior mandibular left buccal sextant [MandL] the maximum buccolingual thickness was found at the 2-mm level distal to second molars (Q3S16D2) 15.14 mm.

Mesial to second molar(Q3S17D6) the maximum buccolingual thickness was found between 1$^{st}$ and 2$^{nd}$ molar at 6 mm level 12.93 mm

In the mandibular anterior [MandM] sextant the maximum buccolingual thickness was found between left central and lateral incisor at the 4-mm level (Q3S23D4) 7.48 mm followed by between right central and lateral incisor at 6 mm level (Q4S25D6) 7.42 mm.

Thus the ideal sites for placement of mini-implants according to our study can be:

In the Maxillary arch –

Q1S2D4, Q1S7D6

Q2S9D6, Q2S14D4

In the Mandibular arch –

Q3S16D2, Q3S17D6, Q3S23D4

Q4S25D6, Q4S30D4, Q4S29D6

The sites not suitable for placement of mini-implants (*thinnest cortical plate thickness*) according to our study can be:

In the Maxillary arch –

Q1S6D2, Q1S10D2

MxS8D2

In the Mandibular arch –

Q3S22D2, Q4S24D4

MdS23D2.

**DISCUSSION**

Anchorage control is very critical aspect of orthodontic treatment. There are cases when absolute or maximum anchorage, i.e., a high resistance to displacement is needed.

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), surgical related (direction of mini-implant placement and placement torque), orthodontic related (magnitude and timing of force), location related (peri-implant bone quantity, cortical bone thickness, keratinized versus oral mucosa), and implant-maintenance related. The exact role of these factors, however, is not fully understood.

Cortical bone density and thickness vary at different sites within and between the maxilla and mandible. This difference could be due to varying muscle strains throughout these bones.

Most studies on this topic have aimed to determine the safest sites for mini-screw placement by focusing on the posterior region of the jaws. The fact, however, is 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. To fulfill this objective in the present study, data on the cortical bone thicknesses were provided for all the teeth, both anteriorly and posteriorly, to provide the clinician with a comprehensive anatomic map of the maxilla and the mandible [5]

The association of gender with the mean buccal cortical thickness at each of the locations showed no statistically significant values. This finding was in accordance to the study done by Kim et al (2009) who found no statistical difference between sexes in the inter-radicular measurements of the posterior maxilla, probably because of the small sample size (35 patients).

Statistical analysis showed that on average the buccal cortical bone was thicker in the mandible than in the maxilla. The buccal sextants of both the jaws maxilla left, maxilla right, mandible left, mandible right had greater cortical bone thickness than the anterior sextants, i.e. maxilla middle and mandible middle. Cortical bone thickness increased in both jaws with the increasing distance from the mid-sagittal plane except distal to the maxillary right second molars where it decreased.

In the maxillary anterior sextant, the buccal cortical plate thickness increased with increasing distance from the alveolar crest being thinnest at 2 mm level and thickest at 6 mm level.

The mandibular anterior sextant was similar to its maxillary counterpart cortical thickness increasing away from the alveolar crest. In the mandibular buccal sextant and the same trend was observed. These findings were in accordance with the study done by Baumgaertal and Hans (2009) in 30 dry skulls. In the maxillary right and left sextants, the cortical bone was thinnest at 2 mm level and thickest at 4 mm level which was in contrast to the study done by Baumgaertal and Hans who noted that in the maxillary buccal sextants cortical thickness was maximum at 6 mm and thinnest at 4 mm [6].

The mandibular anterior sextant was similar to its maxillary counterpart cortical thickness increasing away from the alveolar crest. In the mandibular buccal sextant and the same trend was observed. Based on the findings of the present study, the optimal site for mini-implant placement in the anterior maxilla is the interradicular space between the lateral incisor and canine in the anterior mandible.This is in agreement with the study by Carano et al (2004); Kim et al (2009) and Salah et al(2010) [6-8].

Cortical bone thickness increased in both jaws with the increasing distance from the midsagittal plane except distal to the maxillary right second molars where it decreased. This was similar with the study done by Baumgaertal and Hans (2009).Johnson et al in their study (2007) also concluded that the density in the maxilla and mandible progressively increased from the midline towards the posterior region which could be explained by distribution of occlusal forces during mastication [6,18]

In the anterior maxillary sextant [MaxM] the maximum buccolingual thickness was found between the right central and lateral incisor at the 6mm level (Q1S7D6) 7.51 mm followed by between left central and lateral incisor at 6 mm level (Q1S9D6) 7.45 mm.

In the posterior maxillary right buccal sextant[MaxR] the maximum buccolingual thickness was found at the 4-mm level between the first and second molars (Q1S2D4) 13.23 mm (Table 4).

In the posterior maxillary left buccal sextant[MaxL] the maximum buccolingual thickness was found at the 4-mm level between the first and second molars (Q2S14D4) 13.20 mm.

In the mandibular anterior [MandM] sextant the maximum buccolingual thickness was found between left central and lateral incisor at the 4-mm level (Q3S23D4)7.48 mm followed by between right central and lateral incisor at 6 mm level (Q4S25D6) 7.42 mm.

