Lower incisor inclination changes during Xbow treatment according to vertical facial type

Carlos Flores-Mir[a]; **Arden Young**[b]; **Amira Greiss**[b]; **Matthew Woynorowski**[b]; **James Peng**[b]

ABSTRACT

Objective: To evaluate the magnitude of lower incisor inclination associated with the vertical facial type in adolescent Class II patients treated with the Xbow appliance.

Materials and Methods: A total of 172 consecutive Class II patients treated with only the Xbow appliance were used. The sample was divided into three groups based on their vertical facial type (24 short, 122 normal, and 25 long facial types). The mean age was 11.11 years at T1 with a mean active Xbow time of 4.5 months. A mean of 6.4 months passed after the Xbow deactivation before T2 radiograph.

Results: No significant association between lower incisor proclination and vertical facial type was found. Actual differences between T1 and T2 did exist. In most cases, these differences may be considered clinically relevant, but when the large interindividual variability is considered, the differences between the groups could not be statistically supported. At T1, a distinct trend to have more proclined lower incisors in the short (100.5°) compared with the long (91.3°) facial types was found. During treatment, a trend was identified for more proclination of the lower incisor the shorter the face.

Conclusions: Although lower incisors do procline with the use of the Xbow appliance, facial type does not appear to affect the amount of lower incisor inclination. The magnitude of the incisor proclination can be considered not clinically relevant, but a large individual variation in the incisor response was identified. (*Angle Orthod.* 2010;80:1075–1080.)

KEY WORDS: Class II; Xbow; Facial type; Incisor position

INTRODUCTION

In subjects with either short or long vertical facial types, underlying skeletal and dental variations have been quantified.[1–3] These variations generally represent growth compensation mechanisms to counteract overall vertical facial growth deviations.[3] For patients seeking orthodontic treatment, the extent of the skeletal dysplasia and secondary skeletal and dental compensations will influence the patient's specific treatment objectives. In this regard, suggested tooth movement limitations based on the surrounding soft

[a] Associate Professor and Head of the Division of Orthodontics, Department of Dentistry, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Canada.

[b] Dental Student, Department of Dentistry, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Canada.

Corresponding author: Dr Carlos Flores-Mir, Faculty of Medicine and Dentistry, University of Alberta, Dentistry, 4051 Dentistry/Pharmacy Centre, University of Alberta, Edmonton, AB T6G 2N8 Canada
(e-mail: carlosflores@ualberta.ca)

and hard tissue envelope have been already published.[4] What is not so clear-cut is how the anterior-posterior position of the lower and upper incisors are related to the vertical facial pattern, as different studies[2,3,5–9] have reported contradictory findings. Therefore, an understanding of the dental movements produced by specific orthodontic appliances is important in treatment planning.

A couple of systematic reviews[10,11] have concluded that most available fixed Class II correctors produce short-term effects, which include some minimal skeletal modifications (by a combination of maxillary restriction and mandibular reposition) and more significant dental changes (molar distalization and mandibular incisal proclination), which all together accounted for the correction of mild to moderate Class II occlusions.

The Xbow (crossbow; www.crossboworthodontic. com) appliance is a relatively new fixed Class II corrector. It is designed to obtain a rapid overcorrection of Class II dental malocclusions in children and adolescents just before full fixed appliances are inserted. To date, only one published article[12] about the Xbow appliance can be found in the literature. The short-term changes reported in this article were not significantly different from the

short-term effects of other fixed Class II correctors summarized in the previously mentioned systematic reviews.[10,11] An increased mandibular incisor proclination without significant maxillary incisor retroclination was reported.[12]

It seems clear that the anterior dentoalveolar height is closely related to the vertical growth tendency.[2] What is not so evident is the relationship between the anterior-posterior position of the lower and upper incisors and the vertical facial pattern, as different studies[2,3,5–9] have reported contradictory findings. Some of these articles have hypothesized that a distinct vertical growth type (vertical facial excess or deficiency) could affect the magnitude of incisal proclination/retroclination. In long facial types, the incisors tended to be more upright, which theoretically is a natural compensatory mechanism to try to keep a balanced OB and OJ.

