Assessment of Alveolar Bone Height in Vietnamese Adults with Bimaxillary Protrusion: A Cone Beam Computed Tomography Study

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Abstract

This study aimed to assess the alveolar bone height of anterior teeth in patients with bimaxillary protrusion.

A total of 130 Vietnamese adults diagnosed with bimaxillary protrusion participated, with a mean age of 22.8 years. Cone beam computed tomography (CBCT) images were utilized to scan the twelve lower and upper anterior teeth, and the alveolar bone height was measured from the cementoenamel junction to the alveolar crest on both the buccal and lingual aspects, parallel to the tooth's long axis.

Significant differences in alveolar bone height were observed between the lingual and labial sides of the lower anterior teeth ($p < 0.001$). No statistically significant differences in alveolar bone height were found between males and females with bimaxillary protrusion ($p > 0.05$). Moreover, no significant differences were detected in the alveolar bone height of the lateral incisors and canines between the hyper-divergent and normo-divergent groups ($p > 0.05$).

In conclusion, this study revealed that the lower incisors exhibited a greater alveolar bone height on the lingual side compared to the labial side. Additionally, no significant distinctions were found in alveolar bone height between males and females. Furthermore, there were no notable differences in alveolar bone height of the lateral incisors and canines between the hyper-divergent and normo-divergent groups.

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Introduction

Bimaxillary protrusion is a characteristic dental and facial feature characterized by the forward positioning of the upper and lower anterior teeth, resulting in increased lip protrusion. This dental and facial pattern is commonly observed in African American and Asian populations, but it can also be found in other ethnic groups.[1,2]

Several authors have conducted studies on patients with bimaxillary protrusion and have observed that the lower incisors exhibit greater alveolar bone height compared to the upper incisors. Specifically, the alveolar bone height on the lingual side of the lower incisors tends to be significantly higher than on the buccal side. However, no significant differences in alveolar bone height have been found between genders or age groups.[3] Nonetheless, it is important to acknowledge that distinct craniofacial characteristics may vary among different ethnic groups.

It has been noted that two-dimensional observations alone may not accurately assess the dental-bone complex and identify bone defects.[4,5] Therefore, three-dimensional imaging is necessary to examine these features.

In recent years, cone beam computed tomography (CBCT) has gained popularity as a valuable tool for obtaining accurate anatomical information and detecting pathological conditions. Its benefits include low radiation dose and high-resolution imaging, making it widely used in dentistry.[6] While several studies have examined

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alveolar bone morphology using CBCT, there is a limited amount of research specifically focusing on alveolar bone height in relation to the anterior teeth in individuals with bimaxillary protrusion, which is a prevalent condition among Asians.[7]

In orthodontic treatment, it is recommended to identify alveolar bone defects before initiating the treatment, as several authors have suggested. These defects are of significant concern because studies have shown that over 50% of the affected teeth already exhibit alveolar bone defects prior to orthodontic intervention.[8] Early detection of these defects is crucial for orthodontists to develop appropriate treatment plans and ensure optimal patient outcomes. Therefore, assessing alveolar bone height is essential in orthodontic practice to enhance treatment planning and optimize treatment outcomes.

There is no published research on the alveolar bone height of anterior teeth in Vietnamese individuals with bimaxillary protrusion. Therefore, the aim of this study was to investigate the alveolar bone height of the anterior teeth using CBCT in a sample of Vietnamese adults with bimaxillary protrusion. Our hypothesis for this study was that there would be no significant difference in the alveolar bone height of the anterior teeth between the maxillary and mandibular, as well as among different genders and facial types.

Materials and methods

Study design and study subjects

This retrospective study was conducted utilizing cone beam computed tomography (CBCT) images. The study population consisted of 130 Vietnamese adults (86 females and 44 males) aged between 18 and 57 years, who had sought orthodontic treatment at the Dental Clinic of the University of Medicine Pham Ngoc Thach. Inclusion criteria included an ANB angle of ≤ 5°, angulation between the upper and lower incisors of ≤ 123°, no previous orthodontic treatment, no head or neck injury, and crowding < 5 mm. Exclusion criteria comprised anterior lower tooth loss, missing or impacted teeth, prosthetic crowns, periapical lesions in the lower anterior teeth, periodontitis-induced bone loss, and craniofacial abnormalities. The research protocol was approved by the medical research ethics committee at the University of Medicine and Pharmacy in Ho Chi Minh City (number 319/DHYD-HDDD).

