Comparison of Crown-Root Relationships of Maxillary Central Incisors in Various Malocclusions

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Abstract

Objective The purpose of this study is to compare the crown-root and labial crown-root angles in class I, class II division (div) 1, and class II div 2 malocclusions, using cephalometric radiographs, and to find a correlation between crown-root angulation and labial crown-root angle.

Materials and Methods A sample of 45 patients (23 females and 22 males) with age range from 11 to 27 years and mean age of 17 years was taken. The sample was divided into class I, class II div 2, and class II div 1 malocclusions with 15 patients in each group. The means for various parameters for each group were calculated, and multiple comparisons were made. For correlation of two parameters, Pearson's correlation was used for normally distributed data.

Results Mean crown-root angle for class I was 5.8 ± 6.5 ; for class II div 1, it was 5.3 ± 4.2 ; and for class II div 2, it was 15.6 ± 9.69 degrees. Mean labial crown root angle for class I was 28.8 ± 5.8 ; for class II div 1, it was 27.06 ± 4.9 ; and for class II div 2, it was 39.8 ± 9.8 degrees.

Conclusions Statistically higher values were seen for crown-root angle and labial crown-root angle in class II div 2 malocclusion. A significant correlation was seen between crown-root angle and labial crown-root angle in class I, class II div 1, and class II div 2 malocclusion.

Keywords

- crown-root angle
- class II div 1 malocclusion
- class II div 2 malocclusion
- labial crown-root angle

Introduction

Variability in tooth morphology is a crucial thought within the attainment of an ideal occlusion of teeth. Maxillary central incisors are the greatest noticeable teeth.¹ Typically, even slight misplacement of these incisors is of great deal to the patient. Additionally, very poor positioning of the incisors can affect the facial profile and affects the lip closure. Discrepancies in physical outline of the maxillary central incisors affect the treatment or the posttreatment phase of orthodontic therapy. Crown-root angle is one of the important features comprising the morphology of central incisors.

In cephalometric systems, the longitudinal axis of either of the upper central incisors is recorded daily as the axis is demarcated by Bjork,² which is the line passing through the point incision superius, that is, midpoint of the cutting edge of the more protruding the upper central tooth and

apex.² However, it is repeatedly seen that when the long axis of the root is drawn distinctly from the long axis of the crown, it is often noted that these two axes do not coincide. The longitudinal axis of the crown of a tooth can vary considerably from that of the root. The corresponding angle between these two longitudinal axes is defined as the crown to root angle and was named the collum angle by Andreasen in 1930.³ The collum angle, therefore, is the supplementary angle of the crown to root angulation, used to correlate the angular difference between the two axes. Conferring to Taylor, root-crown relation varies greatly because they are subject to dissimilarities in curvature. In different words, when one sees the central incisor from the proximal, as on a cephalometric radiogram, a line drawn from the root apex to incision superius may not pass through the center of the tooth at the cemento-enamel junction (CEJ).⁴ The crown could

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show “bent” to the lingual or labial, in reference to the root. During a study by Delivanis and Kuftinec, it was seen that in class II division (div) 2 patients, the crowns of the maxillary central incisors bear to be “bent” to the lingual very often than in patients with different types of malocclusion.⁵ This trend has long been well known by orthodontists and was even suggested by Backlund to be a causative factor in the progress of class II div 2 malocclusions.⁶ During a study of extracted maxillary central incisors, Carlsson and Rönnerman found the angle between the crown and root axes to vary by as much as 13 degrees.⁷ It has been anticipated by Delivanis and Kuftinec that the crown-root angulation labeled as occurring in class II div 2 malocclusions may impede orthodontic intrusion and torque of the incisors and, in serious cases, may rise the hazard of perforating the palatal cortical plate. They also recommend that the long axis of the crown alone, and not the complete tooth, be used in analyses, specifically in class II, div 2 cases.⁵

The tradition of current orthodontics is broadly grounded on the usage of the straight wire edgewise appliance initially described by Andrews and Schirmer in 1968.⁸ The arrival of this approach has permitted the orthodontist to proceed more resourcefully by inserting less bends in wires, mainly at the finishing steps of treatment, with further expected results. The drawbacks of the straight-wire appliance become probable, however, once one acknowledges the inconsistency built in natural crown forms, as well as the unpredictability of root location in relationship to the clinical crown. The technique is based on the supposition that root angulation to the crown is 0 degree.

