Original Article

The Third-Order Angle and the Maxillary Incisor's Inclination to the NA Line

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ABSTRACT

Objective: To evaluate the relationship between the angular measurement data (incisor's long axis to NA line) and the third-order angle (TA) according to Andrews' description.

Materials and Methods: The materials in the study included the lateral radiographs and corresponding dental casts of 32 males and 35 females between 10 and 25 years of age, regardless of their skeletal and dental relationships. All subjects were white and none had undergone orthodontic therapy. Using lateral radiographs, upper and lower incisor angulations were assessed in reference to the NA line. These data were compared with third-order angles derived from direct dental cast measurements, which were performed using an incisor inclination recording appliance.

Results: The third-order angle measurements recorded from the dental casts were a mean of 16.2° (SD = 5.3°) smaller than the axial inclination according to the NA line. In this sample, there was a range of 42.7° for the TA variable (mean = 5.6°, SD = 9.73°) and 47° for the 1NA/deg variable (mean = 21.7°, SD = 8.67°). A highly significant correlation existed ($r = 0.84$) between Andrews' angle and the inclination estimated in reference to the NA line.

Conclusion: Incisor inclination can be better estimated by recognizing the relationship between the torque angle and the axial inclination referred to the NA line. Third-order measurements using dental casts can offer a simple way to get an objective and rapid vision of the incisor's inclination.

KEY WORDS: Third-order angle; Upper incisor inclination; NA line

INTRODUCTION

The NA line is commonly used as a reference line for assessing the axial inclination of upper incisors.[1–3] The use of most cephalometric analyses for determination of the incisor's axial inclination (eg, in reference to the NA line) presents the orthodontist with the difficulty of relating the assessed data to the third-order prescription of the brackets used. Because the third-order bracket prescription refers to a perpendicular to Andrews'[4] plane (the occlusal plane), these are different reference lines that cannot be equated. Accordingly, reaching the desired incisor position using straight-wire appliances is fortuitous without any correcting third-order elements.

The purpose of the present study was to quantify the relationship between the angular and linear measurement data (ie, the upper first incisor's long axis related to the NA line [1NA/deg], and the position of the upper first incisor's tip in relation to the NA line [1NA/mm]) and the upper incisor's third-order angle according to Andrews' description (1TA). The definition of this angle is the angle formed by a perpendicular to the occlusal plane and a line that is tangent to the middle of the labial long axis of the clinical crown.[4]

MATERIALS AND METHODS

The material in the study included lateral radiographs and corresponding dental casts of 32 males and 35 females between 10 and 25 years of age, regardless of their skeletal and dental relationships. All of the subjects were white; 6 had Class I, 54 Class II, and 7 Class III skeletal and dental relationships. None had undergone orthodontic therapy. This study was

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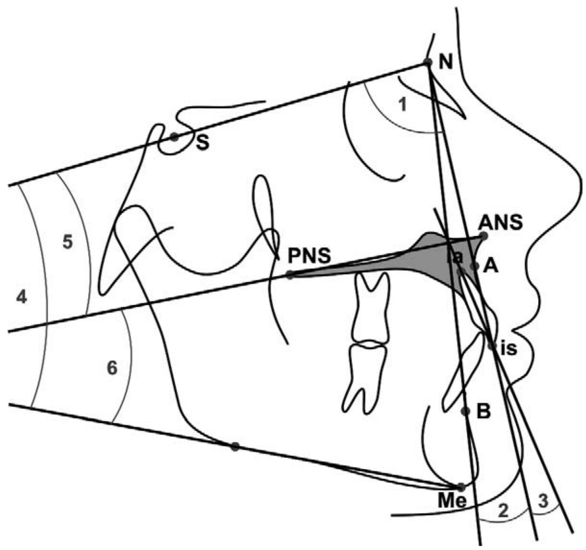

Figure 1. Head film tracing with landmarks. S indicates sella; N, nasion; Me, menton; is, incisor superior, incisal tip of most prominent maxillary central incisor; ia, incisor apex. apex of most prominent maxillary central incisor. Angular measurements: 1 indicates SNA; 2, ANB; 3, 1NA/deg; 4, NSL-ML; 5, NSL-NL; 6, ML-NL.

approved by the Human Subjects Commission (''Ethikkommission'') of our university.