In the posterior mandibular right buccal sextant[MandR] the maximum buccolingual thickness was found at the 4-mm level between the distal to second molars (Q4S30D4) 15.12 mm. Mesial to second molar the maximum buccolingual thickness was found between 1$^{st}$ and 2$^{nd}$ molar at 6 mm level (Q1S29D6) 12.83 mm.

In the posterior mandibular left buccal sextant [MandL] the maximum buccolingual thickness was found at the 2-mm level distal to second molars (Q3S16D2) 15.14 mm.

Mesial to second molar the maximum buccolingual thickness was found between 1$^{st}$ and 2$^{nd}$ molar at 6 mm level 12.93 mm.

The association of gender with the mean buccal cortical thickness at each of the locations showed no statistically significant values. This finding was in accordance to the study done by Kim et al (2009) who found no statistical difference between sexes in the interradicular measurements of the posterior maxilla, probably because of the small sample size (35 patients).

In our study the variation between the right and left sites wasn't much significant. This was in accordance with a study done by Ono et al (2008) evaluated buccal cortical bone thickness mesial and distal to first molar in the maxilla and mandible in 43 adult patients. CT scans were taken of all patients in the areas specified. Cortical bone thickness did not vary significantly from right to left sides [9-12]

In a study done by Cassetta et al (2013) they concluded that adults show a thicker alveolar cortical bone than adolescents. Alveolar cortical bone thickness and density were greater in males than in females, in mandible than in maxilla, in the posterior region than the anterior, in oral than buccal side. There is an increase of thickness and density from crest to base of alveolar crest [10,14,19]

We also evaluated the sites not suitable for placement of mini-implants (*thinnest cortical plate thickness*). In the Maxillary right quadrant the thinnest cortical bone thickness was found between the lateral incisor and canine at 2 mm level [Q1S6D2] .In the Maxillary left quadrant the thinnest cortical bone thickness was found between the lateral incisor and canine at 2 mm level [Q2S10D2].In the Maxillary quadrant the thinnest cortical bone thickness was found between right and left central incisors at 2 mm level [MxS8D2].In the Mandibular right quadrant the thinnest cortical bone thickness was found between the lateral incisor and canine at 2 mm level [Q4S24D4].In the Mandibular left quadrant the thinnest cortical bone thickness was found between the lateral incisor and canine at 2 mm level [Q3S22D2].In the Mandibular quadrant the thinnest cortical bone thickness was found between right and left central incisors at 2 mm level [MdS23D2].

Hence, in the present study, it could be concluded that the optimal site for mini-implant placement in the anterior region is between the central and lateral incisors in the maxilla and between the lateral incisor and the canine in the mandible at the 6-mm level from the alveolar crest. On the buccal aspect of the posterior region of both jaws, the optimal sites are between between the first and second molars. In the Maxillary arch it was found to be at 4 mm level on the right and left side. In the Mandibular arch it was found to be at 6 mm level on the right side and left side.

In the Maxillary and Mandibular arch, the sites not suitable for placement of mini-implants was found between the lateral incisor and canine at 2 mm level in both the right and left quadrant.

These results were charted in a visual format that might help clinicians in selecting the most ideal site for cortical bone availability, and it can serve as a guideline for selecting the ideal site for implant placement.

