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RESEARCH ARTICLE

# COMPARISON OF CORTICAL BONE THICKNESS CHANGES IN MADIBULAR ANTERIOR REGION DURING RETRACTION USING TADS-A CBCT STUDY

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ABSTRACT

**Introduction:** To evaluate and compare the labial and lingual cortical bone thickness in mandibular anterior segments during en masse retraction using skeletal anchorage aided by micro implants.
**Methods:** The study was done in-vivo on 10 subjects, with angle's class i bi-maxillary protrusion and/or angle's class ii div 1 protrusion patients between the age group of 18-30 years in the permanent dentition. Pre-treatment and post treatment CBCT's were taken for all the patients. Titanium small head micro implants, were used as anchor units for en-masse retraction. Changes in cortical bone thickness were measured at cervical (s1), middle (s2) and apical (s3) regions.
**Results:** One-way Anova test and Paired t test were performed on the given data which stated that statistically significant increase in cortical bone thickness was seen in at s1,s2&s3 on the lingual aspect with a p value of <0.001,whereas on the buccal aspect there was significant decrease only in left lateral incisors at s2 and s3 after retraction.
**Conclusion:** This current study concluded that orthodontic retraction force causes significant change in the thickness of cortical plates ie: reduction in thickness along the direction of force and differential remodelling at s1, s2 &s 3. Decrease in lingual cortical plate thickness was seen after correction of inclination and retraction of mandibular anterior segment.



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## INTRODUCTION

Over the years, a lot of research has been conducted on cortical bone thickness before and after orthodontic treatment (Sarikaya *et al.*, 2002; Ferreira *et al.*, 2013; DeAngelis *et al.*, 1970). Some of the patients demonstrated bone dehiscence that was not visible radiographically. Some patients also exhibited fenestration and dehiscence in the direction of movement, although these problems did not exist before treatment (Ferreira *et al.*, 2013). A basic axiom in orthodontics is "bone traces tooth movement," which suggests that whenever orthodontic tooth movement occurs, bone around the alveolar socket will remodel to the same extent (DeAngelis *et al.*, 1970; Meikle, 1980; Reitan, 1963; Reitan, 1964), ie, a ratio of bone remodeling to tooth movement (b/t) of 1:1 develops (Reitan, 1963; Reitan, 1964)In the transverse dimension, dehiscence and fenestration of the buccal cortical plate have been reported in rapid maxillary expansion, suggesting that root movement of the buccal dental segment surpasses lateral bone remodeling (Vardimon *et al.*, 1991). Even a single tooth movement in a buccolingual direction can produce the same effect (Wainwright *et al.*, 1973). In the vertical dimension, during orthodontic tooth extrusion, bone increase is usually less than the dental displacement, leading to an increase in the clinical crown (Kajiyama *et al.*, 1993). In the same vertical dimension, tooth intrusion showed more coherence in maintaining a 1:1 b/t ratio (Murakami *et al.*, 1989), though tooth intrusion has been shown to exceed bone reduction. (Melsen *et al.*, 1988; Melsen *et al.*, 1989) In the sagittal dimension, a different reaction is demonstrated between the posterior and anterior segments. In the posterior dental segment, a 1:1 b/t ratio is well maintained as long as tooth movement is restrained between the two cortical plates, ie, affecting the intermittent cancellous bone in the anterior segment, both the palatal (or lingual) and the labial cortical plates are involved in all antero-posterior tooth movements of the maxillary (or mandibular) anterior dental segments. The bulk of evidence supports the doubt that a 1:1 b/t ratio does not hold true in the anterior segment. (Engelking and Zachrisson, 1982) In an orthodontists office, the most common cases one gets to see is class 2 malocclusions and bimaxillary protrusions. Both of which require anterior teeth retraction to attain a stable occlusion and better profile (Kaur and Pavithra, 2013; Park *et al.*, 2001). Treatment mechanics for both types of malocclusions would require a maximum anchorage in most cases as the anterior segments need to be retracted more than the protraction of posterior teeth, therefore anchorage preparation has to be meticulously planned so as to

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prevent anchorage loss (Bae *et al*., 2002; Al-Sibaie *et al*., 2014). Anchorage loss is the reciprocal reaction of the anchor unit that can obstruct the success of orthodontic treatment by complicating antero-posterior correction.

