ORIGINAL ARTICLE

# Evaluation of Alveolar Bone Thickness Around the Incisors in Various Skeletal Patterns: A Cephalometric Study

Deepankar Bhatnagar[1], Harjoy Khatria[2]

*Received on*: 28 September 2023; *Accepted on*: 01 December 2023; *Published on*: 30 December 2023

## Abstract

**Context:** The major motivation for patients to get orthodontic treatment is the unesthetic placement of incisors. Therefore, correction of these anterior teeth is of prime importance along with their position in the alveolar housing during treatment planning.

**Aim:** This study aimed to evaluate the alveolar bone thickness around the incisors in various skeletal patterns.

**Materials and methodology:** A total of 128 lateral cephalograms of patients visiting the department were traced and divided into four groups ($n$ = 32) based on the sagittal relationship including class I with a bimaxillary protrusion, class II division 1, class II division 2, and class III. The total root length, incisor inclinations, and labial and palatal alveolar bone at the middle and apex of maxillary and mandibular central incisors were measured and subject to statistical analysis using the statistical package for the social sciences (SPSS), version 25, software.

**Results:** According to the analysis of variance (ANOVA) and *post hoc* Tukey honestly significant difference (HSD) tests, there were significant differences between groups in alveolar bone widths of maxillary central incisors at apex and middle. While no significant difference was seen in the case of the middle of mandibular central incisor roots, the alveolar bone width was found to be significant in intergroup comparison at the apex. The inclination of incisors was also significantly different between the groups.

**Conclusion:** The current study showed the dental compensation by central incisors in various sagittal patterns. The palatal bone in maxillary incisors was thinner in class I and class II division 1 due to proclination while the labial bone was thinner in incisors of class II division 2 and mandibular incisors in class III.

**Keywords:** Alveolar bone width, Anteroposterior relationship, Dental compensations, Incisor inclination.

*Dental Journal of Advance Studies* (2023): 10.5005/djas-11014-0027

## Highlights

The study provides insight into the amount of alveolar bone covering the roots of incisors to allow the orthodontist to plan the treatment accordingly and avoid any ill effects of contacting the roots with the cortical bone of the alveolar housing.

## Introduction

Anterior teeth are the key consideration in the line of diagnosis and treatment planning for the orthodontist. Even for patients the prime focus is the front teeth in the chief complaints regardless of any other malocclusion and deformities.[1]

Teeth are surrounded by the alveolar bone, the severity of which, predicts the amount of tooth movement that can be brought about orthodontically.[2] Movement of the tooth outward will lead to bone loss, and traumatized placement; optimized positioning of the teeth is of paramount importance for functional stability and esthetics.[3–6]

Class II malocclusion is the most prevalent malocclusion in the northern part of India with proclination of maxillary incisors being the major concern.[7] During retraction, it is imperative that the position and inclination of incisor roots be well within the cancellous bone and never in proximity to the cortical bone.[8,9]

Although few studies have been carried out to determine the position of incisors within the alveolus, the effect of malocclusion and ethnicity factors is yet to be investigated. This can be done using lateral cephalograms which are a convenient and cost-effective technique to study skeletal and dentoalveolar patterns.[4,10,11]

[1]Department of Orthodontics, Maharishi Markandeshwar College of Dental Sciences and Research, Mullana-Ambala, Haryana, India

[2]Department of Orthodontics and Dentofacial Orthopedics, Maharishi Markandeshwar College of Dental Sciences and Research, Mullana-Ambala, Haryana, India

**Corresponding Author:** Deepankar Bhatnagar, Department of Orthodontics, Maharishi Markandeshwar College of Dental Sciences and Research, Mullana-Ambala, Haryana, India, Phone: +91 8847245115, e-mail: deepankarbhatnagar101@gmail.com

**How to cite this article:** Bhatnagar D, Khatria H. Evaluation of Alveolar Bone Thickness Around the Incisors in Various Skeletal Patterns: A Cephalometric Study. Dent J Adv Stud 2023;11(3):116–123.

**Source of support:** Nil

**Conflict of interest:** None

Hence, our study aims to determine the thickness of alveolar bone around maxillary and mandibular incisors in various skeletal patterns in the North Indian population.

## Materials and Methodology

### Sample Size

A sample size estimation was done using OpenEpi Software, version 3. At a confidence interval of 95% and power of 80%, the minimum sample required was 31 for each group with a total of 124 samples.

