Original Article

A Study of the Spatial Relationship between the Associated Alveolar Bone and the Central Incisors in Different Untreated Malocclusions using Lateral Cephalograms

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Abstract

Background: Induced contact between incisor tooth roots and the alveolar cortical bone can potentially cause external root resorption. In certain patients, the risk of external root resorption from contact between the tooth roots and the incisive canal further limits maxillary incisor mobility. To evaluate incisor position and its relationship to alveolar bone in untreated optimal occlusions and in untreated Class I with bimaxillary protrusion (Class I Bimax) and Class III malocclusions. **Materials and Methods:** Fifty-seven lateral cephalograms of individuals with naturally occurring optimal occlusions (mean age = 23 years) were used to assess the positions of central incisors and their relationships to alveolar bone. Data were compared to a sample of 65 individuals with untreated Class I Bimax and Class III malocclusions, mean age = 28.85 (7.2) and 29.77 (6.56), respectively. **Results:** Significant intergroup differences were found for AP jaw relationship, maxillary alveolar bone thickness, mandibular incisor inclination, maxillary incisor root distance to labial surface of alveolar bone, and mandibular incisor root apex distance to labial surface of alveolar bone. **Conclusion:** In untreated individuals, maxillary central incisors tend to occupy the anterior one-third of the maxillary alveolar process in Class III malocclusion. In untreated individuals with Class III malocclusions, mandibular central incisors are more negatively inclined and their root apices are more anterior than in those with untreated optimal occlusions. In untreated individuals with Class III malocclusions, maxillary central incisors are more positively inclined and midpoints of their roots are more anterior than in those with untreated optimal occlusions.

Keywords: Alveolar bone thickness, Incisor inclinations, Incisor root positions, Naturally optimal occlusion

Introduction

The position of the incisors serves as a crucial criterion for the foundation of an Orthodontic treatment plan and serves as a guide for the position that will be achieved at the end of treatment. A common procedure in Orthodontic diagnosis involves using a lateral cephalogram to assess the position of the central incisors.[1] Treatment choices involving anterior-posterior (AP) incisor movement in the jaws are frequently guided by the central incisors' inclination and relationship to the alveolar bone around them. Orthodontic tooth movement is governed by the cortical surfaces of alveolar bone, beyond which fenestration and/or dehiscence may take place.[2]

Better occlusion, face esthetics, and functional stability can only be attained with the right tooth torque.[3] To discover whether there are any anatomic relationships between central incisor roots and alveolar bone in untreated individuals with Class I with bimaxillary protrusion (Class I Bimax) and Class III malocclusions. From a clinical perspective, a comprehensive understanding of the anterio-posterior constraint of incisor mobility will be essential.[4] A lateral cephalogram is frequently used in orthodontic diagnostics to assess the location of the central incisors. Treatment decisions involving AP incisor motions inside the jaws are frequently influenced by the central incisors' inclination and their relationship to the surrounding alveolar bone, which are easily measured.[5] In this study, the positions of maxillary and mandibular central incisors were assessed using lateral cephalograms. Their long-axis inclination, as well as the AP position of the roots with respect

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to the local alveolar bone, was evaluated. Data from a sample with naturally occurring optimal occlusions (NOOs) were compared to a sample with naturally occurring Class I Bimax and Class III malocclusions with concurrent AP skeletal discrepancies. The aim of this study was to identify prevailing anatomic relationships, if any, between central incisor roots and alveolar bone in untreated individuals with naturally occurring Class I Bimax and Class III malocclusions. The null hypothesis was that there would be no difference in root position or long-axis inclination of central incisors between individuals with NOOs, Class I with Bimaxillary Protrusion Sample, and Class III malocclusion.

Materials and Methods

Informed consent requirements were fulfilled after review by the Institutional Review Board of New Horizon Dental College and Research Institute, Sakri, Bilaspur, Chhattisgarh, with Scientific Committee Clearance No. NHDCRI/2022/MDS/CONS/03-SCC and Ethical Committee Clearance No. NHDCRI/2022/MDS/CONS/03- ECC.

Sample size

A deviation in root position of 1 mm was pre-designated as clinically significant. To detect differences <1 mm, with a standard deviation of 1.5 mm, an α error of 5%, and a test power of 80%, sample sizes of at least 56 individuals per group were deemed necessary in this retrospective cross-sectional study.

NOO sample

Lateral cephalometric images of individuals with NOOs were acquired from a sample originally collected in the 1960s that was instrumental in the discovery of the "Six Keys to Normal (Optimal) Occlusion", obtained from Incisor position and alveolar bone thickness.[6] The criteria for inclusion were as follows:

1. No history of treatment
2. A full complement of erupted permanent teeth (with or without third molars)
3. A static occlusion that would not benefit from orthodontic intervention.

