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Comparative evaluation of cortical bone thickness and total alveolar width in maxillary anterior dentition pre and post levelling and alignment in patients with class I and class II molar relation treated with pre-adjusted edgewise using CBCT- in vivo comparative study

Dr. Veerendra kerudi[1], Dr. Jay Prakash Patil[2], Dr. Aditi Rajesh pawar[3], Dr. Shrutika Tamgadge[4], Dr. Sauravi nimbalkar[5], Dr. Rushikesh sonwane[6]

[1]HOD at Dept. of Orthodontics and dentofacial orthopaedics, JMF's A.C.P.M Dental College and hospital, Dhule, Maharashtra

Email ID: drveerendrakerudi@gmail.com

[2]3rd year post graduate student at Dept. of Orthodontics and dentofacial orthopaedics, JMF's A.C.P.M Dental College and hospital, Dhule,Maharashtra

Email ID: Jaypatil91120@gmail.com

[3]Kishor's dentistry, Tirupur.

Email ID: aditipawar50296@gmail.com

[4]3rd year post graduate student at Dept. of Orthodontics and dentofacial orthopaedics, JMF's A.C.P.M Dental College and hospital, Dhule,Maharashtra

Email ID: Shrutika8tamgadge@gmail.com

[5]3rd year post graduate student at Dept. of Orthodontics and dentofacial orthopaedics, JMF's A.C.P.M Dental College and hospital, Dhule,Maharashtra

Email ID: sauravinimbalkar7@gmail.com

3rd year post graduate student at Dept. of Orthodontics and dentofacial orthopaedics, JMF's A.C.P.M Dental College and hospital, Dhule,Maharashtra

Email ID: rushikeshsonwane146@gmail.com

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ABSTRACT

Background: Orthodontic tooth movement is achieved through bone remodelling of the alveolar process .The effect of orthodontic treatment on changes in alveolar bone thickness have indicated that orthodontic tooth movement can decrease the bone thickness around the teeth.

Materials and method: 20 patients were selected and further divided into 2 groups according to the skeletal and dental malocclusion; each group comprising of 10 patients.Group 1: Skeletal class I mal-occlusion and Angles class I molar relation,Group 2: Skeletal class II malocclusion and Angles class II molar relation.The cortical bone thickness and total alveolar width in maxillary anterior dentition was evaluated using pre treatment CBCT. The measurments were taken at 3mm ,6mm,9mm from CEJ[(16)]. After completion of levelling and alignment with superelastic .014 , .016 round niti , 19*25 rectangular niti and 19*25 SS ; CBCT of these patients was taken and the cortical bone thickness and total alveolar width was measured.

Results: Comparision of difference in pre and post alveolar bone thickness for both the group class I and class II Subject at 3mm,6mm and 9mm was done,The $P \leq 0.005$ was considered statistically significant. The labial cortical bone,palatal cortical plate and alveolar width was significantly($p \leq 0.001$) more reduced in class II than in class I at 3mm,6mm,9mm.

Conclusion" It is concluded from this study that the labial and palatal bone thickness and total alveolar width decreased significantly in class I and class II pt at 3mm 6mm and 9mm from CEJ post levelling and alignment.

1. INTRODUCTION

Malocclusion is defined as an irregularity of the teeth or a malrelationship of the dental arches beyond the range of what is accepted as normal. Orthodontics and dentofacial orthopaedics encompasses modification/ alteration of the teeth and the supporting bones to attain desirable changes in their relative position so that aesthetics, function, and oral health of the patient can be improved. [1]

Orthodontic tooth movement is achieved through bone remodelling of the alveolar process(3). The theory assumes that aseptic necrosis occurs in the compression area, and bone apposition—on the opposite side.[2] Thus, knowledge of the morphological features of the alveolar bone is of paramount importance to orthodontic tooth movement. [3]The dimensions of facial and lingual/palatal aspects of the alveolar process appear to be dependent on the eventual location, the size and inclination of the roots of the erupted teeth.[4]

Some previous studies on the effect of orthodontic treatment on changes in alveolar bone thickness have indicated that orthodontic tooth movement can decrease the bone thickness around the teeth whereas others have reported the opposite. Hence in the present study dental CBCT was applied to evaluate changes in bone thickness around the teeth before and after levelling and alignment.[5,6]

Several methods have been used to assess bone thicknesses; lateral cephalogram was used to measure labiolingual bone width as well as the but the measurements were not accurate when compared with physical measurements of the actual specimens, because all structures overlap on each other on cephalometric images.[7] CT and CBCT enable measuring the Hounsfield units (HU) or grayscale value (GV) of bone tissue; hence, they are also used in assessing radiographic bone density and thickness and are thus applicable to evaluating changes in bone density and bone thickness.[8,9]

Thus aim of the study is to evaluate and compare cortical bone thickness and total alveolar width in maxillary anterior dentition pre and post levelling and alignment in class I and class II malocclusion treated with pre adjusted edgewise using CBCT**.**

2. MATERIAL AND METHODS

The present study was conducted 20 healthy subjects each group consisting of 10 subject each at department of Orthodontics and Dentofacial Orthopaedics.Prior to the start of the present study, a well-defined protocol of the intended study was submitted to the Institutional Ethical Committee and ethical clearance was obtained for the same. A Written and oral informed consent was taken from the patients prior to start of the study. The study purpose was explained to patients before obtaining the consent. The patient information sheet and consent form were made available both in English and Marathi (Local language) for easy comprehension regarding details of the study.