Anchorage loss is a reciprocal reaction that could obstruct the success of orthodontic treatment by complicating the antero-posterior correction of the malocclusion and possibly detracting from facial esthetics. A major concern when correcting severe crowding, excessive over jet, and bimaxillary protrusion is control of anchorage loss. Anchorage loss is an unfavorable sequele that has plagued clinicians since the dawn of orthodontics. The introduction of skeletal anchorage has largely helped counteract this problem and has improved treatment outcomes. Retraction of the anterior segment can be done with the canine being distalised first, followed by the other four incisors, this reduces the anchorage burn of the posterior teeth. Though this method is popular, it still takes extra time because of the lengthy retraction process (Al-Sibaie *et al*., 2014; Hyo-Sang Park and Tae-Geon Kwon, 2004). Keeping time as a determining factor in mind, most patients opt for en-masse retraction of all 6 anterior teeth, which does cause anchorage loss. In such cases anchorage can be augmented by the use of intraoral devises such as transpalatal bars and nance palatal buttons or by extraoral appliances such as headgears (Mclaughlin and Bennett, 1991; Creekmore, 1983). However these intraoral devices provide minimal anchorage preservation and extraoral devices require good patient compliance (Hyo-Sang Park and Tae-Geon Kwon, 2004). Extraoral appliances are bulky and the patient does not prefer wearing it in public.

Creekmore in his studies with mini screws gave us an insight on the possibility of absolute skeletal anchorage (Sung-Seo Mo *et al*., 2010). Mini screws, dental implants and mini plates can be used for absolute anchorage and they have numerous benefits such as ease of placement and removal, cost effectiveness and it requires minimal/no patient compliance. Being small in size they can be placed in various parts of the bone intraorally, even in between the roots of teeth without causing discernable damage (Sung-Seo Mo *et al*., 2010; Deguchi *et al*., 2003) What is most advantageous to orthodontists is the fact that microimplants can be almost immediately loaded with orthodontic forces after placement (Melsen and Costa, 2003; Mah and Bergstrand, 2005). These type of implants can be called as temporary anchorage devices because of the ease of removal. They do not get osseointegrated with the bone therefore they can be removed when the term of their use is completed (Mah and Bergstrand, 2005). Studies have reported successful treatment of bimaxillary protusion with enmasse retraction method done with the use of micro implant aided anchorage system (Upadhyay *et al*., 2008). The best method to analyze alveolar bone thickness in all dimensions is a 3-dimensional approach. One such method could be computed tomography. CBCT is an evolution of the original computed tomography proposed by Hounsfield and Comark. CBCT scans allow the orthodontist to assess the patient's hard and soft tissue in three dimensions (3d) (Grauer *et al*., 2009; Hatcher *et al*., 2003). The accuracy and reliability of such images have been tested and were found to be adequate for implant planning, periodontal disease quantification, and assessment of tumor/lesion volumes. (Misch *et al*., 2006; Pinsky *et al*., 2006) The need for this investigation is to evaluate the precise changes of mndibular labial and lingual cortical bone thickness during en-masse retraction by micro implant anchorage system.

## MATERIALS AND METHODS

The study was done in-vivo on 10 subjects, among the patients with angle's classI bi-maxillary protrusion and/or angle's classII div 1 protrusion patients between the age group of 18-30 years in the permanent dentition. Patients underwent en-masse using TAD aided skeletal anchorage. Consent was taken regarding placement and removal of TADs under local anesthesia, the extraction of 2 upper and 2 lower premolars and of 2 CBCT scans to be done.

