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RESEARCH ARTICLE

ASSESSMENT OF THE AXIAL INCLINATION OF UPPER INCISOR IN RELATION TO THE THIRD ORDER ANGLE, A CEPHALOMETRIC AND DENTAL CAST STUDY

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ABSTRACT

Background and Aim: The aim of this study were to assess the axial inclination of upper incisor and to evaluate the relationship between the angular measurement data (incisor long axis to maxillary plane and occlusal plane) and the third-order angle according to Andrews' description by using the device—the tooth inclination protractor (TIP). The sample comprised 60 subjects of south Indian origin between 15- 30 years of age (regardless of skeletal and dental relationships) seeking orthodontic treatment at the department of orthodontics, K.V.G. Dental college Hospital, Sullia and other dental colleges, with lateral cephalometric radiographs and dental casts. The scores were related to traditionally determined inclinations for the upper incisor to occlusal plane obtained from cephalometric radiographic analysis. The following angles were measured on the radiographs: maxillary incisors to maxillary plane and occlusal plane. Measurements were also made with the TIP: maxillary incisor to occlusal plane. There were statistically significant systematic differences between the TIP and the radiographic assessments. The following differences were found. The TIP over scored the lateral cephalometrically determined maxillary incisor inclination by 14.52°. The TIP was shown to be a simple, inexpensive, reliable, and valid method of assessing incisor inclination.

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INTRODUCTION

The evaluation of maxillary and mandibular incisor inclination is an important aspect of orthodontic treatment planning, assessing treatment progress, as well as determining treatment outcome. Incisor inclination has traditionally been assessed by lateral cephalometric radiographic analysis. However, deriving axial inclinations of incisors from lateral cephalometric radiograph is prone to relatively large radiographic errors (Baumrind and Frantz, 1971; Baumrind and Frantz, 1971; Houston, 1983). In addition, ionizing radiation may cause a small but significant mitotic risk (Wall and Kendal, 1983). Dental casts have been useful in assessing tooth and arch parameters, arch asymmetry, and arch length. Few studies have used dental casts to assess incisor inclination. Techniques have been described relating study casts to lateral cephalometric radiographs (Perera, 1981). Richmond *et al*. (1998) described the use of an acrylic extraoral device to assess incisor inclination. However none of these techniques is routinely used as they may be unreliable, costly, time consuming and require experienced personnel to record and process the data. In addition the radiographic technique usually records the most prominent incisor, and there may be superimposition and lack of clarity between the apices of the six anterior teeth. Third order angle as defined by Andrews' is the angle formed by a line perpendicular to the occlusal plane and a line that is tangent to the middle of the labial long axis of the clinical crown. The aim of this study was to assess the axial inclination of upper incisor to third order angle using the device Tooth inclination protractor (TIP) and lateral cephalograms.

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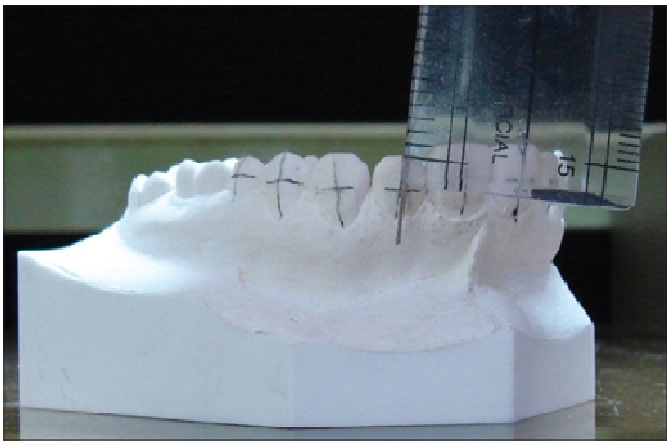
MATERIALS AND METHODS

The material in the study included lateral radiographs and corresponding dental casts of 60 subjects between 15 and 30 years of age, regardless of their skeletal and dental relationships with minimal crowding, rotations or spacing present. All of the subjects were of south Indian origin. None had undergone orthodontic therapy. Using the 60 standardized lateral cephalometric radiographs, selected treatment parameters were analyzed.

- Upper incisor to maxillary plane (U1- MP) - is the angle formed by the long axis of upper incisor to the palatal plane which is drawn through the anterior nasal spine (ANS) to posterior nasal spine (PNS).

- Upper incisor to occlusal plane (U1- OP) - is the angle formed by the long axis of upper incisor to the occlusal plane which is drawn through the overlapping cusps of the first premolars and first molars.