Sample size determination

Patient selection will be based on simple random sampling method from the group of subjects those who fulfil inclusion criteria.Sample size was estimated by using the data obtained from previous study conducted by Phermsang-ngarm and Charoemratrote et al. (Angle Orthodontist. 2018; 88(4):425-34).Substituting the values in formula, the sample size estimated was n = 10 samples per group with power 90%

Inclusion criteria:

- Age above 18 years.
- Complete root apex formation.
- Mild to moderate crowding below 5 mm
- Skeletal relationship of included patients evaluated using
- Cephalograms

Skeletal class I ANB angle=0 to 4°

Skeletal class II ANB angle=greater than 4

Exclusion criteria:

- Patients who have undergone any previous orthodontic treatment.
- Patients with history of trauma to face or jaws.
- medically compromised patients
- malocclusion associated with syndromic patients
- periodontally compromised patients

- Severe facial or dental asymmetries.
- Vertical or horizontal periodontal bone loss.
- Peri-apical or peri-radicular pathologies or radiolucencies of either periodontal or endodontic origin
- Missing first permanent molar

CBCT and Software used.

1. Newtom CBCT, NNT software.
2. Dentium CBCT, rainbow™ CT-RCTME-190121(Rev.7)(Figure 2)

Figure 1 Dentium CBCT, rainbow™ CT-RCTME-190121(Rev.7)

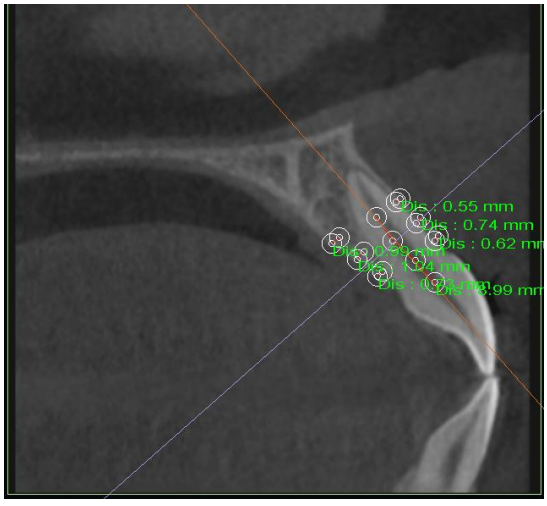


Figure 2.Pre levelling and alignment measurement of labial and palatal cortical plate

Method of grouping the subject

20 patients were selected and further divided into 2 groups according to the skeletal and dental malocclusion; each group comprising of 10 patients.

- Group 1: Skeletal class I mal-occlusion (ANB angle between 0 to 4°) and Angles class I molar relation
- Group 2: Skeletal class II malocclusion (ANB angle greater than 4°) and Angles class II molar relation

Measurement of cortical bone thickness,Palatal bone thickness and alveolar width

Skeletal malocclusion was confirmed by the Cephalometric analysis. Pre-treatment CBCT of these patients were taken. The cortical bone thickness and total alveolar width in maxillary anterior dentition was evaluated using the linear measurements obtained from the CBCT measurement scale. The measurments were taken at 3mm ,6mm,9mm from CEJ[16]. After completion of levelling and alignment with superelastic .014 , .016 round niti , 19*25 rectangular niti and 19*25 SS ; CBCT of these patients was taken and the cortical bone thickness and total alveolar width was measured.(Figure 2)

After obtaining the readings, comparison was made between pre and post levelling and alignment measurements in skeletal class I as well as class II patients; and the final comparison was made between skeletal class I and skeletal class II measurement.

Statistical Analysis:

Statistical analysis was done using a computer with aid of a statistical package for social sciences (SPSS) 25 version software (IBM Armonk, NY, United States of America). Data comparison was done by applying specific statistical tests to find out the statistical significance of obtained results. Depending upon the nature of data, appropriate statistical tests were performed and significance was assessed at 5% level of significance i.e. p-value < 0.05 was considered as significant.

