Original Article

Anchorage Control in Bioprogressive vs Straight-wire Treatment

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Abstract: Orthodontic techniques with different concepts and philosophies have emerged to provide adequate anchorage control. The purpose of this study was to compare the effectiveness of the Bioprogressive and Straight-wire techniques in the control of lower anchorage. Data were obtained from the records of 40 patients presenting Class I and II malocclusions treated with first bicuspid extractions. One group of 20 patients was treated with a utility arch used to set up cortical anchorage in the lower arch and sectional retraction mechanics for space closure. The second group was treated with straight wire with a preadjusted appliance system. Treatment evaluation revealed no significant between-group differences in the amount of skeletal growth relative to cranial base and lower mesial movement of first molars. Mean lower anchorage loss was 3.1 mm in the Bioprogressive patients and four mm in the Straight-wire patients. The apical base change was the most important component to molar correction. Although cortical anchorage did not impede lower molar movement, it was no less effective in controlling molar movement with a partial appliance than was the fully banded Straight-wire appliance. (*Angle Orthod* 2005;75:987–992.)

Key Words: Anchorage; Space closure; Cortical anchorage; Biomechanics; Straight wire; Bioprogressive

INTRODUCTION

In orthodontic treatment, anchorage loss is a potential side effect of orthodontic mechanotherapy and one of the major causes of unsuccessful results. Its cause has been described as a multifactorial response in relation to the extraction site, appliance type, age, crowding, and overjet.[1]

Therefore, clinicians throughout the years have made an effort to find biomechanical solutions to control anchorage.[2–6] Tweed,[2,6] Holdaway,[7] and Merrifield[8] developed different types of anchorage preparation to increase the efficacy of treatment. Although satisfactory results were attained by these methods, the validity of second-order (tip-back) bends during anchorage preparation raised considerable controversy.[9–11]

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Storey and Smith[12] introduced new concepts of force, in which an optimum range of force values should be used to produce a maximum rate of movement of the canine without producing any discernible movement of the molar anchor unit. This underlying concept encouraged Begg[13] to put forth a clinical concept called ‘‘differential forces in orthodontic treatment.’’

The use of multiple teeth at the anchorage segment to form a large counterbalancing unit and the application of differential moments have been investigated as methods to stabilize molar position.[14–16] Retraction mechanisms[17] and bracket designs[18] have also been developed to improve tooth movement and anchorage control.

Bioprogressive technique of Ricketts et al[19] takes advantage of bone physiology and its reactions to applied forces. Ricketts et al[20] suggested that by placing the roots of the molar teeth against the dense and laminated cortical bone with its limited blood supply, tooth movement is delayed and anchorage enhanced. In terms of mechanics, the Bioprogressive technique uses sectional arches that could be more advantageous for tooth movement in force quantity and direction, without disrupting the posterior unit.[21] Besides, the utility arch has been one of the most efficient instruments to neutralize the tendency of the posterior section of the arches to migrate mesially.[22]

TABLE 1. Treatment Group Characteristics

Group	n	Mean Age (y, mo)	Mean Treatment Time (y, mo)
Group I	Female, 13 Male, 7	12.9 ± 3.1	3.8 ± 1.0
Group II	Female, 12 Male, 8	15.9 ± 6.8	3.3 ± 0.8
P value	1.000[a]	.180[b]	.089[c]

[a] χ^2.
[b] Mann-Whitney.
[c] *t*-test.

The development of the Straight-wire appliance by Andrews[23–25] brought about a new technology with simplified mechanics, which has allowed orthodontists to treat patients efficiently with consistent quality results.[26] This sliding technique, however, involves a risk of frictional binding and temporary stops in the tooth movement caused by deformation and irregularities in the arch, and may demand a greater control of the anchorage.[17]

The present study had the purpose of characterizing and comparing the role of growth and lower anchorage control in cases treated using the Bioprogressive and Straight-wire techniques.

