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A retrospective study on the relationship between alveolar-bone morphology at the mandibular incisors and their inclination in adults with low-angle, skeletal class III malocclusion

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***Abstract*---**Background and Aim: The orthodontic tooth movements should be such that the tooth moves safely within the alveolar bone. The alveolar bone around the mandibular central incisors of patients with skeletal class I and II malocclusion is thicker in comparison to those with skeletal class III malocclusion. The present study aimed to investigate an association between low angle inclination skeletal class-III malocclusion and the alveolar bone morphology around it. Materials and Methods: A retrospective study was carried out on 75

malocclusion patients in the Orthodontics Department of a Tertiary Care Hospital of Islamabad, Pakistan from January 2020 to December 2022. The malocclusions were confirmed in the patients via cone beam computed tomography (CBCT) imaging. The low angle, skeletal class III malocclusions were categorized into three different groups: Group-I (lingual-inclination), Group-II (upright), and Group-III (labial-inclination). Outcomes such as height of alveolar bone and area of cortical as well as cancellous thickness were determined independently on each side. Results: The labial cancellous bone thickness, thickness of labial cortical bone, alveolar bone total thickness, labial alveolar bone total area, and labial alveolar bone height were highest in group-III (labial-inclination). There was a positive correlation between mandibular central incisors and other aforementioned variables. Regarding the teeth's 'lingual side', there were no significant differences between all three groups. Conclusion: The present study found that the skeletal class III malocclusion of low-angle labial inclination category was significantly associated with alveolar bone morphology on the mandibular central incisor's labial aspect.

***Keywords*---**malocclusion, alveolar bone loss, cone-beam computed tomography, labial inclination.

Introduction

In oral disease diagnosis, Cone beam computed tomography (CBCT) has been a predominant evaluation method to assess the morphology of the alveolar bone. Numerous investigations have measured the height or else the thickness of alveolar bone by CBCT with no association of any evident reference value which can be rendered as a gold standard for direct physical measurement of bone and CBCT parameters together [1, 2]. The significant displacement of the mandibular central incisor is necessary for the typical treatment required to alleviate the consequences of a skeletal class III malocclusion. In orthodontic tooth movement, the alveolar bone remodels by deposition of bone at the tension side and resorption of it at the pressure side [3]. Nonetheless, studies have discovered unfavorable consequences such as alterations in the overall alveolar bone thickness, fenestration and dehiscence in patients receiving various orthodontic treatment procedures [4, 5]. Therefore, the adequate assessment of the morphology of alveolar bone is very critical prior to the orthodontic treatment initiation i.e. at the diagnosis making stage. Alveolar bone abnormalities such as fenestration and dehiscence are examples of inadequate bone boundary conditions found out while conducting qualitative assessment of the morphology of the alveolar bone present around the teeth [6]. In a study, the prevalence of fenestration and dehiscence was calculated to be 12% among maxillary central incisors prior to the starting of the orthodontic treatment irrespective of absence of any attachment loss [7]. The optimum locality for the maximum root-alveolar bone connection has been seen to be the alveolar bone centre as per the literature search. Numerous studies have found different variations in the alveolar bone-

root position in regards to the maxillary central incisors and it was shown that the ideal sagittal location of the root was more prone to be on the labial side [8, 9]. A recent study mainly focused on the alveolar bone thickness as observed prior and during the orthodontic treatment. The investigations therein measured that majority of the cases failed to differentiate between properly deposited either cancellous bone or cortical bone. Two-dimensional X-ray imaging has historically been used to assess the shape of the alveolar bone, albeit this examination is confined to the area surrounding the anterior teeth mainly. Previous studies have discretely shown that the individuals with malocclusion of skeletal class III type had a thinner alveolar bone with peculiarly malocclusion to be offset to a low-angle [10-12]. The purpose of the present study was to assess an association between low-angle skeletal class III malocclusion inclinations with alveolar bone morphology in adults.