Sample size calculation

The sample size for this study was determined using the formula n ≥ [1.962 × p × (1 × p)]/d2, where n represents the sample size, the alpha value is 0.05, p is 0.69, the prevalence of bimaxillary alveolar protrusion based on a previous study, and d is 0.08.[2] Based on these calculations, it was determined that a total of 130 subjects would need to be recruited for this study.

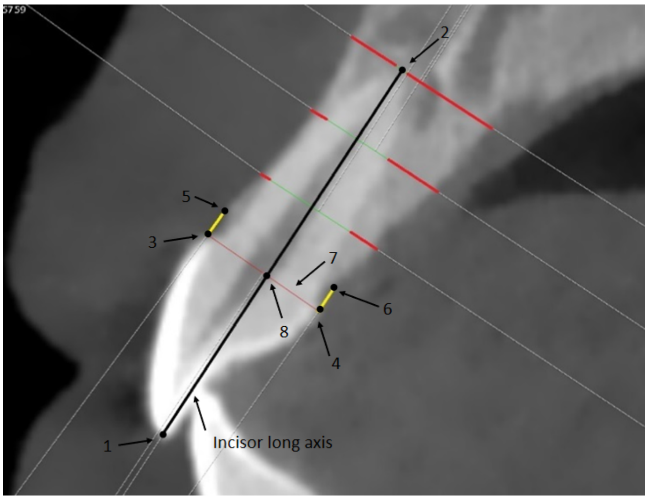

Figure 1. Reference points and measurements for the upper incisors. (1) Incisor edge or canine tip point; (2) root apex point; (3. 4) cementoenamel junction (CEJ) points; (5. 6) alveolar crest points; (7) CEJ line (a line that connects points 3 and 4); (8) intersection point between the long axis (a line from points 1 to 2) and the CEJ line.

CBCT images

A single oral and maxillofacial radiologist performed all CBCT scans and provided consultation on the appropriate CBCT exposure parameters. The CBCT scans were conducted using a NewTom TG machine (Verona, Italy) in accordance with the manufacturer's instructions. The scans covered a field of view (FOV) of 190 × 210 mm and utilized the following parameters: 110 kvp, 6.33 mA, 3.5 s scan time, 0.3 mm^3 isotropic voxel size, and 0.3 mm slice thickness. A total of 1560 teeth from the twelve lower and upper anterior teeth of 130 patients were captured in the CBCT images.

For data analysis, the Digital Imaging and Communications in Medicine (DICOM) format was utilized. Linear measurements were performed by constructing three-dimensional projections of the images using Ondemand3D software (Cybermed, Korea). Measurements were taken from the presumed center where the tooth exhibited the greatest labio-lingual distance.