The mean age of patients was 23.0 years (range, 12–71 years), and the sample consisted of 25 females (mean age ¼ 23.4 years) and 32 males (mean age ¼ 22.8 years).

Class I with Bimax sample

Individuals with Class I malocclusions seeking Orthodontic treatment were obtained from patients reporting to the Department of Orthodontics and Dentofacial Orthopedics, New Horizon Dental College and Research Institute, Sakri, Bilaspur, Chhattisgarh. The inclusion criteria were as follows:

1. No history of Orthodontic treatment
2. A full complement of erupted permanent teeth (with or without third molars)
3. Class I molar relationship of 3.0 mm or more on one or both sides
4. Upper and lower lips are protruded with respect to the E-line
5. Cephalometric image quality is adequate to identify key anatomic landmarks.

Class III sample

Individuals with Class III malocclusions seeking Orthodontic treatment were obtained from patients reporting to the Department of Orthodontics and Dentofacial Orthopedics, New Horizon Dental College and Research Institute, Sakri, Bilaspur, Chhattisgarh. The inclusion criteria were as follows:

1. No history of orthodontic treatment
2. A full complement of erupted permanent teeth (with or without third molars)
3. Class III molar relationship of 3.0mm or more on one or both sides
4. Cephalometric image quality is adequate to identify key anatomic landmarks.

Cephalometric tracings

The lateral cephalograms taken with natural head position will be traced in Dolphin 11.95 premium software by one examiner (a). The structures traced included the maxilla, mandible, inner and outer cortical surfaces of the mandibular symphysis, first molars, and central incisors (left and right average). The occlusal planes, incisal edges, root apices, incisor long axes, maxillary incisor cementoenamel junction (CEJ), and maxillary incisor root midpoint (midpoint between the CEJ and the apex along the tooth's long axis) were also identified and traced.

Measurements (Figure 2) maxillary central incisor root position

The distances (in mm) from the root midpoint to the outer cortical surface of the alveolar process on the labial (U1-lab) and palatal (U1-pal) sides were measured perpendicular to the long axis of the tooth.

Maxillary alveolar process thickness

The total thickness of the maxillary alveolar process (Mx-Alv) was calculated by adding distances U1-lab and U1-pal.

Mandibular central incisor root position

The distances (in mm) from the root apex to the outer cortical surface of the alveolar process on both the labial (L1-lab) and lingual (L1-ling) sides were measured parallel to the occlusal plane.

Mandibular alveolar process thickness

The total thickness of the mandibular alveolar process (Md-Alv) was calculated by adding distances L1-lab and L1-ling.

Incisor inclination

The inclinations of the maxillary (U1-incl) and mandibular (L1-incl) central incisors were measured by the acute angle formed between the long axes of the teeth and a line perpendicular to the occlusal plane.

AP jaw relationship

The Wits appraisal (Wits) was used to assess AP jaw relationships. 23 All measurements were performed by one examiner using an electronic digital caliper (Avenger Products, Boulder City, Nevada) for linear measurements and a manual protractor for angular measurements.

Statistical analysis

Means and standard deviations were used for descriptive statistics. The *t*-tests were used to evaluate differences between variables. A chi-square test indicated that the proportions of males and females within the samples were not significantly different. Ages between samples were not significantly different; however, the ages between males and females within each sample were not significantly different.

Method error

Seventeen lateral cephalograms randomly selected from each sample were remeasured by the same examiner 52 weeks later. Random errors were evaluated with Dahlberg's formula, in which S2 was the error variance and d was the difference between two determinations of the same variable. 24 Systematic errors were evaluated using dependent *t*-tests. Linear measurements showed random errors ranging from 0.12 mm (U1-lab and L1-lab) to 0.30 mm (Md Alv). Angular measurements showed random errors ranging from 0.408 (U1 incl) to 1.808 (L1-incl). Significant systematic errors existed for measurements of U1-pal (mean difference = 0.29 mm) and U1-incl (mean difference = 0.328). The magnitudes of the random and systematic errors in methodology were deemed insufficient to meaningfully impact the veracity of the results.

Results

Descriptive and comparative analysis of the NOO and Class I Bimax group

Intergroup comparative data are reported in Table 1. Maxillary incisor inclination (U1-incl) was found to be significantly greater in Class I Bimax (P =0.001), and the Root midpoint position was significantly more anterior (U1-lab) (P = 0.001) in the Class I Bimax group. Similarly, mandibular incisor inclination (L1-incl) was found to be significantly greater in the Class I Bimax (P = 0.001), and the root apex position was significantly more posterior (L1- lab) (P = 0.001) in the Class I Bimax group.