Methodology

A retrospective study was carried out on 75 malocclusion patients in the Orthodontics Department of a Tertiary Care Hospital of Islamabad, Pakistan from January 2020 to December 2022. The malocclusions were confirmed in the patients via cone beam computed tomography (CBCT) imaging. The low angle, skeletal class III malocclusions were categorized into three different groups: Group-I (lingual-inclination), Group-II (upright), and Group-III (labial-inclination). Outcomes such as height of alveolar bone and area of cortical as well as cancellous thickness were determined independently on each side. A sample size of 75 (1:1:1) group allocation ratio was selected to provide more than 80% power to the study so as to detect any significant differences between the three groups with a 0.524 effect size at the 0.05 significance level. All the participants of the study were between 16 and 35 years of age from either gender with following inclusion criteria: Skeletal class III malocclusion (-4˚≤, ANB ≤1˚), MP-FH < 28˚, no prior orthodontic treatment history, development of complete root and no cleft lip asymmetry evidence. The categorization of patients in the three groups is shown in Table-I.

Table-I: Patients' categorization in different groups

Groups	Number of cases
Group-I (lingual-inclination) L1-MP < 85.6˚	25 cases
Group-II (upright) L1-MP 85.6˚–99.6˚	25 cases
Group-III (labial-inclination) L1-MP > 99.6˚	25 cases

Statistical Package for Social Sciences (SPSS) version 27 was used for statistical analysis of the data. Means and standard deviations were used to express variables having a normal distribution. The alveolar bone height, thickness, and area of mandibular central incisor were matched using variance of one-way analysis. To analyze systematic and random errors, paired t-tests were used, and intra-class correlation coefficients (ICCs) were obtained. *p*-value of ≤0.05 was considered to be statistically significant.

Results

The labial cancellous bone thickness, thickness of labial cortical bone, alveolar bone total thickness, labial alveolar bone total area, and labial alveolar bone height were highest in group-III (labial-inclination). There was a positive correlation between mandibular central incisors and other aforementioned variables. Regarding the teeth's 'lingual side', there were no significant differences between all three groups. Table-II represents the thickness of cortical bone as compared in the three groups. Thickness of cancellous bone compared between the three groups is shown in Table-III. Table-IV represents the thickness of the overall alveolar bone as compared in three groups whereas area of alveolar bone as compared between the three groups is shown in Table-V.

Table-II: Comparison of thickness (mm) of cortical bone among the three groups

Side and Position	Group-I (n=25)	Group-II (n=25)	Group-III (n=25)	*p*-value
Labial				
3 mm below CEJ	0.63±0.29	0.76±0.19	0.79±0.21	0.219
6 mm below CEJ	0.45±0.19	0.70±0.29	0.97±0.41	<0.001
9 mm below CEJ	0.86±0.32	1.26±0.49	1.59±0.69	0.001
At root apex	1.41±0.35	1.66±0.43	2.01±0.41	<0.001
Lingual				
3 mm below CEJ	0.89±0.39	0.73±0.27	1.02±0.49	0.121
6 mm below CEJ	1.79±0.59	1.48±0.50	1.67±0.59	0.129
9 mm below CEJ	2.51±0.62	2.20±0.44	2.28±0.57	0.342
At root apex	2.59±0.36	2.66±0.51	2.69±0.51	0.826

Table-III: Comparison of thickness (mm) of cancellous bone in the three groups

Side and Position	Group-I (n=25)	Group-II (n=25)	Group-III (n=25)	*p*-value
Labial				
3 mm below CEJ	0	0.02±0.08	0	0.129
6 mm below CEJ	0	0.06±0.21	0	0.067
9 mm below CEJ	0.41±0.46	0.29±0.51	0.67±0.59	0.059
At root apex	1.31±0.49	0.06±0.19	2.87±127	<0.001
Lingual				
3 mm below CEJ	0	0	0	-
6 mm below CEJ	0.15±0.21	0.26±0.29	0.17±0.32	0.683
9 mm below CEJ	1.20±0.73	0.99±0.49	1.19±0.76	0.599
At root apex	2.79±1.22	3.41±0.72	2.79±0.79	0.143

Table-IV: Comparison of the overall thickness (mm) of alveolar bone in the three groups

