A cephalometric study of Class II Division 1 malocclusions treated with the Jasper Jumper appliance

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Abstract: This lateral cephalometric study investigated the dental and skeletal effects of the Jasper Jumper appliance used in the correction of Class II Division 1 malocclusions. A sample of 36 growing patients treated with the Jasper Jumper appliance was divided into two groups: (1) 24 patients with records obtained at the start and completion of orthodontic treatment, and (2) 12 patients with records available at the beginning and end of the Jumper phase of treatment. Treatment effects were determined by statistical comparisons of cephalometric changes in the patients relative to age-adjusted cephalometric standards, and from structural superimpositions. While the Jumpers were in place, maxillary incisors were retroclined and the molars were moved distally, tipped back, and intruded. The mandibular incisors were proclined and intruded, while the molars were translated mesially, tipped forward, and extruded. Skeletal measures showed reduced forward maxillary displacement and no significant alteration of horizontal mandibular growth. During orthodontic finishing, molar tipping and maxillary incisor retroclination were corrected, although the mandibular incisors remained proclined. In summary, this study found that the Jasper Jumper appliance corrected Class II discrepancies largely through maxillary and mandibular dentoalveolar effects and, to a limited extent, by restraint of forward maxillary growth.

Key Words: Jasper Jumper, Class II correction, Cephalometrics, Dentoalveolar, Skeletal growth

The Jasper Jumper® appliance (American Orthodontics, Sheboygan, Wisc) is a fixed functional appliance used to correct Angle Class II malocclusions by linking the dental arches with bilateral, fixed, flexible springs.[1] The springs apply posteriorly directed forces to the maxillary dentition and reciprocal anteriorly directed forces to the mandibular dentition. The appliance design and clinical applications have been reviewed in detail by Jasper and McNamara.[2] Although a number of studies have demonstrated the clinical effectiveness of the appliance for correcting Class II Division 1 malocclusions, conclusions differ with regard to how the correction is achieved, particularly the relative magnitude of skeletal versus dentoalveolar effects.

In the first comprehensive report (1994) of the treatment effects of the Jasper Jumper, Cope and associates studied 31 Class II adolescent patients.[3] The patients were compared with 31 matched controls (Human Growth Research Center, University of Montreal). Anatomic superimpositions of lateral headfilms based on anterior cranial base, maxilla, and mandible showed that the Class II correction was due primarily to dental changes. In the maxillary arch, the molars demonstrated posterior tipping and relative intrusion, while the incisors underwent posterior tipping and eruption (extrusion). In the mandibular arch, the molars underwent anterior bodily movement, tipping, and eruption (extrusion), while the incisors were tipped forward and intruded. Similar dental effects have since been reported by Weiland and Bantleon[4] and Stucki and Ingervall.[5] In a comparison of the Class II correction achieved by activator, activator-headgear combination, and Jasper Jumpers, Weiland and colleagues found that correction of the molar relationship was most rapid and

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pronounced with Jasper Jumpers.[6] The correction was attributed mainly to marked dental changes, including distal movement of the maxillary molars and mesial movement of the mandibular molars.[6]

Descriptions of the dentoalveolar treatment effects of the Jasper Jumper in case reports and abstracts generally conform to those of the comprehensive studies described above. Cash, in a case report on adult nonextraction treatment with a Jasper Jumper, showed distal movement and intrusion of the maxillary molars with minimal forward movement of the mandibular incisors.[7] Blackwood illustrated changes that included intrusion and distal movement of the maxillary molars with occasional opening of the posterior bite, anterior migration of the mandibular teeth through alveolar bone, and intrusion of the mandibular incisors.[8] Expansion of the maxillary molars occurred unless a heavy, constricted maxillary archwire or a transpalatal bar was used.[8] More recently, Mills and McCulloch[9] found that Class II correction in the mixed dentition using a modified Jasper Jumper (no bonded anterior brackets) resulted largely from dentoalveolar changes. In abstracts, Rankin[10] reported that most Class II correction was from mesial movement of the mandibular molars, and Kucukkeles and Orgun[11] reported maxillary and mandibular dental effects consistent with those described above.