MATERIALS AND METHODS

The sample consisted of two groups of 20 subjects, each treated at the Orthodontic Graduate Program, Center for Professional Development of the Brazilian Association of Dentistry. Characteristics of the samples are listed in Table 1. The criteria for selection were the existence of a Class I or II molar relationship, a mesiofacial pattern, more than eight mm of lower arch length deficiency, and requiring four first premolar extractions. All patients were selected on the basis of maximum anchorage needs. Cervical headgear was used for upper anchorage in both groups. The lower molar anchorage was chosen for evaluation because its maintenance did not require any appliance dependent on patient compliance.

Group I was treated using the Bioprogressive technique of Ricketts et al[19] (3M Unitek, 0.018 × 0.025-inch bracket slots) and group II was treated using the Straight-wire technique (Brackets, A-Company 0.021 × 0.028 inch). The Roth prescription system was used in both groups.

Treatment mechanics

The segmented approach of the Bioprogressive technique consisted of a utility arch, 0.016- by 0.016-inch stainless steel arch wire used to set up cortical anchorage in the lower arch. Cuspid retraction springs were followed by closing utility arches of blue Elgilloy (0.016 × 0.016 inch).[21] Because the subjects had a mixed dentition, the second molar could not yet be included in the appliance. The Straight-wire technique followed the method developed by McLaughlin and Bennett.[26–28] In this group, retraction consisted of one step retraction of the maxillary anterior segment. Second molars were included in the mechanics. Lingual arches were used during the aligning phase in the patients who did not have second molars at the start.

Data collection

Each patient had two lateral cephalometric radiographs taken, one before and the other after treatment. Tracing, superimposition, and measurements all were done by hand (with the aid of digital calipers). The linear measurements were executed to the nearest 0.1 mm.

To separate growth from treatment, the Johnston cephalometric method[29] was used (Figure 1). Accordingly, the sources of molar correction were assessed by measuring movements of the molars relative to basal bone and the translatory growth of the jaws with respect to both the cranial base and one another.

Changes that contributed to a Class II correction (eg, mandibular growth or distal movement of the upper molars) were given a positive sign and those that detracted (eg, maxillary growth, upper anchorage loss) were given a negative sign. In this analysis, sagittal changes that affect molar correction (ie, growth, anchorage loss) can be distinguished with respect to magnitude and source.

Statistical analysis

Common descriptive statistics were calculated for each of the various measures of treatment change, and the differences between the two groups were examined by means of analysis of variance.

Because the present study covered both sexes and a wide range of starting ages and treatment times, Schulhof and Bagha's[30] sex-specific growth curves were integrated over each subject's period of treatment observation. For each year of development, the

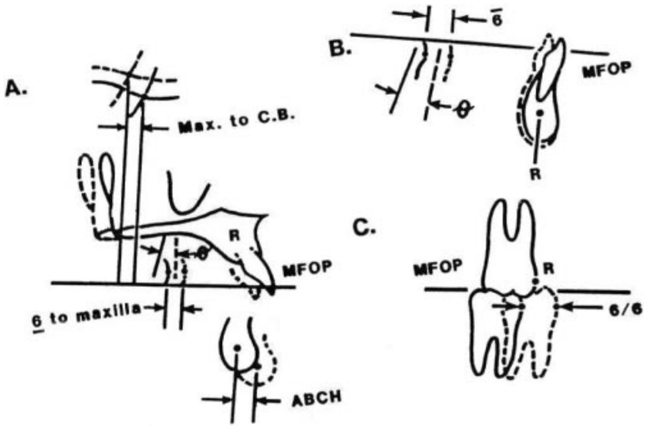

FIGURE 1. Cephalometric analysis. (A) Maxillary regional superimposition to estimate the growth of the maxilla relative to cranial base (Max), mandible relative to maxilla (apical base change [ABCH]), and upper molars relative to maxillary basal bone. Mandibular advancement (Mand) is obtained by algebraic subtraction: Mand = ABCH − Max. (B) Mandibular regional superimposition to measure the movement of the lower molars relative to basal bone. (C) Dental superimposition to measure total molar correction. In each instance, orientation is along the mean functional occlusal plane (MFOP), and registration is at R (sphenoethmoid point, maxillary internal architecture, labial mandibular symphyseal architecture).

areas under the appropriate curve were divided by the area of minimum prepubertal year (male-female average). This resulted in the expected growth unit (EGU), an individualized estimate of the relative intensity of growth that an untreated subject of the same age and sex would be expected to experience during the specified interval.[31,32] Pearson's correlation coefficient (*r*) was calculated to estimate the strength of the relationship between mean treatment changes and EGU.