3. RESULTS

The skeletal relationship of the included patients was first evaluated using cephalograms and the evaluation was based on ANB angle as follows:

Pre-treatment CBCT of these patients were taken. The cortical bone thickness ie labial and palatal bone and total alveolar width in maxillary anterior dentition was evaluated using the linear measurements obtained from the CBCT measurement scale. And the following data was obtained

Comparision of pre and post levelling cortical bone thickness and total alveolar width at 3mm

In class I the paired t test indicates a significant difference (p=0.001)

The post levelling labial cortical plate thickness was significantly (p=0.01) lower with a difference of 0.008 than pre levelling labial cortical bone thickness. Similarly the post levelling palatal bone thickness was significantly (p=0.01) lower with a difference of 0.009 than pre levelling palatal bone thickness. And the post levelling total alveolar width was signifantly (p=0.01) lower with a difference of 0.729 than pre levelling total alveolar bone thickness.(Table 1)(Graph 1). In class II the paired t test indicates a significant difference (p=0.01)The post levelling labial cortical plate thickness was significantly (p=0.01) lower with a difference of 0.020 than pre levelling labial cortical bone thickness. Similarly the post levelling palatal bone thickness was significantly (p=0.01) lower with a difference of 0.016 than pre levelling palatal bone thickness. And the post levelling total alveolar width was signifantly (p=0.01) lower with a difference of 1.250 than pre levelling total alveolar bone thickness.(Table 2)(Graph 2)

Table 1.Comparison of pre and post-leveling alveolar bone thickness in Class I subjects at 3mm

Region	Pre-levelling		Post-leveling		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.662	0.217	0.654	0.216	0.008	<0.001*
Palatal	0.929	0.301	0.921	0.300	0.009	<0.001*
Total	7.655	1.316	6.926	1.475	0.729	<0.001*

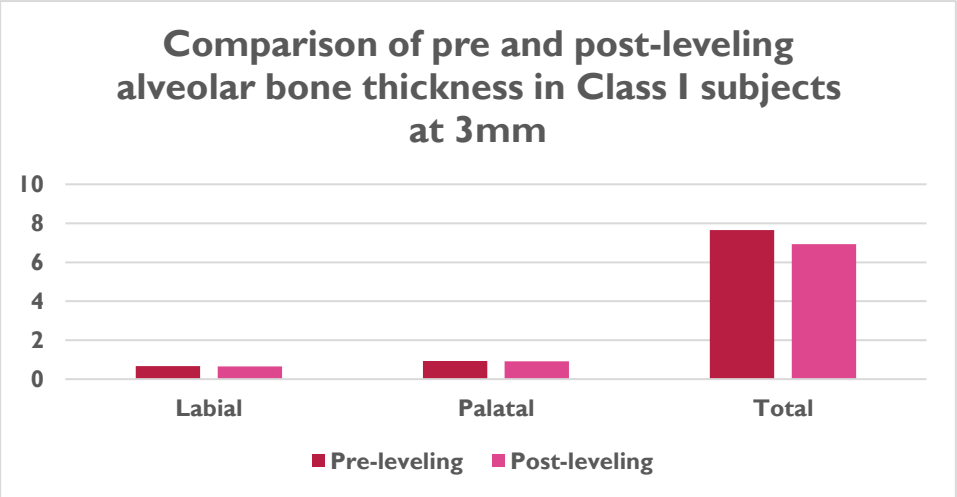
Paired t test; * indicates a significant difference at p≤0.05

Table 2.Comparison of pre and post-leveling alveolar bone thickness in Class II subjects at 3mm

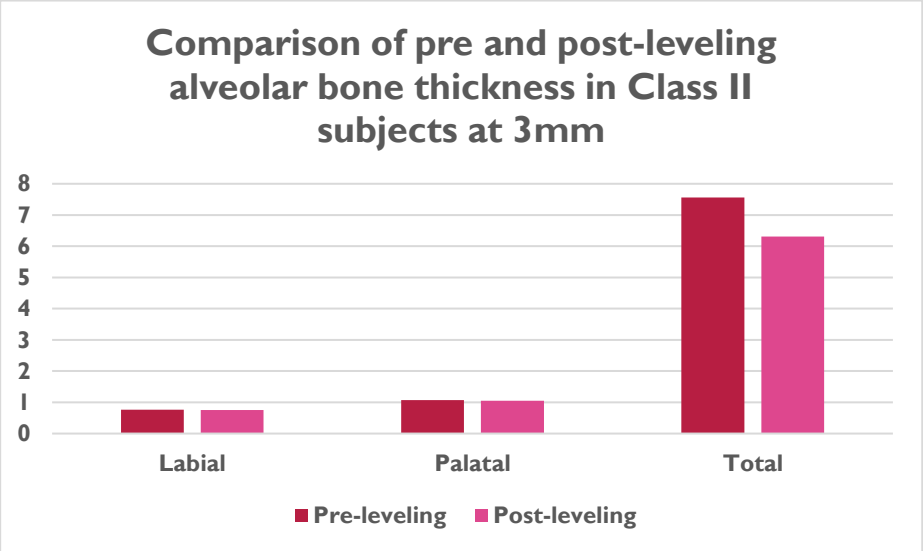
Region	Pre-leveling		Post-leveling		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.769	0.243	0.750	0.244	0.020	<0.001*
Palatal	1.072	0.271	1.056	0.267	0.016	<0.001*
Total	7.558	1.351	6.308	1.520	1.250	<0.001*