There has been less agreement describing the skeletal changes produced with the Jasper Jumper. Relative to the anterior cranial base, Cope and associates[3] and Stucki and Ingervall[5] found that the maxilla underwent limited posterior displacement. In one study, the mandible rotated open slightly and showed little or no additional growth or glenoid fossa remodeling.[3] In contrast, Weiland and Bantleon[4] found that the appliance had minimal effect on the maxilla while mandibular growth was increased. However, a subsequent study by some of the same authors showed a smaller effect on the mandible than in their aforementioned report.[6] Stucki and Ingervall[5] and Rankin[10] found that much of the Jasper Jumper Class II correction was expressed by enhanced mandibular growth.

The purpose of this study was to closely examine the dental and skeletal effects of the Jasper Jumper in a sample of 36 growing patients. Dentoalveolar and skeletal changes were measured from lateral headfilms using horizontal and vertical reference axes and by anterior cranial base, maxillary, and mandibular superimpositions based on Björk's structural superimposition technique.[12,13] In addition, for comparison with the total treatment effect, changes examined in part of the sample were isolated to the segment of treatment when the Jumpers were in place.

Materials and methods

Treatment sample

The sample consisted of 36 (19 male and 17 female) Class II Division 1 patients treated with the Jasper Jumper by one orthodontist (RW). The following pretreatment criteria were used for sample selection:

1. Class II Division 1 malocclusion: First molars at least one-half cusp Class II (bilateral) and incisor overjet at least 4 mm
2. ANB angle greater than 5 degrees
3. Growing adolescent patient treated with the Jasper Jumper
4. Nonextraction treatment plan

There were two treated samples. One group (T2-T3) consisted of 12 (7 male and 5 female) patients with lateral cephalometric radiographs made immediately prior to placement of the Jasper Jumper (T2) and immediately after removal (T3). The mean age of this group at T2 was 13 years 2 months (13:2; range: 9:3 to 17:3). The average time the Jumpers were in place (T2 to T3) was 5 months (range: 2 to 8 months). The Jasper Jumper was removed when the molar relationship was Class I. This group of patients had not completed orthodontic treatment at the time of this study. Because end-of-treatment records were not available, these patients were not included in the T1-T4 sample.

The other group (T1-T4) consisted of 24 (12 male and 12 female) patients with lateral cephalometric radiographs taken before (T1) and after (T4) active edgewise orthodontic treatment. The mean age at T1 was 12:11 (range: 9:10 to 15:8). In this group, the Jasper Jumper was used for an average of 5.5 months (range: 2 to 12 months), but T2 and T3 records had not been made. The average total active treatment time T1 to T4 was 2 years, 4 months (range: 1:9 to 3:7).

Treatment methods

A fixed, preangulated and pretorqued edgewise appliance was used to level and align the dental arches. First and second molars (when present) were banded and the remainder of the dentition bonded with 0.022" edgewise brackets. The Jasper Jumpers were placed after 0.018x0.025" or larger stainless steel maxillary and mandibular archwires were engaged. In the mandibular archwire, 10 to 15 degrees of labial root torque was incorporated to counteract the tendency for labial incisor tipping.[8] A transpalatal bar was placed between the maxillary first molars to control the tendency for transverse expansion.[8]

Size determination of the Jumper springs was made according to the manufacturer's instructions with independent measurements made for the right and left sides. Each spring was attached to the maxillary first molar using a ball-pin through the "headgear" tube. The other end of the spring was attached to the mandibular arch using an auxiliary stainless steel jig. The distal end of a jig was attached to the hook of the first molar band, and the mesial end hooked over the mandibular archwire between the canine and first premolar brackets (Figure 1). The mesial end of the Jasper Jumper was free to slide along the jig during opening and excursive mandibular movements. The maxillary and mandibular archwires were cinched back. The patients were evaluated at 4-week intervals, and the appliance activated as needed.