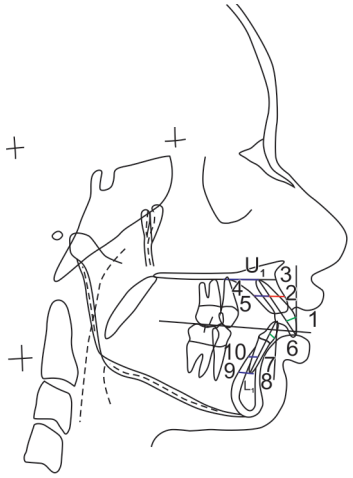


**Fig. 1:** Linear and angular measurements taken on the tracing of lateral cephalogram. U1, maxillary central incisor; L1, mandibular central incisor; 1, inclination of U1; 2, U1 labial middle; 3, U1 labial apex; 4, U1 palatal apex; 5, U1 palatal middle; 6, inclination of L1; 7, L1 labial mid; 8, L1, labial apex; 9, L1 lingual apex; 10, L1 lingual middle

## Sample/Patient Selection

In this retrospective study, lateral cephalograms of 128 patients visiting the department were traced using 3H pencil and acetate paper.

*Inclusion Criteria*

- A full set of erupted teeth.
- Age range of 18–25 years.
- No previous Orthodontic treatment.

*Exclusion Criteria*

- Severe crowding of teeth.
- History of trauma or pathology.
- Periodontally compromised patients.

Based on the anteroposterior jaw relationship and incisor inclination, the sample was divided into the following four groups:

- Group I – *n* = 32; Class I with bimaxillary protrusion
- Group II – *n* = 32; Class II division 1
- Group III – *n* = 32; Class II division 2
- Group IV – *n* = 32; Class III

The structures marked on the cephalogram were the maxilla, mandibular symphysis, maxillary and mandibular central incisors; first molars along with the occlusal plane; and incisal long axis. The following measurements were taken (Figs 1 and 2):

- Total root length: It was measured to calculate the center of root length to evaluate the labial and palatal bone width at the middle.
- Inclination of maxillary (U1) and mandibular (L1) central incisors.
- Alveolar bone width labial (U1 lab apex) and palatal (U1 pal apex) at the apex of the root of maxillary central incisors.
- Alveolar bone width labial (U1 lab middle) and palatal (U1 pal middle) at the middle of root of maxillary central incisors.
- Alveolar bone width labial (L1 lab apex) and palatal (L1 pal apex) at the apex of the root of mandibular central incisors.
- Alveolar bone width labial (L1 lab middle) and palatal (L1 pal middle) at the middle of root of mandibular central incisors.

**Fig. 2:** Lateral cephalogram showing the linear and angular measurements. 1, inclination of U1; 2, U1 labial middle; 3, U1 labial apex; 4, U1 palatal apex; 5, U1 palatal middle; 6, inclination of L1; 7, L1, labial middle; 8, L1, labial apex; 9, L1, lingual apex; 10, L1 lingual middle

The measurements for all four groups were tabulated and subject to statistical analysis using the statistical package for the social sciences (SPSS), version 25, software (SPSS, Inc., PASW statistics for Windows, version 25, Chicago, USA). Analysis of variance test was used to determine the means and standard deviations of different variables in all four groups along with their significance (*p*-value). The *post hoc* Tukey honestly significant difference (HSD) tests were used to analyze significant intergroup comparisons of the variables.

## Results

- U1 at apex: U1 lab apex was significantly increased in group I as compared to group III (0.002) and group IV (0.008), and group II was significantly increased than group III (0.020). While the opposite was true for values of U1 pal apex (Tables 1 and 2).
- U1 at middle: While no significant intergroup difference was observed for U1 lab middle, the alveolar width was significantly increased in group IV (0.020) than in group I (Tables 1 and 2).
- L1 at apex: The value for L1 lab apex was significantly increased in group III as compared to group II (0.011) and group IV (0.000). Also, group I showed a significant difference (0.035) in L1 lab apex than group IV whereas the intergroup difference between the values of L1 pal apex was not significant (Tables 1 and 2).
- L1 at middle: No significant difference was found in intergroup comparison for L1 Lab middle and L1 Pal middle values (Tables 1 and 2).
- Incisal inclination: The upper central incisor showed highly significant (0.000) proclination in groups I, II, and IV as compared to group III. The inclination of the lower central incisor was significantly increased in group I (0.000) and group II as compared to group III (0.004) and group IV (0.003) (Tables 1 and 3).