Paired t test; * indicates a significant difference at p≤0.05

Graph 1



Graph 2



Comparision of pre and post levelling cortical bone thickness and total alveolar width at 6 mm

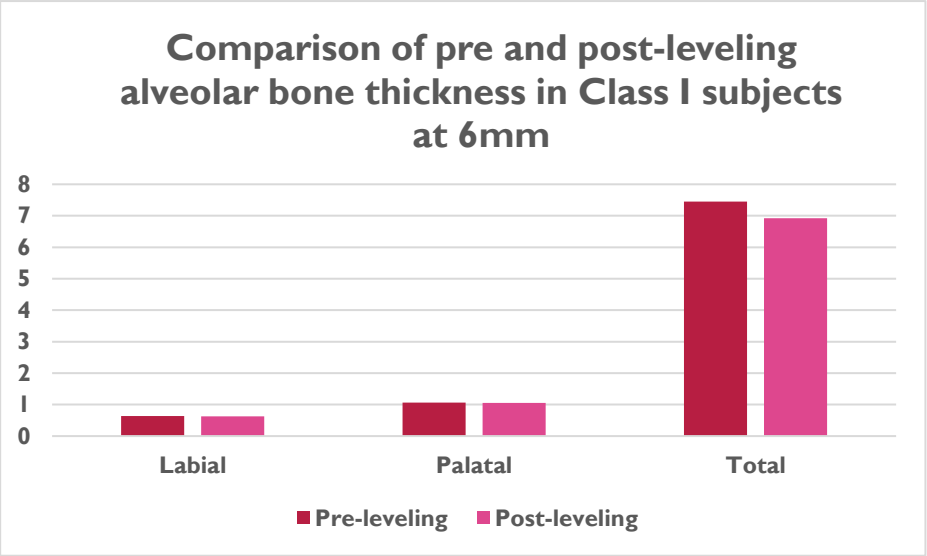
In class I The post levelling labial cortical plate thickness was significantly (p=0.01) lower with a difference of 0.006 than pre levelling labial cortical bone thickness. Similarly the post levelling palatal bone thickness was significantly (p=0.01) lower with a difference of 0.009 than pre levelling palatal bone thickness. And the post levelling total alveolar width was signifantly (p=0.01) lower with a difference of 0.522 than pre levelling total alveolar bone thickness.(Table 3)(Graph 3) In class II the paired t test indicates a significant difference (p=0.01)

Table 3. Comparison of pre and post-leveling alveolar bone thickness in Class I subjects at 6mm

Region	Pre-leveling		Post-leveling		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.635	0.189	0.629	0.189	0.006	<0.001*
Palatal	1.064	0.302	1.055	0.302	0.009	<0.001*
Total	7.448	1.469	6.926	1.475	0.522	<0.001*

Paired t test; * indicates a significant difference at p≤0.05

Graph 3



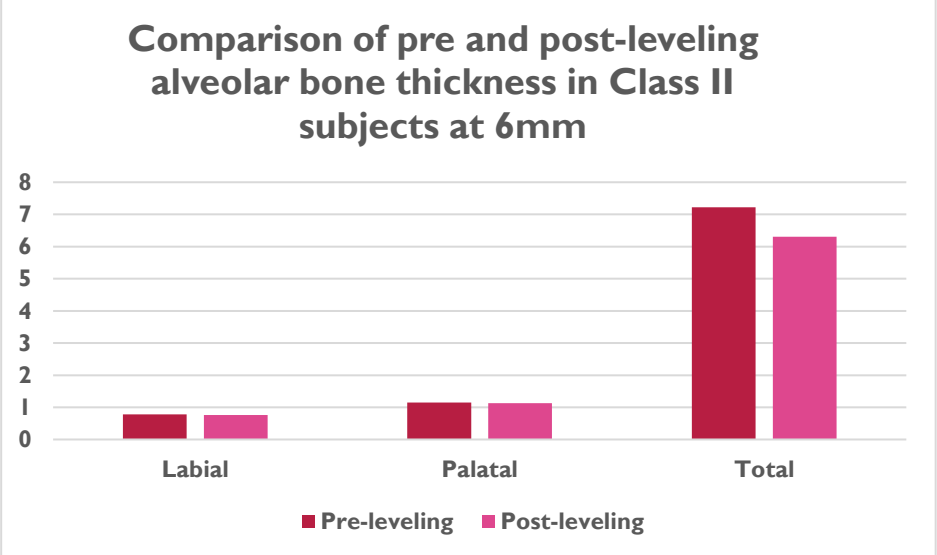
The post levelling labial cortical plate thickness was significantly (p=0.01) lower with a difference of 0.016 than pre levelling labial cortical bone thickness. Similarly the post levelling palatal bone thickness was significantly (p=0.01) lower with a difference of 0.016 than pre levelling palatal bone thickness. And the post levelling total alveolar width was signifantly (p=0.01) lower with a difference of 0.911 than pre levelling total alveolar bone thickness.(Table 4)(Graph 4)