This becomes important where torquing of the crowns may affect root position. In severe cases, the root may inadvertently encroach the labial or lingual cortical plates, causing unwarranted root resorption and dehiscence. In addition, aberrant crown to root angulations may confound intended axial loading when attempting to intrude or extrude teeth.⁹ Thus, the angle formed by the anatomical axes of the crown and root may have a noteworthy impact in the treatment in orthodontics. Sometimes, it is difficult to calculate the collum angle by the technique proposed by Andreasen. Another method to describe the crown and root axes has been proposed by Bauer. It is called *labial crown-root angle*.¹⁰

Aims and Objectives

The aim of this study is to compare the crown-root and labial crown-root angles in class I, class II div 1, and class II div 2 malocclusion, and to find a correlation between crown-root and labial crown-root angles.

- To measure and compare crown-root and labial crown-root angles in patients with class I and class II div 1 malocclusions.
- To measure and compare crown-root and labial crown-root angles in patients with class I and class II div 2 malocclusions.
- To measure and compare crown-root and labial crown-root angles in patients with class II div 1 and class II div 2 malocclusions.
- To find a correlation between crown-root and labial crown-root angles.

Materials and Methods

This research was planned as a cross-sectional cephalometric study to measure the crown-root and labial crown-root angles of maxillary central incisors on cephalogram of patients with class I, class II div 1, and class II div 2 malocclusions. Samples were collected from the patient reporting to the Department of Orthodontics and Dentofacial Orthopedics Bhojia Dental College, Baddi, Himachal Pradesh.

Three groups were formed on the base of skeletal and dental malocclusions. A sample of 45 patients (23 females and 22 males) with age range from 11 to 27 years and mean age of 17 years was taken. The sample was divided into class I, class II div 2, and class II div 1 malocclusions with 15 patients in each group (►Table 1).

All lateral cephalographs were taken by the operator with patients standing with Frankfort horizontal plane parallel to the floor, the sagittal plane perpendicular to the X-ray beam, and the teeth in centric occlusion. All radiographs were taken using the cephalostat from Advapex Panoramic Systems (Apex Medical Systems Pvt. Ltd., New Delhi, India). The exposure of the X-ray source was 65 kV and 16 Ma for 1.2 seconds. The equipment had a fixed film to focus plane distance of 190 cm and a fixed film to midsagittal plane distance of 10 cm with a final amplification of 10%. For all patients 8- × 10-in (20.32 × 25.4 cm) films were used, and cephalogram tracings were done on acetate sheet.

- Inclusion criteria for class I malocclusion: Skeletal class I, dental class I, proper image quality, and clarity of cephalograms.
- Inclusion criteria for class II div 1 malocclusion: Skeletal class II, dental class II div 1, proper image quality, and clarity of cephalograms.
- Inclusion criteria for class II div 2 malocclusion: Skeletal class II, dental class II div 2, proper image quality, and clarity.

Crown-Root Angle

The crown-root angle was conventionally measured according to three points on the most forward maxillary central incisor: (1) the intact incisal edge (incisor superius [IS]), (2) the established bisection of the facial CEJ (fCEJ) and lingual CEJ (lCEJ), and (3) the anatomic root apex (upper incisor apical [UIA]).¹¹ The crown-root angle is the supplement (180 degrees – x) of this angle. A straight tooth was taken to have a crown-root angle of 0, a lingually inclined root was taken to have a (+) angle, and a labially inclined root was taken to have a (–) angle. The crown-root angulation measurement, used in this study, is shown in ►Fig. 1.