Descriptive and comparative analysis of the NOO and Class III group

Mandibular incisor inclination, as shown in Table 2 (L1-incl), was significantly different between samples (P = 0.001). The root apex position in the Class III group was significantly more anterior (L1-lab) (P = 0.01); however, maxillary incisor inclination (U1-incl) was found to be significantly greater in the Class III group (P = 0.001). The maxillary root midpoint position was significantly more anterior (U1-lab) (P = 0.001) in the Class III group as compared to the NOO group.

Descriptive and comparative analysis of the Class I Bimax and Class III group

Total maxillary alveolar thickness elucidated in Table 3 (Mx-Alv) and total mandibular alveolar thickness (Md-Alv) were similar for both the groups (P = 0.88); (P = 0.16). Mandibular incisor inclination (L1-incl) was significantly different between samples (P < 0.001). The mandibular root apex position in the Class III group was significantly more anterior (L1-lab) (P <0.001). Maxillary incisor inclination

Table 1: Descriptive and comparative analysis of the NOO and Class I Bimax (*t*-test)

Measurement	NOO (*n*=57)		Class I Bimax (*n*=39)		*P*-value
	Mean	SD	Mean	SD	
Mx-Alv	10.32	1.22	10.2	0.8	0.56 NS
Md-Alv	10.4	2.23	10.68	1.11	0.42 NS
U1-pal	6.49	1.09	7.44	0.53	0.001 HS
U1-lab	3.84	0.5	2.76	0.28	0.001 HS
L1-ling	5.32	1.41	4.41	0.55	0.001 HS
L1-lab	5.08	1.44	6.57	0.6	0.001 HS
Wits	−0.72	2.33	1.75	0.66	0.001 HS
U1-incl	28.11	4.69	30.67	2.67	0.001 HS
L1-incl	19.23	5.16	25.59	2.77	<0.001 HS

NOO: Naturally occurring optimal occlusion, Class I Bimax: Class I Bimaxillary protrusion, SD: Standard deviation, NS: Not significant, HS: Highly significant

Table 2: Descriptive and comparative analysis of the NOO and Class III group (*t*-test)

Measurement	NOO (*n*=57)		Class III (*n*=26)		*P*-value
	Mean	SD	Mean	SD	
Mx-Alv	10.32	1.22	10.28	1.01	0.67 NS
Md-Alv	10.4	2.23	11.19	1.6	0.051 NS
U1-pal	6.49	1.09	6.86	1.06	0.048 S
U1-lab	3.84	0.5	3.06	0.37	0.001 HS
L1-ling	5.32	1.41	6.45	0.85	0.001 HS
L1-lab	5.08	1.44	4.62	0.76	0.01 S
Wits	−0.72	2.33	−2.36	1.11	0.001 HS
U1-incl	28.11	4.69	29.64	1.49	0.001 HS
L1-incl	19.23	5.16	18.46	4.4	0.001 HS

NOO: Naturally occurring optimal occlusion, SD: Standard deviation, S: Significant, NS: Not significant, HS: Highly significant

Table 3: Descriptive and comparative analysis of the Class I Bimax and Class III group (*t*-test)

Measurement	Class I Bimax (*n*=39)		Class III (*n*=26)		*P*-value
	Mean	SD	Mean	SD	
Mx-Alv	10.2	0.8	10.28	1.01	0.88 NS
Md-Alv	10.68	1.11	11.19	1.6	0.16 NS
U1-pal	7.44	0.53	6.86	1.06	<0.01 S
U1-lab	2.76	0.28	3.06	0.37	<0.001 HS
L1-ling	4.41	0.55	6.45	0.85	<0.001 HS
L1-lab	6.57	0.6	4.62	0.76	<0.001 HS
Wits	1.75	0.66	−2.36	1.11	<0.001 HS
U1-incl	30.67	2.67	29.64	1.49	<0.001 HS
L1-incl	25.59	2.77	18.46	4.4	<0.001 HS

Class I Bimax: Class I Bimaxillary protrusion, SD: Standard deviation, S: Significant, NS: Not significant, HS: Highly significant

(U1-incl) was found to be significantly greater in the Class I Bimax group ($P < 0.001$). U1-pal was smaller in the Class III group (Class I Bimax: 7.44 mm; Class III: 6.03; $P < 0.001$) and similarly, U1-lab was greater in the Class III group (Class I Bimax: 2.76mm; Class III: 4.55; $P < 0.001$).