## Discussion

Skeletal discrepancies in adult patients can be managed through two main treatment options usually by orthodontic camouflage or in combination with orthognathic surgery. Patients who are reluctant to surgery have to be treated by orthodontic camouflage where compensation of maxillary and mandibular teeth is done to

**Table 1:** Means of values obtained for variables in all four groups

| *Dependent variable* | *Group* | *N* | *Mean* | *Standard deviation* | *Significance* |
|---|---|---|---|---|---|
| U1_Labial_mid | Group I | 32 | 5.2969 | 1.45834 | 0.634 |
| | Group II | 32 | 5.2031 | 1.33114 | |
| | Group III | 32 | 5.0625 | 1.38395 | |
| | Group IV | 32 | 4.8750 | 1.31370 | |
| U1_Labial_apex | Group I | 32 | 7.9531 | 2.72491 | 0.000** |
| | Group II | 32 | 7.4844 | 2.93611 | |
| | Group III | 32 | 5.6813 | 2.24103 | |
| | Group IV | 32 | 5.9688 | 1.70832 | |
| U1_Palatal_mid | Group I | 32 | 7.1406 | 1.85017 | 0.018* |
| | Group II | 32 | 7.4063 | 2.17922 | |
| | Group III | 32 | 8.0156 | 2.21244 | |
| | Group IV | 32 | 8.6250 | 1.77800 | |
| U1_Palatal_apex | Group I | 32 | 9.1250 | 2.57782 | 0.000** |
| | Group II | 32 | 9.8219 | 3.25514 | |
| | Group III | 32 | 11.9219 | 2.97329 | |
| | Group IV | 32 | 11.2188 | 2.10199 | |
| L1_Labial_mid | Group I | 32 | 4.1875 | 1.19643 | 0.105 |
| | Group II | 32 | 4.2344 | 2.20697 | |
| | Group III | 32 | 4.4531 | 1.03456 | |
| | Group IV | 32 | 3.5938 | 0.94560 | |
| L1_Labial_apex | Group I | 32 | 6.3125 | 1.75862 | 0.000** |
| | Group II | 32 | 5.6719 | 2.33352 | |
| | Group III | 32 | 7.1875 | 2.18037 | |
| | Group IV | 32 | 5.0000 | 1.19137 | |
| L1_Palatal_mid | Group I | 32 | 4.9688 | 1.48072 | 0.094 |
| | Group II | 32 | 4.4063 | 1.26004 | |
| | Group III | 32 | 4.5469 | 1.13847 | |
| | Group IV | 32 | 4.2031 | 1.04619 | |
| L1_Palatal_apex | Group I | 32 | 4.7906 | 1.61632 | 0.070 |
| | Group II | 32 | 3.8594 | 1.31514 | |
| | Group III | 32 | 4.5938 | 1.53685 | |
| | Group IV | 32 | 4.0625 | 1.86110 | |
| U1_Inclination | Group I | 32 | 39.5000 | 5.89149 | 0.000** |
| | Group II | 32 | 39.5000 | 9.50042 | |
| | Group III | 32 | 12.7813 | 7.19648 | |
| | Group IV | 32 | 35.3438 | 6.07273 | |
| L1_Inclination | Group I | 32 | 27.9375 | 7.94715 | 0.000** |
| | Group II | 32 | 25.5625 | 7.95121 | |
| | Group III | 32 | 18.4219 | 8.50911 | |
| | Group IV | 32 | 18.0938 | 8.85496 | |
| | Total | 128 | 22.5039 | 9.30361 | |

*Significant when *p*-value ranges 0.01–0.05; **Highly significant when $p < 0.01$

overcome skeletal disharmony. However, the position of the root apex housed in the alveolar bone needs to be thoroughly studied to explain its proximity to the cortical bone. Quite a few studies use lateral cephalogram for evaluating the alveolar bone since it is economical, effortless, and easily available.[4,5,11–15]

Furthermore, Nayak et al. found similar results of reduced lingual bone of all incisors.[14] Rojo–Sanchis J et al. conducted a systematic review and meta-analysis on the effect of modifying factors on facial alveolar bone thickness and reported that the bone overlying the anterior teeth is generally very thin typically in females and those over 50 years of age.[16] Hence, any contact with the cortical bone during treatment may bring about iatrogenic damage. These may include root resorption, bone loss, and periodontal problems such as dehiscence and fenestrations. Additionally, tooth movement may also be hampered. Therefore, it becomes imperative to determine the position of incisors in the alveolus to diagnose and plan treatment for various skeletal malocclusions. The current study was undertaken to establish and