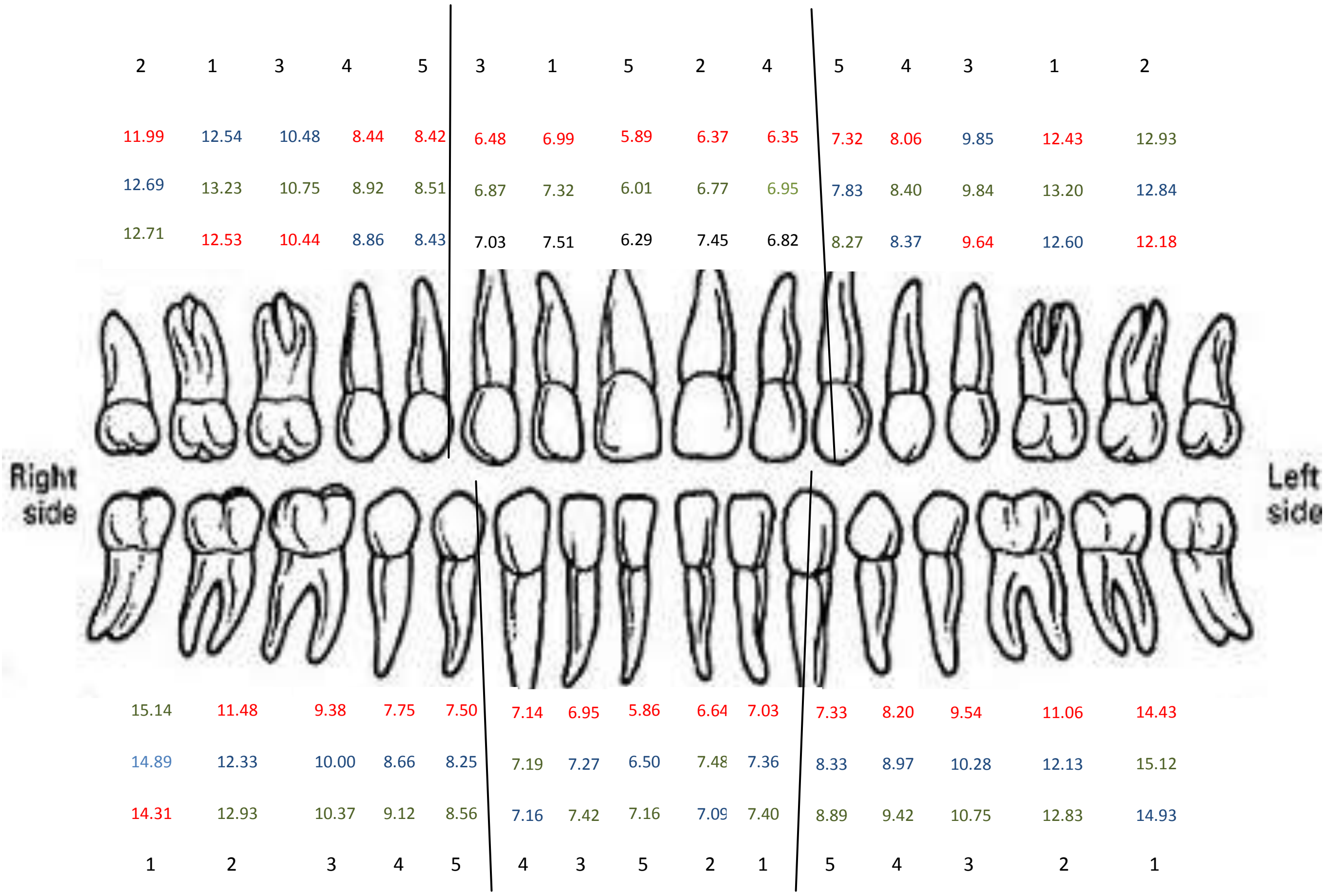


Fig 5 - Map of buccal cortical bone thickness in each measurement area: Measurement sites are ranked by overall buccal cortical bone thickness in each sextant (1 is the thickest). *red* is the thinnest measurement in the site ; *yellow* is the medium measurement ; *green* is the thickest measurement

## CONCLUSION

The conclusions drawn from the present study are:

- A distinctive pattern of variation was noted in the interdental buccal cortical thickness.
- The optimal site for mini-implant placement in the anterior region is between the central and lateral incisors in the maxilla and between the lateral incisor and the canine in the mandible at the 6-mm level from the alveolar crest.
- On the buccal aspect of the posterior region of both jaws, the optimal sites are between between the first and second molars. In the Maxillary arch it was found to be at 4 mm level on the right and left side. In the Mandibular arch it was found to be at 6 mm level on the right side and left side.
- In the Maxillary and Mandibular arch, the sites not suitable for placement of mini-implants was found between the lateral incisor and canine at 2 mm level in both the right and left quadrant.

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## TABLES & GRAPHS SECTION

## TABLES

| Demographic characteristics of study subjects | | | |
|---|---|---|---|
| Variables | Categories | n | % |
| Age group | 16-20 yrs | 10 | 33.3% |
| | 21-25 yrs | 19 | 63.3% |
| | 26-30 yrs | 1 | 3.3% |
| Gender | Males | 11 | 36.7% |
| | Females | 19 | 63.3% |

Table 1 – Demographic characteristics of study subjects

| Comparison of mean cortical bone thickness between 2, 4 & 6 mm points in each sextant using One-way ANOVA test | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 mm | | 4 mm | | 6 mm | | | |
| Sextant | Mean | SD | Mean | SD | Mean | SD | F | P-Value |
| MaxR | 10.38 | 1.47 | 10.82 | 1.23 | 10.59 | 1.58 | 0.710 | 0.49* |
| MaxM | 6.42 | 1.14 | 6.78 | 1.46 | 7.02 | 1.58 | 1.405 | 0.25* |
| MaxL | 10.12 | 1.19 | 10.42 | 1.32 | 10.21 | 1.59 | 0.381 | 0.68* |
| MandL | 10.11 | 1.28 | 10.96 | 1.18 | 11.37 | 1.25 | 8.027 | 0.001*** |
| MandM | 6.72 | 1.15 | 7.16 | 1.30 | 7.25 | 1.24 | 1.542 | 0.22* |
| MandR | 10.25 | 1.49 | 10.83 | 1.37 | 11.06 | 1.47 | 2.512 | 0.09* |

Table 2 -Mean bone depth measurements in each sextant

**P-value :**

*****Highly significant (≤0.001)**

**** Significant (≤0.05)**

*** Not significant (> 0.05)**

| Multiple comparison using Tukey's Post hoc Analysis | | | | | | |
|---|---|---|---|---|---|---|
| Sextant | 2 Vs 4 Diff | P-Value | 2 Vs 6 Diff | P-value | 4 Vs 6 Diff | P-Value |
| MandL | -0.85 | 0.02** | -1.25 | 0.001*** | -0.40 | 0.43* |