Dental cast measurements- Tooth Inclination Protractor recordings- The maxillary incisor third order angle on dental casts are recorded using the Tooth inclination protractor device. The acquired cephalometric data were compared with Andrews' third-order angle (TA), derived from direct dental cast measurements of upper incisor. All measurements were performed by one examiner. The facial axis of the clinical crown (FACC) of the maxillary incisor is marked on the dental cast by locating the facial axis point. The TIP angle to be measured was formed by the intersection of the occlusal plane and a line tangent to the midpoint of the labial or buccal long axis of the clinical crown. 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 facial axis of the incisor's clinical crown (FACC), the upper incisors were adjusted with its edge parallel to the sledge's front side and was then guided forward against a straight wire until it touched the FACC. The wire's excursion on the protractor marks the inclination of the incisor's facial surface to the occlusal plane according to Andrews' description. The TIP device can be used to determine the angulation of cuspids, bicuspids and molars on dental casts. It can be used intra-orally also and helps in assessing incisor inclination in pre- mid- and post-treatment.



***Statistical analysis*-** Statistical analysis was performed using the statistical package for social sciences (SPSS). For each variable the mean, standard deviation, standard deviation of paired differences was calculated. The difference between the means were calculated using the student's paired t-test and correlation among various variables was calculated by using Karl Pearson Correlation Coefficient.

RESULTS

The mean values for each parameter studied along with the mean paired differences and standard deviation of paired differences and pearson correlation coefficient for the axial inclination and third order angle are depicted in Table 1. In our sample there was a mean difference of 14.52 degrees between U1-MP and TIP (Table 1) and a mean difference of 22.45 degrees between the TIP scores and equivalent radiographic scores (U1-OP) (table 2) with a significant correlation of P< 0.01.

Table 1. Correlations of u1-mp and tip measurements

Parameter	Mean	SD	Mean Deviation	Correlation P
U1- MP	56.73	8.77	14.52	0.000
TIP	71.25	7.61		

**correlation is significant at the 0.01level

Table 1. Correlations of u1-op and tip measurements

Parameter	Mean	SD	Mean Deviation	Correlation P
U1- OP	48.8	7.68	22.45	0.000
TIP	71.25	7.61		

**correlation is significant at the 0.01level

DISCUSSION

The purpose of this study was to investigate the relationship between the axial inclination of upper incisors, as estimated by angular measurements in reference to the maxillary plane and occlusal plane, and the third-order angle described by Andrews (Andrews, 1972). An esthetically pleasing position of the maxillary incisors is one of the foremost concerns of a patient seeking orthodontic treatment. Torque of the maxillary incisors is particularly critical in establishing an esthetic smile line, proper anterior guidance, and a Class I relationship, because undertorqued anterior teeth can preclude the distal movement of the anterior maxillary dentition. Inadequately inclined incisors deprive the dental arch of space, because it has been shown that for every 5° of anterior inclination, about 1mm of arch length is generated (Gioka and Eliades, 2004). Richmond (Richmond *et al*., 1998) 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 was $r = 0.77$. The TIP tended to record the upper incisor's axial inclination as 10.46° discrepancy. Similarly, Ghahferokhi *et al*. (2002) found a discrepancy of 14° using a similar, intraoral method. Knosel *et al*. (2007) also found a strong correlation of 0.84 between incisors long axis and third order angle, although another caphalometric plane i.e. U1-NA has been used. 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 U1-MP and U1- OP to TIP in this study. Also the TIP overscores the lateral cephalometric radiographic determined maxillary incisor angulation by 14.52°.

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. (Delivanis and Kuftinec, 1980; Harris *et al*., 1993; Bryant *et al*., 1984; Carlsson and Ro¨nnermann, 1973) 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, (Andrews, 1972) 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. (Germane *et al*., 1989; Dellinger, 1978; Meyer and Nelson, 1978; Taylor, 1969) The labial surface angle (between the crown's facial tangent and the tooth's long axis) varies from 7° to 24° (n = 198). (Bryant *et al*., 1984) Similarly, Fredericks (Fredericks, 1974) found a range of 21° for the same angle. Carlsson and Ronnermann (1973) stated a range of 13°. According to Vardimon and Lambertz, (1986) the contour of the facial surfaces is ''subject to normal biologic variation''. The TIP records crown inclination only. However this device can record the individual inclinations of all eight incisors allowing more detailed assessment of proclined or retroclined teeth. The assessment of the crowns to the occlusal plane may be variable especially in the lower arch where there may be problems with a deep curve of spee. In terms of clinical implication, whenever a torque measurement needs to be assessed during the treatment procedure, the third order angle can be directly measured with the help of this device rather than exposing the patient to radiation. Therefore, the single use of the direct-cast TA measurement data with the tooth inclination protractor device 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 tooth inclination protractor (TIP) is a simple, non-invasive and quick technique to assess incisor inclination. It can be used to record changes in the incisor inclination during the treatment.

Conclusion

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. Differing interindividual facial morphology as well as variation in crown-root inclination must be considered and also the effect of bracket positioning on assessing incisor inclination should be considered. The TIP may also be used to record changes of incisor inclination during treatment. However, the effect of bracket positioning will require further investigation.

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