Original Article

Does proclination of maxillary incisors really affect the sagittal position of point A?

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ABSTRACT

Objective: To examine the effect of maxillary incisor proclination due to orthodontic treatment upon the sagittal position of point A and evaluate the effect of this possible movement of point A on sella-nasion-point A (SNA) angle.

Materials and Methods: A study group was formed from 25 subjects (12 male and 13 female) who had Class II division 2 malocclusion with retroclined upper incisors, and a control group was formed from 25 subjects (12 male and 13 female) who had minor crowding in the beginning of the treatment and required no or minimal maxillary anterior tooth movement. Treatment changes in maxillary incisor inclination, sagittal position of point A, SNA angle, and movement of incisor root apex and incisal edge were calculated on pretreatment and posttreatment lateral cephalographs.

Results: Maxillary incisors were significantly proclined (17.33°) in the study group and not significantly proclined (1.81°) in the control group. This proclination resulted in 2.12-mm backward movement of the root apex and 5.76-mm forward movement of the incisal edge of maxillary incisors. Point A moved 1.04 mm backward ($P = .582$) and 0.48 mm ($P = .811$) forward in the study and control groups, respectively. Incisor root apex and incisal edge almost remained stable in the control group. No significant change was observed in the value of the SNA angle in both the study and control groups.

Conclusions: Proclination of maxillary incisors accompanied by backward movement of incisor root apex caused posterior movement of point A. However, this posterior movement does not significantly affect the SNA angle. (*Angle Orthod.* 2013;83:943–947.)

KEY WORDS: Class II division 2; Point A; Maxillary incisor proclination

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INTRODUCTION

Cephalometric analyses are the major processes for orthodontists to clarify the position and location of the skeletal part of the stomatognathic system such as the maxilla and mandible, and upper and lower teeth. Although many analyses are available in the orthodontic field, orthodontists' expectations from the analyses are simply what the position of the maxilla and mandible is, where and how the lower and upper incisors are located, and how vertical the dimension is. In order to present the sagittal position of the maxilla in the craniofacial system, point A, the most concave point of the anterior border of the maxilla has already been used by nearly all of the popular analyses. Accurate and easy localization could be determined as the major factor for preferring point A in these analyses. However, point A has also been considered as an unreliable anatomic landmark in order to represent the skeletal position of the maxilla because it is influenced by growth and dentoalveolar remodeling associated with orthodontic tooth movement of the upper incisors.[1–4]

There are limited studies investigating the effects of anterior tooth movement on the position of point A in the literature.[1,3,5–10] An earlier study by Van der Linden[8] showed that point A was related to the inclination of the incisor teeth since labial inclination was associated with a more anteriorly positioned point A. In a recent

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study by Al-Abdwani et al.,[5] it was shown that each 10° proclination of upper incisors resulted in a statistically significant change in point A of 0.6 mm in the horizontal plane. In another study, it was observed that 14° proclination of upper incisors resulted in 0.6-mm significant retraction of point A, which was similar to the results of Al-Abdwani et al.[6] Cangialosi and Meistrell[1] demonstrated a stronger correlation between changes in maxillary incisor inclination and sagittal position of point A than the previous two studies as they retracted point A 1.7 mm due to 12.28° proclination of upper incisors. Goldin[7] evaluated the effect of labial root torque on sagittal position of point A in 17 subjects and performed a control group in an attempt to account for growth, which was weakness of previous studies evaluating the effect of incisor tooth movement on position of point A. The measurements were made on cephalographs taken at the first time period (1.5 years) and at the end of total treatment. The results showed that labial root torque resulted in significant anterior movement of point A at the first time period; however, no difference was observed between the control and study groups for the anterior movement of point A at the end of total treatment time.

In order to evaluate the effect of any tooth movement on skeletal structures, the studies should be performed on subjects at the similar age because the skeletal response may be different in growing or nongrowing patients. However, previous studies evaluating the relationship between the incisor inclination and movement of point A were performed on subjects showing a wide range of ages, which may affect the response of point A to maxillary incisor movement. In addition, it is better to perform a control group in an attempt to account for growth. However, in the orthodontic literature, almost all previous studies evaluating the effect of maxillary incisor inclination on the position of point A lack a control group.[1,3,5,6,8–10]

The aim of this study was to evaluate the effect of maxillary incisor proclination on the sagittal position of point A on subjects of similar age as a result of orthodontic treatment and to compare the results to a matched control in an attempt to account for growth.