Table 3 – Multiple comparisons at each measurement points

| Comparison of mean cortical bone thickness between 2, 4 & 6 mm points using One-way ANOVA test | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 mm | | 4 mm | | 6 mm | | | |
| Site no. | Mean | SD | Mean | SD | Mean | SD | F | P-Value |
| 1 | 11.99 | 3.55 | 12.69 | 2.88 | 12.71 | 2.43 | 0.565 | 0.57* |
| 2 | 12.54 | 1.90 | 13.23 | 1.74 | 12.53 | 3.54 | 0.749 | 0.48* |
| 3 | 10.48 | 1.34 | 10.75 | 1.62 | 10.44 | 2.27 | 0.262 | 0.77* |
| 4 | 8.44 | 1.17 | 8.92 | 1.39 | 8.86 | 1.42 | 1.130 | 0.39* |
| 5 | 8.42 | 2.42 | 8.51 | 1.79 | 8.43 | 1.73 | 0.017 | 0.98* |
| 6 | 6.48 | 1.39 | 6.87 | 1.82 | 7.03 | 2.07 | 0.743 | 0.48* |
| 7 | 6.99 | 1.61 | 7.32 | 2.08 | 7.51 | 2.54 | 0.464 | 0.63* |
| 8 | 5.89 | 1.57 | 6.01 | 2.02 | 6.29 | 1.77 | 0.395 | 0.68* |
| 9 | 6.37 | 1.81 | 6.77 | 2.26 | 7.45 | 3.38 | 1.352 | 0.26* |
| 10 | 6.35 | 1.33 | 6.95 | 1.43 | 6.82 | 1.52 | 1.495 | 0.23* |
| 11 | 7.32 | 1.31 | 7.83 | 1.58 | 8.27 | 1.77 | 2.715 | 0.07* |
| 12 | 8.06 | 1.71 | 8.40 | 1.72 | 8.37 | 1.66 | 0.358 | 0.70* |
| 13 | 9.85 | 1.55 | 9.84 | 1.95 | 9.64 | 2.30 | 0.104 | 0.90* |
| 14 | 12.43 | 1.95 | 13.20 | 1.56 | 12.60 | 2.82 | 1.040 | 0.36* |
| 15 | 12.93 | 2.06 | 12.84 | 2.39 | 12.18 | 3.65 | 0.657 | 0.52* |
| 16 | 14.43 | 2.79 | 15.12 | 1.75 | 14.93 | 2.10 | 0.750 | 0.48* |
| 17 | 11.06 | 1.87 | 12.13 | 1.84 | 12.83 | 1.97 | 6.674 | 0.002** |
| 18 | 9.54 | 1.41 | 10.28 | 1.30 | 10.75 | 1.52 | 5.631 | 0.005** |
| 19 | 8.20 | 2.00 | 8.97 | 1.73 | 9.42 | 1.66 | 3.512 | 0.03** |
| 20 | 7.33 | 2.07 | 8.33 | 2.03 | 8.89 | 2.12 | 4.351 | 0.02** |
| 21 | 7.03 | 2.00 | 7.36 | 1.97 | 7.40 | 1.82 | 0.321 | 0.73* |
| 22 | 6.64 | 1.77 | 7.48 | 2.79 | 7.09 | 2.22 | 0.999 | 0.37* |
| 23 | 5.86 | 1.49 | 6.50 | 1.93 | 7.16 | 2.17 | 3.553 | 0.03* |
| 24 | 6.95 | 2.51 | 7.27 | 1.40 | 7.42 | 1.46 | 0.504 | 0.61* |
| 25 | 7.14 | 1.34 | 7.19 | 1.46 | 7.16 | 1.49 | 0.010 | 0.99* |
| 26 | 7.50 | 1.83 | 8.25 | 1.63 | 8.56 | 1.59 | 3.172 | 0.05** |
| 27 | 7.75 | 1.78 | 8.66 | 1.93 | 9.12 | 2.02 | 3.984 | 0.02** |
| 28 | 9.38 | 2.05 | 10.00 | 2.09 | 10.37 | 2.11 | 1.735 | 0.18* |
| 29 | 11.48 | 3.02 | 12.33 | 1.83 | 12.93 | 1.94 | 2.948 | 0.06* |
| 30 | 15.14 | 1.99 | 14.89 | 2.21 | 14.31 | 2.43 | 1.095 | 0.34* |

