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ORIGINAL ARTICLE:

COMPARATIVE EVALUATION OF ALVEOLAR BONE THICKNESS IN ANTERIOR REGION IN SKELETAL CLASS I, CLASS II, AND CLASS III MALOCCLUSION USING CBCT- AN IN VIVO COMPARATIVE STUDY

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ABSTRACT:

Background: In orthodontics, the assessment of alveolar bone thickness (ABT) plays a pivotal role in treatment planning and biomechanical considerations. Variations in ABT, especially in the anterior region, have significant clinical implications for patients with different skeletal malocclusions. This study specifically focuses on assessing ABT using Cone Beam Computed Tomography (CBCT) among different sagittal skeletal patterns in maxillary and mandibular anterior regions.

Method: A total of 15 healthy subjects aged 18 years or above were selected based on specific criteria and categorized into 3 groups: Class I, Class II, and Class III malocclusions. CBCT scans were obtained to measure the ABT at 5mm, 8mm, and 10mm from the Cementoenamel Junction (CEJ) on both labial and palatal/lingual sides. Ethical clearance was obtained, and subjects were stratified based on inclusion and exclusion criteria. Statistical analysis was performed using SPSS software.

Outcome of the study: Significant differences in ABT were observed among skeletal malocclusion classes, particularly notable at a 5mm distance from the CEJ. Class I consistently exhibited thicker alveolar bone compared to Class II and III in the palatal region of maxillary anterior teeth and the labial region of mandibular anterior teeth. However, at 8mm and 10mm distances, no significant differences were detected among malocclusion classes in the labial region of maxillary teeth.

Conclusion: The study highlights nuanced variations in ABT among different sagittal skeletal patterns. Contrasting findings emerged compared to previous research, emphasizing the complex nature of alveolar bone morphology. Personalized treatment planning based on individual anatomical characteristics becomes crucial for effective orthodontic interventions, ensuring safer and more tailored patient care.

Keywords: *Alveolar bone thickness, anterior region, Maxillary bone thickness, Mandibular bone thickness, Cone Beam Computed Tomography*

INTRODUCTION

The significance of orthodontics and dentofacial orthopedics lies in their ability to facilitate beneficial alterations in tooth positioning and the underlying bone structure, thereby improving aesthetics, functionality, and overall oral health. The World Health Organization recognizes malocclusion as a substantial concern within the scope of oral health, particularly in children and adolescents, following dental caries and periodontal disease, with its prevalence varying widely. Malocclusions can manifest in different spatial planes, including sagittal, transverse, and vertical. Within the sagittal plane, three distinct skeletal classes are identified using ANB angle, representing the anteroposterior intermaxillary relationship. These classes are associated with varying relationships between the upper and lower jaws, affecting facial aesthetics, masticatory function, and overall well-being.[1]

The alveolar bone, which provides support for dentition, is composed of spongy bone encased in a layer of compact bone, and its dimensions are influenced by factors such as tooth root size, location, and inclination. Understanding the limitations of hard and soft tissues is critical to minimize the risk of complications during orthodontic tooth movement.[2] Proper labial-lingual movement of anterior teeth is imperative for improving the sagittal relationship between the upper and lower dental arches, as it impacts aesthetics and periodontal health.[3]

Of particular importance are skeletal Class II and III malocclusions, which are common in orthodontic patients and have significant implications for facial appearance and overall health. A clear understanding of the limitations in tooth movement is vital, particularly for cases involving severe skeletal discrepancies or orthodontic-surgical interventions.[4]

Excessive retraction or proclination of anterior teeth can lead to various complications, including root absorption, alveolar bone loss, dehiscence, fenestration, and gingival recession. Therefore, evaluating the thickness of the cortical bone is crucial in understanding the forces acting during orthodontic tooth movement.[4]

CBCT has revolutionized the field of dentistry by offering a low-dose radiation alternative for assessing teeth and supporting bone. It allows for accurate measurement of alveolar bone, which is essential for treatment planning in different skeletal malocclusions.[5] This study is designed to assess and compare the alveolar bone thickness at various levels on the labial and lingual/palatal surfaces of upper and lower anterior teeth among patients with varying sagittal skeletal patterns.

METHODOLOGY

The present study aimed to compare ABT in the anterior region among skeletal class I, II, and III patients using CBCT. This in-vivo comparative study was conducted over one year from November 2020 to December 2021 in the Department of Orthodontics and Dentofacial Orthopaedics of a Dental Institute. The sample size of 15 healthy subjects aged 18 years and above was determined using Gpower software based on prior research by **Al-Masri MM et al.**[5] Ethical clearance was obtained from the Institutional Ethical Committee, and subjects were selected through stratified sampling based on inclusion criteria, which included age, complete root apex formation, periodontal health, and mild to moderate crowding.