Intragroup comparison of root positions (maxillary)

Intragroup data for maxillary root position are reported in Table 4. The difference between U1-pal and U1-lab was statistically significant within the samples ($P < 0.001$), with U1-pal roughly double in magnitude to U1-lab in NOO, Class III groups.

Intragroup comparison of root positions (mandibular)

Intragroup data for mandibular root position are reported in Table 4. In the NOO group, the mandibular root apex position was virtually centered in the alveolar process (L1-ling = 5.32 mm; L1-lab = 5.08 mm; $P = 0.37$). In Class I Bimax groups, the mandibular incisor root apex position was posterior to the center of the alveolus ($P < 0.01$; $P < 0.001$). In the Class III group, the mandibular incisor root apex position was positioned anterior to the center of the alveolus (L1-ling = 6.45 mm; L1-lab = 4.73 mm; $P < 0.001$).

Discussion

Dentoalveolar compensation is a natural system for camouflaging skeletal discrepancies in three planes of space.[7] There are two different kinds of compensatory mechanisms that occur during normal facial growth and development. While full compensatory occlusal development allows for normal relationships even in the presence of some skeletal abnormalities, inadequate compensatory guidance of tooth eruption can result in future malocclusion.[8]

Adult patients with a skeletal discrepancy can be treated with growth modification, orthodontic camouflage, or orthognathic surgery, in which proper dentoalveolar compensation or decompensation is required for a successful treatment outcome. Hence, anterior dentoalveolar compensation is the main and the cornerstone for successful orthodontic treatment, either by orthodontic compensation (camouflage) or decompensation (skeletal base correction).[7] Coordination of maxillary and mandibular development is not always perfect.[9] Therefore, the mechanisms that regulate tooth eruption and position relative to the base of the jaw to achieve and maintain a normal relationship between the upper and lower dental arches are required.[10] This mechanism is called the dentoalveolar compensatory mechanism and can be defined as a system that attempts to maintain a normal intermaxillary relationship in a variety of jaw relationships.[11]

In this study, the position and inclination of upper and lower central incisors were evaluated in Class I Bimax and Class III groups, using a lateral cephalogram of non-treated cases to assess various natural compensation provided by anterior teeth in different malocclusions. This study provided a chance to assess incisor position in a significant historical sample, the NOOs group that served as the foundation for the six keys to normal (optimal) Occlusion and later as a basis for the creation of the first Straight-Wire Appliance.[6]

The results of our study indicated several differences among the three groups in incisor position and incisal inclination, when compared to NOO group. The root locations seen in people with NOOs were remarkably consistent, with mandibular root apices approximately centered within the alveolus and maxillary root midpoints nearly always occupying the anterior one-third of the alveolar process. A similar pattern for maxillary incisor was observed in the Class III group as well.

The findings of the present study indicate, the mandibular central incisors in the Class I Bimax and Class III groups showed indications of positional compensation for the AP skeletal discrepancies that were already present. This was demonstrated by labial tipping of mandibular central incisor in Class I Bimax, where the mandibular central incisors were more inclined than in NOO and farther from the labial surface of the mandibular alveolar process and closer to the labial surface in the Class III group.

Table 4: Intragroup comparison of root positions (*t*-test)

Tooth region	Group	Palatal/lingual mean	SD	Labial mean	SD	*P*-value
Maxillary	NOO (*n*=57)	6.49	1.09	3.84	0.50	<0.001 HS
	Class I Bimax (*n*=39)	7.44	0.53	2.76	0.28	<0.001 HS
	Class III (*n*=26)	6.86	1.06	3.06	0.37	<0.01 S
Mandibular	NOO (*n*=57)	5.32	1.41	5.08	1.44	0.37 NS
	Class I Bimax (*n*=39)	4.41	0.55	6.27	0.60	<0.001 HS
	Class III (*n*=26)	6.45	0.85	4.73	0.76	<0.001 HS

NOO: Naturally occurring optimal occlusion, Class I Bimax: Class I Bimaxillary protrusion, SD: Standard deviation, S: Significant, NS: Not significant, HS: Highly significant

Conclusion

- In untreated individuals, maxillary central incisors tend to occupy the anterior one-third of the maxillary alveolar process, in Class III malocclusion.
- In untreated individuals with Class III malocclusions, mandibular central incisors are more negatively inclined and their root apices are more anterior than in those with untreated optimal occlusions.
- In untreated individuals with Class III malocclusions, maxillary central incisors are more positively inclined and midpoints of their roots are more anterior than in those with untreated optimal occlusions.
- Differences between females and males were statistically non-significant.
- The null hypothesis was rejected for mandibular central incisors and maxillary central incisors.

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