Table 4 – Comparison of Mean cortical bone thickness at each ROI

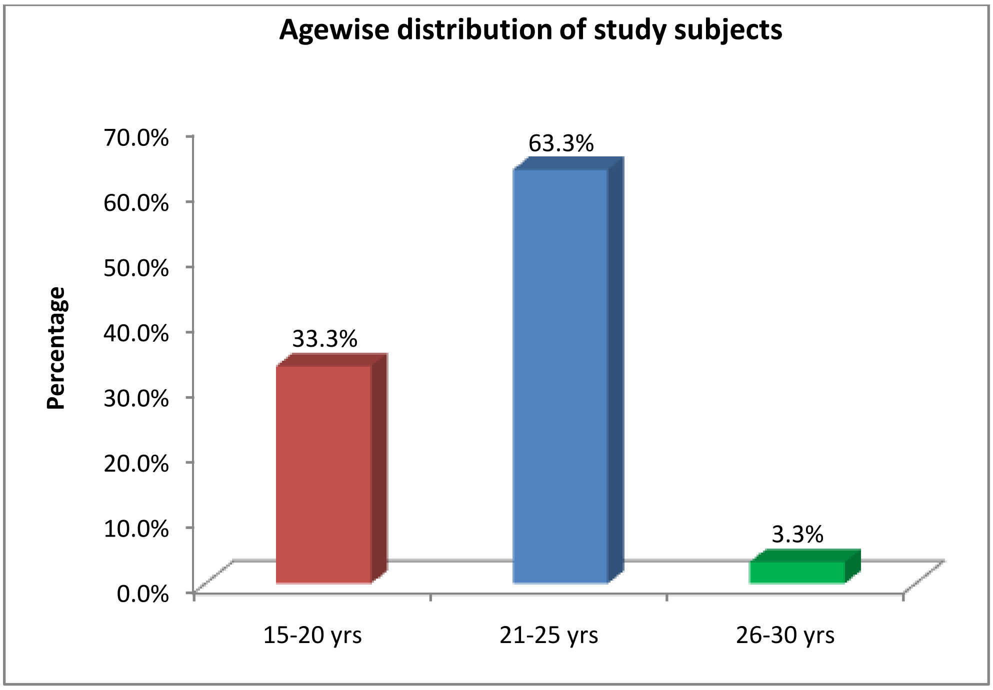
| Multiple comparison using Tukey's Post hoc Analysis | | | | | | |
|---|---|---|---|---|---|---|
| Site no. | 2 Vs 4 Diff | P-Value | 2 Vs 6 Diff | P-value | 4 Vs 6 Diff | P-Value |
| 17 | -1.07 | 0.08* | -1.77 | 0.001*** | -0.70 | 0.33* |
| 18 | -0.75 | 0.11* | -1.21 | 0.004** | -0.47 | 0.41* |
| 19 | -0.77 | 0.23* | -1.22 | 0.03** | -0.45 | 0.60* |
| 20 | -0.99 | 0.16* | -1.56 | 0.01** | -0.57 | 0.54* |
| 23 | -0.64 | 0.39* | -1.30 | 0.03** | -0.66 | 0.37* |
| 27 | -0.97 | 0.16* | -1.37 | 0.02** | -0.46 | 0.63* |

Table 5 – Multiple comparisons using Tukey's post hoc analysis

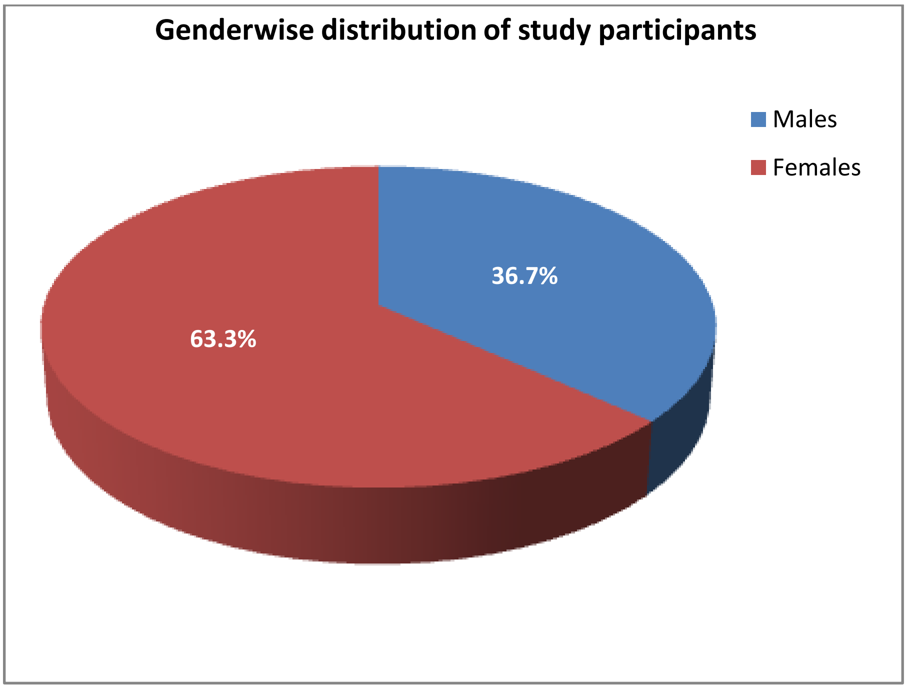
| Sextant | 2 mm | 4 mm | 6 mm |
|---|---|---|---|
| MaxR | 10.38 | 10.82 | 10.59 |
| MaxM | 6.42 | 6.78 | 7.02 |
| MaxL | 10.12 | 10.42 | 10.21 |
| MandL | 10.11 | 10.96 | 11.37 |
| MandM | 6.72 | 7.16 | 7.25 |
| MandR | 10.25 | 10.83 | 11.06 |

Table 6 – Comparison of mean cortical bone thickness at each ROI in each sextants