MATERIALS AND METHODS

In order to perform study and control group comparisons, lateral cephalographs of 25 subjects (12 male and 13 female) who had Class II division 2 malocclusion and 25 Class I subjects (12 male and 13 female) with minor crowding who required minimal maxillary anterior tooth movement were selected from the archives of Cumhuriyet University Faculty of Dentistry, Department of Orthodontics, respectively. Ethical approval was obtained for this study from the

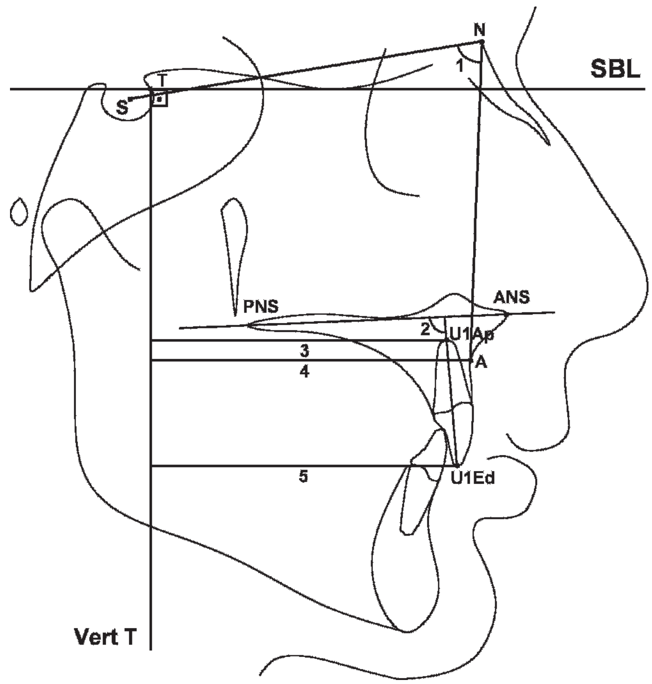

Figure 1. Cephalometric landmarks, angular and linear measurements. Sella (S): center of the pituitary fossa of the sphenoid bone. Point T (T): most superior point of the anterior wall of sella turcica at the junction with tuberculum sellae. Nasion (N): the most anterior point of the frontonasal suture in the median plane. Anterior nasal spine (ANS): tip of the median anterior bony process of the maxilla. Posterior nasal spine (PNS): tip of the posterior nasal spine. Point A (A): deepest point on the curve of the maxilla between the anterior nasal spine and supradentale. Maxillary incisor apex (U1Ap): root apex of the most prominent maxillary central incisor. Maxillary incisor edge (U1Ed): incisal edge of the most prominent maxillary central incisor. SBL: stable basicranial line. Vertical reference line (Vert T). 1. SNA angle, 2. U1-PP angle. 3. Vert T-U1Ap distance. 4. Vert T-point A distance. 5. Vert T-U1Ed distance.

Research Ethical Committee of Cumhuriyet University (2012–02/44). The average age of the sample in the study group was 13.2 ± 1.1 years, while it was 13.5 ± 0.4 years in the control group.

All radiographs used in the present study were taken with the same x-ray machine (Planmeca, Proline 2002 CC, Helsinki, Finland). Cephalographs were traced by the same operator by hand, and all measurements were carried out with a gauge to the nearest 0.1 mm. Cephalometric landmarks used in this study are identified in Figure 1. Two inclusion criteria were taken into consideration in the present study. First, both study and control groups included subjects in similar age groups. Second, the difference between the initial and posttreatment U1-PP angle (angle formed by the intersection of the long axis of the maxillary incisor and the anterior nasal spine and posterior nasal spine line) should be at least 10° for the study group. The control group included subjects for whom upper incisors were of average inclination at the beginning of the treatment

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Table 1. Treatment Changes in Study and Control Groups[a]

	Class II Division 2 Group (n = 25)					Control Group (n = 25)				
	T1	T2	T2–T1			T1	T2	T2–T1		
Measurement	Mean ± SD	Mean ± SD	Mean ± SD	*P*	Sig	Mean ± SD	Mean ± SD	Mean ± SD	*P*	Sig
SNA, degree	79.30 ± 3.60	79.12 ± 4.00	−0.18 ± 1.81	.743	NS	80.75 ± 2.94	80.70 ± 4.21	−0.05 ± 1.82	.929	NS
U1-PP, degree	96.32 ± 2.16	113.65 ± 3.40	17.33 ± 2.84	.001	***	112.43 ± 4.71	114.24 ± 2.14	1.81 ± 2.12	.819	NS
Vert T-U1Ap, mm	53.47 ± 3.04	51.35 ± 2.76	−2.12 ± 2.09	.001	***	55.00 ± 3.64	54.60 ± 1.99	−0.40 ± 2.61	.925	NS
Vert T-A, mm	59.76 ± 2.14	58.72 ± 1.86	−1.04 ± 2.17	.582	NS	60.41 ± 4.44	59.93 ± 3.16	−0.48 ± 0.79	.811	NS
Vert T-U1Ed, mm	57.48 ± 1.91	63.24 ± 2.35	5.76 ± 3.41	.001	***	64.25 ± 3.96	64.45 ± 2.04	0.20 ± 1.14	.856	NS

[a] Wilcoxon *t*-test.
*** $P = .001$; NS indicates not significant.

and remained stable or changed minimally at the end of the orthodontic treatment.