**Inclusion criteria**

1- Class I bi-maxillary protrusion cases, class II div 1 malocclusion cases
2- No impacted teeth except third molars
3- No missing teeth except third molars
4- Medically fit individuals with no systemic diseases and not under any medications.
5- Healthy periodontium
6- Age group 18-30

**Exclusion criteria**

1- Previous history of orthodontic treatment
2- Syndromic patients
3- Cleft lip and palate cases
4- Pregnant women

In all subjects pre-treatment CBCT scans of the anterior mandibular dentoalveolar complex region were taken. All patients were treated with the preadjusted edgewise appliance system, MBT prescription, slot size 0.022 x 0.028". The teeth were levelled and aligned with the following wire sequence- 0.016 HANT, 0.017x0.025 HANT, 0.019x0.025 HANT. The initial round wire was kept as long as the crowding was relieved, the average time being about 3 months. Only the first molars were banded, the second molars and the teeth mesial to the first molars were bonded. After levelling and aligning, 0.19 x 0.025 stainless steel archwires were placed for a period of 4 weeks before the start of retraction phase. This was done to ensure that the wires would remain passive. These wires had crimpable hooks placed distal to the lateral incisor brackets, which would aid in retraction. Periapical radiographs, taken with the paralleling technique, aided in the placement of the TADs. Titanium small head micro implants, were used as anchor units, the diameter being 1.3mm and 0.6mm in the maxilla. The TADs were placed between the roots of the 2$^{nd}$ premolar and 1$^{st}$ molar at a height of about 3-5mm at the muco-gingival junction. To avoid trauma, these were placed 2-3 mm higher if there was any root interference predicted. Retraction was done with the help of e-chains/closed coil springs from the TAD head to the crimpable hook. The force measured in each quadrant was averaged to about 150 grams. The surgical procedure for TAD placement involved manual insertion of the screws into the buccal cortical bone under local anesthesia with a TADdriver. TheTADs were checked for primary stability and strict instructions were given to the patient regarding oral hygiene. The TADs were then immediately loaded extending from the TAD head to the crimpable hooks for en-masse retraction of anterior teeth.After retraction was completed, another CBCT scan was done to evaluate changes in cortical bone thickness in both cases. The Dicom files were then transferred to the radiant dicom viewer (64-bit) software for cortical bone thickness estimation. The length tool was used for linear measurements of bone thickness (Figure:2a,b,c). This method was used to measure the pre treatment and post treatment cortical bone thickness of all the mandibular anterior teeth and the mean value was taken.

## RESULTS

One-way ANOVA comparison tests, and paired t test were used to compare pre and post treatment cortical bone thickness changes. On comparison of the mean values of pretreatment and posttreatment buccal cortical bone thickness of mandibular incisors the mean values of posttreatment is higher and is statistically not significant except for left lateral incisors at s2 and s3 level (Table 1,2 &3). On comparing mandibular lingual cortical bone thickness change, there was significant reduction in thickess seen for all four incisors at all levels (s1,s2 &s3) with a p value of 0.001. (Tables:4,5 & 6)

Fig1.a

Fig1.b

Fig1.c

Fig 1.d

Fig 1.e

**Fig.1. Intraoral photographs after TAD placement and loading. a)right lateral view b)left lateral view c)frontal view d) maxillary occlusal view e)mandibular occlusal view**