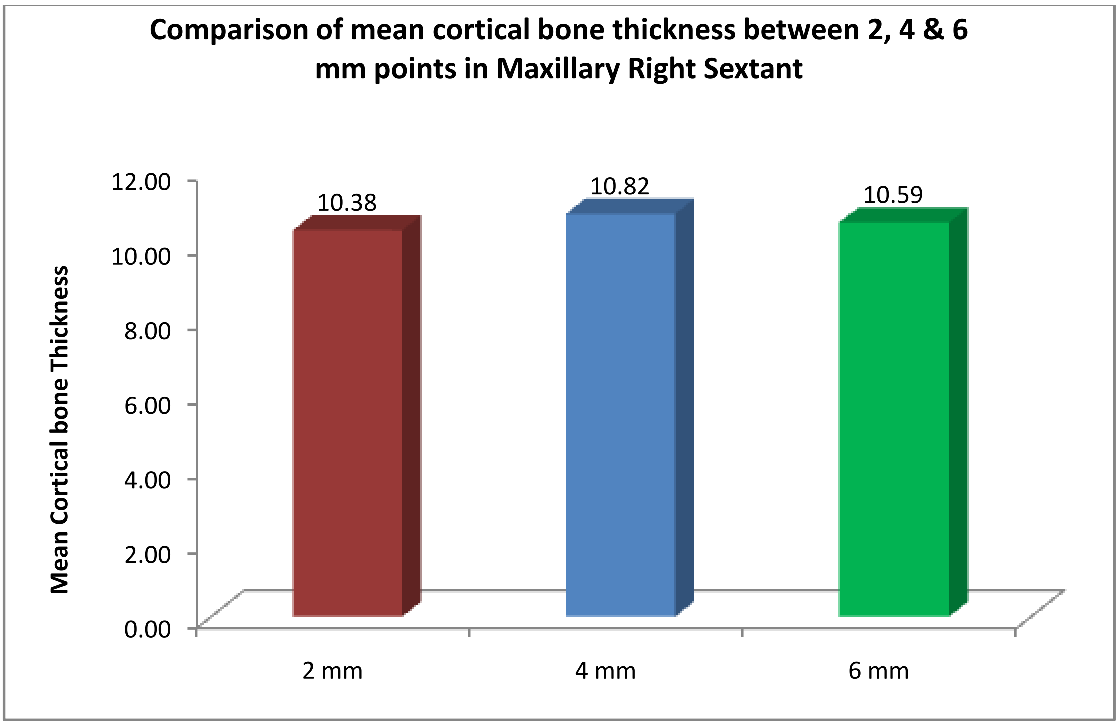
**GRAPHS**



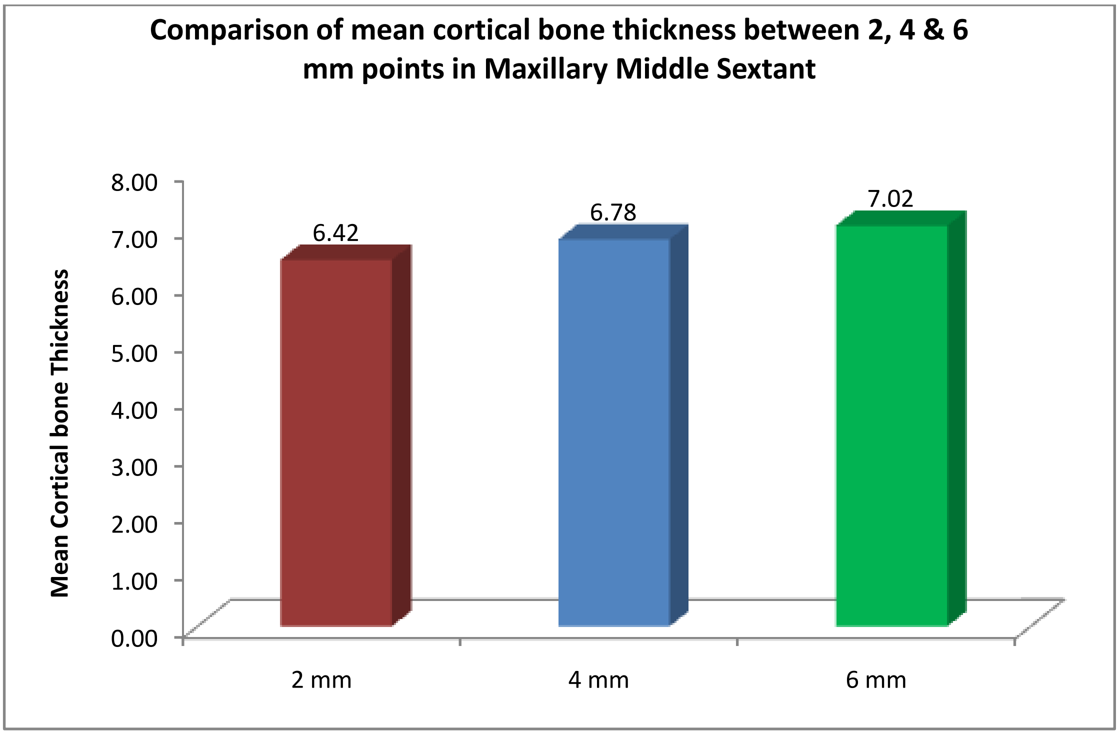

Graph 1 – Age wise distribution of study subjects



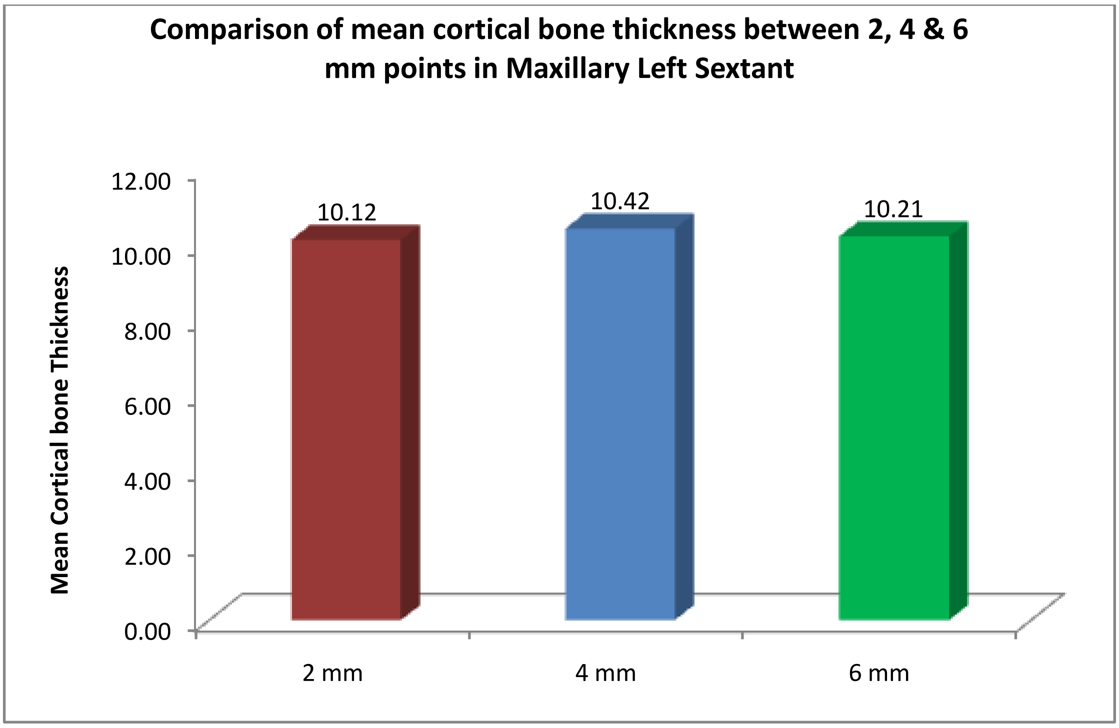