RESULTS

Method error

To address reliability issues, the cephalometric tracings of 50% of the total sample were randomly selected. Differences between the original and the retraced cephalometric radiographs were statistically analyzed using a matched paired *t*-test. The results of the analysis indicated that there were no statistically significant differences between the original and repeated measurements at the 0.05 level.

Means and standard deviations for the various components of the molar correction are summarized in Table 2. When the movement of the lower molar crown was assessed, there was no significant difference in the amount of mesial movement between groups (Table 2). Patients treated by the Bioprogressive therapy presented a mesial movement of the lower first molar crown of 3.1 mm (4.7 mm bodily and −1.6 mm tipping). The patients treated using the Straight-wire appliance presented a lower molar anchorage loss of four mm (5.4 mm bodily and −1.4 mm tipping). Relative to the maxilla, the lower molar moved mesially 5.6 mm in the Bioprogressive group and 6.2 mm in the Straight-wire group. This change is the composite effect of orthodontic intervention and the translatory movement of mandibular growth.

The total molar correction was assessed by the effective amount of movement of the maxillary and mandibular first molars relative to one another. A mean of 2.6 mm of molar correction (range −1.1 to 5.9 mm) occurred in group I and 1.5 mm (range −0.7 to 5.2 mm) in group II.

No significant between-group differences were observed in the amount of maxillary or mandibular growth measured relative to the cranial base. The mandible grew forward 5.1 mm in the Bioprogressive group and 4.9 mm in the Straight-wire group. The maxilla was displaced 2.6 mm anteriorly through growth in both groups, and this detracted from the molar correction effect. The skeletal differential resulted in a net apical base difference of 2.5 mm in group I and 2.2 mm in group II. This is one component of the total molar correction. The remaining correction came

TABLE 2. Means and *t* scores for Between-treatment Differences[a]

	Group I			Group II			
	Mean	SD	Median	Mean	SD	Median	*P*[b]
Max	−2.65	1.82	−2.40	−2.65	1.77	−2.17	.989
Mand	5.18	2.83	4.45	4.92	3.34	5.13	.850
ABCH	2.53	1.70	2.44	2.27	2.70	1.91	.715
U6 (total)	−3.02	1.87	−3.31	−4.83	2.34	−5.33	.005
L6 (total)	3.11	1.53	2.99	4.01	2.21	3.93	.190
L6 (bodily)	4.79	1.81	5.26	5.43	2.28	5.84	.273
L6 (tipping)	−1.68	1.12	−1.77	−1.41	0.99	−1.35	.675
6/6	2.62	2.13	2.90	1.51	2.02	1.12	.102
EGU	3.46	2.12	3.80	2.23	1.84	2.09	.055

[a] High SD-median use is recommended.
[b] Mann-Whitney.
[c] ABCH indicates apical base change; EGU, expected growth unit.

TABLE 3. Correlation Coefficients for the Relationship Between Treatment Change and Expected Growth Unit

	Bioprogressive Group		Straight-wire Group	
	Correlation Coefficient (r)	P	Correlation Coefficient (r)	P
Max	$r = -0.7252$	$P < .0001$	$r = -0.3363$	$P = .1471$
Mand	$r = +0.6932$	$P < .0001$	$r = +0.5427$	$P = .0134$
ABCH	$r = +0.3783$	$P = .1001$	$r = +0.4504$	$P = .0462$
U6 (total)	$r = -0.3830$	$P = .0956$	$r = -0.4348$	$P = .0554$
L6 (total)	$r = +0.1499$	$P = .5283$	$r = +0.1555$	$P = .5126$
L6 (bodily)	$r = +0.1699$	$P = .4740$	$r = +0.1644$	$P = .4885$
L6 (tipping)	$r = -0.0713$	$P = .7653$	$r = -0.0313$	$P = .8959$
6/6	$r = +0.0743$	$P = .7555$	$r = +0.2390$	$P = .3103$

[a] ABCH indicates apical base change; EGU, expected growth unit.

from the differential anterior movements of the maxillary and mandibular first molars.