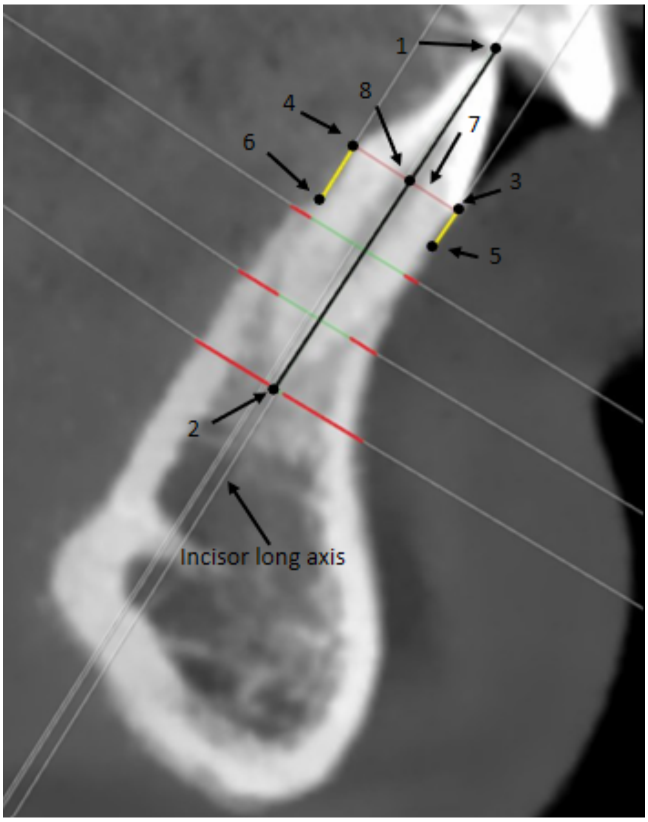

Figure 2. Reference points and measurements for the lower incisors. (1) Incisor edge or canine tip point; (2) root apex point; (3. 4) cementoenamel junction (CEJ) points; (5. 6) alveolar crest points; (7) CEJ line (a line that connects points 3 and 4); (8) intersection point between the long axis (a line from points 1 to 2) and the CEJ line.

Measurements

We followed the method described in a previous study to measure the alveolar bone height.[9] To determine the long axis of the mandibular and maxillary anterior teeth, we connected the distance between the incisor edge or canine tip point and the root apex point. Additionally, the alveolar bone height was measured from the cementoenamel junction to the alveolar crest, parallel to the long axis of the tooth, on both the buccal and lingual aspects. Figure 1 and 2 illustrate the measurement procedure.

Measurement error

Throughout the study, a single operator conducted all CBCT scans using a standardized machine. To ensure precision, a trained examiner meticulously measured all alveolar bone height parameters. To establish measurement reliability, we randomly selected 10 patients and, after a one-month interval, redefined landmarks and re-measured the alveolar bone height of anterior teeth to assess consistency.

Statistical analysis

For all statistical analyses, we utilized R software version 4.1.0. To assess the normality of the data, we employed the Shapiro-Wilk test, and to evaluate the homogeneity of variance, we used Levene's test. If the data were normally distributed with homogeneous variance, we conducted t-tests or analysis of variance (ANOVA) as appropriate. In cases where the data were non-normally distributed, we applied the Mann-Whitney test or Friedman test as appropriate. A significance level of $p < 0.05$ was considered statistically significant. In cases where ANOVA or Friedman tests yielded significant results ($P < 0.05$), we performed the Bonferroni post hoc multiple comparisons test to identify differences between groups.

Results

The alveolar bone height of the anterior teeth (not separated by sex)

The analysis of the lower anterior teeth revealed a significant difference in the alveolar bone height between the lingual and labial sides ($p < 0.001$). Specifically, the alveolar bone height was found to be greater on the lingual side compared to the labial side. On the other hand, the analysis of the upper anterior teeth did not show a statistically significant difference in the alveolar bone height between the labial and lingual sides ($p > 0.05$), as indicated in Table 1.

Differences in the alveolar bone height of the anterior teeth between upper and lower

The findings from Table 2 demonstrate that the measurements of alveolar bone height in the lower jaw were significantly larger than those in the upper jaw, with a high level of statistical significance ($p < 0.001$). This indicates a notable difference in the alveolar bone height between the two jaws.

Differences in the alveolar bone height of the anterior teeth between the sexes.

According to Table 3, the results reveal that there is no statistically significant difference in the alveolar bone height of the incisors between males and females with bimaxillary protrusion ($p > 0.05$).

Differences in the alveolar bone height of the anterior teeth between hyper-divergent and normo-divergent subjects.

In accordance with cephalometric norms specific to the Vietnamese population[10], the Mandibular plane angle is recommended as a determinant for facial types. A Mandibular plane angle of SN-GoGn >33^0 indicates hyper-divergent facial patterns, while a Mandibular plane angle of SN-GoGn between 21.4^0 and 32.2^0 signifies normo-divergent facial patterns. Additionally, a Mandibular plane angle of SN-GoGn <21^0 denotes hypo-divergent facial patterns. In this particular study, the distribution of facial types among the patients was as follows: one patient exhibited a hypo-divergent facial pattern (0.8%), 69 patients displayed normo-divergent facial patterns (53.1%), and 60 patients presented hyper-divergent facial patterns (46.2%). Consequently, the comparison of alveolar bone height was conducted solely between the normo-divergent and hyper-divergent groups.