The previously published article[12] about the Xbow appliance found a degree of incisal proclination after its use, but no analysis about a possible influence of distinct facial types was included. The objective of this study was therefore to evaluate if indeed the post-treatment incisor proclination is associated with the vertical facial type in adolescent Class II patients treated with the Xbow appliance. This information could be valuable for clinicians as it may influence their treatment planning decisions when considering the Xbow appliance as an alternative.

MATERIALS AND METHODS

Sample

The sample was retrieved from a private practice and consisted of all patients consecutively started exclusively with the Xbow appliance. All had both pretreatment and posttreatment lateral cephalograms taken between January 2003 and December 2008. This resulted in a sample of 174 consecutively started patients. Only two of the patients did not complete the initial treatment phase because of soft tissue sores. Both cases did not have any outstanding skeletal and/or dental characteristic that would make them particularly different from the treated sample. Therefore, at the end, 172 cases were considered. A representative part of the total sample was used in the previous Xbow publication.[12] The mean age of the patients was 11.11 years (SD, 1.3) at T1 and 13.2 years (SD, 1.3) at T2. The mean time the Xbow was in the mouth was 4.5 months (SD, 1.6), and a mean of 6.4 months passed after the Xbow deactivation before the T2 radiograph.

Xbow Appliance

The Xbow appliance (Crossbow, Delta, BC) encompasses the combination of a maxillary expansion appliance, a mandibular triple arch (lingual and labial arches), and a couple of bilateral (also unilateral placement is possible) Forsus Fatigue Resistance Device springs (Unitek, Monrovia, Calif; Figure 1). Specific details about the appliance construction, insertion, and clinical management can be found elsewhere (www.crossboworthodontic.com). As a summary after the Xbow appliance is inserted, the Class II correction is monitored until an overcorrection of half to a full cusp is attained. The springs are then removed and maxillary expansion started, if required. The patient is recalled after 1 month to evaluate the degree of relapse. If the relapse is acceptable, the Hyrax (if no expansion was required) and the triple arch are removed. After this, at least 3 months are allowed before progress records are taken to plan the second phase of treatment. This period of time is expected to provide the full expression of any further physiologic relapse.

Data Collection

All cephalometric radiographs were taken with an Orthoceph OC100D (General Electric, Tuusula, Finland). The radiographs were printed twice each and coded for blinding purposes. No information in the printed radiographs gave a hint about age, gender, or if the radiograph was from before or after the Xbow was used. Only a person outside the research team had the code. Four different evaluators grouped in two pairs landmarked and measured each half of the sample. The radiographs were randomly assigned to both groups.

Landmarks and Cephalometric Analysis

Commonly used landmarks, reference planes, and measurements were used. Definitions of points (S, Go, N, M, ANS, and PNS) and lines (SGo, NM, ANSPNS, MGo, U1, and L1) can be found elsewhere.[4] Some of the less common abbreviations are defined in Table 1.

Vertical facial type (SGo/NM). Upon calculation of the individual distances (SGo and NM), a proportion between them was calculated (SGo/NM). The total sample was thereafter grouped in three categories (long, normal, and short) based on the data distribution. Values that were within one standard deviation (0.05) of the mean (0.64) were considered for the normal group. If the values were larger than one standard deviation from the mean, the individuals were grouped in the long face ($>$0.69) and short face ($<$0.60) groups. For classification purposes, the sample was also divided in the same three groups but based on predefined cutoff values (less than 0.62, between 0.62 and 0.65, and more than 0.65, respectively).

OB and OJ. OB and OJ were calculated as continuous variables measured in millimeters. Values were rounded to closest half millimeter.

Figure 1. Photo of the appliance.

Upper incisor inclination (U1.ANSPNS). Upper incisor inclination was calculated in degrees, rounding to a full degree.

Lower incisor inclination (L1.MGo). Lower incisor inclination was calculated in degrees, rounding to a full degree.