**Figure 2. a Radiant software panel showing saggital view**

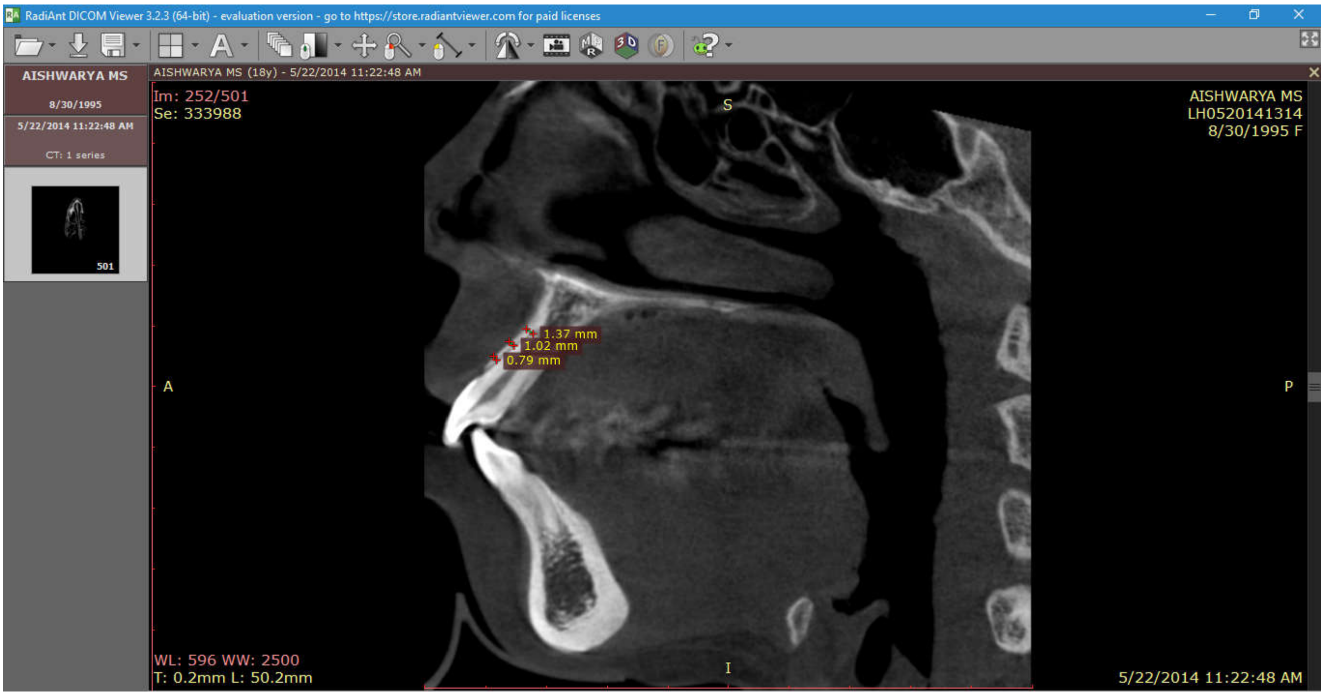


**Figure 2. b Linear measurements of buccal cortical bone thickness**

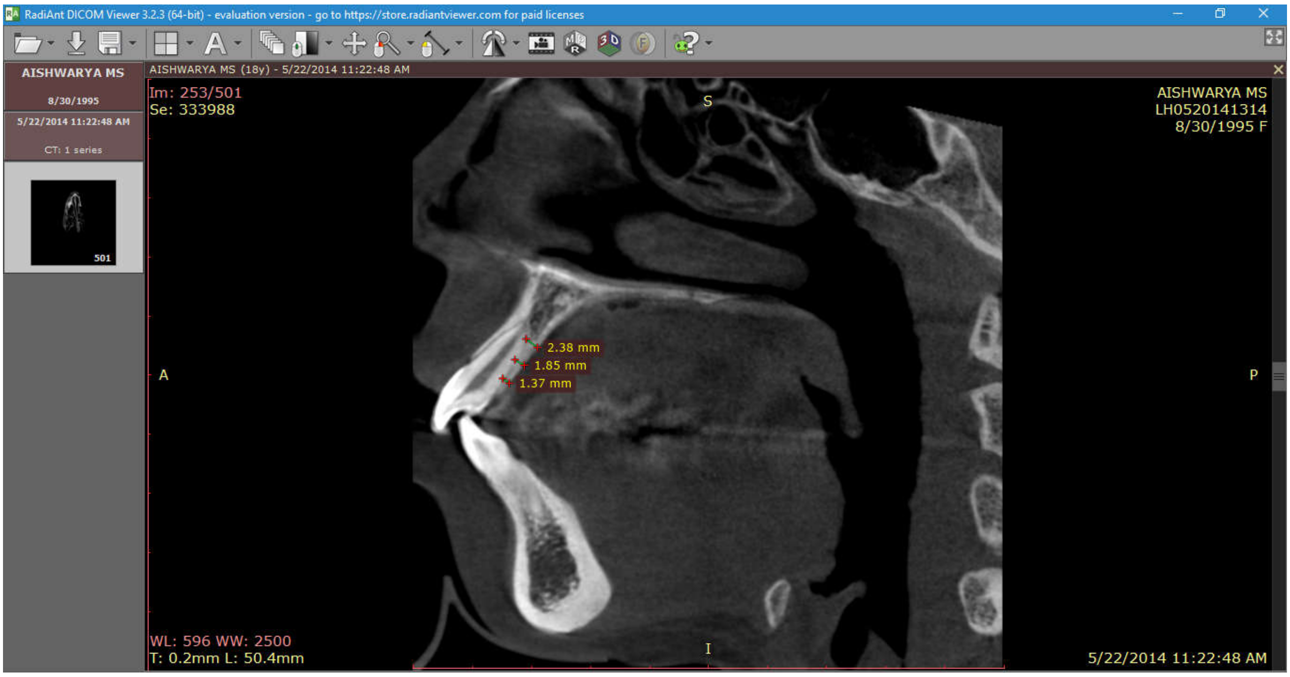


**Figure 2. c Linear measurements of lingual cortical bone thickness**

**Table 1. Comparison of the pre and post values in the mandibular buccal region at s1 level**

| | GROUP | | | Mean | N | Std. Deviation | Paired Differences | | t | df | P VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Difference | Std. Deviation | | | |
| S1 | GROUP 1 | Pair 1 | PRETREATMENT Right lateral | 0.482 | 10 | 0.066299 | 0.038 | 0.097274 | 1.235 | 9 | 0.248 |
| | | | POSTTREATMENT Right lateral | 0.444 | 10 | 0.122129 | | | | | |
| | | Pair 2 | PRETREATMENT Right central | 0.608 | 10 | 0.091506 | 0.004 | 0.074117 | 0.171 | 9 | 0.868 |
| | | | POSTTREATMENT Right central | 0.604 | 10 | 0.13882 | | | | | |
| | | Pair 3 | PRETREATMENT Left central | 0.599 | 10 | 0.089994 | 0.029 | 0.058963 | 1.555 | 9 | 0.154 |
| | | | POSTTREATMENT Left central | 0.57 | 10 | 0.112052 | | | | | |