A vertical reference line (Vert T) was used as a reference plane constructed through craniofacial stable structures as described previously.[11–13] The following parameters were used in this study (Figure 1):

- SNA angle: angle formed by the intersection of the nasion-sella and nasion-point A lines;
- U1-palatal plane angle (U1-PP): angle formed by the intersection of the long axis of the maxillary incisor and the anterior nasal spine–posterior nasal spine line;
- Vert T-U1Ap: perpendicular distance from the maxillary incisor root apex to the vertical reference line;
- Vert T-A distance: perpendicular distance from point A to the vertical reference line; and
- Vert T-U1Ed: perpendicular distance from the incisal edge of the maxillary incisor to the vertical reference line.

To determine the errors associated with cephalometric measurements, 10 randomly selected cephalographs were retraced 3 weeks after the first measurement, and all measurements were repeated to estimate the repeatability of the measurements. Reproducibility coefficients were found greater than 0.90 for both linear and angular measurements, which did not reveal any measurement error. For a critical trial with a power of 80% and an alpha level of .05, a sample size of 25 patients was considered suitable.

Statistical Analysis

Data analysis was performed by SPSS for Windows, version 14.0 (SPSS Inc, Chicago, Ill). The differences for the age, gender, and treatment time were measured using chi-square test. Means and standard deviation between the pretreatment and posttreatment measurements were studied using Wilcoxon paired *t*-test. Differences between groups were analyzed by Mann-Whitney *U*-test. The level of significance was set at $P < .05$.

RESULTS

There was no difference for the ages and gender of the subjects between the two groups. The mean treatment times for the control and study groups were 23 ± 4 months and 22 ± 5 months, respectively, and the difference was statistically nonsignificant ($P = .884$). The maxillary incisor proclination (U1-PP) was found to be 17.33° and 1.81° for the study and control groups, respectively. The difference between the two measurements performed pre and post treatment (T2–T1) was statistically significant in the study group ($P = .001$) and nonsignificant ($P = .819$) in the control group, Table 1. The difference between the two groups was statistically significant ($P = .001$), Table 2. Incisal edges of maxillary incisors were moved forward 5.76 mm in the study group, which was statistically significant ($P = .001$), Table 1. Statistically nonsignificant forward movement of 0.2 mm was observed in the control group ($P = .856$), Table 1. The difference for the movement of the incisal edge between the two groups was statistically significant ($P = .001$), Table 2. The apex of maxillary incisors was moved backward 2.12 mm and 0.4 mm in the study and control groups, respectively. The movement in the study group was statistically significant ($P = .001$), while it was nonsignificant in the control group ($P = .925$), Table 1. The difference between the two groups was also statistically significant ($P = .001$), Table 2. The change in SNA degree was observed to be 0.18° and 0.05° for the study and control groups, respectively. The difference between T1 and T2 measurements for both groups was statistically nonsignificant ($P = .743$, $P = .929$), Table 1. The change in SNA between the two groups was found to be nonsignificant ($P = .818$), Table 2.

Linear measurements evaluating the sagittal positional changes showed that A point moved 0.48 mm forward but 1.04 mm backward in the control and study groups, respectively. The difference between the two groups was found to be statistically not significant. ($P = .766$), Table 2.

DISCUSSION

The aim of this study was to examine the relationship between maxillary incisor inclination change and

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Table 2. Pairwise Comparison of Treatment Changes Between Study and Control Groups for Angular and Linear Measurements[a]

	Class II Division 2 Group (n = 25)		Control Group (n = 25)			
	T2–T1		T2–T1			
Measurement	Mean	SD	Mean	SD	*P*	Sig
SNA, degree	−0.18	1.81	−0.05	1.82	.818	NS
U1-PP, degree	17.33	2.84	1.81	2.12	.001	***
Vert T-U1Ap, mm	−2.12	2.09	−0.40	2.61	.001	***
Vert T-A, mm	−1.04	2.17	−0.48	0.79	.766	NS
Vert T-U1Ed, mm	5.76	3.41	0.20	1.14	.001	***

[a] Mann-Whitney *U*-test.
*** $P = .001$; NS indicates not significant.

the sagittal position of point A, which was found to be interrelated in previous studies.[1,3,5–10]

The wide range of ages of samples and the lack of a control group in order to account for the effect of growth on the position of point A could be interpreted as the weakness of the previous studies evaluating the relationship between incisor inclination and point A movement. Only in one study was the effect of growth considered by using a control group.[7] In another, the effect of growth was evaluated but in an unusual way, as the need of a control group was eliminated with the aid of a statistical model rather than a routine control group.[5] In the present study, a control group was used with the subjects whose maxillary incisor inclinations remained stable or changed slightly during orthodontic treatment in order to evaluate the effect of growth on the sagittal position of point A. Obviously, it would be better to include a control group of untreated Class II division 2 subjects; however, the lack of these data in our institution and the impossibility of performing new data analyses due to ethical considerations, obligated us to use a control group as explained above.