Cephalometric methods

Cephalometric norms for untreated patients were obtained from the University Elementary and Secondary School study,[14] henceforth referred to as the Michigan study. This untreated sample consisted of 83 (47 male, 36 female) children who were in continuous attendance at the school from their sixth to sixteenth birthdays. Lateral cephalometric radiographs were obtained yearly on their birthdays. The composite cephalometric standards were matched to each Jasper Jumper patient based on age and sex. Due to the relatively short time interval when the Jumpers were in place (T2-T3), growth increments from the annual composite cephalometric standards[14] were mathematically adjusted (interpolated to the month) on a case by case basis to match the duration of Jumper treatment using the following formula:

Jumper increment= (incremental change of norm) X (number of months with Jumper)/12

For the T1-T4 group the cephalometric standards were age-matched based on each patient's age rounded to the nearest whole year.

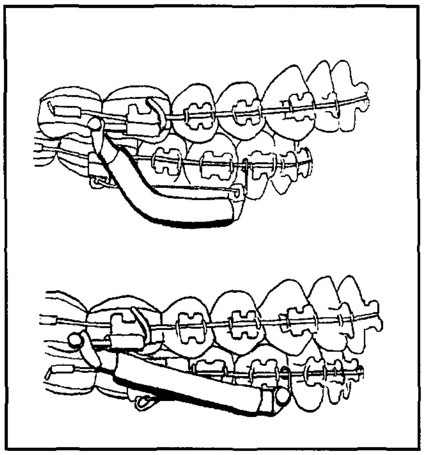

Figure 1
Class II malocclusion with the mandible in a retruded position and the Jasper Jumper spring activated (upper drawing). Activation is decreased when the mandible is protruded to a Class I molar relationship (lower drawing).

Lateral cephalograms for each patient in the experimental sample were taken with Frankfort horizontal parallel to the floor and the teeth in centric occlusion. All radiographs were made using the same cephalostat, and film processing was standardized. The headfilms were traced on acetate paper by one examiner (DT). For each cephalogram, 21 cephalometric landmarks were identified as described by Riolo and associates,[14] from which 27 cephalometric measurements were made. Identification of the cephalometric landmarks and construction of measurement planes are demonstrated in Figures 2 and 3, respectively. The measurements were similar to those used by Valant and Sinclair[15] and were selected to provide data on changes in five areas of interest: anteroposterior skeletal, rotational skeletal, vertical skeletal, incisor position, and molar position. The measurements also allowed direct comparisons with the published composite cephalometric values from the Michigan study (Tables 1 and 2).[14] Linear distances were measured to the nearest 0.1 mm using digital calipers, and an-

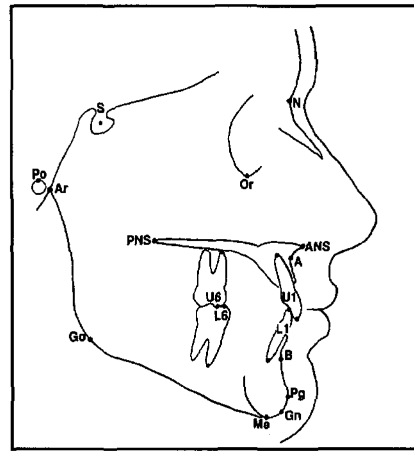

Figure 2
Cephalometric landmarks: porion (Po), articulare (Ar), sella (S), nasion (N), orbitale (Or), anterior nasal spine (ANS), posterior nasal spine (PNS), A-point (A), B-point (B), pogonion (Pg), gnathion (Gn), menton (Me), gonion (Go), upper incisor (U1), lower incisor (L1), upper molar (U6), lower molar (L6).