Exclusion criteria were set to exclude patients under 18 years, those who had undergone previous orthodontic treatment, individuals with a history of facial or jaw trauma, severe medical or dental history, severe facial or dental asymmetries, vertical or horizontal periodontal bone loss, and radiological pathologies of periodontal or endodontic origin. Clinical examinations and lateral cephalograms were used to confirm malocclusion and informed consent was obtained from the patients before performing CBCT.

The study used Newtom and Dentium CBCT equipment to capture images of maxillary and mandibular anterior regions. The ABT was measured on the labial and palatal aspects of the teeth at various distances from the cemento-enamel junction (CEJ). This measurement was performed for individual teeth and averaged for each group of patients with different skeletal malocclusions.

Statistical analysis: Statistical analysis was conducted using SPSS software, and the data were presented systematically in MS Excel. Specific statistical tests were applied to assess the statistical significance of the results, with a p-value less than 0.05 considered significant.

RESULTS

One-way ANOVA test; *significant difference; NS: Non-significant difference. At 5mm in the labial region, a significant statistical difference (p = 0.001) exists among occlusion classes, with mean values of 1.22mm, 0.79mm, and 0.85mm for Class I, II, and III, respectively. Similar pattern is observed in the palatal region, with statistically significant differences (p = 0.001), where Class I has the highest mean value of 2.90mm, followed by Class III (2.35mm) and Class II (1.74mm).

However, at 8mm and 10mm in the labial region, no statistically significant distinctions are found among occlusion classes ($p > 0.05$), indicating comparable measurements. In contrast, in the palatal region at the same distances (8mm and 10mm), statistically significant differences ($p = 0.001$) suggest variations in measurements between occlusion classes. (Table 1)

In the labial region at 5mm, statistically significant differences are evident between Class I and II (0.43, p = 0.001*) and between Class I and III (0.37, p = 0.001*), while no statistical significance is observed in the comparison between Class II and Class III (-0.06, p = 0.662). However, at 8mm and 10mm, no statistically significant differences are discerned among the occlusion classes.

Within the palatal region at 5mm, statistically significant differences are observed between Class I and II (1.16, p = 0.001*), between Class I and III (0.55, p = 0.033*), with no statistical significance between Class II and Class III (-0.61, p = 0.020*). At 8mm and 10mm, significant differences persist across all class pairings (p = 0.001*), with Class I consistently exhibiting higher values compared to Class II and III. (Table 2)

The data presents measurements in millimeters at varying distances from the cementoenamel junction (CEJ) for three occlusion classes: Class I, II, and III. At 5mm, a statistically significant difference (p = 0.007*) is evident among the classes, with mean values of 0.83mm for Class I, 1.85mm for Class II, and 0.54mm for Class III.

Similarly, at 8mm and 10mm, significant differences (p = 0.001*) persist. At 8mm, Class I has the highest mean value (2.34mm), followed by Class II (1.61mm) and Class III (0.97mm). At 10mm, Class I also exhibits the highest mean value (2.68mm), followed by Class II (1.75mm) and Class III (1.66mm). (Table 3)

Significant differences are evident at 5mm, where Class I and Class II show a notable distinction (-1.02, p = 0.032*), indicating a lower mean value for Class I. However, no significant difference is observed between Class I and III (0.29, p = 0.683). A substantial difference is noted between Class II and III (1.31, p = 0.007*), indicating a higher mean value for Class II at 5mm.

At 8mm, significant differences exist between Class I and II (0.73, p = 0.040*) and between Class I and III (1.37, p = 0.001*), with Class I having a higher mean value in both cases. However, no significant difference is observed between Class II and III (0.64, p = 0.077). Moving to 10mm, significant differences persist between Class I and II (0.93, p = 0.002*) and between Class I and III (1.02, p = 0.001*), with Class I consistently exhibiting higher mean values. No significant difference is noted between Class II and III (0.09, p = 0.887) at this distance. (Table 4)

The dataset, comprising millimeter measurements at different distances from the cementoenamel junction (CEJ) for occlusion classes I, II, and III, shows no statistically significant differences at 5mm (p = 0.194), 8mm (p = 0.832), and a suggestive trend at 10mm (p = 0.061). Mean values for Class I, II, and III at 10mm are 3.24mm, 2.45mm, and 2.19mm, respectively. These results suggest comparable measurements among occlusion classes, with no statistically significant differences detected at 5mm and 8mm.(Table 5)