Statistical Analysis

SGo/NM was considered the independent variable and OB, OJ, L1MGo, and U1PP were considered dependent variables for the statistical analysis. Al-

Table 1. List of Abbreviations Used

SGo: Linear distance between the points S (Sella) and G (Gonion).
NM: Linear distance between the points N (Nasion) and M (Menton).
ANSPNS: Plane formed between the points ANS (Anterior Nasal Spine) and PNS (Posterior Nasal Spine).
MGo: Plane formed between the points M and Go.
U1: Long axis of the upper incisor.
L1: Long axis of the lower incisor.
OB: Overbite.
OJ: Overjet.
U1.ANSPNS: Angle formed by the intersection of the projections of U1 and ANSPNS.
L1.MGo: Angle formed by the intersection of the projections of L1 and MGo.

though the distribution of the sample could be assumed normal, this was not clear cut (*P* values for Komolgorov-Smirnov on the dependent variables showed weak significance, between .05 and .1). Therefore, it was decided to use both parametric and nonparametric tests.

After descriptive statistics were calculated, both *t*-test and Wilcoxon sign rank tests were used to determine if there were significant differences between the mean values of the dependant variables at T1. Thereafter, a multivariate analysis of variance (MANOVA) was applied to analyze the data interactions when the sample was grouped based on the vertical facial type. The MANOVA tested the T2–T1 difference for the four dependent variables for differences between the levels of the SGO/NM grouping variable (split by the 0.62 and 0.65 cutoffs or by plus/minus one standard deviation from the mean).

Error of Method

Each pair of evaluators independently traced and measured the radiographs for the same half of the total study sample. Using this approach, every radiograph was measured twice. An initial visual analysis identified discrepancies larger than 2 mm, 2%, or 2° for every traced radiograph. If the differences were smaller than

Table 2. Intraclass Coefficient (ICC) for Inter and Intra Reliability

Variable	Intra ICC	Inter ICC
SGo.NM	0.972	0.966
U1.ANSPNS	0.892	0.924
L1.MGo	0.949	0.960
OJ	0.794	0.694
OB	0.881	0.669

these values, the mean between both values was considered. For the discrepancies above those values, the radiographs were retraced by both evaluators and measured a second time. The mean between these second measurements was then considered.

For reliability purposes, the senior author also traced a random coded selection of 10 radiographs and landmarked and measured them twice with several days in between. The same 10 radiographs were landmarked and measured by all four evaluators, and the means from each pair of evaluators were compared with the mean from the senior author's measurements for reliability analysis.

Both intraclass correlation coefficients (ICCs) and mean errors were used to assess the degree of any landmark error. To calculate the mean errors, the three sets of mean measurements (from the senior author and the two pairs of evaluators) had their maximum difference calculated for each of the 10 radiographs, and the mean was taken.

RESULTS

Reliability

The ICCs were in the .90s for SGoNM, U1ANSPNS, and L1MGo. For OB and OJ, the ICCs were relatively lower (in the high .60s; Table 2). This was reflected as mean differences of 2% (0.02) for SGoNM, 3.5° for U1ANSPNS, 2.5° for L1MGo, 1.9 mm for OJ, and 1.4 mm for OB.

Main Results

As the two classification systems consistently reported the same statistical results, only the data for the classification based on standard deviation will be reported. This implied a grouping of 24 individuals in the short face group, 122 individuals in the normal face group, and 25 individuals in the long face group.

Descriptive Analysis for the Independent Variables at T1

The mean inclination at T1 for the upper incisor was 110.6° (SD, 8.9°; Table 2). No significant differences were found for the upper incisor proclination between

Table 3. Descriptive Statistics for the Evaluated Variables Grouped by Facial Vertical Growth Tendency at T1

Group at T1		U1 to ANSPNS	L1 to MGo	OJ	OB
Short face	Mean	112.26	91.31	8.36	5.74
	n	24	24	24	24
	SD	6.36	6.09	2.64	2.27
Normal face	Mean	110.37	96.42	7.06	6.73
	n	122	122	122	122
	SD	8.70	6.01	2.11	1.68
Long face	Mean	110.25	100.47	7.42	6.39
	n	25	25	25	25
	SD	11.84	6.84	2.88	1.93
Total	Mean	110.62	96.30	7.30	6.54
	n	171	171	171	171
	SD	8.917	6.59	2.34	1.83

the different groups ($P = .624$, both ANOVA and Kruskal-Wallis).

