EVALUATION OF INCISORS INCLINATION IN FIVE CEPHALOMETRIC ANALYSIS METHODS

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ABSTRACT

Various cephalometric analyses may provide conflicting results for the skeletal sagittal relationship and incisors inclination. The aim of this study was to evaluate the various cephalometric analyses by relating the upper and lower incisors to different reference points and lines. One hundred and two pre-treatment lateral cephalometric radiographs were selected and stratified into three groups according to their skeletal sagittal relationship. Five methods for measuring the upper and lower incisors inclination were applied and then compared using Analysis of Variance (ANOVA) statistical test. The findings of the present study demonstrated that there is a statistically significant ($p<0.05$) difference between the angular and the linear evaluation methods in lower incisors. More than half (55%) of the cases showed a difference of ≥ 3 standard deviations (SD) between the five methods in the mandibular incisors. L1-NA (mm) and L1-APog (mm) had a weak correlation with the other measurements, while the angular measurements were strongly correlated. Variations in the measurements of incisors inclination exist due to many factors. The clinicians should understand the weaknesses of each method and interpret the results cautiously.

Key words: *Cephalometric, Incisor Inclination, Evaluation*

INTRODUCTION

Radiographic cephalometry has been almost exclusively the domain of the orthodontist since 1950s. Orthodontic diagnosis and treatment planning rely on accurately analyzed lateral cephalometric radiographs. Research in the field of radiographic cephalometry has evolved and many analyses are now available. Those of Downs,[1-3] Steiner,[4-6] Tweed,[7,8] Ricketts,[9-11] Wits,[12,13] McNamara,[14] and many other less widely used methods have their own reference points, lines, and norms. The different cephalometric analyses provide conflicting results for the skeletal sagittal relationship and incisors inclination.[18, 19, 21, 23-26] Jacobson (1975)[12] introduced the Wits appraisal to eliminate the inherent problems when using angle ANB. Studies have shown that the ANB angle is affected by the rotations and the variations in sagittal and vertical jaw relation to the cranial base[15-17], whereas Wits analysis is affected by the position of the functional occlusal plane and the vertical alveolar dimension.[18] Rushton *et al.* (1991)[18] while comparing the reproducibility and the reliability of the Wits appraisal and the angle ANB, found that these two methods were consistent, however, small errors in location of functional occlusal plane have a greater effect on the Wits value than small errors in A, B, or N on angle ANB. Kirchner and Williams (1993)[19] have also compared five different methods of expressing sagittal jaw relationship with conclusion that the correlation between the various results was generally poor.

The ability to determine the anteroposterior position of a patient's incisors utilizing cephalometric radiographs enhances the orthodontic diagnosis and treatment planning, and facilitates assessment of treatment progress and treatment outcome.[20] In Downs analysis, the evaluation of the maxillary and mandibular incisors inclination is measured by relating the upper incisors to the A-Pog line and the lower incisors to the mandibular plane respecively.[1-3] On the other hand, Steiner analysis[4-6] has its own method where the upper incisors are related to the N-A line to indicate the relative angular position of the upper incisors, and the upper

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incisors to the N-A measured in millimeter provides information on the relative forward or backward position of the incisors to the N-A line. The lower incisors to N-B line measured in millimeter shows the relative forward or backward position of these teeth to the N-B line, and the measurement to N-B line in degrees indicates the relative axial inclination.[4-6]

In Ricketts analysis[9-11], the upper and the lower incisors are related to the A-Pog line to measure the sagittal position of the anterior teeth. However, McNamara analysis[14] measures the position of the maxillary incisors in relation to a vertical line drawn through point A parallel to Nasion perpendicular. To determine the anteroposterior position of the lower incisors, the distance is measured between the edge of the mandibular incisor and a line drawn from point A to Pogonion (A-Pog).[14]

Corelius & Linder-Aronson (1976)[27] evaluated relationship between the incisors inclination and various reference lines for the lower incisors (only) utilizing lateral cephalometric radiographs of 60 Swedish children; the measurements L1-NB (mm), L1-NB° and L1-ML° were correlated. The study demonstrated a strong correlation between L1-ML° with L1-NB° (r=0.66), L1-ML° with L1-NB (mm) [r=0.63] and L1-NB° with L1-NB (mm) [r=0.84].[27]

Practicing orthodontists routinely face the dilemma of interpreting the different results of the various cephalometric analyses. The purpose of this study was to compare the different lateral cephalometric analyses by relating both the upper and lower incisors to different reference points and lines in order to identify the most reliable method for determining the incisors inclination in different skeletal sagittal relationships.