**Table 2:** Comparison of labial and palatal alveolar bone thickness around roots of maxillary central incisor (U1) and mandibular central incisor (L1) among groups

| *Dependent variable* | *Groups* | *Groups* | *Mean difference* | *Standard error* | *Significance* |
|---|---|---|---|---|---|
| U1_Labial_mid | Group I | Group II | 0.09375 | 0.34323 | 0.993 |
| | | Group III | 0.23438 | 0.34323 | 0.903 |
| | | Group IV | 0.42188 | 0.34323 | 0.610 |
| | Group II | Group I | −0.09375 | 0.34323 | 0.993 |
| | | Group III | 0.14063 | 0.34323 | 0.977 |
| | | Group IV | 0.32813 | 0.34323 | 0.775 |
| | Group III | Group I | −0.23438 | 0.34323 | 0.903 |
| | | Group II | −0.14063 | 0.34323 | 0.977 |
| | | Group IV | 0.18750 | 0.34323 | 0.947 |
| | Group IV | Group I | −0.42188 | 0.34323 | 0.610 |
| | | Group II | −0.32813 | 0.34323 | 0.775 |
| | | Group III | −0.18750 | 0.34323 | 0.947 |
| U1_Labial_apex | Group I | Group II | 0.46875 | 0.61220 | 0.870 |
| | | Group III | 2.27187* | 0.61220 | 0.002 |
| | | Group IV | 1.98438* | 0.61220 | 0.008 |
| | Group II | Group I | −0.46875 | 0.61220 | 0.870 |
| | | Group III | 1.80312* | 0.61220 | 0.020 |
| | | Group IV | 1.51563 | 0.61220 | 0.069 |
| | Group III | Group I | −2.27187* | 0.61220 | 0.002 |
| | | Group II | −1.80312* | 0.61220 | 0.020 |
| | | Group IV | −0.28750 | 0.61220 | 0.966 |
| | Group IV | Group I | −1.98438* | 0.61220 | 0.008 |
| | | Group II | −1.51563 | 0.61220 | 0.069 |
| | | Group III | 0.28750 | 0.61220 | 0.966 |
| U1_Palatal_mid | Group I | Group II | −0.26563 | 0.50355 | 0.952 |
| | | Group III | −0.87500 | 0.50355 | 0.309 |
| | | Group IV | −1.48438* | 0.50355 | 0.020 |
| | Group II | Group I | 0.26563 | 0.50355 | 0.952 |
| | | Group III | −0.60938 | 0.50355 | 0.622 |
| | | Group IV | −1.21875 | 0.50355 | 0.079 |
| | Group III | Group I | 0.87500 | 0.50355 | 0.309 |
| | | Group II | 0.60938 | 0.50355 | 0.622 |
| | | Group IV | −0.60938 | 0.50355 | 0.622 |
| | Group IV | Group I | 1.48438* | 0.50355 | 0.020 |
| | | Group II | 1.21875 | 0.50355 | 0.079 |
| | | Group III | 0.60938 | 0.50355 | 0.622 |
| U1_Palatal_apex | Group I | Group II | −0.69688 | 0.69033 | 0.744 |
| | | Group III | −2.79688* | 0.69033 | 0.001 |
| | | Group IV | −2.09375* | 0.69033 | 0.015 |
| | Group II | Group I | 0.69688 | 0.69033 | 0.744 |
| | | Group III | −2.10000* | 0.69033 | 0.015 |
| | | Group IV | −1.39687 | 0.69033 | 0.185 |
| | Group III | Group I | 2.79688* | 0.69033 | 0.001 |
| | | Group II | 2.10000* | 0.69033 | 0.015 |
| | | Group IV | 0.70313 | 0.69033 | 0.739 |
| | Group IV | Group I | 2.09375* | 0.690330 | 0.015 |
| | | Group II | 1.39687 | 0.69033 | 0.185 |
| | | Group III | −0.70313 | 0.69033 | 0.739 |