Graph 2 – Gender wise distribution of study subjects



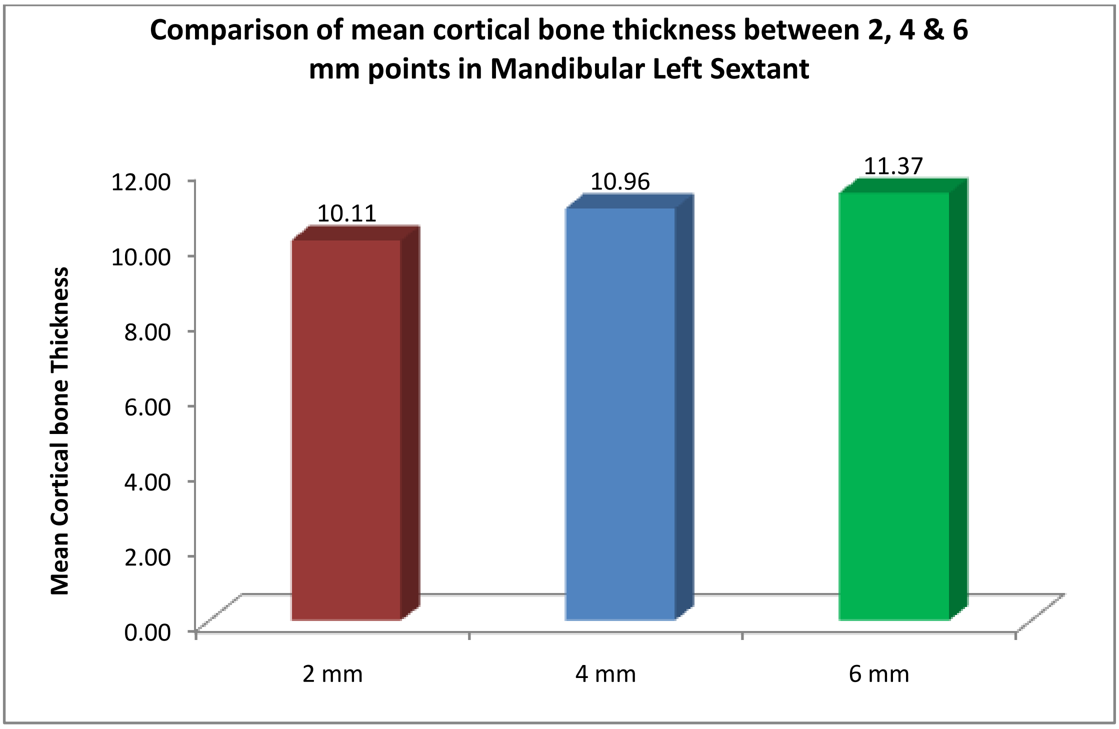

Graph 3 - Comparison of mean cortical thickness between 2, 4 and 6 mm in Maxillary right sextant