METHODOLOGY

One hundred and two randomly selected pre-treatment lateral cephalometric radiographs of adult patients (above the age of 18 years) attending the Orthodontic Clinics of College of Dentistry King Saud University, were reviewed. The radiographs were divided into three groups according to their skeletal sagittal relationship:

1 Class I (ANB = 1°-4°, n = 33).

2 Class II (ANB > 4.5°, n = 34).

3 Class III (ANB < 0.5°, n = 35).

The lateral cephalometric radiographs were analyzed using Dolphin Imaging® 10.0 software (Dolphin Imaging and Management Solutions, Chatsworth, Calif). Four angular measurements for the upper incisors inclination (U1-SN, U1-PP, U1-MxOP, U1-NA) and one linear method (U1-NA (mm)) were used. Whereas, in mandibular incisors, three angular measurements (L1-GoGn, L1-MnOP, L1-NB) and two linear variables [L1-NB (mm) & L1-APog (mm)] were recorded (Figures 1 & 2).

The data were analyzed using SPSS® statistical software (Version #16, SPSS Inc., Chicago, Ill) at a predetermined significance level of p<0.05. The differences between the incisors inclination measurements were first analyzed by ANOVA. If a statistically significant difference was observed, the difference between the methods was further analyzed by post-hoc Tuckey test. Frequencies of the differences between the five methods in measuring the incisors inclination in the three types of skeletal relationships were evaluated using Chi-square test. Correlation analysis was also performed between the methods.

RESULTS

To test the intra-examiner reliability of cephalometric landmark identification, the same researcher re-evaluated ten randomly selected radiographs two weeks after the first evaluation. The results showed no significant (p>0.05) differences between the first and second readings. The correlation analysis revealed a high correlation coefficient value (r=0.874) between the assessments, supporting the reproducibility of the method used.

To address the objectives of this study, the incisors inclination measuring methods were subtracted from the published average mean of each measurement (U1-SN = 102.8°±5.5, U1-PP = 110°±5.0, U1-MxOP = 56.8°±2.5, U1-NA = 22.8°±5.7, U1-NA = 4.3mm±2.7, L1-GoGn = 93°±6.0, L1-MnOP = 64.3°±3.2, L1-NB = 25.3°±6.0, L1-NB = 4mm±1.8, L1-APog = 2.7mm±1.7) and the results of this study were compared with the published standard deviation of that measurement. Results which indicated the number of SDs above or below the mean were compared using ANOVA. In the maxillary incisors, there was no statistical difference (p=0.062) between the five different methods, however, a significant statistical difference (p<0.0001) existed

between the five methods in measuring mandibular incisors. The linear measurements of the mandibular incisors were significantly ($p<0.05$) different from the angular measurements (Figure 3).

The range of standard deviations in the measurements between the upper and lower incisor inclination measurements were calculated and cases were distributed into four groups depending on how many SD of

TABLE 1: FREQUENCIES OF THE DIFFERENCES BETWEEN THE FIVE METHODS IN MEASURING THE UPPER INCISORS INCLINATION

		Malocclusion Classification			Total
		I	II	III	
Upper Incisors	0 SD	1	0	0	1 1%
Inclination	1 SD	9	10	11	30 29.4%
Differences	2 SD	9	14	8	31 30.4%
	3 SD	12	8	14	34 33.3%
	> 3 SD	2	2	2	6 5.9%

Pearson Chi-Square p=0.670.

TABLE 2: FREQUENCIES OF THE DIFFERENCES BETWEEN THE FIVE METHODS IN MEASURING THE LOWER INCISORS INCLINATION

		Malocclusion Classification			Total
		I	II	III	
Lower Incisors	0 SD	2	0	0	2 2%
Inclination Range	1 SD	7	6	6	19 18.5%
	2 SD	8	7	7	22 21.5%
	3 SD	11	10	5	26 25.5%
	> 3 SD	5	11	17	33 32.4%

Pearson Chi-Square p=0.108.