Labial Crown-Root Angle

The labial crown-root angle was built on a cephalometric radiograph with three points on the most forward maxillary

Table 1 Grouping of the sample

Grouping	Malocclusion	Number of patients
Group A	Class I	15
Group B	Class II div 1	15
Group C	Class II div 2	15

Fig. 1 (A) Crown-root angle in class I patients. (B) Crown-root angle in class II div 1 patients. (C) Crown-root angle in class II div 2 patients.

Fig. 2 (A) Labial crown-root angle in class I patients. (B) Labial crown-root angle in class II div 1 patients. (C) Labial crown-root angle in class II div 2 patients.

Table 2 Mean crown-root angle in three groups

Descriptive				
Crown-root angle				
Group	N	Mean	Standard deviation	Standard error
A (class I)	15	5.8000	6.55962	1.69369
B (class II div 1)	15	5.3333	4.28730	1.10698
C (class II div 2)	15	15.6000	9.69389	2.50295
Total	45	8.9111	8.50621	1.26803

central incisor: (1) IS, (2) fCEJs, and (3) UIA. The labial crown-root angle is the supplement ($180 \text{ degrees} - x$) of this angle. The labial crown-root angle is illustrated in ► Fig. 2.

The measurement for these two parameters that is crown-root and labial crown-root angles was completed on all the 45 patients of three groups. The data so obtained were collected and analyzed statistically.

Statistical Methods

The statistical analysis was done using IBM SPSS (Statistical Package for Social Sciences, Armonk, New York, United States) statistical version 20. Normality of data was checked by Kolmogorov-Smirnov tests of normality. All quantitative variables were assessed using measures of central location (mean) and measures of dispersion (standard deviation). For normally distributed data, the comparison of crown-root and labial crown-root angles among various groups was made by comparing the means using one-way analysis of variance (ANOVA) (for more the two groups) with post hoc. Multiple

comparisons were made using Scheffe test. For correlation of two parameters, Pearson's correlation was used for data normally distributed. Altogether statistical tests were seen at two-tailed level of significance ($p \leq 0.01$ and $p \leq 0.05$).

Explanation of Pearson's Correlation Coefficient

±0.0 No correlation
 ±0.2 Weak
 ±0.5 Moderate
 ±0.8 Strong
 ±1.0 Perfect

Results

Mean Crown-Root Angle

This study compared the crown-root angle in various malocclusions. The mean value of crown-root angle was found to be highest in group C, that is, class II div 2 group, that is, 15.6 ± 9.69 degrees. This was followed by the crown-root angle of group A, that is, 5.8 ± 6.5 degrees and then crown-root angle of group B, that is, 5.3 ± 4.2 degrees (► Table 2, ► Fig. 3).

Comparison of Three Groups for Measurement of Crown-Root Angle

On comparison of crown-root angle of different malocclusion groups, no significant difference was found between groups A and B whereas there was a statistically significant difference between groups B and C with a $p = 0.001$. A statistically significant difference was also found between groups A and C with a $p = 0.002$ (► Table 3).

Fig. 3 Mean crown-root angle in three groups.

Table 3 Comparison of crown-root angle in three groups

Group	Group	Mean difference	Standard error	p-Value
A (class I)	B (class II div 1)	-0.46667	2.62789	0.984
B (class II div 1)	C (class II div 2)	-10.26667	2.62789	0.001**
C (class II div 2)	A (class I)	-9.80000	2.62789	0.002**

**p-value is less than 0.01.

Mean Labial Crown-Root Angle

The mean labial crown-root angle was compared for various groups. The mean crown-root angle for group C, that is, class II div 2 group was found to be highest, that is, 39.8 ± 9.8 degrees. This was followed by labial crown-root angle of 28.8 ± 5.8 degrees for group A and then labial crown-root angle of 27.06 ± 4.9 degrees for group B. Mean labial crown-root angle for group A was 28.8667 degrees. Mean labial crown-root angle for group B was 27.0667 degrees. Mean crown-root angle for group C was 39.8000 degrees (►Table 4, ►Fig. 4).