Using the 67 standardized lateral cephalometric radiographs, selected treatment parameters were analyzed. These included angular measurements (1NA/deg, SNA, SNB, ANB, NSL-NL, NSL-ML, ML-NL) and linear measurements (1NA/mm). These were performed after digitizing 10 landmarks (sella, nasion, A, B, tip and root apex of the most proclined upper incisor, anterior nasal spine [ANS], posterior nasal spine [PNS], menton, and most inferior point on the outline of the mandible at the gonion angle) (Figure 1).

The acquired data were compared with Andrews' third-order angle (TA), derived from direct dental cast measurements of the most proclined upper incisor (1TA), which were assessed using an incisor inclination recording device (TIP appliance; Figure 2) according to the description of Richmond et al.[5] All measurements were performed by one examiner.

The maxillary dental casts were positioned on a table-tracked sledge by contacting molars and bicuspids in order to maintain the occlusal plane. After marking of the middle of the labial long axis of the incisor's clinical crown (LACC), the upper incisor was adjusted with its edge parallel to the sledge's front side and was then guided forward against a straight wire until it touched the LACC (Figure 3). The wire's excursion marks the inclination of the incisor's facial surface to the occlusal plane according to Andrews' description. Correspondingly, the measured 1TA data were defined as positive if the gingival portion of the facial tangent represented by the wire was lingual to the incisal portion, and vice versa.

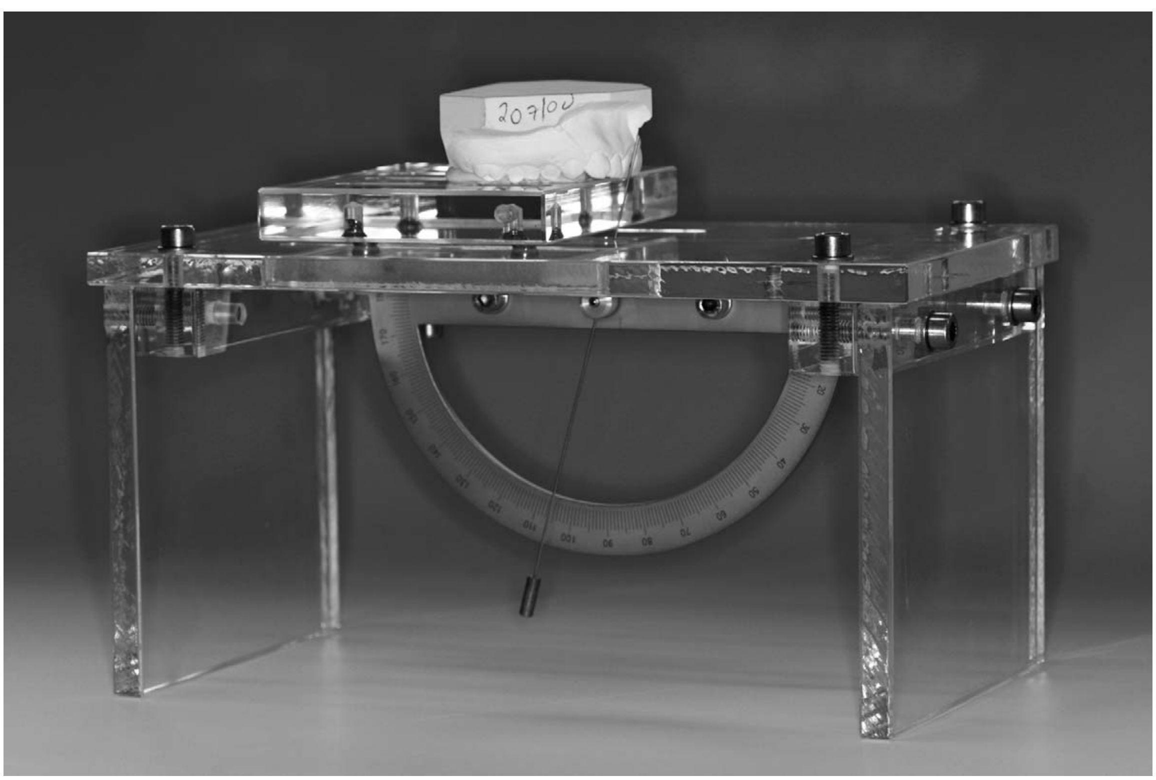

Figure 2. The torque-recording device.