The research findings indicate that there is no statistically significant difference in the height of the alveolar bone of the lateral incisors and canines between the hyper-divergent group and the normo-divergent group ($p > 0.05$) according to Table 4.

Discussion

In this study, in the upper jaw, the height of the alveolar ridge was smallest for the lateral incisors and largest for the canines. There was no significant difference in the height of the alveolar ridge between the outer and inner sides in the upper anterior teeth group ($p > 0.05$) according to Table 1. This finding is contrary to the study by Nahm KY et al., where the authors found that the height of the alveolar ridge on the outer side was greater than the inner side for the upper incisors.[3]

In the lower anterior teeth, the height of the alveolar bone on the lingual side was consistently greater than the labial side ($p < 0.001$). When comparing the upper and lower jaws, the height of the alveolar bone in the lower anterior teeth group was significantly larger than the upper anterior teeth group, both on the labial and lingual sides ($p < 0.001$) according to Table 1. This finding is consistent with the results of several CBCT studies investigating alveolar bone morphology.[3,11] Kook YA et al. compared the height of the alveolar bone between the Class III malocclusion group and the normal occlusion group, and the results showed that in the Class III malocclusion group, the height of the alveolar bone was larger than in the normal occlusion group, especially in the lingual side. Furthermore, in both groups, the height of the alveolar bone on the lingual side was greater than the labial side, and the lower anterior teeth had a greater alveolar bone height than the upper anterior teeth.[12] Therefore, orthodontists should pay attention to the lower anterior teeth when planning tooth movements, and patients should be informed about the vertical bone resorption status.[12]

Some studies have reported an increase in alveolar bone height in individuals over the age of 30.[13] Advanced age may be a contributing factor to increased alveolar bone height in adults, although the anatomical characteristics of thin labial alveolar bone should also be taken into consideration.[14] In our study, the majority of patients fell within the age range of 18 to 30. Consequently, the average alveolar bone height of the anterior teeth remained within the normal range, except for the lingual alveolar bone height of the lower anterior teeth. When comparing alveolar bone height in the anterior teeth between genders, no statistically significant difference was found between males and females. However, a study on Chinese individuals with Class III malocclusion by Jing W.D. et al. reported a higher prevalence of alveolar bone dehiscence in males.[11]Additionally, previous research has indicated that the association between gender and alveolar bone dehiscence may vary based on ethnicity.[11]

In a study examining modern human cranial remains of Americans of African descent, it was found that males of African descent have a higher susceptibility to alveolar bone dehiscence compared to females of African descent. In contrast, Caucasian males exhibited a lower risk of alveolar bone dehiscence compared to Caucasian females.[15] However, another study conducted on South African black patients did not find a statistically significant difference in the risk of alveolar bone dehiscence between males and females.[16] These findings highlight the complexity of the relationship between gender and alveolar bone dehiscence, which may vary across different populations and ethnicities. Further research is needed to explore the underlying factors contributing to these gender-related differences in alveolar bone morphology and to better understand their clinical implications in diverse populations.

In our study, when comparing the hyper-divergence group and the normo-divergent group, we found no significant difference in alveolar bone height between the lateral incisors and canines in both groups. This finding aligns with the results reported by Evangelista et al., who also found no difference in alveolar bone height among different facial types in Class I and Class II malocclusion groups.[8]

In contrast to our findings, there have been studies that reported contradictory results. Gaffuri et al. found no significant difference in alveolar bone height on the lingual side between the hyper-divergence group and the normo-divergent group, but they did observe a statistically significant difference on the labial side.[17] Additionally, Chung et al. discovered that in patients with Class III malocclusion and a high facial angle, the alveolar bone height was significantly lower compared to patients with Class III malocclusion and an average facial angle.[18] These conflicting findings suggest that there may be variations in alveolar bone height based on different factors such as facial angle and tooth position. It is important to consider these factors when assessing alveolar bone morphology and its implications in orthodontic treatment planning.