| | | Pair 4 | PRETREATMENT Left lateral | 0.481 | 10 | 0.090486 | 0.031 | 0.098483 | 0.995 | 9 | 0.346 |
| | | | POSTTREATMENT Left lateral | 0.45 | 10 | 0.173141 | | | | | |

**Table 2. Comparison of the pre and post values in the mandibular buccal region at s2 level**

| | Group | | | Mean | N | Std. Deviation | Paired Differences | | t | df | P Value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Difference | Std. Deviation | | | |
| S2 | Group 1 | Pair 1 | PRETREATMENT Right lateral | 0.664 | 10 | 0.114232 | -0.019 | 0.078379 | -0.767 | 9 | 0.463 |
| | | | POSTTREATMENT Right lateral | 0.683 | 10 | 0.158188 | | | | | |
| | | Pair 2 | PRETREATMENT Right central | 0.86 | 10 | 0.087939 | 0.01 | 0.049216 | 0.643 | 9 | 0.537 |
| | | | POSTTREATMENT Right central | 0.85 | 10 | 0.086538 | | | | | |
| | | Pair 3 | PRETREATMENT Left central | 0.857 | 10 | 0.090437 | -0.009 | 0.046774 | -0.608 | 9 | 0.558 |
| | | | POSTTREATMENT Left central | 0.866 | 10 | 0.087458 | | | | | |
| | | Pair 4 | PRETREATMENT Left lateral | 0.664 | 10 | 0.108648 | -0.076 | 0.041952 | -5.729 | 9 | <0.001 |
| | | | POSTTREATMENT Left lateral | 0.74 | 10 | 0.102848 | | | | | |