The mean inclination at T1 for the lower incisor was 96.3° (SD, 6.6°; Table 2). Significant differences ($P < .001$, both ANOVA and Kruskal-Wallis) were found for the lower incisor proclination between the different groups. A distinct trend to have more proclined lower incisors in the short (100.5°) compared with the long (91.3°) faces was found.

The mean OJ at T1 was 7.3 mm (SD, 2.3 mm; Table 3). No significant differences (preference given to the Kruskal-Wallis values) were found between the different groups ($P = .048$, ANOVA; $P = .138$, Kruskal-Wallis).

The mean OB at T1 was 6.5 mm (SD, 1.8 mm; Table 3). No significant differences (preference given to the Kruskal-Wallis values) were found between the different groups ($P = .042$, ANOVA; $P = .086$, Kruskal-Wallis).

Descriptive Changes for the Independent Variables

Regarding the upper incisor inclination, the mean change between T1 and T2 was a decrease of 1.0° (SD, 7.7°; Table 4) but without a statistically significant difference ($P = .088$, t-test). It should be noted that the nonparametric test did show a significant difference ($P = .016$, Wilcoxon).

Regarding the lower incisor inclination, the mean change between T1 and T2 was an increase of 3.6° (SD, 4.9°; Table 4), with a statistically significant difference ($P < .001$, t-test; $P < .001$, Wilcoxon).

Regarding OJ, the mean change between T1 and T2 was a decrease of 2.6 mm (SD, 2.0; Table 4) with a statistically significant difference ($P < .001$, t-test; $P < .001$, Wilcoxon).

Regarding OB, the mean change between T1 and T2 was a decrease of 1.9 mm (SD, 1.8; Table 4) with a statistically significant difference ($P < .001$, t-test, $P < .001$, Wilcoxon).

Table 4. Descriptive Statistics for the Treatment Changes in the Evaluated Variables Grouped by Facial Vertical Growth Tendency Between T1 and T2

Group at T1		U1 to ANSPNSdiff	L1 to MGodiff	OJdiff	OBdiff
Short face	Mean	−2.71	4.86	−3.27	−1.56
	n	24	24	24	24
	SD	3.68	4.20	1.70	2.40
Normal face	Mean	−1.08	3.58	−2.47	−2.07
	n	122	122	122	122
	SD	7.31	4.87	1.91	1.76
Long face	Mean	1.04	2.40	−2.72	−1.54
	n	25	25	25	25
	SD	11.16	5.64	2.60	1.29
Total	Mean	−1.00	3.59	−2.62	−1.92
	n	171	171	171	171
	SD	7.65	4.92	2.01	1.81

Influence of Vertical Facial Type on the Independent Variables

To test whether the T2–T1 differences for the four dependent variables were related to vertical facial type, MANOVA was performed. The T2–T1 differences for the four dependent variables were grouped by SGo/NM (with groups defined by standard deviation), and the overall Wilks Lambda showed only weak significance in the differences between the groups (P = .076). In addition, the univariate between-subjects tests were all nonsignificant and are discussed individually below. To confirm the results of the univariate analyses, a nonparametric Kruskal-Wallis test to compare SGo/NM groups was also performed for each of the four difference variables.

Upper incisor inclination had a noticeable trend in the changes that could be identified between groups. It should be noted that the standard deviations were large (3.7°–11.2°; Table 4). The perceived differences were not confirmed statistically (P = .225, MANOVA; P = .486, Kruskal-Wallis).

For lower incisor inclination, a trend was found in which incisors had less proclination the more vertical the face (from 4.9° to 2.4°; Table 4). It should be noted that the standard deviations were large (4.2°–5.6°). Although the trend did exist, the differences were not confirmed statistically (P = .218, MANOVA; P = .335, Kruskal-Wallis).