In the Bioprogressive group the lower anchorage loss was more than matched by extra anchorage loss in the maxilla (3.1 and three mm, respectively). Hence, the molar correction resulted almost entirely from the maxillomandibular differential (95%). The same occurred in the Straight-wire group (Table 2).

When treatment changes in the Bioprogressive group were compared with those in the Straight-wire group, no statistical differences were found between groups, except for the upper molar movement ($P = .011$).

Group I demonstrated a slightly greater growth potential. The EGU was 3.4 in group I and 2.2 in group II ($P = .05$) (Table 2). Considering the resulting EGU, a correlation was used to examine the relationship between mean treatment changes and EGU (Table 3). A positive correlation was seen between EGU and mandibular growth in groups I and II ($r = +0.69$, $P < .0001$ and $r = +0.54$, $P = .0134$, respectively) and a negative relationship to maxillary displacement in group I ($r = -0.72$, $P < .0001$). The apical base change (ABCH) presented a significant correlation with EGU in group II patients ($r = +0.45$, $P = .04$).

In Figures 2 and 3, the components of the molar correction achieved in groups I and II are graphed as a function of expected growth. It may be seen that the majority of the correction was due to differential jaw growth.

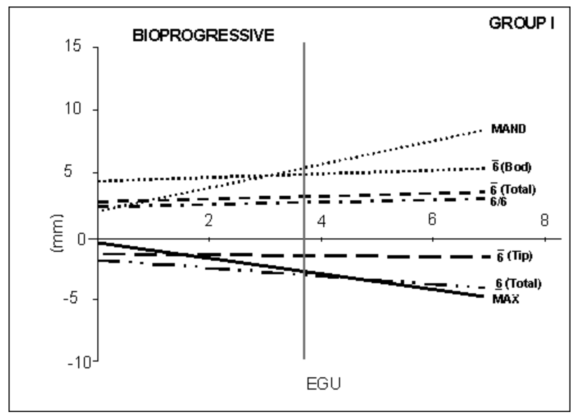

FIGURE 2. Group I: components of molar correction graphed as a function of EGU. Average EGU denoted by vertical interrupted line. EGU indicates expected growth unit.

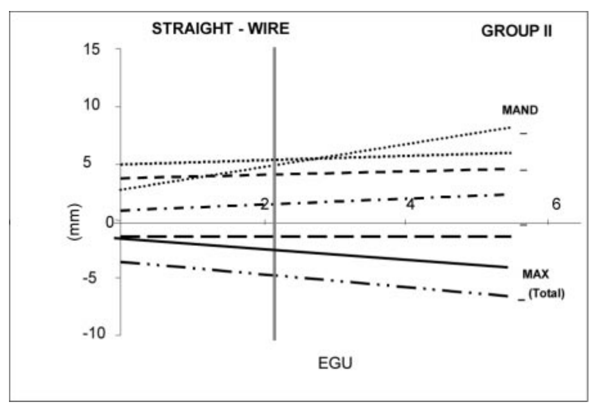

FIGURE 3. Group II: components of molar correction graphed as a function of EGU. Average EGU denoted by vertical interrupted line. EGU indicates expected growth unit.