Table 4.Comparison of pre and post-leveling alveolar bone thickness in Class II subjects at 6mm

Region	Pre-leveling		Post-leveling		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.779	0.218	0.763	0.218	0.016	<0.001*
Palatal	1.147	0.266	1.131	0.266	0.016	<0.001*
Total	7.220	1.578	6.308	1.520	0.911	<0.001*

Paired t test; * indicates a significant difference at p≤0.05

Graph 4



Comparision of pre and post levelling cortical bone thickness and total alveolar width at 9 mm

In class I the paired t test indicates a significant difference (p=0.01).The post levelling labial cortical plate thickness was significantly (p=0.01) lower with a difference of 0.008 than pre levelling labial cortical bone thickness. Similarly the post levelling palatal bone thickness was significantly (p=0.01) lower with a difference of 0.009 than pre levelling palatal bone thickness. And the post levelling total alveolar width was signifantly (p=0.01) lower with a difference of 0.503. (Table 5)(Graph 5) In class II The post levelling labial cortical plate thickness was significantly (p=0.01) lower with a difference of 0.014 than pre levelling labial cortical bone thickness. Similarly the post levelling palatal bone thickness was significantly (p=0.048) lower with a difference of 0.034 than pre levelling palatal bone thickness. And the post levelling total alveolar width was significantly (p=0.01) lower with a difference of 0.723.(Table 6)(Graph 6)

Table 5.Comparison of pre and post-leveling alveolar bone thickness in Class I subjects at 9mm

Region	Pre-leveling		Post-leveling		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.605	0.245	0.597	0.245	0.008	<0.001*
Palatal	1.092	0.322	1.083	0.321	0.009	<0.001*
Total	7.241	1.733	6.739	1.607	0.503	<0.001*

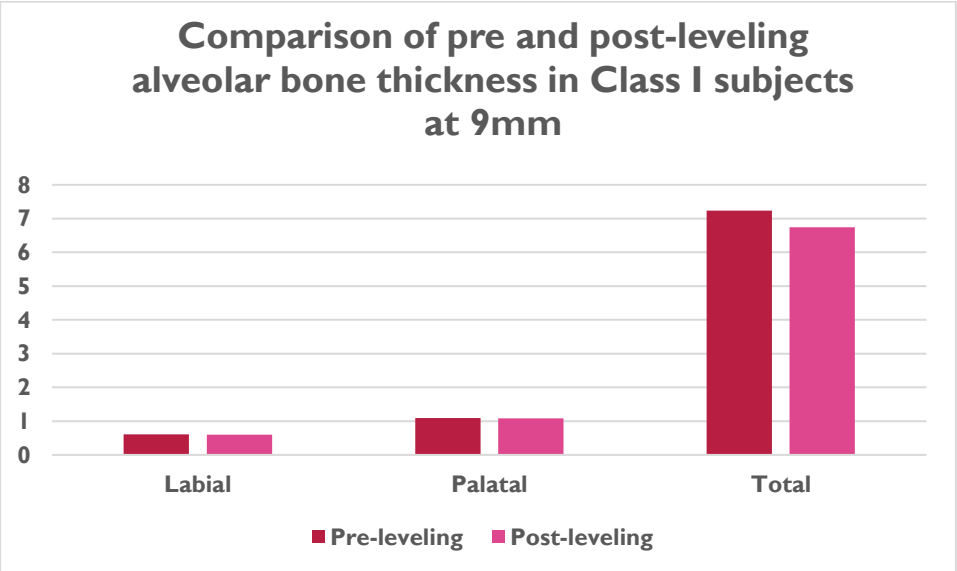
Paired t test; * indicates a significant difference at p≤0.05

Table 6.Comparison of pre and post-leveling alveolar bone thickness in Class II subjects at 9mm

