Original Article

"Effective" TMJ and Chin Position Changes in Class II Treatment

Orthodontics versus Orthopedics

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ABSTRACT

Objective: To evaluate the "effective" temporomandibular joint (TMJ) changes (the sum of condylar modeling, glenoid fossa modeling, and condylar position changes within the fossa), and their influence on chin position in patients with a Class II division 1 malocclusion treated orthodontically with a multibracket appliance and Class II elastics (Tip-Edge) and orthopedically with a fixed functional appliance (Herbst).

Materials and Methods: Two groups of successfully treated subjects were evaluated: Tip-Edge (n = 24) and Herbst (n = 40). The Bolton Standards served as a control group. Lateral head films obtained before treatment and after an observation period of 2.6 years (Herbst also after 0.6-year period) were analyzed.

Results: In comparison with the Herbst and control groups, the Tip-Edge group exhibited less favorable sagittal "effective" TMJ growth and chin position changes necessary for skeletal Class II correction.

Conclusions: Orthodontic therapy with a multibracket appliance and Class II elastics seems not to have any favorable sagittal orthopedic effect on the mandible, while bite jumping with the Herbst appliance has a favorable sagittal orthopedic effect on a short-time basis.

KEY WORDS: TMJ; Changes; Herbst; Treatment; Multibracket; Chin

INTRODUCTION

In Class II treatment the main goal is an increase in mandibular prognathism. This can be accomplished by (1) three components of temporomandibular joint (TMJ) changes (each component separately or all three in combination): condylar modeling, glenoid fossa modeling, and anterior condylar displacement in the fossa and by (2) an anterior rotation of the mandible causing the chin to come forward. The single components of the TMJ changes are difficult to assess as appropriate TMJ landmarks are difficult to define on lateral head films.[1] However, with the method of Creekmore[2] using an arbitrary condylar point, condylar modeling, glenoid fossa modeling, and condylar displacement can easily be measured as the sum of changes, ie, "effective" TMJ changes.

In previous studies, the "effective" TMJ changes and their effect on the position of the chin have been analyzed in Class II, division 1 patients treated with two functional appliances: the fixed Herbst[3–7] and the removable Activator.[8–11] For both appliances favorable "effective" TMJ as well as associated chin changes have been shown. Furthermore, magnetic resonance imaging (MRI) of the TMJ performed in Herbst treated patients disclosed condylar and glenoid fossa modeling promoting a Class II correction.[6,7,12,13]

When using multibracket appliances with Class II elastics, the general opinion is that Class II correction is accomplished by dentoalveolar changes and not by mandibular (TMJ) growth stimulation. Experimental studies in monkeys[14,15] and in rats,[16] however, have shown that condylar and glenoid fossa modeling could be accomplished by Class II elastics. In man, on the other hand, this has never been verified.

Therefore, the aim of the present investigation was to assess and compare the "effective" TMJ changes

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and corresponding chin changes in Class II, division 1 patients treated with either an orthodontic approach using a multibracket appliance with Class II elastics (Tip-Edge) or an orthopedic approach using a fixed functional appliance (Herbst). Furthermore, the study addressed the question of whether Class II elastics had any orthopedic effects.

MATERIALS AND METHODS

The following two groups of successfully treated Class II division 1 subjects were evaluated:

- Twenty-four patients (9 male, 15 female) treated with a Tip-Edge multibracket appliance in the maxilla and mandible together with Class II elastics.[17–22] The force of the elastics was approximately 2.5 ounces corresponding to 70 cN. The patients were selected from the total pool of Class II division 1 patients treated with Tip-Edge appliances at the Department of Orthodontics, University of Giessen (Germany) 1996–2005. The mean age of the subjects before treatment was 12.3 years (SD $\pm$ 3.1 years). The average examination period (treatment period) was 2.6 years.
- Forty patients (20 male, 20 female) treated with a Herbst appliance.[23,24] The patients were selected randomly from the total pool of 118 Class II division 1 patients treated with the banded type of Herbst appliance, at the Department of Orthodontics, University of Malmö (Sweden). The mean age of the subjects before treatment was 12.4 years (SD $\pm$ 1.3 years). The average examination period was 2.6 years (a 0.6-year treatment period with the Herbst appliance plus posttreatment period of 2.0 years with a multibracket appliance in both arches for occlusal refinement).

The following criteria had to be fulfilled for patient selection: (1) a Class II molar relationship of at least one-half cusp width if the second deciduous molars were lost or at least three-fourths cusp width if the second deciduous molars were still in place; (2) no extractions of permanent teeth; and (3) no syndromes.