At 5mm, none of the comparisons between occlusion classes exhibit statistically significant differences (p > 0.05), with minimal observed disparities. Likewise, at 8mm and 10mm, all inter-class differences fail to reach statistical significance (p > 0.05), signifying the absence of significant variations in measurements among the classes at these distances. In conclusion, the data implies a lack of statistically significant differences in measurements between occlusion classes at 5mm, 8mm, and 10mm from the cementoenamel junction (CEJ). (Table 6)

TABLES:

Table 1: Overall comparison of average alveolar bone thickness in labial region and palatal region in maxillary anterior teeth among different skeletal malocclusion categories.

Labial region					
Distance from CEJ	**Group**	**N**	**Mean**	**SD**	**p-value**
5mm	Class I	5	1.22	0.06	**0.001***
	Class II	5	0.79	0.18	
	Class III	5	0.85	0.05	
8mm	Class I	5	0.93	0.30	0.817 (NS)
	Class II	5	0.98	0.26	
	Class III	5	0.87	0.20	
10mm	Class I	5	1.30	0.47	0.672 (NS)
	Class II	5	1.15	0.19	
	Class III	5	1.09	0.40	
Palatal region					
5mm	Class I	5	2.90	0.38	**0.001***
	Class II	5	1.74	0.19	
	Class III	5	2.35	0.30	
8mm	Class I	5	3.66	0.40	**0.001***
	Class II	5	2.42	0.20	
	Class III	5	3.00	0.41	
10mm	Class I	5	4.96	0.35	**0.001***
	Class II	5	3.55	0.38	
	Class III	5	3.73	0.52	

One-way ANOVA test; *significant difference; NS: Non-significant difference.

Table 2: Intergroup comparison of average alveolar bone thickness in the labial region and palatal region in maxillary anterior teeth among different skeletal malocclusion categories.

Distance from CEJ	Class I vs Class II		Class I vs Class III		Class II vs Class III	
	Difference	p-value	Difference	p-value	Difference	p-value
Labial region						
5mm	0.43	0.001*	0.37	0.001*	-0.06	0.662
8mm	-0.05	0.955	0.06	0.935	0.11	0.801
10mm	0.15	0.807	0.21	0.662	0.06	0.966
Palatal region						
5mm	1.16	0.001*	0.55	0.033*	-0.61	0.020*
8mm	1.24	0.001*	0.66	0.027*	-0.58	0.055
10mm	1.41	0.001*	1.23	0.002*	-0.18	0.785

Post-hoc Tukey test; * indicates significant difference; NS: Non-significant difference.

Table 3: Overall comparison of average ABT in the labial region in mandibular anterior teeth among different skeletal malocclusion categories.

Distance from CEJ	Group	N	Mean	SD	p-value
5mm	Class I	5	0.83	0.04	0.007*
	Class II	5	1.85	0.94	
	Class III	5	0.54	0.13	
8mm	Class I	5	2.34	0.65	0.001*
	Class II	5	1.61	0.24	
	Class III	5	0.97	0.21	
10mm	Class I	5	2.68	0.07	0.001*
	Class II	5	1.75	0.17	
	Class III	5	1.66	0.51	

One-way ANOVA test; * indicates significant difference.

Table 4: Intergroup comparison of average alveolar bone thickness in the labial region in mandibular anterior teeth among different skeletal malocclusion categories.

Distance from CEJ	Class I vs Class II		Class I vs Class III		Class II vs Class III	
	Difference	p-value	Difference	p-value	Difference	p-value
5mm	-1.02	0.032*	0.29	0.683	1.31	0.007*
8mm	0.73	0.040*	1.37	0.001*	0.64	0.077
10mm	0.93	0.002*	1.02	0.001*	0.09	0.887

Post-hoc Tukey test; * indicates significant difference; NS: Non-significant differenc

Table 5 : Overall comparison of average alveolar bone thickness in the lingual region in mandibular anterior teeth among different skeletal malocclusion categories.

Distance from CEJ	Group	N	Mean	SD	p-value
5mm	Class I	5	1.92	0.10	0.194 (NS)
	Class II	5	1.45	0.60	
	Class III	5	1.44	0.47	
8mm	Class I	5	2.07	0.59	0.832 (NS)
	Class II	5	2.02	0.55	
	Class III	5	1.85	0.64	
10mm	Class I	5	3.24	0.10	0.061 (NS)
	Class II	5	2.45	0.71	
	Class III	5	2.19	0.86	

One-way ANOVA test; NS: Non-significant difference

Table 6: Intergroup comparison of average alveolar bone thickness in the lingual region in mandibular anterior teeth among different skeletal malocclusion categories.