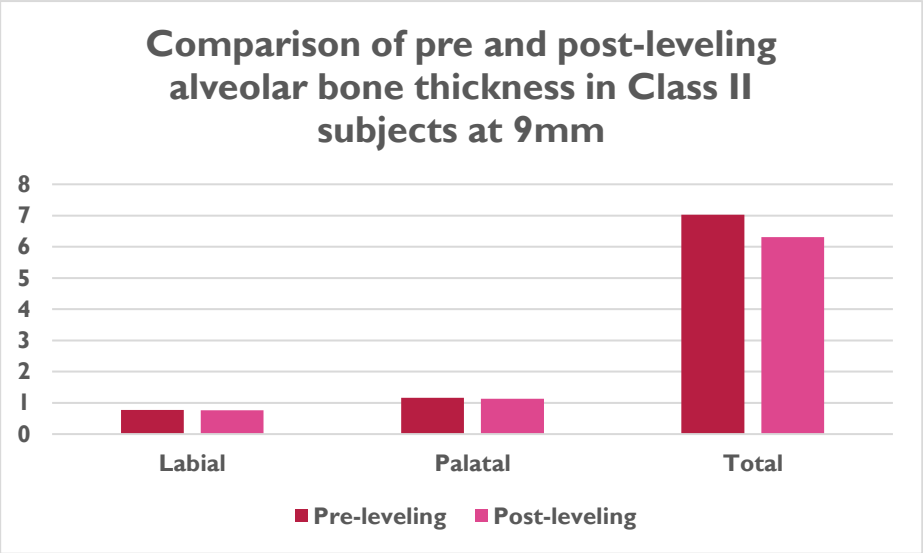
Region	Pre-leveling		Post-leveling		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.775	0.257	0.761	0.257	0.014	<0.001*
Palatal	1.161	0.275	1.127	0.271	0.034	0.048*
Total	7.031	1.730	6.308	1.616	0.723	<0.001*

Paired t test; * indicates a significant difference at p≤0.05

Graph 5



Gaph 6



Comparision of difference in pre and post alveolar bone thickness between class I and class II Subject at 3mm

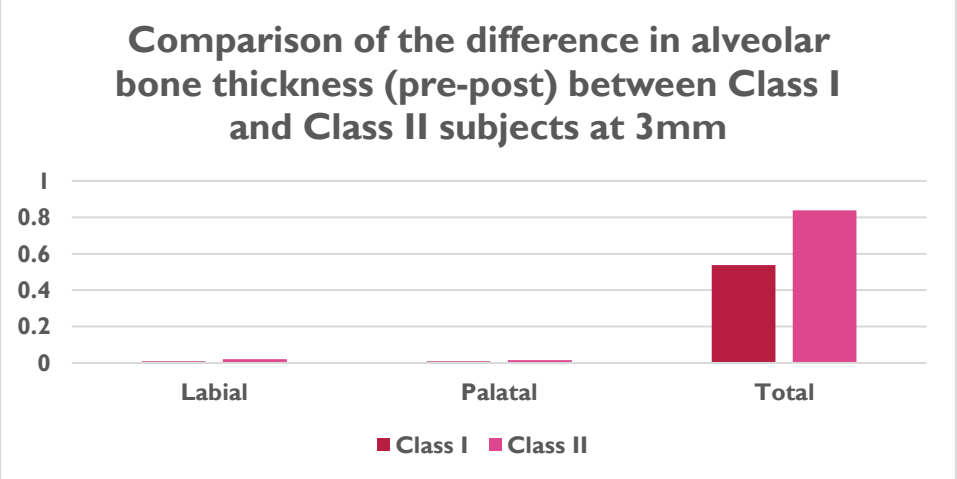
The labial cortical bone was significantly(p=0.001) more reduced in class II than in class I with a difference of (-0.012) similarly the palatal cortical plate was significantly(p-0.001) more reduced with difference of (-0.007) in class II and likewise total alveolar width showed more significant (p=0.001)reduction in class II with a difference of (-0.300) than in class I.(Table 7)(Graph 7)

Table 7.Comparison of the difference in alveolar bone thickness (pre-post) between Class I and Class II subjects at 3mm

Region	Class I		Class II		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.008	0.005	0.020	0.011	-0.012	<0.001*
Palatal	0.009	0.005	0.016	0.012	-0.007	<0.001*
Total	0.538	0.521	0.838	0.422	-0.300	0.001*

Independent t test; * indicates a significant difference at p≤0.05

Graph 7



Comparision of difference in pre and post alveolar bone thickness between class I and class II Subject at 6mm

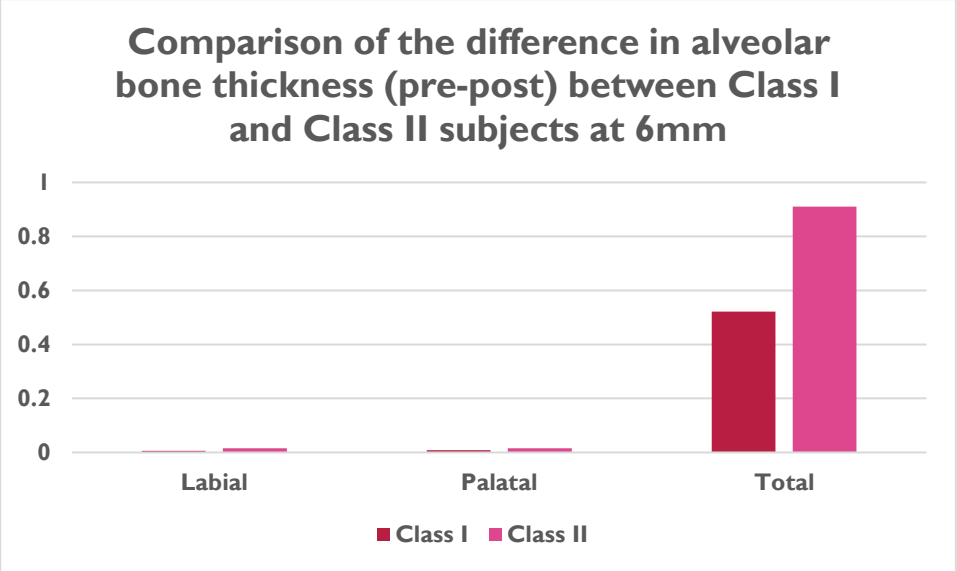
The labial cortical bone was significantly(p=0.001) more reduced in class II than in class I with a difference of (-0.010) similarly the palatal cortical plate was significantly(p-0.001) more reduced with difference of (-0.007) in class II and likewise total alveolar width showed more significant (p=0.001)reduction in class II with a difference of (-0.389) than in class I.(Table 8)(Graph 8)