Comparison of Three Groups for Labial Crown-Root Angle

When labial crown-root angle for the three groups was compared, no significant difference was found between groups A and B whereas a statistically significant difference was found between groups B and C with a $p = 0.0001$.

A statistically significant difference was also found between groups A and C with a $p = 0.001$ (►Table 5).

Correlation between Crown-Root and Labial Crown-Root Angles

The crown-root and labial crown-root angles were evaluated for correlation in all the three groups. A strong correlation was found for both the angles in all the three groups with a Pearson's correlation coefficient of 0.939** (**indicates $p < 0.01$).

There was significant correlation between crown-root and labial crown-root angles in combined values for all the three groups, as shown in ►Table 6.

There was a significant correlation between the crown-root and labial crown-root angles with groups A, B, and C, as shown in ►Tables 7 to 9, respectively.

Table 4 For mean labial crown-root angle in three groups

Descriptive				
Labial crown-root angle (LCRA)				
Group	N	Mean	Standard deviation	Standard error
A (class I)	15	28.8667	5.80476	1.49878
B (class II div 1)	15	27.0667	4.94927	1.27790
C (class II div 2)	15	39.8000	9.85031	2.54334
Total	45	31.9111	9.04238	1.34796

Table 5 Comparison of labial crown-root angle in three groups

Group	Group	Mean difference	Standard error	p-Value
A (class I)	B	-1.8000	2.62652	0.792
B (class II div 1)	C	-12.73333	2.62652	0.0001**
C (class II div 2)	A	-10.93333	2.62652	0.001**

**p-value is less than 0.01.

Discussion

The variability of tooth morphology has been reported in the literature for all the malocclusion. The tooth morphology varies in crown shape and size, root shape and size, and their relation to each other. Since the advent of cephalometry and its use in orthodontics, the angulation of the central incisors has been evaluated and studied. The relationship of the

Fig. 4 For mean labial crown-root angle in three groups. CI, confidence interval.

Table 6 Correlation between labial crown-root and crown-root angles in all three groups

Correlations			
		Collum angle (CA)	Labial crown-root angle (LCRA)
Crown-root angle	Pearson's correlation	1	0.939**
	p-Value		0.000
	N	45	45
Labial crown-root angle	Pearson's correlation	0.939**	1
	p-Value	0.000	
	N	45	45

**p-value is less than 0.01.

Table 8 Correlation between labial crown-root and crown-root angles in group B

Correlations			
		Collum angle (CA)	Labial crown-root angle (LCRA)
Crown-root angle	Pearson's correlation	1	0.867**
	p-Value		0.0001
	N	15	15
Labial crown-root angle	Pearson's correlation	0.867**	1
	p-Value	0.0001	
	N	15	15

**p-value is less than 0.01.

Table 7 Correlation between labial crown-root and crown-root angles in group A

Correlations			
		Collum angle (CA)	Labial crown-root angle (LCRA)
Crown-root angle	Pearson's correlation	1	0.828**
	p-Value		0.0001
	N	15	15
Labial crown-root angle	Pearson's correlation	0.828**	1
	p-Value	0.0001	
	N	15	15

**p-value is less than 0.01.

upper central incisors to the surrounding structures in all the planes of space is very important for the purpose of diagnosis and treatment planning. It has been assumed for all clinical

and cephalometric purposes that the long axis of the crown and root of the central incisors coincides.

This idea has been perpetrated further by the Andrews straight-wire appliance. When Dr. Andrews designed the first fully programmable brackets, he revolutionized the field of orthodontics. This development was based on the six keys of normal occlusion, wherein he named crown inclination as the third key.¹² Although the importance of crown inclination was widely discussed, no mention of the crown in relation to the root was made in the "six keys of normal occlusion."¹² This omission may have subsequently propagated the assumption that the longitudinal axis of crown and root formed a straight line.⁹ The aforementioned concept is especially apparent in cephalometric analyses in which the crown to root angulation is not evident in the maxillary incisor templates.¹³ Instead, the maxillary incisor template is automatically drawn in, such that the long axes of the crown and root are identical. By doing so, crown inclination is taken into consideration, but no forethought is given to the inclination of the root and its inherent consequences.