TABLE 3: CORRELATION IN THE MEASUREMENTS OF THE MAXILLARY INCISORS INCLINATION

	U1-SN	U1-PP	U1-MxOP	U1-NA
U1-SN				
U1-PP	0.915*			
U1-MxOP	0.814*	0.806*		
U1-NA	0.869*	0.825*	0.744*	
U1-NA mm	0.595*	0.539*	0.542*	0.792*

*Correlation is significant at 0.01 level.

TABLE 4: CORRELATION IN THE MEASUREMENTS OF THE MANDIBULAR INCISORS INCLINATION

	L1-Mn	L1-MnOP	L1-NB	L1-NB mm
L1-Mn				
L1-MnOP	0.831**			
L1-NB	0.790**	0.720**		
L1-NB mm	0.636**	0.676**	0.873**	
L1-APo mm	0.237*	0.257**	0.547**	0.661**

*Correlation is significant at the 0.05 level.
**Correlation is significant at the 0.01 level.

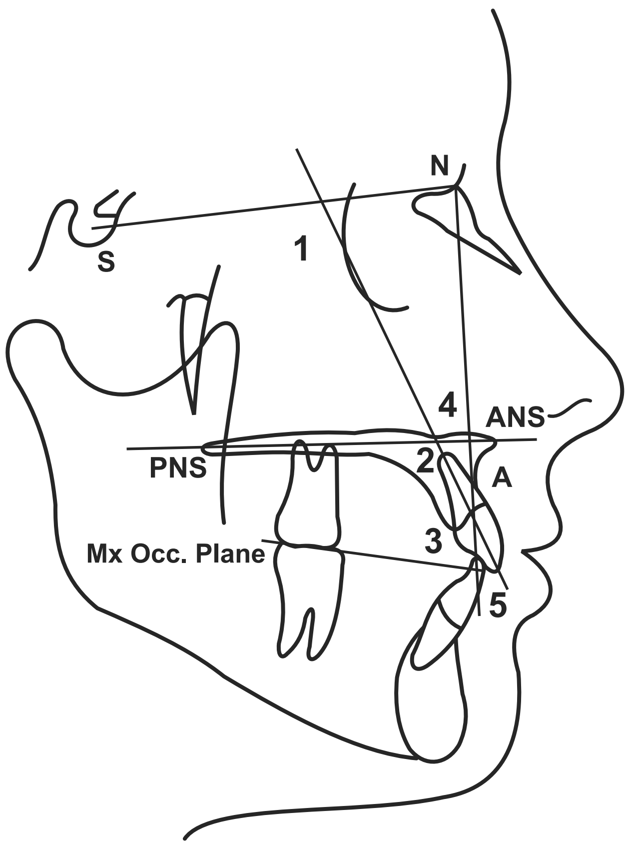

Fig 1 : **A tracing of a lateral cephalometric radiograph showing the measurements used to evaluate the upper incisors inclination in this study: 1. U1-SN, 2. U1-PP, 3. U1-MxOP, 4. U1-NA, 5. U1-NA (mm).**

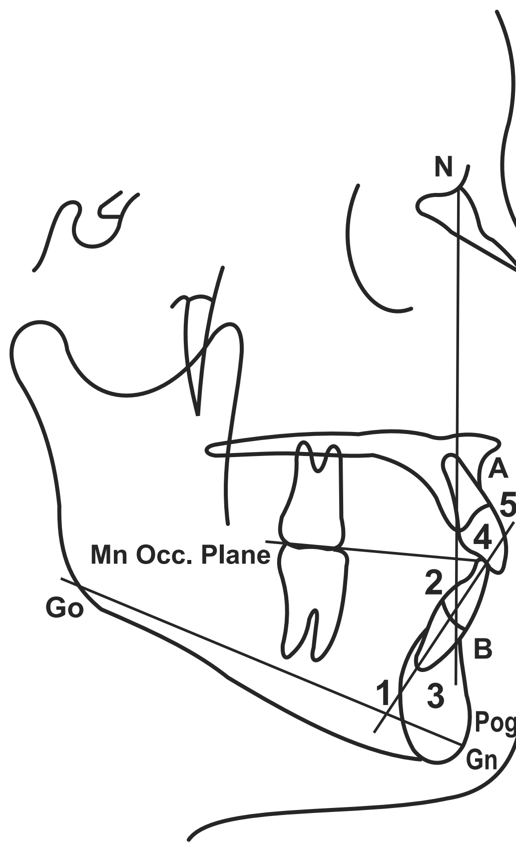

Fig 2: **A tracing of a lateral cephalometric radiograph showing the measurements used to evaluate the lower incisors inclination in this study: 1. L1-GoGn, 2. L1-MnOP, 3. L1-NB, 4. L1-NB (mm), 5. L1-APog (mm)**