**Table 3. Comparison of the pre and post values in the mandibular buccal region at s3 level**

| | GROUP | | | Mean | N | Std. Deviation | Paired Differences | | t | df | P VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Difference | Std. Deviation | | | |
| S3 | GROUP 1 | Pair 1 | PRETREATMENT Right lateral | 1.361 | 10 | 0.057822 | -0.013 | 0.095458 | -0.431 | 9 | 0.677 |
| | | | POSTTREATMENT Right lateral | 1.374 | 10 | 0.121491 | | | | | |
| | | Pair 2 | PRETREATMENT Right central | 1.588 | 10 | 0.080111 | -0.008 | 0.050947 | -0.497 | 9 | 0.631 |
| | | | POSTTREATMENT Right central | 1.596 | 10 | 0.089839 | | | | | |
| | | Pair 3 | PRETREATMENT Left central | 1.604 | 10 | 0.072296 | -0.008 | 0.113998 | -0.222 | 9 | 0.829 |
| | | | POSTTREATMENT Left central | 1.612 | 10 | 0.115547 | | | | | |
| | | Pair 4 | PRETREATMENT Left lateral | 1.369 | 10 | 0.050432 | -0.083 | 0.03401 | -7.717 | 9 | <0.001 |
| | | | POSTTREATMENT Left lateral | 1.452 | 10 | 0.058271 | | | | | |

**Table 4. Comparison of the pre and post values in the mandibular lingual region at s1 level**

| | GROUP | | | Mean | N | Std. Deviation | Paired Differences | | t | df | P VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Difference | Std. Deviation | | | |
| S1 | GROUP 2 | Pair 1 | PRETREATMENT Right lateral | 0.848 | 10 | 0.091627 | 0.358 | 0.150614 | 7.517 | 9 | <0.001 |
| | | | POSTTREATMENT Right lateral | 0.49 | 10 | 0.137518 | | | | | |
| | | Pair 2 | PRETREATMENT Right central | 0.848 | 10 | 0.043154 | 0.349 | 0.189939 | 5.81 | 9 | <0.001 |
| | | | POSTTREATMENT Right central | 0.499 | 10 | 0.198631 | | | | | |
| | | Pair 3 | PRETREATMENT Left central | 0.893 | 10 | 0.044485 | 0.385 | 0.243641 | 4.997 | 9 | 0.001 |
| | | | POSTTREATMENT Left central | 0.508 | 10 | 0.219383 | | | | | |
| | | Pair 4 | PRETREATMENT Left lateral | 0.881 | 10 | 0.057629 | 0.401 | 0.170193 | 7.451 | 9 | <0.001 |
| | | | POSTTREATMENT Left lateral | 0.48 | 10 | 0.146515 | | | | | |

**Table 5. Comparison of the pre and post values in the mandibular lingual region at s2 level**

| | GROUP | | | Mean | N | Std. Deviation | Paired Differences | | t | df | P VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Difference | Std. Deviation | | | |
| | GROUP 2 | Pair 1 | PRETREATMENT Right lateral | 1.392 | 10 | 0.055937 | 0.296 | 0.13906 | 6.731 | 9 | <0.001 |
| | | | POSTTREATMENT Right lateral | 1.096 | 10 | 0.158899 | | | | | |
| | | Pair 2 | PRETREATMENT Right central | 1.33 | 10 | 0.067987 | 0.244 | 0.140886 | 5.477 | 9 | <0.001 |
| | | | POSTTREATMENT Right central | 1.086 | 10 | 0.181426 | | | | | |
| | | Pair 3 | PRETREATMENT Left central | 1.335 | 10 | 0.075314 | 0.266 | 0.223815 | 3.758 | 9 | 0.004 |
| | | | POSTTREATMENT Left central | 1.069 | 10 | 0.235393 | | | | | |
| | | Pair 4 | PRETREATMENT Left lateral | 1.367 | 10 | 0.051001 | 0.274 | 0.181855 | 4.765 | 9 | 0.001 |
| | | | POSTTREATMENT Left lateral | 1.093 | 10 | 0.166936 | | | | | |