As a control group the Bolton Standards[25] were used. The Standards are composed of composite lateral head film tracing from 32 untreated subjects (16 boys and 16 girls) with ideal occlusion followed annually from 6 years to 18 years of age. The Tip-Edge and the Herbst subjects were compared with the 12 years and 15 years Bolton Standards, thus covering an observation period of 3 years.

In all three examination groups lateral head film tracings in habitual occlusion from before and after the examination period were evaluated by one of the authors. A linear roentgenographic enlargement of 7% in the Tip-Edge and Herbst groups was not corrected. The enlargement of 5.5%–5.8% in the Bolton group was adjusted to that of the two treatment groups. Linear and angular measurements were performed to the nearest 0.5 mm and 0.5°, respectively. In order to reduce the method error, all registrations were done twice and the mean value of the duplicate registrations was used in the final evaluation.

The methods for the assessment of ''effective TMJ changes'' (the sum of condylar modeling, fossa modeling, and condylar position changes within the fossa), chin position changes, and mandibular growth rotation are summarized in Figure 1A through D.

The following variables were considered:

- Co/RLp The horizontal distance of the arbitrary condylar point (Co) to the RLp reference line
- Co/RL The vertical distance of the arbitrary condylar point (Co) to the RL reference line
- Pg/RLp The horizontal distance of the chin point pogonion (Pg) to the RLp reference line
- Pg/RL The vertical distance of the chin point pogonion (Pg) to the RL reference line
- RL The line from the incisal edge of the lower central incisor to the distobuccal cusp of the first upper molar. This line could be considered as an artificial implant line[26] due to the mandibular superimposition procedure used (see Figure 1D).[27]

Statistical Methods

For each variable, the arithmetic mean (mean) and the standard deviation (SD) were calculated. The existence of a normal variable distribution was verified by the Kolmogorov-Smirnov test. To assess the significance of changes in the two treatment groups, the Student's *t*-test for paired samples was used. For group comparisons the Student's *t*-test for unpaired samples was utilized. The levels of significance applied were $P < .001$, $P < .01$, and $P < .05$. $P \geq .05$ was considered not significant (NS). All calculations were performed with a personal computer and the software Office XP 2003.

Method Error Evaluation

The size of the combined method error (ME) in locating the reference points, superimposing the roentgenograms, and measuring the variables was assessed upon double registrations of all 24 Tip-Edge subjects using the formula of Dahlberg[28]:

$$ME = \sqrt{\frac{\sum d^2}{2n}}$$

where d is the difference between two registrations of a pair and n is the number of double registrations. For