DISCUSSION

One of the major concerns of orthodontics has been the development of techniques that could adequately control anchorage units in the selective movement of individual teeth or groups of teeth. In the Bioprogressive therapy, lower molar anchorage is enhanced by expanding the molar roots into the dense cortical bone on their buccal surface.[20] This technique suggests that the use of light continuous pressure during space closure on sectional arches will result in less strain on the anchorage.[20,22]

In the Straight-wire technique, lingual arches can support anchorage during the leveling and aligning phase and during the resolution of crowding.[28] As proper alignment of bracket slots is attained, the anchorage needs toward the end of the case diminishes.[27]

Although the two techniques used in this study make use of different resources to control anchorage, the mesial movement of the molars was not significantly different (Table 2). The mandibular molars came forward 3.1 mm in the Bioprogressive group and four mm in the Straight-wire group. It is interesting to note that the principle of holding the molars against cortical bone to improve anchorage is not supported by the present findings. A study comparing anchorage loss in a group of patients treated by the Bioprogressive with a group treated by the Standard-edgewise mechanics demonstrated similar results.[33]

Other studies have reported one-third of the mesial movement of posterior teeth on the first bicuspid extraction.[34,35] Johnston[31] found a mean amount of 3.8 mm of anchorage loss in the lower arch in a study of Class II extraction patients treated edgewise. Tooth movement accounted for 40% of the molar correction, whereas the remaining 60% of the correction came from ABCH. In a similar study of three groups of patients treated with conventional anchorage preparation, ten-two system, and without anchorage preparation, the mesial displacement of the lower molars was 3.2, 2.6, and 3.4 mm, respectively.[10]

In this study, 44% and 57% of the extraction space was lost by mesial movement of the lower molars in groups I and II, respectively. Considering that the extraction of a first premolar in each quadrant produces approximately 14-mm space in each arch, little was left for correction of crowding and uprighting of lower incisors.

According to Bench et al,[20] reaction to treatment mechanics is dependent on the influence of the facial pattern. Baretta,[36] in a study of Class II extraction treatment by the Bioprogressive therapy, found 3.6 mm of lower anchorage loss in the mesiofacial pattern, against 4.5 mm in the dolichofacial and 2.9 mm in the brachyfacial pattern.

In this study, group I demonstrated a slightly greater growth potential as estimated by EGU (Table 3). This is explained by the fact that usually Bioprogressive treatment starts at an earlier age. Meanwhile, a positive correlation was seen between EGU and mandibular growth in groups I and II, which means that ABCH was more important than tooth movement (Figures 2 and 3). The contribution to the correction came about as a by-product of the usual pattern of facial growth. The mandible outgrew the maxilla in the 20 patients in group I and 19 in group II. This means that when mandibular growth ceases, the main source of molar correction is no longer present. Treatment may last longer. Nevertheless, tooth movement is the key variable, and it may result in a deficient molar correction.[10]

Bien[37] concluded that anchorage is enhanced by increasing the number of teeth in the anchorage unit, thereby increasing the root area resisting displacement. However, clinical experience based on the practice of banding second molars has shown that this is not always reliable. This anchorage strategy was not supported by the present findings. Actually, the anchor unit receives the lesser amount of force per unit area along the periodontal membrane than the nonanchor unit (canines), which may be more physiologic.[15] Loss of anchorage may then ensue.

This study demonstrated that only a partial appliance incorporating cortical anchorage provided anchorage equal to a fully banded lower arch. Although cortical anchorage and the concept of segmented retraction mechanics was not demonstrated to be more efficacious than the Straight-wire appliance, it was not worse either. This implies that Class II correction, space closure, and the use of Class II elastics may all be accomplished when the entire lower arch (second molars) is not available for strap-up.

In this study, estimates of expected growth intensity derived from the integration of sex-specific incremental growth curves were used to adjust a wide range of starting ages and treatment times.[30] Therefore, the use of an untreated control group (eg, Bolton, Burlington, Michigan) would possibly yield better comparisons.

CONCLUSIONS

The results of this study support the following conclusions:

- There were no differences in anchorage loss between the two groups studied even though the source of anchorage was different. Therefore, the present results do not support the notion that one treatment strategy is superior to the other in terms of anchorage control.
- The pattern of jaw growth was similar in both groups, with a higher growth expected unit in the Bioprogressive group because of an earlier treatment starting age.
- Lower anchorage loss was matched by upper mesial movement of upper posterior teeth in both groups. Differential jaw growth was the most important component to molar correction.

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