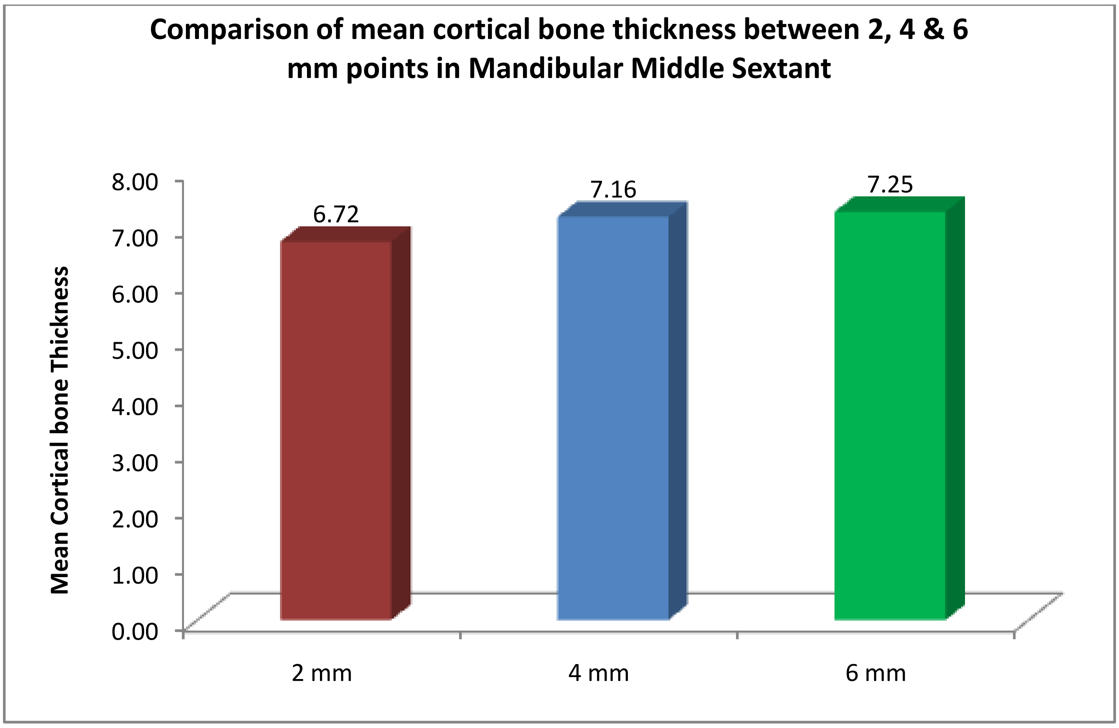

Graph 4 - Comparison of mean cortical thickness between 2, 4 and 6 mm in Maxillary middle sextant



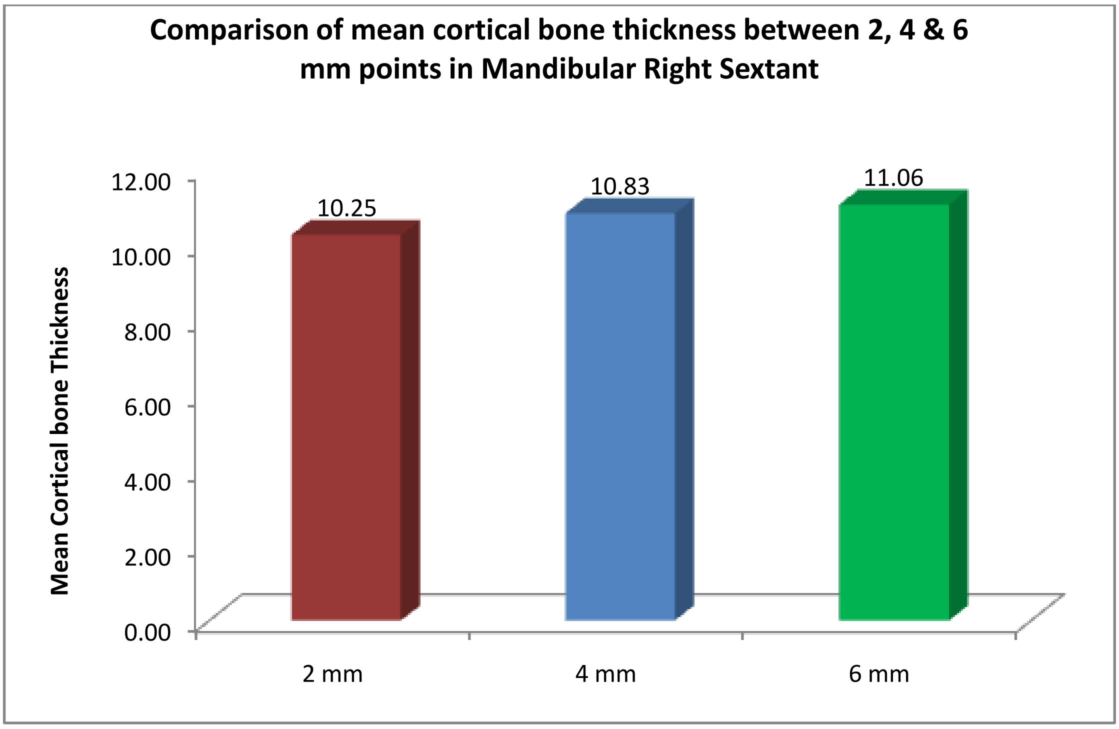

Graph 5 - Comparison of mean cortical thickness between 2, 4 and 6 mm in Maxillary left sextant




Graph 6 - Comparison of mean cortical thickness between 2, 4 and 6 mm in Mandibular left sextant




Graph 7 -Comparison of mean cortical thickness between 2, 4 and 6 mm in Mandibular middle sextant




Graph 8 - Comparison of mean cortical thickness between 2, 4 and 6 mm in Mandibular right sextant