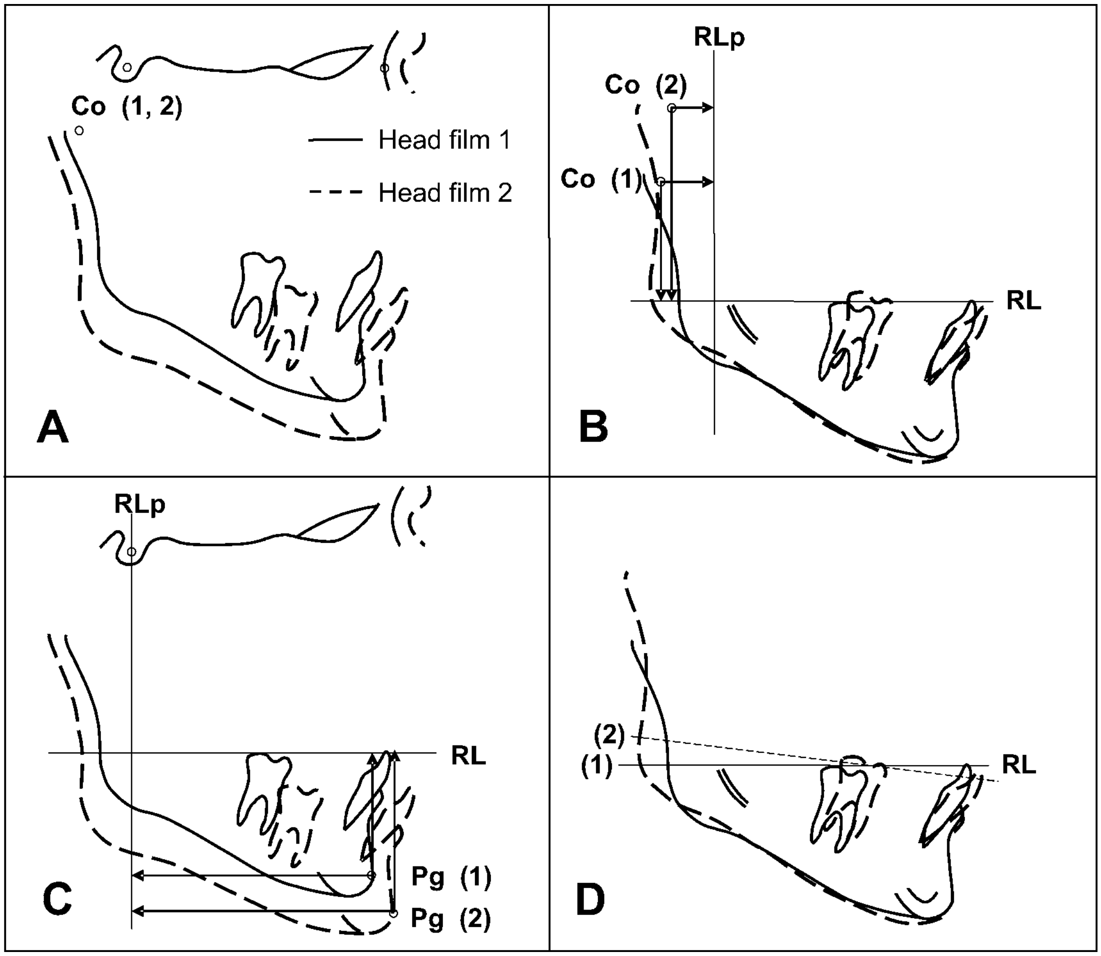

Figure 1. Methods for assessing the "effective" TMJ changes (the sum of condylar modeling, fossa modeling, and condylar position changes within the fossa), chin position changes, and mandibular growth rotation: (A) An arbitrary condylar point (Co) was defined on head film 1 (before the examination) and transferred to head film 2 (at the end of the examination) after superimposition of the films on the stable bone structures of the anterior cranial base.[26] (B) The change of the Co-point (the sum of condylar modeling, glenoid fossa modeling, and anterior displacement of the condyle in the fossa) is measured in relation to a reference grid RL/RLp, where RL is a line from the incisal edge of the lower central incisor to the distobuccal cusp of the first upper molar and RLp is a line perpendicular to RL through the point Sella (defined on the first head film), after superimposition of the head films on the stable bone structures of the mandible.[26] (C) The change of the Pg-point (the sum of the changes of the Co-point plus the growth rotation of the mandible is measured in relation to the reference grid RL/RLp after superimposition of the head films on the stable bone structures of the anterior cranial base.[26] (D) The mandibular growth rotation (the inclination change of the reference line RL) is measured after superimposition of the head films on the stable bone structures of the mandible.[26]

the different variables the method error varied between 0.60 mm and 1.07 mm for the linear measurements and was 0.65° for the angular measurement. The errors corresponded to those in previous investigations using the same cephalometric method.[3,8,9]

RESULTS

At the end of the examination period of 2.6 years all Tip-Edge and Herbst subjects had a Class I occlusion with a normal overjet and overbite. Because no statistically significant gender differences existed for the cephalometric variables, the male and female subjects were pooled in the presentation of the results.

The changes of the different variables during the examination period of 2.6 years in the two appliance groups and the control group are presented in Table 1. Figure 2 shows the "effective" TMJ changes and chin position changes. Additionally, for the Herbst group the active treatment changes during the 0.6-year period are depicted graphically in Figure 2. Furthermore, to make group comparisons possible for this shorter period, a 0.6-year period was also marked on the graph for the Tip-Edge and control groups by data interpolation.

"Effective" TMJ Changes (Co)

When looking at the changes during 2.6 years, in the Tip-Edge group the Co-point moved 1.6 mm less

Table 1. Variable Changes in the Tip-Edge (n = 24), Herbst (n = 40), and Bolton (n = 32) Samples During 2.6 years (Bolton 3 years) of Examination. The Statistical Significance (Sign) of Changes and Group Differences are Given[a]

Variable	Tip-Edge			Herbst			Bolton	Tip-Edge/Herbst
	Mean	SD	Sign	Mean	SD	Sign	Mean	Sign
Co/RLp, mm	−1.1	1.78	**	−2.7	2.03	**	−3.5	**
Co/RL, mm	+6.7	4.02	***	+7.5	3.61	***	+7.5	NS
Pg/RLp, mm	+1.2	4.12	NS	+3.8	2.90	**	+3.8	**
Pg/RL, mm	−6.0	3.33	***	−6.2	2.85	**	−6.3	NS
RL, degree	−0.1	1.99	NS	+0.7	2.07	NS	−0.3	NS

*** $P < .001$; ** $P < .01$; * $P < .05$; NS indicates not significant, $P \geq .05$.

[a] − indicates posterior movement of Co, inferior movement of Pg, and anterior rotation of RL; + indicates superior movement of Co, anterior movement of Pg, and posterior rotation of RL.