Table 9 Correlation between labial crown-root and crown-root angles in group C

Correlations		Collum angle (CA)	Labial crown-root angle (LCRA)
Crown-root angle	Pearson's correlation	1	0.962**
	p-Value		0.0001
	N	15	15
Labial crown-root angle	Pearson's correlation	0.962**	1
	p-Value	0.0001	
	N	15	15

**p-value is less than 0.01.

All treatment approaches in the various techniques are based on the assumption, but over time, various authors have found this notion to be incorrect. It is frequently found that in the long axis of crown and root does not coincide and treatment mechanics based on this assumption can lead to root apices coming in contact with the bone.

The crown-root angle is evaluated by drawing a line from incisal edge, point bisecting the fCEJ and lCEJ and anatomic root apex.

In some cases, it may not be possible to accurately locate the midpoint of the CEJ, so a point on the labial surface of the CEJ was proposed by Bauer (2014).¹⁰ The advantage of the point was easy location by different observers. The aim of this study was to correlate this point with the crown-root angle to ascertain whether this point can be used routinely for the purpose of checking the angulation between the crown and root.

Correlation between Crown-Root and Labial Crown-Root Angles

A significant correlation was found between crown-root and labial crown-root angles in all the groups in this study, thus validating the use of labial crown-root angle with crown-root angle. This trend is similar to that reported by Bryant and colleagues (1984)¹³ and Bauer (2014).¹⁰

Comparing Groups A (Class I) and B (Class II Div 1)

In this study, mean value for groups A and B shows no significant difference regarding the collum angle (►Table 3). It goes same with the mean value for labial crown-root angle (►Table 5). The results presented a trend that is parallel to trends reported by other researchers such as Delivanis (1980),⁵ Bryant and colleagues (1984),¹³ Williams and Woodhouse (1983),¹⁴ Shen and colleagues (2012),¹⁵ and Shailaja and colleagues (2016).¹⁶

Comparing Groups B (Class II Div 1) and C (Class II Div 2)

This study shows a significant difference between mean values for crown-root angle in groups B and C (►Table 3). Also, for the labial crown-root angle, both the groups show significant difference in mean values (►Table 5). The results

showed a trend (►Table 2). Similar results have been reported by other researchers such as Delivanis (1980),⁵ Bryant and colleagues (1984),¹³ Williams and Woodhouse (1983),¹⁴ Shen and colleagues (2012),¹⁵ Shailaja and colleagues (2016).¹⁶

Comparing Groups C (Class II Div 2) and A (Class I)

Both the groups show significant difference in mean values for crown-root angle (►Table 3). The same follows for the mean values for the labial crown-root angle (►Table 5). The results showed a trend (►Table 2) parallel to trends reported by other researchers such as Delivanis (1980),⁵ Bryant and colleagues (1984),¹³ Williams and Woodhouse (1983),¹⁴ Shen and colleagues (2012),¹⁵ Shailaja and colleagues (2016).¹⁶

Thus, it can be said that an accurate evaluation of the angulation of crown and root axis is crucial for the determination of diagnosis and treatment planning. The crown-root and labial crown-root angulations should be evaluated and taken into consideration when planning for the central incisors and anterior segment.

Conclusions

- Class II div 2 malocclusion group has greater crown-root and labial crown-root angles than class II div 1 and class I malocclusion.
- Class I malocclusion and class II div 1 have similar crown-root angle and labial crown-root angle values.
- Crown-root and labial crown-root angles are strongly correlated in all the three malocclusions: class I, class II div 1, and class II div 2.

Conflict of Interest

None declared.

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