For OJ, no noticeable trend in the changes could be identified between groups (Table 4). It has to be noted that the standard deviations were large (1.7–2.6 mm). The lack of differences was confirmed statistically (P = .193, MANOVA; P = .299, Kruskal-Wallis).

For OB, no noticeable trend in the changes could be identified between groups (Table 4). It has to be noted that the standard deviations were large (1.3–2.4 mm). The lack of differences was confirmed statistically (P = .241, MANOVA; P = .57; Kruskal-Wallis).

DISCUSSION

The main finding of this study is that there is no significant association between lower incisor proclination and vertical facial type after conventional use of the Xbow appliance. Although differences between T1 and T2 are apparent, they could not be statistically supported. The large interindividual variability likely explains this finding. It should be noted that initially (T1), the lower incisors were more proclined in the long facial types, but the treatment-generated proclination was less in long facial types than in the short ones.

As with any classification system, subjectivity exits; therefore, for safety, two different systems were used. At the end, neither grouping made a difference. Using two methods diminishes the possibility that the classification per se could be the source of error. Studies have used two different methods to classify vertically the facial types. They either used the mandibular plane angle[8,13,14] or they used upper and lower anterior facial height proportion.[1–3] There is also no universal agreement on the cutoff values to be used by either classification method; consequently, a decision was made to additionally use a statistical cutoff.

Statistically significant changes were found within most of the measured variables (lower incisor proclination, OB, and OJ). The direction of the changes was as expected with a proclination of the lower incisors that implied a reduction of the OJ. In addition to the reduction of OB due to the lower incisor proclination, the relatively small but still present vertical vector of force could also have been a factor. Finally, the lack of significant movement of the upper incisors should be related to the absence of any appliance component that directly interacts with those teeth.

As mentioned in the introduction, different studies have evaluated the dentoskeletal relationships in vertically compromised faces. Some studies have suggested[8,9] that the incisors adapted a more upright position in the long face types, while others[3,5,6] concluded that the incisor's more upright position happened in the short face group. The present results do agree with the first group.[8,9] This is theoretically a natural compensation mechanism to try to keep an ideal OB and OJ.

Somehow, the lower incisors that were less proclined at the start of treatment proclined more significantly during Xbow treatment. In some way, the treatment produced a tendency to the mean effect, in which the initial differences after the relapse period in the lower incisor angulation between the groups were diminished. Is this the effect of the relapse period per se, and all the incisors regardless of the facial type do procline and the vertical facial type influence happens only after the appliance removal, or does this influence happen even during appliance activation? The answer remains

unknown. The lack of radiographs immediately after appliance removal prevents light from being shed on this, but at the same time, the period between appliance removal and the time when the progress radiographs were taken allows for full expression of any potential relapse, which is clinically important. In addition, when you consider incisor position in the context of overall vertical facial pattern, the reference for incisor position is important. Incisor position relative to mandibular plane can actually be retroclined, yet lower incisor to NB or APg lines can show incisor proclination.

Regarding OB, previous studies[2,3] have not found an association with vertical facial types, although a trend to have deeper bites in short faces and shallower bites in long faces has been shown.[3] This study did not identify any related tendency. Theoretically, in long/short faces, the compensatory lengthening/decreasing of the lower dentoalveolar height has a limit, and after that, the OB may decrease/increase as suggested before.[3]

An understanding of the changes in the relationships between the incisors and the dentoalveolar and facial structures through the patient's growth and development is important. Long-term final inclination and relative position of the incisors have not been associated with negative occlusal changes as well as facial vertical patterns.[15–17] The effect of facial growth has been quantified in the previous Xbow publication, and it was not deemed necessary to analyze it again.

Caution has to be exercised regarding the study results. Specific initial malocclusion characteristics, in some of the cases use of 2×4 to align palatally positioned incisors, breakage of the appliance, and length of use and secondary insertion of springs, among other factors, have not been considered. This is clearly an initial exploratory study that helps the generation of working hypotheses for future related studies.

CONCLUSIONS

- Although lower incisors do procline with the use of the Xbow appliance, vertical facial type does not appear to affect the amount of lower incisor inclination.
- A large individual variation in the incisor response was identified.

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