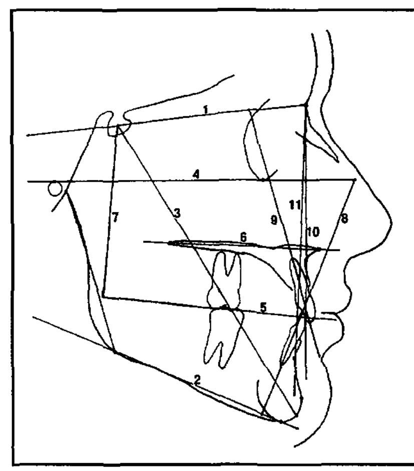

Figure 3
Cephalometric lines and planes: Sella-nasion (1), mandibular (2), y-axis (3), Frankfort (4), occlusal (5), palatal (6), occlusal perpendicular (7), lower incisor (8), upper incisor (9), nasion–A-point (10), nasion–B-point (11).

gular measurements were determined to the nearest 0.5 degree using a protractor. For comparison with the Michigan study,[14] our linear measurements were increased by a factor of 2.9% to account for mean cephalometric enlargement differences between the norms (12.9%) and our headfilms (10.0%).

To distinguish between dentoal-

Table 1
Cephalometric measurements and statistical comparison of adjusted norms[14] to Jasper Jumper patients at insertion (T2), removal (T3), and during the course of Jasper Jumper treatment (T2-T3)