*(Contd...)*

**Table 2:** *(Contd...)*

| *Dependent variable* | *Groups* | *Groups* | *Mean difference* | *Standard error* | *Significance* |
|---|---|---|---|---|---|
| L1_Labial_mid | Group I | Group II | −0.04688 | 0.35940 | 0.999 |
| | | Group III | −0.26563 | 0.35940 | 0.881 |
| | | Group IV | 0.59375 | 0.35940 | 0.354 |
| | Group II | Group I | 0.04688 | 0.35940 | 0.999 |
| | | Group III | −0.21875 | 0.35940 | 0.929 |
| | | Group IV | 0.64063 | 0.35940 | 0.287 |
| | Group III | Group I | 0.26563 | 0.35940 | 0.881 |
| | | Group II | 0.21875 | 0.35940 | 0.929 |
| | | Group IV | 0.85938 | 0.35940 | 0.084 |
| | Group IV | Group I | −0.59375 | 0.35940 | 0.354 |
| | | Group II | −0.64063 | 0.35940 | 0.287 |
| | | Group III | −0.85938 | 0.35940 | 0.084 |
| L1_Labial_apex | Group I | Group II | 0.64063 | 0.47944 | 0.542 |
| | | Group III | −0.87500 | 0.47944 | 0.267 |
| | | Group IV | 1.31250* | 0.47944 | 0.035 |
| | Group II | Group I | −0.64063 | 0.47944 | 0.542 |
| | | Group III | −1.51563* | 0.47944 | 0.011 |
| | | Group IV | 0.67188 | 0.47944 | 0.501 |
| | Group III | Group I | 0.87500 | 0.47944 | 0.267 |
| | | Group II | 1.51563* | 0.47944 | 0.011 |
| | | Group IV | 2.18750* | 0.47944 | 0.000 |
| | Group IV | Group I | −1.31250* | 0.47944 | 0.035 |
| | | Group II | −0.67188 | 0.47944 | 0.501 |
| | | Group III | −2.18750* | 0.47944 | 0.000 |
| L1_Palatal_mid | Group I | Group II | 0.56250 | 0.31052 | 0.273 |
| | | Group III | 0.42188 | 0.31052 | 0.528 |
| | | Group IV | 0.76563 | 0.31052 | 0.070 |
| | Group II | Group I | −0.56250 | 0.31052 | 0.273 |
| | | Group III | −0.14063 | 0.31052 | 0.969 |
| | | Group IV | 0.20313 | 0.31052 | 0.914 |
| | Group III | Group I | −0.42188 | 0.31052 | 0.528 |
| | | Group II | 0.14063 | 0.31052 | 0.969 |
| | | Group IV | 0.34375 | 0.31052 | 0.686 |
| | Group IV | Group I | −0.76563 | 0.31052 | 0.070 |
| | | Group II | −0.20313 | 0.31052 | 0.914 |
| | | Group III | −0.34375 | 0.31052 | 0.686 |
| L1_Palatal_apex | Group I | Group II | 0.93125 | 0.39859 | 0.095 |
| | | Group III | 0.19688 | 0.39859 | 0.960 |
| | | Group IV | 0.72813 | 0.39859 | 0.266 |
| | Group II | Group I | −0.93125 | 0.39859 | 0.095 |
| | | Group III | −0.73438 | 0.39859 | 0.259 |
| | | Group IV | −0.20313 | 0.39859 | 0.957 |
| | Group III | Group I | −0.19688 | 0.39859 | 0.960 |
| | | Group II | 0.73438 | 0.39859 | 0.259 |
| | | Group IV | 0.53125 | 0.39859 | 0.544 |
| | Group IV | Group I | −0.72813 | 0.39859 | 0.266 |
| | | Group II | 0.20313 | 0.39859 | 0.957 |
| | | Group III | −0.53125 | 0.39859 | 0.544 |

*The mean difference is significant at the 0.05 level

**Table 3:** Comparison of inclinations of maxillary central incisor (U1) and mandibular central incisor (L1) among groups

| *Dependent variable* | *Groups* | *Groups* | *Mean difference* | *Standard errors* | *Significance* |
|---|---|---|---|---|---|
| U1 Inclination | Group I | Group II | 0.00000 | 1.82703 | 1.000 |
| | | Group III | 26.71875* | 1.82703 | 0.000 |
| | | Group IV | 4.15625 | 1.82703 | 0.110 |
| | Group II | Group I | 0.00000 | 1.82703 | 1.000 |
| | | Group III | 26.71875* | 1.82703 | 0.000 |
| | | Group IV | 4.15625 | 1.82703 | 0.110 |
| | Group III | Group I | −26.71875* | 1.82703 | 0.000 |
| | | Group II | −26.71875* | 1.82703 | 0.000 |
| | | Group IV | −22.56250* | 1.82703 | 0.000 |
| | Group IV | Group I | −4.15625 | 1.82703 | 0.110 |
| | | Group II | −4.15625 | 1.82703 | 0.110 |
| | | Group III | 22.56250* | 1.82703 | 0.000 |
| L1 Inclination | Group I | Group II | 2.37500 | 2.08114 | 0.665 |
| | | Group III | 9.51563* | 2.08114 | 0.000 |
| | | Group IV | 9.84375* | 2.08114 | 0.000 |
| | Group II | Group I | −2.37500 | 2.08114 | 0.665 |
| | | Group III | 7.14063* | 2.08114 | 0.004 |
| | | Group IV | 7.46875* | 2.08114 | 0.003 |
| | Group III | Group I | −9.51563* | 2.08114 | 0.000 |
| | | Group II | −7.14063* | 2.08114 | 0.004 |
| | | Group IV | 0.32813 | 2.08114 | 0.999 |
| | Group IV | Group I | −9.84375* | 2.08114 | 0.000 |
| | | Group II | −7.46875* | 2.08114 | 0.003 |
| | | Group III | −0.32813 | 2.08114 | 0.999 |

*The mean difference is significant at the 0.05 level

evaluate the incisor position while taking into consideration the skeletal malocclusion.