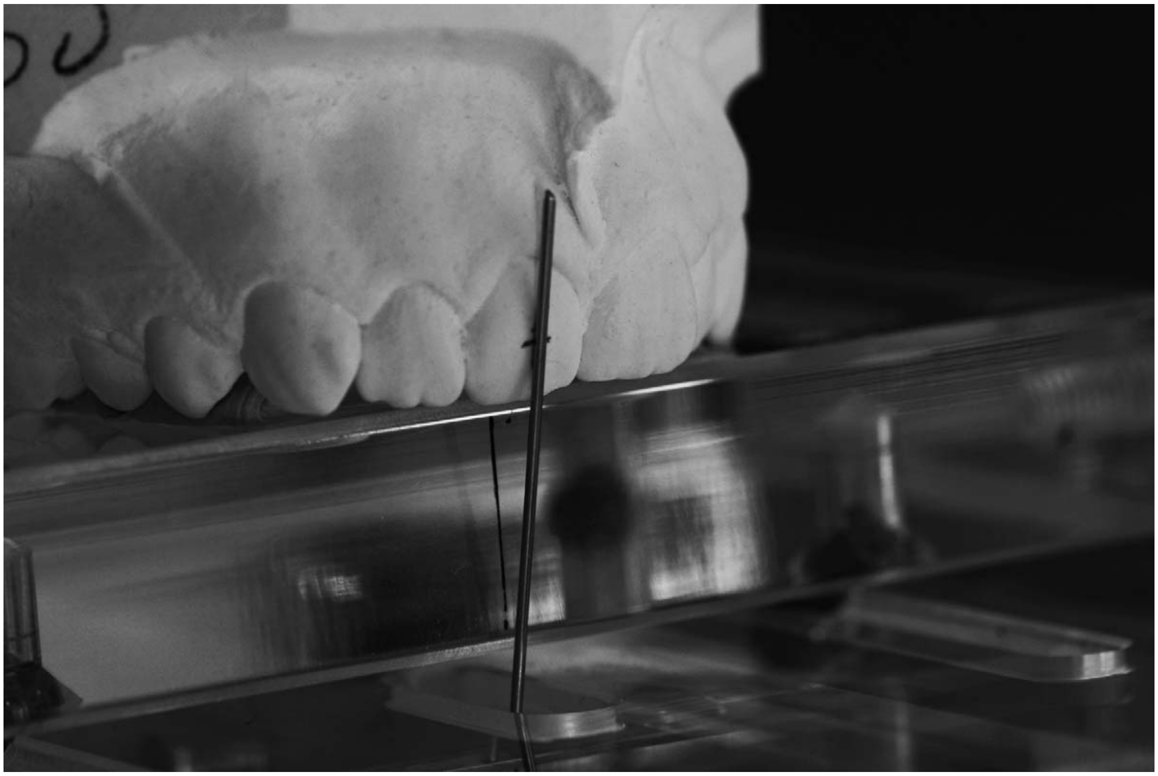

Figure 3. The dental cast positioned on the sledge with the wire touching the LACC.

Statistical Analysis

Statistical analysis was performed using the SAS program (StatSoft Inc, Tulsa, OK). In this study, a paired *t*-test was applied ($\alpha = .05$) to ascertain the reliability of the dental cast measurements, and an unpaired *t*-test ($\alpha = .05$) to compare the data of both sexes. The method error was calculated according to Dahlberg[6] and distinguished from biological variance[7]

Error Analysis

After initial measurement of the 1TA and NA/deg, the dental cast third-order angle assessments as well as the lateral cephalographic measurements were repeated two times at 3-week intervals. The mean values of these data were considered. The mean standard deviation was 0.7° for the three 1TA measurements and 0.3° for the 1NA/deg measurements. No significant differences ($\alpha = .05$) between the repeated 1TA measurements could be stated.

The method error was calculated according to Dahlberg[6]:

$$\delta = \sqrt{\frac{\sum d^2}{2n}}$$

where δ = method error, d = the difference between a single (1TA or 1NA/deg) measurement and the mean of the single (1TA or 1NA/deg) measurements, and n = the number of measurements. A method error of 0.47° was calculated for the 1TA measurements and 0.69° for the radiographic inclination measurements.