Measurement	T2 Norm Mean (SD)	T2 Jumper Mean (SD)	T3 Norm Mean (SD)	T3 Jumper Mean (SD)	T3-T2 Norm Mean (SD)	T3-T2 Jumper Mean (SD)
Anteroposterior skeletal						
SNA (°)	81.0 (0.3)	82.5 (4.6)	81.1 (0.3)	81.7 (4.7)	0.1 (0.1)	-0.8 (0.5)***
Sella–A-point (mm)	91.0 (4.2)	93.6 (6.1)	91.8 (4.2)	93.6 (6.3)	0.7 (0.4)	0.0 (0.6)**
SNB (°)	77.4 (0.5)	76.7 (3.7)	77.6 (0.6)	77.0 (3.9)	0.2 (0.2)	0.3(0.9)
ANB (°)	3.6 (0.3)	5.8 (1.6)***	3.5 (0.3)	4.8 (2.1)	-0.1 (0.1)	-1.0 (1.1)**
Ar-Pg (mm)	112.4 (6.1)	114.1 (7.5)	113.5 (6.1)	114.7 (7.3)	1.1 (0.4)	0.6(1.2)
Rotational skeletal						
MPA-Frankfort (°)	27.6 (1.8)	26.3 (4.6)	27.6 (1.8)	26.0 (5.5)	0.0 (0.2)	-0.4 (1.8)
Y axis (°)	61.2 (1.6)	61.4 (3.5)	61.2 (1.8)	61.6 (3.8)	0.0 (0.3)	0.2 (1.3)
Me-Go/SN (°)	33.8 (0.8)	32.0 (4.4)	33.6 (0.8)	31.3 (5.0)	-0.2 (0.2)	-0.7 (1.6)
Ar-Go-Me (°)	125.3 (1.3)	125.0 (4.4)	125.1 (1.3)	125.0 (4.8)	-0.2 (0.3)	0.0 (1.8)
SN-PP (°)	7.4 (0.6)	6.7 (4.2)	7.4 (0.5)	6.1 (3.6)	0.0 (0.2)	-0.6 (1.4)
SN-OP (°)	15.8 (1.0)	14.6 (4.4)	15.5 (1.1)	17.0 (5.4)	-0.3 (0.2)	2.4 (2.8)**
Vertical skeletal						
N-ANS (mm)	55.6 (2.9)	55.7 (3.2)	56.0 (2.8)	55.8 (3.5)	0.5 (0.5)	0.1 (0.9)
ANS-Me (mm)	71.0 (4.2)	71.2 (6.4)	71.5 (4.4)	71.0 (6.5)	0.6 (0.4)	-0.2 (1.3)*
LFH (%)	0.6 (0.0)	0.6 (0.0)	0.6 (0.0)	0.6 (0.0)	0.0 (0.0)	0.0 (0.0)
Ar-Go (mm)	47.1 (3.4)	50.6 (4.9)	47.8 (3.6)	49.8 (5.9)	0.6 (0.4)	-0.8 (2.5)
Incisor position						
U1-NA (mm)	4.2 (0.2)	5.2 (2.5)	4.2 (0.3)	3.8 (2.5)	0.1 (0.2)	-1.4 (1.1)***
U1-NA (°)	22.8 (1.0)	24.8 (8.9)	22.7 (1.0)	20.0 (8.7)	0.0 (0.4)	-4.8 (4.0)***
U1-Sn (°)	103.8 (0.9)	107.5 (7.8)	103.8 (0.9)	101.4 (7.7)	0.0 (0.4)	-6.0 (4.7)***
U1-Ans (mm)	30.2 (2.1)	29.9 (2.9)	30.3 (2.1)	30.4 (2.9)	0.2 (0.2)	0.5(1.6)
U1-L1 (°)	127.9 (1.4)	126.0 (9.0)	128.2 (1.5)	125.2 (7.5)	0.3 (0.9)	-0.8(5.0)
L1-MPA (°)	94.7 (0.6)	94.4 (5.4)	94.5 (0.9)	102.3 (6.8)***	-0.2 (0.6)	7.9 (4.4)***
L1-NB (mm)	4.9 (0.4)	5.4 (2.5)	4.8 (0.5)	7.2 (2.1)**	0.0 (0.3)	1.8 (0.8)***
L1-NB (°)	25.7 (0.5)	23.3 (4.5)	25.5 (0.6)	30.2 (5.2)**	-0.2 (0.6)	6.9 (4.6)***
L1-MPA (mm)	43.3 (2.6)	43.4 (3.7)	43.7 (2.8)	42.4 (4.3)	0.4 (0.3)	-1.0 (1.4)**
U1-PP (mm)	30.0 (2.1)	29.4 (3.2)	30.1 (2.1)	30.4 (3.4)	0.2 (0.2)	1.0 (1.8)
Molar position						
U6-PP (mm)	23.4 (2.2)	23.8 (2.9)	23.8 (2.3)	22.8 (2.7)	0.4 (0.3)	-1.0 (0.9)***
L6-MP (mm)	33.2 (2.4)	33.5 (3.1)	33.6 (2.5)	34.4 (3.2)	0.4 (0.3)	0.9(0.8)

*$p<0.05$, **$p<0.01$, ***$p<0.001$

veolar and skeletal changes, cranial base and individual maxillary and mandibular superimpositions were made from T1 to T4 and from T2 to T3 radiographs.[12,13] On the pretreatment (T1) and pre-Jumper (T2) tracings, an occlusal plane reference line (OP) was constructed tangent to the mesiobuccal cusp of the maxillary permanent first molar, bisecting the incisal overbite. A second line, the occlusal line perpendicular (OPp) was constructed through sella, perpendicular to OP. These reference lines were transferred to the post-Jumper (T3) or posttreatment (T4) tracings by superimposing on anterior cranial base. (See Valant and Sinclair[15] and Pancherz.[16]) Changes in the horizontal dimension were measured parallel to OP, and those in the vertical dimension were measured parallel to OPp.