Traditional two-dimensional imaging techniques such as periapical, panoramic, and cephalometric films have been historically used to assess the alveolar bone status. However, these methods have limitations as the images are distorted and unclear due to overlapping anatomical structures, making it difficult to accurately measure alveolar bone height especially in lingual and labial sides.[19] Consequently, relying solely on two-dimensional imaging for diagnosing alveolar bone conditions may not provide a comprehensive evaluation of the risks associated with orthodontic treatment.[20,21]

In contrast, cone beam computed tomography (CBCT) offers significant advantages in evaluating alveolar morphology. CBCT provides reliable three-dimensional images that allow for precise assessments of tooth root orientation and comprehensive analysis of the alveolar structure.[22] Numerous studies have demonstrated the accuracy of distance measurements based on CBCT images, highlighting its effectiveness in evaluating and quantifying alveolar bone characteristics with high precision.[23,24] The utilization of CBCT eliminates concerns regarding magnification and overlapping anatomical structures, enabling clinicians to obtain a clear view of the three-dimensional alveolar structure and make precise measurements.

In our study, we employed a large field of view (FOV) to consider craniofacial features, which may have influenced image quality. However, the voxel size used in our measurements was 0.3 mm^3. Previous research has indicated that when assessing alveolar bone height and width, voxel sizes of 0.4 mm^3 are equally accurate as voxel sizes of 0.125 mm^3.[25] This finding aligns with the study conducted by Torres et al., where no significant differences were observed in linear bone measurements among voxel sizes of 0.2, 0.3, and 0.4 mm^{326} Similarly, Sherrard et al. found no significant differences between CBCT-based assessments and gold standard measurements when evaluating root and tooth length using voxel sizes of 0.2, 0.3, and 0.4 mm^3.[27]
The use of CBCT in our study provides reliable and precise measurements of alveolar bone parameters, offering valuable insights into the assessment of alveolar morphology.

Conclusions

Our study found that the lower incisors possess a higher alveolar bone height on the lingual side in comparison to the labial side. Conversely, the upper incisors showed no significant difference in alveolar bone height between the labial and lingual sides. Moreover, the alveolar bone height of the anterior teeth in the lower jaw was greater than that of the upper jaw. We also observed that there was no notable discrepancy in alveolar bone height between males and females. Notably, among individuals with hyper-divergent facial patterns, the upper central incisors exhibited a greater alveolar height on the labial side in comparison to those with normo-divergent facial patterns. Similarly, among individuals with hyper-divergent facial patterns, the lower central incisors displayed a greater alveolar height on the lingual side in comparison to those with normo-divergent facial patterns.

Declaration of Interest

The authors have no conflicts of interest relevant to this article.

Position		Central incisors (n = 260)		Lateral incisors (n = 260)		Canines (n = 260)		P^{*}	Post hoc analysis P^{***}		
		Mean ± SD	Median	Mean ± SD	Median	Mean ± SD	Median		Central incisors vs. lateral incisors	Central incisors vs. canines	Lateral incisors vs. canines
Upper	Labial	1.44±0.54	1.34	1.6±0.53	1.5	1.89±0.64	1.81	<0.001	0.304	<0.001	0.004
	Lingual	1.53±0.49	1.41	1.53±0.56	1.46	1.57±0.54	1.5	0.718	1	0.811	1.000
	P^{**}	0.112		0.252		<0.001					
Lower	Labial	2.36±5.49	1.8	1.95±0.96	1.77	2.22±0.74	2.06	<0.001	1	1	0.011
	Lingual	2.22±0.71	2.04	2.18±0.65	2.12	1.85±0.68	1.72	<0.001	1	<0.001	<0.001
	P^{**}	<0.001		<0.001		<0.001					

Table 1. The alveolar bone height of anterior teeth in maxillary and mandible.
*Friedman test; **Friedman test; ***group comparisons with the post hoc Bonferroni test; SD: standard deviation.

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