difference existed. In the maxillary incisors, 60% of the cases had a difference of d" 2 SD between the five methods [Table 1]. The distribution of the differences was equal among the three skeletal classes and no statistical difference (p>0.67) was detected with Chi-square test. In the mandibular incisors, nearly 58% of the cases showed a considerable difference between the five methods (e" 3 SD) [Table 2]. No tendency for a specific distribution of differences in certain types of skeletal relationship was detected by Chi-square test (p=0.10). When correlation analysis was performed between the five methods of the maxillary incisors, strong correlations were found between the four angular measurements [Table 3]. Weaker correlations were

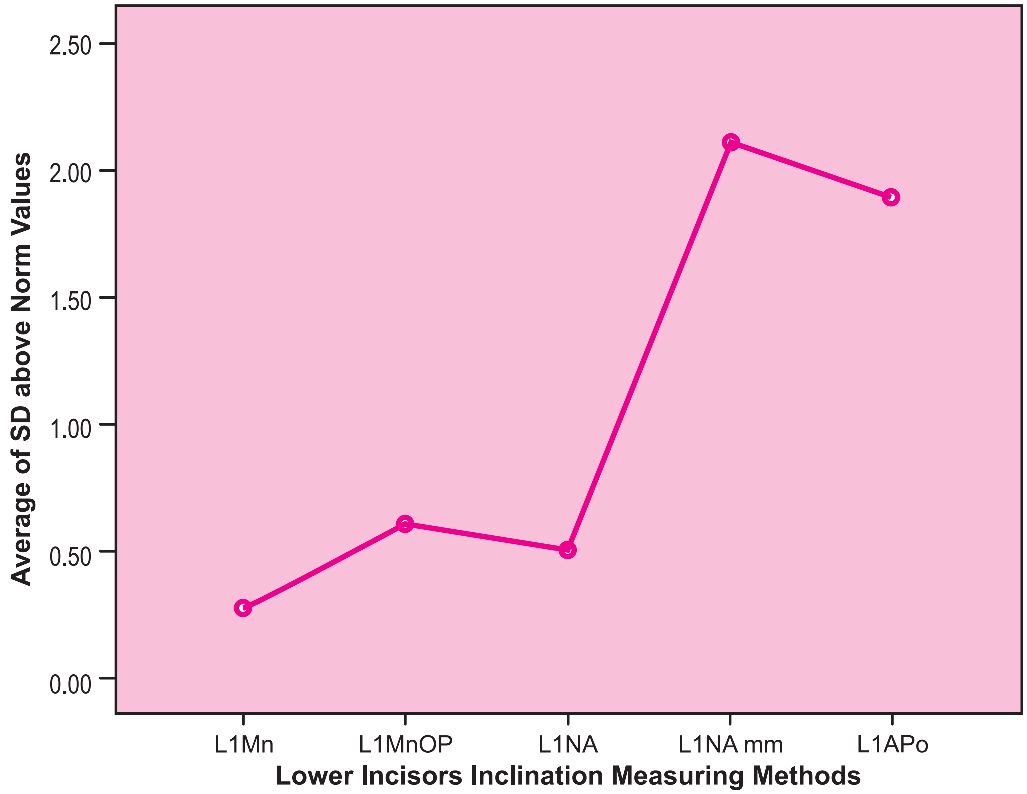

Fig 3 : **A plot showing the means of the five different methods in the measurement of the lower incisors inclination.**

seen between the linear (U1-NA (mm)) and the angular measurements. In the mandibular incisors, less strong correlations were present between the angular methods (L1-Mn, L1-MnOP, L1-NA) [Table 4]. In addition, poor correlations were obtained between the angular measurements and L1-APog (mm).