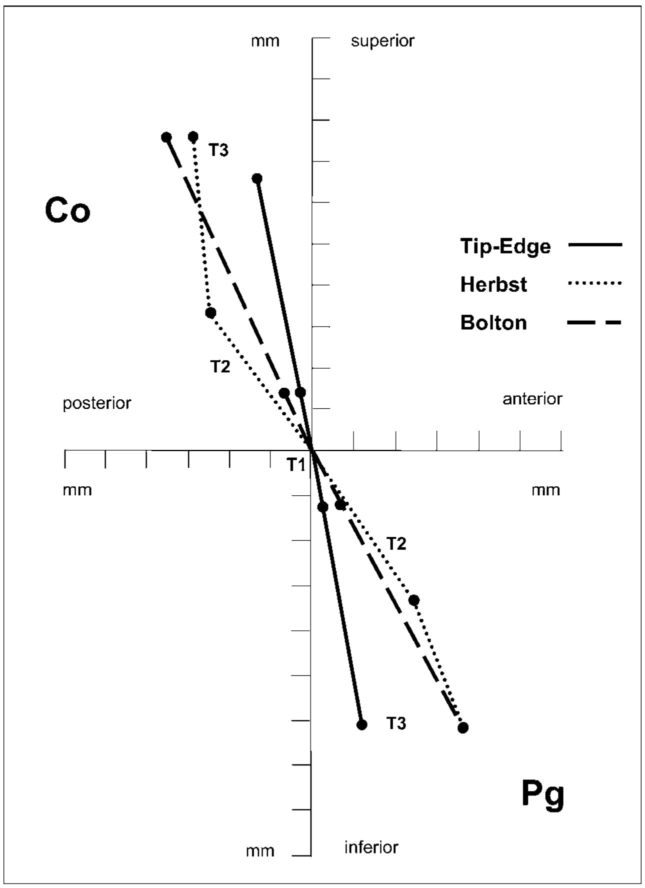

Figure 2. "Effective" TMJ (Co) and chin changes (Pg) (mean values) in the Tip-Edge, Herbst, and Bolton groups. T1: Before treatment. T2: After the 0.6-year period (corresponding to the end of active Herbst treatment). T3: After 2.6 years (corresponding to the end of Tip-Edge treatment).

posteriorly ($P < .01$) and 0.8 mm less superiorly (NS) than in the Herbst group. When compared to the control group, the Co-point in the Tip-Edge group moved 2.4 mm less posteriorly and 0.8 mm less superiorly. In the Herbst group the Co-point moved 0.8 mm less posteriorly and a similar amount superiorly.

Considering the treatment changes of the 0.6-year period, in the Tip-Edge group the Co-point moved 2.3 mm less posteriorly and 1.7 mm less superiorly than in the Herbst group. Compared to the control group the Co-point in the Tip-Edge group moved 0.5 mm less posteriorly and to a similar amount superiorly. In the Herbst group the Co-point moved 1.5 mm more posteriorly and 1.7 mm more superiorly than in the control group.

Chin Position Changes (Pg)

When looking at the changes during 2.6 years, in the Tip-Edge group the Pg-point moved 2.6 mm less anteriorly ($P < .01$) and 0.2 mm less inferiorly (NS) than in the Herbst group. When compared with the control group, the Pg-point in the Tip-Edge group moved 2.6 mm less anteriorly and 0.3 mm less inferiorly. In the Herbst group the Pg-point moved to a similar amount anteriorly and 0.1 mm less inferiorly than in the control group.

Considering the treatment changes of the 0.6-year period, in the Tip-Edge group the Pg-point moved 2.1 mm less posteriorly and 1.9 mm less superiorly than in the Herbst group. When compared with the control group, the Pg-point in the Tip-Edge group moved 0.5 mm less posteriorly and 0.1 mm more superiorly. In the Herbst group the Pg-point moved 1.7 mm more anteriorly and 2.0 mm more inferiorly than in the control group.

Mandibular Growth Rotation (RL)

When looking at the changes during 2.6 years, in the Tip-Edge group the RL line rotated 0.8° less posteriorly (NS) than in the Herbst group. Compared with the control group the RL line in the Tip-Edge group rotated 0.2° less anteriorly and in the Herbst group 1° less anteriorly.