To judge the reliability of the 1TA variable, the method error was put in relation to the biological variance[7]:

$$Reliability = 1 - \frac{\delta^2}{s_v^2}$$

where s_v^2 = total variance of the measurement.

There is a reliability of 0.99 for the 1TA variable in this study.

Table 1. Axial Inclination vs. Vertical Skeletal Dimension: Coefficient of Correlation

	1NA/deg	1TA	1NA/mm
NSL-NL	−0.1636	−0.063	−0.17565
ML-NL	0.09625	0.1078	0.2014

RESULTS

In this sample of nontreated cases that were lacking ideal occlusion, there was a poor correlation between 1NA/deg and the ANB angle. Tables 1 and 2 give the coefficients of correlation between axial inclination vs vertical skeletal dimension and axial inclination vs sagittal skeletal dimension.

Table 2. Axial Inclination vs. Sagittal Skeletal Dimension: Coefficient of Correlation

	1NA/deg	1NA/deg-1TA	1NA/mm
SNA	−0.0442	0.117333	−0.3329
ANB	−0.284	−0.3917	−0.33

Table 3. 1TA and NA/deg: Descriptive Statistics (°)

	Minimum	Maximum	Mean	SD
1TA (males)	−10	26	5.5	11.2
1TA (females)	−17.5	25.2	5.7	8.0
1TA (both sexes)	−17.5	25.2	5.6	9.73
1NA/deg (males)	11	41	23.01	5.99
1NA/deg (females)	−6	35	20.52	10.49
1NA/deg (both sexes)	−6	41	21.71	8.67

Table 4. 1TA-NA/deg (°)

	Mean	SD
Males	17.4	5.23
Females	16.1	5.21
Both sexes	16.2	5.3

In our sample, there was a range of 42.7° for the 1TA variable and 47° for the 1NA/deg variable. No statistically significant difference was noted between the mean 1TA measurements of the two sexes ($P = .838$). The 1TA and NA/deg findings are shown in Table 3.

The torque angle measurements derived from the casts (1TA) were smaller by a mean of 16.2° (SD = 5.3°) than the axial inclination measurements in reference to NA derived from the lateral cephalograms (Table 4).

A highly significant ($P < .001$) coefficient of correlation between Andrews' third-order angle (1TA) and the inclination estimated in reference to NA/deg of $r = 0.84$ can be stated. The radiographic linear (1NA/mm) measurement is correlated to the axial inclination measurements (1NA/deg) with $r = 0.76$, and with $r = 0.63$ to the 1TA measurements ($P < .001$).

The regression equation for incisor position (1NA [deg]) illustrates the relationship between the third-order angle measurements and the cephalographic axial inclination findings:

$$1\text{NA (deg)} = 17.553 + (0.748 * \text{TA})$$

With the help of the regression equation, the TA measurement data can be used to explain 70.5% ($r^2 = (0.84)^2 = 0.705$) of the 1NA/deg deviation.

DISCUSSION

The purpose of this study was to investigate the relationship between the axial inclination of upper incisors, as estimated by angular and linear measurements in reference to the NA line, and the third-order angle described by Andrews,[4] and moreover to examine the several correlations among selected groups.

Richmond[5] proved a correlation of the angle between the upper incisor's long axis and the palatal plane and the torque angular measurements, which he derived from direct dental cast measurements using the TIP appliance. The correlation between the radiographic and the cast measurements in his study ($r = 0.77$) was quite similar to that found in ours, although another cephalometric reference plane has been used. The TIP tended to record the upper incisor's axial inclination as 10.46° smaller than did the lateral radiograph. Similarly, Ghahferokhi et al[8] found a discrepancy of 14° using a similar, intraoral method.

Andrews' measurements describe the inclination of the crown's facial surface. Measuring axial inclination means to approximate the crown-root relation illustrates something entirely different. The fact that both are on the same tooth and that therefore the incisor's facial tangent is individually related to the tooth's long axis explains the strong correlation of 0.84 between 1NA/deg and TA. Moreover, the cant of the occlusal plane is related to sagittal-skeletal patterns[3,9,10] as well as to skeletal-vertical structures.[2,11–14] The data for 1NA/mm and NA/deg show a weaker correlation of 0.75, which follows from using only the incisor's tip as one point of reference in the linear measurement.