In the previous studies evaluating the effect of incisor inclination on the point A position, the age of subjects was not homogeneous such as 12.2 to 19.5 years, 8.8 to 39 years, 13 to 25 years, and 13.2 to 16.6 years. If one desires to exhibit the effect of maxillary incisor inclination on the remodeling of point A, it is better to be presented on patients of similar age. In the present study, the average ages of the sample in the study and control groups were 13.2 ± 1.1 and 13.5 ± 0.4 years with a range from 13 to 15 years and 13 to 14 years, respectively. It is clear that skeletal response to tooth movement will not be similar in growing and nongrowing patients. If a remodeling occurs in point A due to maxillary incisor proclination, it is expected to be more noticeable in the growing patients.

It would be better to perform the present study on nongrowing patients in order to eliminate the effect of growth on the sagittal position of point A. However, in the present study, the patients in the study group included subjects who had Class II division 2 malocclusions and following the incisor proclination, most of them underwent functional orthopedic treatment to move their mandibles forward. Consequently, we had to perform this study on growing patients and used a control group with subjects for whom maxillary incisors remained stable or moved slightly during orthodontic treatment.

The results of the present study showed that in the study group, the incisal edge of the maxillary incisors was moved 5.76 mm forward, while the apex moved 2.12 mm backward during orthodontic treatment, which would result in 17.33° of proclination. This finding indicated that the movement generated due to the orthodontic treatment is a rotational movement with the center of rotation closer to the apex than to the bracket. The effect of this change on the sagittal position of point A appeared as 1.04-mm backward movement. Axial inclination of the upper incisors could be changed in various ways. The critical situation that should be considered here is where the center of rotation should be. Orthodontists can procline the maxillary incisors by leaving their apices stable or moving them posteriorly in different amounts with adjusting the center of rotation between apex and bracket. Cangialosi and Meistrell[1] examined the effect of lingual root torque on the sagittal position of point A and showed that 3.5-mm posterior movement of the apex and 1.62-mm forward movement of the incisal edge of the maxillary incisors, which indicates that the center of rotation is closed bracket, resulted in 1.7-mm posterior movement of point A. It was demonstrated that point A follows the apex of the upper incisors, however by as much as half. This finding is in accordance with the results of the present study indicating that point A moved 1.04 mm, while the apex of the maxillary incisors moved 2.12 mm backward. As it was noted, the usual position of point A was around the level of and anterior to the apex of the maxillary central incisors.[14] The relationship between sagittal movement of the incisor apex and point A was an expected result, and it would be better to consider the movement of the incisor apex in order to evaluate the sagittal change of point A rather than the angular measurements.

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In the present study, 1.04-mm posterior movement of point A led to 0.18° decrease in the SNA angle, which was found not significant. However, the majority of the studies evaluating the relationship between the sagittal position of point A and the SNA angle found a positive relationship between the linear movement of point A and the change in the SNA angle in that 1-mm backward movement of A point resulted in nearly 1° decrease in the SNA angle.[1,9,15–17] The results of the longitudinal growth studies have shown that due to the apposition in the glabella region, nasion moves forward in an upward or downward direction throughout the whole growth period due to the individual growth pattern.[18,19] If nasion moves in a downward direction, then the inclination of the sella-nasion line (cranial base) will change, and this would lead to a more obtuse SNA angle. In the present study, nasion might have moved in a forward, however mainly in a downward direction during the treatment, so the posterior movement of point A could not lead to a significant decrease in SNA angle. The downward movement of nasion in the study group may also be attributed to the posterior rotational effect of the functional therapy on the associated maxillary complex as well as the individual growth pattern.

Following the first introduction as a skeletal landmark, point A has become very popular in orthodontics to determine the position of the maxilla. Many authors have used point A to prove the effectiveness of their treatment modalities, especially in the treatment of Class III malocclusion.[20–23] However, the results of the present study showed that the sagittal position of point A could be influenced by tooth movement; hence, this may lead to errors in evaluation of the true efficiency of orthodontic treatments on the skeletal base of the maxilla.

CONCLUSIONS

- If proclination of the maxillary incisors produces posterior movement of the incisor root apex, then point A follows this retraction in half amount.
- However, this posterior movement of point A does not significantly lead to a reduction in the SNA angle.

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