Considering the treatment changes of the 0.6-year period, in the Tip-Edge group the RL line rotated 0.1° less posteriorly than in the Herbst group. Compared with the control group the RL line in the Tip-Edge group rotated to a similar amount anteriorly and in the Herbst group 0.6° more posteriorly.

DISCUSSION

To distinguish between treatment effects and normal growth, the Bolton Standard control sample was used for comparison. This is not an ideal reference group and it would have been better to use a group of untreated Class II, division 1 subjects, but no such sample exists that covers a period of about 3 years, from the age of 12 to 15 years.

The method of Creekmore for the assessment of ''effective'' TMJ changes has the following advantages: (1) an arbitrary condylar point (Co) is used which implies no difficulties in the identification of an anatomic reference point; (2) all TMJ changes (condylar modeling, glenoid fossa modeling, and condylar position changes) are assessed simultaneously as a sum of changes; and (3) using a common reference grid (RL/RLp) for before and after examination period measurements, a quantitative evaluation of both the amount and direction of changes can be performed.

Changes During the 0.6-Year Period

When comparing the Tip-Edge and the Herbst groups with respect to the amount and direction of changes during the first 0.6 year of observation it could be seen that the ''effective'' TMJ (Co) and chin (Pg) changes in the Tip-Edge group were much less pronounced and more vertically directed (upward for Co and downward for Pg) (Figure 2).

Furthermore, when comparing the changes in the two appliance groups with those of the control group, in the Tip-Edge subjects the Co as well as the Pg changes were of about the same amount but more vertically directed (upward for Co and downward for Pg), while in the Herbst subjects the Co and Pg changes were much larger and more horizontally directed (backward for Co and forward for Pg) (Figure 2).

The differences between the two appliance groups could be explained by the different treatment approaches used in the correction of the Class II malocclusions: Class II elastics in the Tip-Edge and bite jumping in the Herbst cases. The Class II elastics seemed to have no effect on the amount and direction of mandibular growth. The forced mandibular advancement (bite jumping) procedure with the Herbst appliance, on the other hand, resulted in condylar growth stimulation in a posterior direction[3–7,29] and glenoid fossa modeling, thus moving the condyle anteriorly in relation to the skull.[4,5] Due to these TMJ changes in the Herbst patients the chin was displaced anteriorly.[3–5]

Changes During the 2.6-Year Period

When comparing the Tip-Edge and Herbst groups with respect to the amount and direction of changes during the total observation period of 2.6 years, it could be seen that the ''effective'' TMJ (Co) and chin (Pg) changes in the Tip-Edge and Herbst groups were of about the same amount. However, the direction of changes in the Tip-Edge group was more vertical (upward for Co and downward for Pg) than in the Herbst group. In the interpretation of the results however, it must be remembered that the Tip-Edge cases received treatment throughout the 2.6 years while the Herbst cases were treated only for the 0.6-year period and unaffected growth changes prevailed during the following 2.0 years. Thus, in the Herbst subjects there was a catch-up in growth for both Co and Pg during the follow-up period of 2 years, and the amount of growth was smaller and more vertical. This has been verified in earlier Herbst studies as well.[3,4,29]

When comparing the changes in the two appliance groups with those of the control group, the Co as well as the Pg changes in the Tip-Edge subjects were of about the same amount, but more vertically directed (upward for Co and downward for Pg). Also in the Herbst subjects the amount of growth (Co and Pg) was similar to that of the control group, but the Co changes were directed more posteriorly while no group differences existed for the Pg-point (Figure 2). Thus, on a long-time basis it seems as if Class II elastics and the Herbst appliance have no orthopedic effect on the mandible.[30]

When considering the changes of the Pg-point with respect to mandibular growth rotation, an anterior mandibular rotation contributes to an advancement of the Pg-point and helps to correct a Class II malocclusion, whereas a posterior rotation is a disadvantage in correcting a Class II malocclusion. Thus, when comparing the two appliance groups with respect to mandibular growth rotation, the mandible rotated minimal anteriorly in the Tip-Edge group while a small rotation posteriorly was seen in the Herbst group. In the control sample the mandible rotated slightly in an anterior direction (physiologic autorotation).[26,27] However, the amount of rotation in the two treatment groups was so small, that it most likely did not play a significant role in the correction of the Class II malocclusion.

CONCLUSIONS

- The present results indicate that Class II elastics in connection with multibracket appliances (orthodontic treatment approach) have no favorable sagittal orthopedic effect on the mandible.
- Jumping the bite with the Herbst appliance (orthopedic treatment approach) has a favorable sagittal orthopedic effect on the mandible on a short-time, but not on a long-time basis.

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