Distance from CEJ	Class I vs Class II		Class I vs Class III		Class II vs Class III	
	Difference	p-value	Difference	p-value	Difference	p-value
5mm	0.47	0.262 (NS)	0.048	0.243 (NS)	0.01	0.998 (NS)
8mm	0.05	0.988 (NS)	0.22	0.829 (NS)	0.17	0.900 (NS)
10mm	0.79	0.175 (NS)	1.05	0.060 (NS)	0.26	0.801 (NS)

Post-hoc Tukey test; NS: Non-significant

DISCUSSION

The study conducted on skeletal Class I, II, and III malocclusions, specifically examining the morphological features of the alveolar bone with vertical and sagittal facial types, yielded noteworthy findings. These malocclusions significantly impact facial aesthetics, masticatory function, and mental health in orthodontic patients. Notably, the research delved into the assessment of maxillary and mandibular ABT in high-angle adults with severe skeletal Class II and III malocclusions using CBCT.

The results obtained from this study indicated significant variations in ABT in the maxillary and mandibular anterior regions across different skeletal patterns. In the overall comparison among Class I, II, and III, intriguing disparities emerged. According to the research conducted by **Eraydın F et al.,**[6] Class III patients have a relatively thin alveolar bone thickness, which may be a risk factor for proclamation. Contrary to previous studies, the ABT was found to be thickest in Class I on the palatal side of the maxillary anterior and thinnest in Class II. On the labial side, however, the ABT was thickest in Class I followed by Class II, and thinnest in Class III, albeit the differences were statistically non-significant.

These findings diverged from studies by **Jing Ma et al**[7], and **Kook et al**[8], which observed thinner alveolar bone in Class III compared to Class II, particularly on the lingual side. Similarly, other studies indicated a relationship between sagittal facial type and jaw morphology, highlighting narrower lingual bone levels in Class III compared to I or II groups.

In the intergroup comparison, notable differences emerged. For instance, between Class I and Class II, significant variations in ABT were observed at different distances from the cementoenamel junction (CEJ) in both maxillary and mandibular anterior. Class I consistently exhibited thicker alveolar bone compared to Class II, emphasizing potential implications for treatment planning in Class II malocclusions necessitating incisor protrusion due to thinner alveolar bone susceptibility to damage.

Comparing Class I with Class III, discrepancies in ABT were evident, especially in the palatal region. Class I consistently showcased thicker alveolar bone than Class III, opposing findings from previous studies by **Chester S. Handelman**,[9] that suggested greater bone levels in Class III than in Class I. Additionally, when comparing Class II with Class III, variations in ABT were noted at different distances from CEJ, primarily in the palatal region of the maxillary anterior and labial region of the mandibular anterior. These findings were aligned with studies indicating greater apical buccal thickness in Class II compared to Class III patients.

These contrasting results from our study compared to previous research underscore the complexity and variability in alveolar bone morphology among different malocclusions. While some findings align with prior studies, discrepancies exist, emphasizing the need for further investigation to comprehensively understand the nuanced relationship between skeletal patterns and alveolar bone thickness, crucial for devising tailored orthodontic treatments.

CONCLUSION

In conclusion, this study represents a significant contribution to the field of orthodontics by shedding light on the intricate relationship between alveolar bone thickness and skeletal malocclusions. The findings underscore the importance of personalized treatment planning and the need for orthodontists to adapt their approaches based on the unique anatomical characteristics of each patient. Ultimately, this knowledge empowers orthodontists to provide more effective and safer orthodontic care, enhancing the overall quality of treatment outcomes and patient satisfaction.

LIMITATIONS

The investigation did not explore potential gender differences in alveolar bone thickness, warranting further gender-specific analyses in future research. A relatively small sample size was employed, underscoring the need for larger and more diverse populations to enhance result accuracy and generalizability. Additionally, although Cone Beam Computed Tomography (CBCT) demonstrated its advantages in assessing alveolar bone thickness, the study emphasized the importance of a thorough evaluation of the risks and benefits associated with routine CBCT use in orthodontic treatment planning. Lastly, the study focused exclusively on bone thickness and did not consider bone density, hence future research is warranted to include assessments of these factors to provide a more comprehensive study of alveolar bone characteristics with implications for orthodontic treatment.

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