- Class I: The maxillary and mandibular central incisors were found to be proclined as compared to class II division 2 malocclusion (Tables 1 and 3). In cases of Angle's class I malocclusion with the orthognathic maxilla and mandible, the bimaxillary protrusion is a relatively common finding in the Indian population.[17] In such instance, the alveolar bone width labial to the root apex of U1 was increased and the palatal bone was decreased in comparison to class II division 2 and class III malocclusion owing to proclined maxillary central incisors (Tables 1 and 2) This was also noted by Chu et al. in the Asian population where the palatal bone plate was thin in severely proclined maxillary incisors in class I malocclusion.[18] Similar observations were found by Gracco et al. in maxillary incisors with severe proclination.[19] Moreover, in this study, the palatal bone at the middle of the root of the maxillary central incisor was also found to be reduced. Proclination of mandibular central incisors also led to a wide labial bone at its root apex (Tables 1 and 2). Do TA et al. found similar results in their study stating that the palatal bone thickness had a negative correlation with the buccolingual angulation of lateral incisors.[20]

  Therefore, the bimaxillary protrusion may be well treated by retraction of interiors since the apex is nearer to the palatal bone, and tipping the teeth lingually will place the roots in the center of the alveolus.
- Class II division 1: The central incisors in maxillary and mandibular arches were proclined in comparison to class II division 2 as in line with the classical feature of class II division I malocclusion (Tables 1 and 3). Andrews et al. examined the position of maxillary and mandibular central incisors in alveolar bone and also concluded that mandibular central incisors in class II exhibited signs of positional compensation for the anteroposterior skeletal discrepancy.[12] Our results are in accordance with those by Baysal et al. who observed a positive correlation between lingual bone and lower incisors with protrusive mandibular incisors in the class II group.[21] The width of the alveolar bone labial and palatal to the root apex of the maxillary central incisor was similar to that seen in class I malocclusion (Tables 1 and 2). Tian et al. in their study, assessed the alveolar bone thickness in different inclinations of maxillary incisors and found similar results of increased labial alveolar bone at the apex of flared maxillary incisors.[22] On the contrary, the labial alveolar bone at the apex of L1 was thinner (Tables 1 and 2) probably due to the forwardly positioned mandibular central incisors to compensate for large overjet and anteroposterior skeletal disharmony. These results are in accordance with those by Baysal et al. who observed a positive correlation between lingual bone and lower incisors with protrusive mandibular incisors in the class II group.[21]

  Hence, the proclined maxillary anterior may be retracted safely for correction of a skeletal discrepancy, whereas due to thin labial bone at the apex of mandibular incisors, the tipping of the lower anterior should be avoided. Furthermore, over-retraction of the upper anterior can also cause increased nasolabial angle and compromise the profile of the patient.
- Class II division 2: As commonly observed as a distinguishing feature, the maxillary and mandibular central incisors were found

to be retroclined in the samples of this study (Tables 1 and 3). Due to the retroclined maxillary central incisors, the labial alveolar bone at the root apex was thinner, and the palatal alveolar bone was thicker as opposed to class I and class II division I (Tables 1 and 2). This was in agreement with that by Tian et al. where the root of the maxillary incisor was closer to the labial cortical plate implying a thin alveolar bone in cases of negatively inclined upper incisors and thicker palatal bone over its roots.[22] While, for the mandibular central incisors, the labial bone at the apex showed increased width than in class III patterns (Table 3). This may be due to the retroclination of mandibular anterior to a larger extent in class III (Tables 1 and 3).

Thus, compensation for skeletal discrepancy seems impossible by tipping the anterior teeth lingually without associated sequelae.

- Class III: The maxillary central incisors in class III malocclusion were proclined in comparison to class II division 2, while the mandibular central incisors showed retroclination in relation to class I and class II division 1 malocclusion (Tables 1 and 3). This result strongly agrees with previous studies which depicted compensation of maxillary and mandibular central incisors to skeletal class III pattern.[23–25] The labial alveolar bone width at the apex of U1 was reduced and palatal bone at the apex and middle was increased in comparison to the class I pattern (Tables 1 and 2). This may be attributed to the slightly upright position of U1 in class III than in class I cases. Ma J et al. analyzed the morphology of alveolar bone around anterior teeth in skeletal classes II and III cases with a severe vertical pattern. They inferred that the maxillary incisor roots were placed more lingually and had a thinner alveolar bone in skeletal class III cases.[26]