	Group-I (n=25)	Group-II (n=25)	Group-III (n=25)	*p*-value
3 mm below CEJ	6.79±0.32	6.92±0.55	7.11±0.44	0.072
6 mm below CEJ	7.09±1.04	7.11±1.02	7.69±0.79	0.077
9 mm below CEJ	7.10±1.01	7.89±1.58	8.11±3.12	0.0921
At root apex	8.13±1.83	7.99±1.59	10.49±1.69	0.001

Table-V: Comparison of area (mm^2) of alveolar bone in all the groups

Side	Group-I (n=25)	Group-II (n=25)	Group-III (n=25)	*p*-value
Labial				
Alveolar bone total area	8.19±1.79	13.62±5.09	15.95±2.89	<0.001
Cortical bone area	6.62±1.89	10.79±4.59	13.22±2.09	<0.001
Cancellous bone area	1.59±0.98	2.69±2.79	3.32±2.24	0.062
Lingual				
Alveolar bone total area	21.89±9.45	23.89±6.69	22.69±7.12	0.642
Cortical bone area	17.78±7.59	17.34±4.62	17.31±5.83	0.929
Cancellous bone area	5.66±3.95	7.69±4.39	5.62±3.89	0.152

Discussion

The present study mainly focused on the association of skeletal class III malocclusion with alveolar bone morphology retrospectively and it was found that skeletal class III malocclusion of low-angle labial inclination type was significantly associated with alveolar bone morphology's various parameters particularly those present on the incisor's labial side. In order to obtain a more desirable face form and bite in individuals who are undergoing decompensation therapy to overcome malocclusion of skeletal class III type, the frequent relocation of mandibular central incisors is done. Research has indicated that iatrogenic complications are commonly caused by excessive orthodontic tooth movements [13].

It is not practically possible to carry out a CBCT on every patient in a clinical scenario due to cost bearing issues. The present study found that the skeletal class III malocclusion (group-III) patients had a higher value of both height and area of alveolar bone on the labial side of the mandibular central incisors as compared to their lingual side. These findings are consistent with those of Tian et al., who found such similar results. Due to closeness of the root of the mandibular central incisor towards the labial side, the alveolar bone thickness was less there as compared to the tooth's lingual side [14].

The cortical bone thickness and the overall area of the alveolar bone as found on the mandibular central incisors' labial side had higher values in group-III than group-I and group-II both. Casanova-Sarmiento et al. reported that the labial side had higher correlation values than the lingual side during tooth's labial inclination while changes also do take place in its associated alveolar bone's angulations and inclination as well [15]. In another study, contradictory results were found where the alveolar bone thickness had similar values for both the labial and lingual sides due to human skeleton's physiological adjustment protocols [16].

Similarly, the mandibular central incisor's thickness of alveolar bone had a significant association with the tooth's labial inclination which is comparable to the findings of Morais et al. [17]. Another study conducted by Fuhrmann et al. reported a negative association between the thickness of the alveolar bone at root apex and the labial inclination of varying degrees of mandibular central incisor [18].

The majority of the teeth experience a complicated displacement during any orthodontic treatment causing their long-term stability favored by basal bone centre shift that comes from the mandibular central incisors [19]. The labial inclination of the mandibular central incisors in the orthodontic tooth movement is relatively effective, safe and simple as compared to their lingual inclination. The accuracy of simple radiography imaging was found to be lower in terms of alveolar bone shape determination surrounding the anterior teeth [20, 21]. In contrast, the alveolar bone's lingual and labial sides could be more effectively and accurately measured with the aid of a CBCT image which makes better illustration of the bone's super positioning and the associated tooth deformation display as well [22].

Conclusion

The present study found that the skeletal class III malocclusion of low-angle labial inclination category was significantly associated with alveolar bone's morphological parameters peculiarly those on the mandibular central incisor's labial aspect. To avoid the creation of any untoward response during orthodontic treatments, the physicians should analyze the alveolar bone's morphological properties prior to the treatment's initiation for individuals with malocclusions.

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