Table 8.Comparison of the difference in alveolar bone thickness (pre-post) between Class I and Class II subjects at 6mm

Region	Class I		Class II		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.006	0.006	0.016	0.010	-0.010	<0.001*
Palatal	0.009	0.005	0.016	0.012	-0.007	<0.001*
Total	0.522	0.484	0.911	0.370	-0.389	<0.001*

Independent t test; * indicates a significant difference at p≤0.05

Graph 8



Comparision of difference in pre and post alveolar bone thickness between class I and class II Subject at 9mm

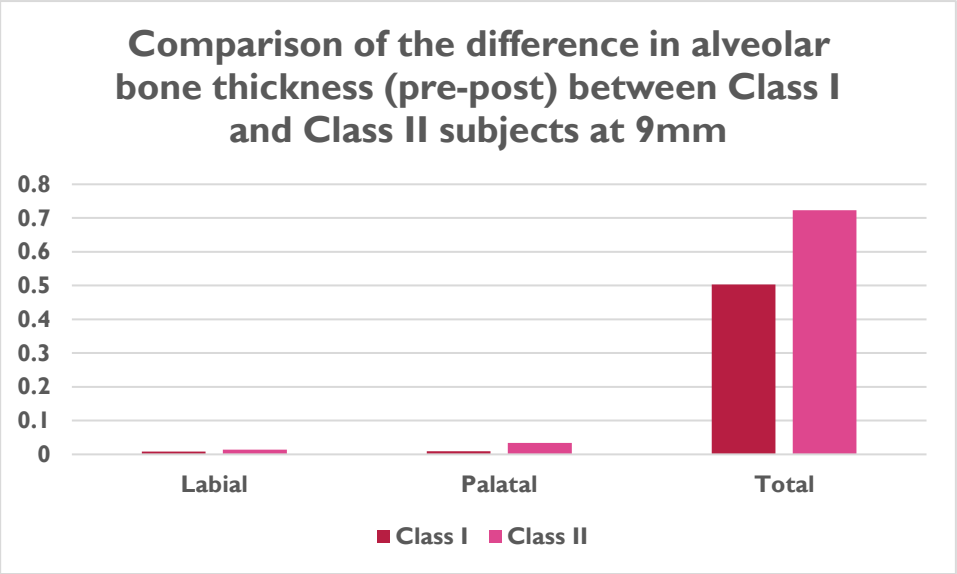
The labial cortical bone was significantly(p=0.001) more reduced in class II than in class I with a difference of (0.006) similarly the palatal cortical plate was significantly(p=0.140) more reduced with difference of (-0.025) in class II and likewise total alveolar width showed more significant (p=0.037)reduction in class II with a difference of (-0.220) than in class I.(Table 9)(Graph 9)

Table 9.Comparison of the difference in alveolar bone thickness (pre-post) between Class I and Class II subjects at 9mm

Region	Class I		Class II		Difference	p-value
	Mean	SD	Mean	SD		
Labial	0.008	0.006	0.014	0.012	0.006	0.001*
Palatal	0.009	0.006	0.034	0.131	-0.025	0.140
Total	0.503	0.455	0.723	0.662	-0.220	0.037*

Independent t test; * indicates a significant difference at p≤0.05

Graph 9



4. DISCUSSION

The main purpose of the study was to compare the total alveolar width and thickness of labial and lingual/palatal cortical plate pre and post levelling and alignment in class I and class II patients.

In order to reduce this force with better torque control, 0.016 x 0.022-inch beta-titanium archwires with multiple loops can be introduced. However, complicated archwire bending, prolonged chair time, and the difficulty of oral hygiene practice must be considered. Therefore, a conventional sequence making use of the NiTi archwire for aligning is inevitable.[10] In our study the superelastic round niti was used for levelling and alignment followed by rectangular niti and finally alignment was completed with 19*25 SS wire.