  On the contrary, the alveolar bone present labially to the apex of L1 showed marked thinness as compared to class I and class II division 2 malocclusion (Tables 1 and 2). Yamada et al. showed similar results wherein they studied the alveolar bone around mandibular incisors in cases with mandibular prognathism.[27] Also, they concluded that the incisor root was closer to the labial cortical plate than the lingual with a maximum value for the lingual to be 4.7 mm and for the labial to be 1.9 mm.[5,27]

In conclusion, mandibular prognathism cases cannot be solely treated by overcompensation as the root of lower incisors is close to the labial cortical plate and we must abstain from tipping it lingually.

Through the current study, we aim to evaluate the position of the root in the alveolar housing by determining the width of bone present labially and lingually to the maxillary and mandibular incisors in various patients with skeletal disharmony. This knowledge is necessary to plan and carry out orthodontic tooth movement without encountering any side effects for efficient orthodontic treatment. Ghassemian M et al. assessed the facial bone at points 1–5 mm from the alveolar crest.[17] Their study concluded there is a high chance of fenestration in the anterior maxillary arch.

Lastly, the goal is to place the teeth upright in the alveolar bone as only then can we achieve a stable occlusion with good periodontal health and favorable esthetics.[28]

## Conclusion

- It was verified through our study that maxillary and mandibular incisors show dental compensations for skeletal deviations.
- The alveolar bone covering the maxillary incisors showed a similar pattern of thinner palatal bone in class I with bimaxillary protrusion and class II division 1. While the same was true for mandibular incisors in class I, labial bone in the case of class II division 1 was found to be thinner.
- The alveolar bone covering the root apices labially in cases of maxillary and mandibular incisors in class II division 2 and mandibular incisors in class III was significantly thin.
- The above findings should be kept in mind by the orthodontist during treatment planning and before proceeding with the intended mechanics for treating skeletal malocclusion through correction of incisal inclination.

## Orcid

*Deepankar Bhatnagar* https://orcid.org/0000-0002-7260-6461
*Harjoy Khatria* https://orcid.org/0000-0003-0535-2980

## References

1. Kerosuo H, Hausen H, Laine T, et al. The influence of incisal malocclusion on the social attractiveness of young adults in Finland. Eur J Orthod 1995;17(6):505–512. DOI: 10.1093/ejo/17.6.505.
2. Garib DG, Yatabe MS, Ozawa TO, et al. Alveolar bone morphology under the perspective of the computed tomography: Defining the biological limits of tooth movement. Dental Press J Orthod 2010;15:192–205. DOI: https://doi.org/10.1590/S2176-94512010000500023.
3. Meeran NA. Iatrogenic possibilities of orthodontic treatment and modalities of prevention. J Orthod Sci 2013;2(3):73–86. DOI: 10.4103/2278-0203.119678.
4. Wehrbein H, Bauer W, Diedrich P. Mandibular incisors, alveolar bone, and symphysis after orthodontic treatment. A retrospective study. Am J Orthod Dentofacial Orthop 1996;110(3):239–246. DOI: 10.1016/s0889-5406(96)80006-0.
5. Handelman CS. The anterior alveolus: Its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. Angle Orthod 1996;66(2):95–109. DOI: 10.1043/0003-3219(1996)066<0095:TAAIII>2.3.CO;2.
6. Mulie RM, Hoeve AT. The limitations of tooth movement within the symphysis, studied with laminagraphy and standardized occlusal films. J Clin Orthod 1976;10(2):882–893. PMID: 1074868.
7. Agarwal SS, Jayan B, Chopra SS. An overview of malocclusion in India. J Dent Health Oral Disord Ther 2015;3(3):319–322. DOI: 10.15406/jdhodt.2015.03.00092.
8. Lund H, Gröndahl K, Gröndahl HG. Cone–beam computed tomography evaluations of marginal alveolar bone before and after orthodontic treatment combined with premolar extractions. Eur J Oral Sci 2012;120(3):201–211. DOI: 10.1111/j.1600-0722.2012.00964.x.
9. Yared KFG, Zenobio EC, Pacheco W. Periodontal status of mandibular central incisors after orthodontic proclination in adults. Am J Orthod Dentofacial Orthop 2006;130(1):6.e1–6.e8. DOI: 10.1016/j.ajodo.2006.01.015.
10. Nauert K, Berg R. Evaluation of labio–lingual bony support of lower incisors in orthodontically untreated adults with the help of computed tomography. J Orthofac Orthop 1999;60(5):321–334. DOI: 10.1007/BF01301245.
11. Sarikaya S, Haydar B, Ciğer S, et al. Changes in alveolar bone thickness due to retraction of anterior teeth. Am J Orthod Dentofacial Orthop 2002;122(1):15–26. DOI: 10.1067/mod.2002.119804.
12. Andrews WA, Abdulrazzaq WS, Hunt JE, et al. Incisor position and alveolar bone thickness: A comparative analysis of two untreated samples using lateral cephalograms. Angle Orthod 2022;92(1):3–10. DOI: 10.2319/022320-122.1.
13. Hong SY, Shin JW, Hong C, et al. Alveolar bone remodeling during maxillary incisor intrusion and retraction. Prog Orthod 2019;20(1):47–54. DOI: 10.1186/s40510-019-0300-2.
14. Nayak KUS, Shetty A, Girija MP, et al. Changes in alveolar bone thickness due to retraction of anterior teeth during orthodontic treatment: A cephalometric and computed tomography comparative