Cranial base superimpositions were used to measure the total amount of anteroposterior and vertical change of the molar and incisor positions (Table 3, Total molar/incisor). Using axes related to the occlusal plane of the earlier radiograph (OP and OPp), anteroposterior and vertical measurements were made between the mesiobuccal cusps and incisal edges of the molars and incisors, respectively. Individual regional maxillary[13] and mandibular[12] superimpositions were used to measure the amount of anteroposterior and vertical dental (molar and incisor) movement in each jaw (Table 3, Dental molar/incisor). To determine the skeletal change (Table 3, Skeletal molar/incisor) of the maxilla or the mandible, the dental change (measured in the individual jaw superimposition) was subtracted from the total change (measured in the cranial base superimposition). In addition, maxillary and mandibular super-

Table 2
Cephalometric measurements and statistical comparison of adjusted norms[14] to Jasper Jumper patients at the start (T1) and finish (T4) of orthodontic treatment, and during the entire course of orthodontic treatment (T1-T4)

Measurement	T1 Norm (N) Mean (SD)	T1 Jumper (J) Mean (SD)	T4 Norm (N) Mean (SD)	T4 Jumper (J) Mean (SD)	T4-T1 Norm (N) Mean (SD)	T4-T1 Jumper (J) Mean (SD)
Anteroposterior skeletal						
SNA (°)	81.1 (0.2)	82.3 (3.2)	81.4 (0.4)	80.6 (3.7)	0.3 (0.4)	-1.6 (1.8)***
Sella–A-point (mm)	90.5 (2.2)	90.2 (4.5)	93.6 (2.9)	90.1 (5.5)*	3.0 (1.3)	-0.1 (2.4)***
SNB (°)	77.4 (0.4)	76.1 (2.9)*	78.3 (0.7)	76.8 (3.3)*	0.9 (0.5)	0.7 (1.1)
ANB (°)	3.7 (0.3)	6.2 (1.2)***	3.1 (0.3)	3.8 (1.7)*	-0.6 (0.2)	-2.4 (1.8)***
Ar-Pg (mm)	111.7 (2.7)	111.0 (6.0)	117.1 (3.5)	116.6 (7.4)	5.4 (2.0)	5.6 (4.2)
Rotational skeletal						
MPA-Frankfort (°)	27.3 (1.8)	26.5 (5.1)	26.8 (1.7)	26.3 (5.9)	-0.5 (1.3)	-0.3 (1.9)
Y-axis (°)	60.7 (1.4)	60.6 (4.1)	60.9 (2.2)	61.0 (4.4)	0.2 (1.2)	0.4 (1.7)
Me-Go/Sn (°)	33.9 (0.5)	34.3 (4.7)	32.5 (0.8)	33.5 (5.4)	-1.4 (1.0)	-0.8 (1.5)
Ar-Go-Me (°)	125.8 (1.0)	128.4 (3.7)**	123.6 (0.9)	127.1 (4.2)***	-2.2 (0.9)	-1.2 (2.4)
SN-PP (°)	7.5 (0.8)	7.3 (3.5)	7.5 (0.5)	7.6 (3.1)	0.0 (0.4)	0.3 (1.8)
SN-OP (°)	15.8 (0.7)	15.3 (4.5)	14.4 (0.7)	15.9 (4.0)	-1.4 (0.7)	0.6 (3.4)**
Vertical skeletal						
N-ANS (mm)	55.3 (1.5)	55.0 (4.1)	57.2 (1.8)	57.2 (4.5)	1.9 (1.6)	2.2 (2.5)
ANS-Me (mm)	70.0 (2.3)	70.0 (5.3)	73.0 (4.0)	72.3 (6.4)	3.0 (2.1)	2.3 (2.7)
LFH (%)	0.6 (0.0)	0.6 (0.0)	0.6 (0.0)	0.6 (0.0)	0.0 (0.0)	0.0 (0.0)
Ar-Go (mm)	46.4 (1.7)	47.6 (3.4)	50.1 (2.1)	52.0 (5.2)	3.8 (0.9)	4.2 (3.9)
Incisor position						
U1-NA (mm)	4.3 (0.2)	4.8 (2.9)	4.2 (0.5)	5.4 (2.7)	-0.1 (0.5)	0.6 (2.5)
U1-NA (°)	22.9 (0.7)	23.0 (9.1)	22.1 (0.7)	23.9 (6.8)	-0.8 (1.2)	0.9 (8.5)
U1-Sn (°)	103.9 (0.8)	105.6 (9.6)	103.5 (0.8)	105.1 (7.5)	-0.5 (1.3)	-0.5 (8.6)
U1-Ans (mm)	29.9 (1.3)	29.8 (3.3)	31.1(1.4)	30.3 (2.9)	1.1 (0.4)	0.5 (1.5)
U1-L1 (°)	127.6 (1.5)	125.7 (12.6)	130.5 (2.5)	121.5 (10.3)***	2.9 (2.7)	-4.2 (12.3)**
L1-MPA (°)	94.7 (1.0)	94.5 (5.8)	93.6 (1.5)	99.8 (6.3)***	-1.0 (1.0)	5.3 (5.2)***
L1-NB (mm)	4.9 (0.3)	5.8 (1.9)	4.5 (0.9)	7.4 (2.5)***	-0.4 (0.8)	1.6 (1.9)***
L1-NB (°)	25.9 (0.7)	24.5 (6.7)	24.4 (1.5)	30.2 (5.2)***	-1.6 (1.5)	5.7 (5.8)***
L1-MPA (mm)	42.9 (1.4)	43.7 (3.1)	44.3 (2.8)	44.4 (4.3)	1.4 (1.7)	0.7 (2.2)
U1-PP (mm)	29.7 (1.3)	29.4 (3.2)	30.9 (1.4)	30.0 (2.9)	1.1 (0.4)	0.6 (1.4)
Molar position						
U6-PP (mm)	23.1 (1.0)	22.6 (2.7)	25.3 (1.4)	24.1 (3.0)	2.2 (0.9)	1.5 (1.9)
L6-MP (mm)	32.6 (1.3)	32.1 (2.5)	34.5 (2.1)	34.7 (2.9)	1.9 (1.2)	2.6 (1.8)