Forgoing another lateral radiograph during treatment, the regression equation enables the clinician to use the 1TA data for calculating the axial inclination to the NA line. Moreover, the single use of the direct-cast TA measurement data might be a better guideline to adjusting incisor inclination, because these measurements can be directly compared to the third-order prescription of the preadjusted appliance, the wire dimension, and the expected loss of third-order control by slot-archwire play.

The use of lateral cephalograms for assessing axial inclination is based on the assumption that a line connecting the apex and the incisal edge reflects the long axis of the tooth, but in some cases there is a difference between the crown and the root's long axis, especially in Class II/2 cases.[15–18] Because Andrews' third-order angle considers the labiolingual crown inclination regardless of the root's inclination or the inclination of the long axis of the entire tooth,[4] there might be a gap between the two measurements. A tooth that appears to be proclined on the lateral cephalogram might show a retroclined crown on the dental cast.

The facial morphology of incisor crowns differs interindividually.[19–22] The labial surface angle (between the crown's facial tangent and the tooth's long axis) varies from 7° to 24° (n = 198).[17] Similarly, Fredericks[23] found a range of 21° for the same angle. Carlsson and Rönnermann[18] stated a range of 13°. According to Vardimon and Lambertz,[24] the contour of the facial surfaces is "subject to normal biologic variation." The SD of 5.3° (1NA/deg vs 1TA) in our study is in agreement with Vardimon's study, which stated a SD of ±5 degrees as characteristic for all teeth. Apart from morphological variation of facial enamel surface,[24] the influence of vertical patterns[12] as well as the variation of the occlusal plane[2] contribute to the SD of 5.3° (1NA/deg-1TA) in this study.

Another point is the reliability of the head film measurements itself, which affects the stated relation between radiographic and dental measurements. The accuracy of the determination of the upper incisor's axial inclination was reported by Baumrind and Frantz.[25,26] In this study 93% of the errors of 1NA/deg measures were within −3° and +3°. The standard deviations found in their study were 1.85° for 1NA/deg, 1.18° for SNA angle and 0.86 mm for 1NA/mm. Compared with the method error of the radiographic inclination measurements in this study, the direct dental cast data appear to be more precise.

Another difficulty is the determination of the plane of occlusion. In this study, the dental casts were positioned on the torque-recording device's table by contacting upper molars and bicuspids. This method should reflect the occlusal plane, but it is not without flaws, especially in cases with a distinctive curve of Spee.

Unlike the examination outcomes of Bibby,[27] Hasund and Ulstein,[3] and Steiner,[1] no statistically significant relationship between axial inclination data (according to 1NA/deg, 1NA/mm and 1TA) and either sagittal or vertical skeletal configurations was found in our study. This could be explained by the nature of our sample, which consisted of untreated cases regardless of their skeletal and dental relationship and lacking ideal occlusion, whereas Bibby[27] and Hasund and Ulstein[3] proved a relationship between sagittal-skeletal structures and the incisor's axial inclination (dentoalveolar compensation of skeletal bias) using ideal occlusion samples.

In the present study, the mean deviation between 1NA/deg and 1TA was 16.2°. Those authors who use the NA line for assessing the upper incisor's axial inclination recommend an angle of approximately 22°.[1,3,10,27] By subtracting the mean deviation between the two values of our present sample, we obtain a value of 5.8° for the 1TA variable. Consequently, the result of the present study is in agreement with Andrews' examination outcomes: Andrews[4,28] derived a 7° torque angle for upper incisors from dental cast examination of an "ideal" occlusion sample.

CONCLUSIONS

- An incisor's inclination can be better estimated by recognizing the relationship between the torque angle and the axial inclination referred to the NA line.
- Third-order measurements using dental casts can offer a simple way to get an objective and rapid vision of the incisor's inclination and might be a helpful guideline to the choice of low or high torque brackets.
- Direct dental cast measurements appear to be more precise and more valuable than lateral radiographs, as the remaining torque potential of brackets and wires during treatment can be better estimated from direct measurements than from 1NA/deg-measurement evaluation, which requires the use of the given regression equation.
- Differing interindividual facial morphology as well as variation in crown-root inclination must be considered.

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