The dimensions of facial and lingual/palatal aspects of the alveolar process appear to be dependent on the eventual location, the size and inclination of the roots of the erupted teeth.[11,12] According to a study done by Michelle Sendyk Orthodontic treatments that result in pronounced tooth inclinations are considered to be risk factors for dehiscence and fenestration.One possible factor related to these occurrences is the reduced thickness of the alveolar bone around the roots.[13]

However, excessive tooth movement can cause iatrogenic sequelae including root resorption, gingival recession, and alveolar bone loss. Apart from esthetics, periodontal health and the alveolar bone boundaries are important factors in orthodontic treatment

Despite the success of orthodontic treatment in realigning the teeth, this type of treatment can also affect the appearance and thickness of the alveolar bone.[14]

(Traditional radiographic images such as cephalograms, panoramic views, and periapical radiographs are less accurate for evaluating bony architecture. Fuhrmann[15] found that there is a general overestimation of the labial-lingual bone width on lateral cephalograms when compared with physical measurements of the actual specimens, and Wehrbein et al. concluded that iatrogenic bony damage was substantially more pronounced than radiographic and macroscopic evaluations revealed.[16] Since we cannot see the damage, it does not mean it is not there understanding orthodontic treatment-induced

According to study by Abdelshafy Ali Megahed Abdelshaf orthodontic tooth movement is a process whereby the application of a force induces bone resorption on the compression side and bone apposition on the tension side. Moving teeth beyond anatomical limits with orthodontic treatment increases the risk of bone loss and formation of anatomical defects such as dehiscence or fenestration and so this current study was done to compare the bone changes that happens during initial levelling and alignment.[17]

Ghassemian *et al.*values were comparable with the values found in this study.[18] The palatal bone thickness was more at 3mm from CEJ in maxillary anterior region compared to buccal bone thickness which showed a similar result done in the study by S.Rai [19]

Pre levelling and alignment labial cortical bone thickness were in agreement with the result oF study done by S.rai on maxillary anterior cortical bone thickness. The findings were similar to previously described values of buccal thickness by Huynh-Ba *et al.* (2010) who concluded that the mean width of the buccal bony wall was 0.8 mm.[20]

According to study done by Papatpong Phermsang-ngarm[a] and Chairat Charoemratrote on Tooth and bone changes after initial anterior dental alignment using preformed vs customized nickel titanium archwires in adults Decreased bone thickness was observed in both groups.. As the teeth extruded, they moved toward a narrower alveolar bone configuration, leading to decreased bone thickness around the teeth.[21] Changes in the bone thickness were consistent with the observed tooth movement This was in agreement with previous studies that used CBCT to measure bone thickness changes.

In our study the pre levelling total alveolar bone thickness was moire reduced at 3mm distance from CEJ than at 9mm and 6mm from CEJ. Least changes in thickness was seen at 9mm from cej and which was in contradictory to the study done by Udom Thongudomporn said The palatal and total alveolar bone thickness at the midroot and apical levels decreased, but these changes could be considered clinically insignificant.(27) This disagreement may be related to the difference in the way of measurement or to the amount of force applied.

In our study when compared between pre levelling bone thickness and post levelling bone thickness at 3 different level from CEJ that is at 3mm , 6mm, 9mm in class II at all level the post levelling cortical and total alveolar thickness was reduced significantly. The more reduction was seen at 3mm from CEJ. Which is in agreement with the study byOleksandr Kobylyanskyy.[23]

Our observations are consistent with the data of Chaimongkol et al., showing a statistically significant decrease in the thickness of the alveolar bone on the palatal side of the upper incisors at the level of 6–9 mm from the CEJ after proclination.[24]

Recently, Ma et al administered orthodontic treatment to 41 people with healthy periodontal tissue and 40 patients with chronic periodontitis. The results confirmed that the alveolar bone height remained constant, but their alveolar bone density and thickness was significantly reduced. In particular, the extent of the reduction was clearly noticeable in the patients with chronic periodontitis.[25]

5. CONCLUSION

It is concluded from this study that the labial and palatal bone thickness and total alveolar width decreased significantly in class I and class II pt at 3mm 6mm and 9mm from CEJ post levelling and alignment. The decrease in the thickness was more at 3mm than 6 mm and least changes were seen at 9mm.

The thickness of alveolar bone decreased during alignment because while alignment as the teeth extrude they move towards a narrow alveolar bone configuration, leading to decreased bone thickness around the teeth.

It was also concluded from the study that class II patient showed significantly more reduction in thickness compared to class I as class I and class II, muscle activities and typers, maximal isometric bite forces , masticatory efficiencies, and stress directions on temporomandibular joint differ from those in class I subjects. Compared with class I subjects and since jaw bone morphology appears closely related to function , as per the functional matrix hypothesis it is logical that class I and class II may also present with difference in alveolar cortical plate thickness which are similar to that of our study.

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