study. Ind J Dent Res 2013;24(6):736–741. DOI: 10.4103/0970-9290.127623.
15. Zhang F, Lee SC, Lee JB, et al. Geometric analysis of alveolar bone around the incisors after anterior retraction following premolar extraction. Angle Orthod 2020;90(2):173–180. DOI: 10.2319/041419-266.1.
16. Rojo–Sanchis J, Soto–Penaloza D, Penarrocha–Oltra D, et al. Facial alveolar bone thickness and modifying factors of anterior maxillary teeth: A systematic review and meta-analysis of cone–beam computed tomography studies. BMC Oral Health 2021;21(1):143–159. DOI: 10.1186/s12903-021-01495-2.
17. Ghassemian M, Nowzari H, Lajolo C, et al. The thickness of facial alveolar bone overlying healthy maxillary anterior teeth. J Periodontol 2012;83:187–197. DOI: 10.1902/jop.2011.110172.
18. Chu YM, Bergeron L, Chen YR. Bimaxillary protrusion: an overview of the surgical–orthodontic treatment. Semin Plast Surg 2009;23(1): 32–39. DOI: 10.1055/s-0028-1110099.
19. Gracco A, Lombardo L, Mancuso G, et al. Upper incisor position and bony support in untreated patients as seen on CBCT. Angle Orthod 2009;79(4):692–702. DOI: 10.2319/081908-437.1.
20. Do TA, Shen YW, Fuh LJ, et al. Clinical assessment of the palatal alveolar bone thickness and its correlation with the buccolingual angulation of maxillary incisors for immediate implant placement. Clin Implant Dent Relat Res 2019;21(5):1080–1086. DOI: 10.1111/cid.12835.
21. Baysal A, Ucar FI, Buyuk SK, et al. Alveolar bone thickness and lower incisor position in skeletal Class I and Class II malocclusions assessed with cone–beam computed tomography. Korean J Orthod 2013;43(3):134–140. DOI: 10.4041/kjod.2013.43.3.134.
22. Tian YL, Liu F, Sun HJ, et al. Alveolar bone thickness around maxillary central incisors of different inclination assessed with cone–beam computed tomography. Korean J Orthod 2015;45(5):245–252. DOI: 10.4041/kjod.2015.45.5.245.
23. Solow B. The dentoalveolar compensatory mechanism: Background and clinical implications. Br J Orthod 1980;7(3):145–161. DOI: 10.1179/bjo.7.3.145.
24. Worms FW, Isaacson RJ, Speidel TM. Surgical orthodontic treatment planning: Profile analysis and mandibular surgery. Angle Orthod 1976;46(1):1–25. DOI: 10.1043/0003-3219(1976)046<0001:SOTPPA>2.0.CO;2.
25. Rakosi T. Treatment of class III malocclusions. In: Graber TM, Rakosi T, Petrovic A, editors. Dentofacial Orthopedic with Functional Appliances. St. Louis, MO: Mosby; 1997, pp. 391–411.
26. Ma J, Huang J, Jiang JH. Morphological analysis of the alveolar bone of the anterior teeth in severe high angle skeletal class II and class III malocclusions assessed with cone–beam computed tomography. PLoS One 2019;14(3):e0210461. DOI: 10.1371/journal.pone.0210461.
27. Yamada C, Kitai N, Kakimoto N, et al. Spatial relationships between the mandibular central incisor and associated alveolar bone in adults with mandibular prognathism. Angle Orthod 2007;77(5):766–772. DOI: 10.2319/072906-309.
28. Grunder U, Gracis S, Capelli M. Influence of 3-D bone-to-implant relationship on esthetics. Int J Periodontics Restorative Dent 2005;25(2):113–119. PMID: 15839587.