DISCUSSION

Correct incisal inclination contributes to an attractive facial appearance, in addition to its functional role in the determination of overbite stability. Therefore it is important to assess incisor inclination before, during and then at the end of orthodontic treatment.[21] The present study tested the possibility whether various available sagittal skeletal relationship incisors inclination measurement methods differ in their evaluation of the incisors' inclination. Though, comparisons have been carried out to evaluate various available methods used for measuring the sagittal relationship between maxilla and mandible,[18,19,22-25] yet, no attempt have been made to evaluate the incisors inclination measurement methods. During cephalometric analysis, errors in locating the dental landmarks have greater effects on incisors' angulations than the error in locating the skeletal landmarks.[26] To minimize any such landmark identification errors, intra-examiner reproducibility test was carried out that showed a high reproducibility.

All the measurements methods use the same landmarks to identify the incisors' long axis (i.e. the incisal edge and the root apex), however, the methods differ in their reference lines to which the incisors long axes are related.[1,4,9] The initial evaluation of the five methods used to measure the upper incisors inclination showed that the difference between their means was not statistically significant. However, the difference was significant for lower incisors. As the measurements regards to incisal edge and the root apex are constant, the difference in incisor angulation between various methods can be attributed to the effect of identification of other points and geometrical problems in the methods. Rothberg *et al.* (1976)[22], Järvinen (1981, 1985, 1988)[23-25], Rushton *et al.* (1991)[18] and Kirchner & Williams (1993)[19] have reported these effects in their correlation studies between the Wits appraisal and the ANB angle.

The present study showed a significant correlation between L1-ML° and L1-NB°, the result was similar to that of Corelius and Linder-Aronson[27]. A minor difference between in results between the two studies may be explained in terms of changes in the incisors inclination with growth as the sample in the present study were adults. The correlation between the L1-ML° with L1-NB (mm) and, L1-NB° with L1-NB (mm) were also similar between the present study and that of Corelius and Linder-Aronson.[27] The current study, however, has expanded the analysis by inclusion of maxillary incisors, and of more angular and linear measurements as compared to Corelius and Linder-Aronson.[27]

The present study found a strong correlation between the angular methods in the maxillary incisors. Although, the U1-SN and U1-PP use two reference lines that are not topographically related, and they depend on completely separate anatomical landmarks, they were are strongly correlated. Ishikawa *et al.* (1999)[28] have shown that U1-SN is preferable than U1-PP as an appropriate cephalometric parameter for describing dental compensation quantitatively.[28] Based on the results of this study, both measurements may be used interchangeably in clinical practice due to the significant correlation found.

Linear measurements showed weak correlations with the angular methods in both upper and lower arches. In the lower arch, they tend to exaggerate the positive inclinations of the incisors, while the angular methods present the inclinations conservatively. This might result from the reference points through which linear methods determine the incisors positions i.e. the incisal edge and the labial surface of the incisor, rather than the long axis.[4-6, 9-11] The strongest correlations between the angular and linear methods were detected in cases of U1-NA (mm) with U1-NA° and L1-NB (mm) with L1-NB°, as expected due to the topographical relationship between these variables. This finding has also been described in Corelius and Linder-Aronson (1976) study.[27] Clinicians need to understand the weakness of each measurement tool and interpret the results of the linear methods cautiously.

Earlier studies by Noyes *et al.* (1945)[29], and King (1962)[30], have demonstrated a similarity of inclination of maxillary and mandibular incisors in normal and both classes of malocclusion. The present study has confirmed that variation in incisors inclination did not significantly change in different malocclusion classes especially in the maxillary arch.

In future, the effects of various vertical skeletal relationships on the incisors inclination need to be studied utilizing more robust statistical analyses. Nevertheless, it is hoped that results of the present study would assist clinicians in assessment of incisors inclination evaluations.

CONCLUSIONS

1 There was a significant difference between the five methods used for measuring the inclination of the mandibular incisors, where the linear measurements (L1-NB (mm), L1-APog (mm)) tend to overestimate the proclination of the incisors.

2 There was no statistical difference between the different methods in measuring the upper incisors inclination, and the angular measurement methods were closely correlated.

3 There was no effect of the skeletal relationship on the variability of the incisors inclination evaluation results.

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