**Table 6. Comparison of the pre and post values in the mandibular lingual region at s3 level**

| | GROUP | | | Mean | N | Std. Deviation | Paired Differences | | t | df | P VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Difference | Std. Deviation | | | |
| | GROUP 2 | Pair 1 | PRETREATMENT Right lateral | 1.795 | 10 | 0.073824 | 0.336 | 0.18644 | 5.699 | 9 | <0.001 |
| | | | POSTTREATMENT Right lateral | 1.459 | 10 | 0.213877 | | | | | |
| | | Pair 2 | PRETREATMENT Right central | 1.859 | 10 | 0.048865 | 0.435 | 0.202882 | 6.78 | 9 | <0.001 |
| | | | POSTTREATMENT Right central | 1.424 | 10 | 0.217266 | | | | | |
| | | Pair 3 | PRETREATMENT Left central | 1.836 | 10 | 0.033731 | 0.375 | 0.173221 | 6.846 | 9 | <0.001 |
| | | | POSTTREATMENT Left central | 1.461 | 10 | 0.18248 | | | | | |
| | | Pair 4 | PRETREATMENT Left lateral | 1.842 | 10 | 0.050067 | 0.365 | 0.220668 | 5.231 | 9 | 0.001 |
| | | | POSTTREATMENT Left lateral | 1.477 | 10 | 0.218584 | | | | | |

## DISCUSSION

The present study reveals that the changes in thickness of the buccal and lingual plates of the mandibular anterior teeth after retraction using TADs. The thickness of labial plates in the mandibular anterior teeth is thinner than other segments of the dention and found to be thinnest at the alveolar crest. In our study the sample consisted of patients with bimaxillary dentoalveolar protrusion, which manifests with flared and labially positioned mandibular incisors. This feature of bimaxillary protrusion predisposes the mandubular anteriors to increased incidence of fenestration and dehiscence, due to anterior positioning and thin alveolar plate. Pre treatment CBCT is of utmost importance for the orthodontist to evaluate the thickness, quality of bone and also location of such bony defects. The amount of retraction that can be carried out for the anteriors is limited to the cortical plates on the labial and palatal sides also known as the orthodontic walls. As all the samples taken, underwent first premolar extraction, maximum amount of space available was used for retaction of anteriors using mini-implants. Wainwright (1973), Vardimon *et al*. (1991), and Wehrbein (1995) *et al* stated that there was significant reduction in the cortical bone thickness toward the direction of tooth movement. These findings justify the reduction of cortical bone thickness at all the three level at the lingual cortical plate with a statistically significant difference. Labial cortical plate experienced post treatment increase in thickness and the amount of increase was statistically significant in left lateral incisor. Sarikaya *et al* in their study observed that Some patients developed fenestration and dehiscence in the direction of movement during retraction, although these defects did not exist before treatment. This highlights the need to evaluate the thickness of cortical prior to retraction to determine the amount, direction ans limit of retaction that can be achieved within the physiological limits. The retraction force was applied from the mini-implant as close to CR as possible to facilitate bodily tooth movement of the anterior segment. During the levelling and aligning phase, complete torque expression was achieved by rectangular arch wire, to position the root in the cancellous bone, which was positioned close to the labial cortical plate. The post treatment CBCT was taken immediately after completion of treatment to evaluate the immediate effects of retraction force on the cortical plate thickness, and eliminate any change due to osteoblastic activity during the retentive phase. New alveolar bone formation at the defect sites are expected to form by 4 to 6 months of retention period. This changes in thickness of alveolar bone can be attributed to two basic phenomenon ie remodelling activity and alveolar bone bending.

### Conclusion

The results indicates that when maxillary anteriors are retracted using TADs there is differential deposition and resorption in the anterior cortical bone thickness. These changes can be precisely measured using CBCT and will help to reduce the risk of dehiscence and fenestration. Long term follow up is needed to evaluate the amount of cortical bone repair that takes place during the retentive period.

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