*$p<0.05$, **$p<0.01$, ***$p<0.001$

impositions were used to measure molar and incisor angular changes.

Data analysis

The reliability of the measurement method was assessed by comparing each measurement made from repeat tracings and anterior cranial base, maxillary and mandibular superimpositions, made at least 4 weeks apart on five cephalograms selected at random. Comparisons of the two sets of measurements (original and repeat) were made using a paired *t*-test. The statistical comparison did not demonstrate a significant difference ($p<0.05$) for any of the measurements.

Mean and standard deviations were calculated for each cephalometric variable. Because the data tended to be distributed normally, Student's *t*-test was used to determine the level of significance of the differences between group means. To analyze measurements made from the superimpositions, statistical comparison of changes from T1 to T4 and from T2 to T3 were compared to no change (zero) using a single sample *t*-test.

Results

T2-T3: Placement to removal of Jasper Jumper

Comparisons of the cephalometric measurements of the Jasper Jumper patients at T2 with the matched standards showed no statistically significant differences except for the ANB angle (Table 1). The larger ANB angle in the treatment group reflected the patient selection criteria of a 5-degree or greater ANB angle.

When the average treatment changes in cephalometric measurements (T2-T3) were compared with those determined from the cephalometric standards, several statistically significant differences were found (Table 1). Restraint of forward maxillary growth was reflected in a reduction in the SNA angle (0.8 degrees), no increase in the sella–A-point distance and a reduction in the ANB angle (-1.0 degrees). There was a slight reduction (-0.2 mm) in lower face height and a clockwise or opening rotation of the occlusal plane (increase in the SN-OP angle of 2.4 degrees). The maxillary incisors were retroclined (U1-NA: -1.4 mm, -4.8 degrees; U1-Sn: -6.0 degrees) and the mandibular incisors proclined (L1-MPA: +7.9 degrees; L1-NB: +1.8 mm, +6.9 degrees). The mandibular incisors and maxillary molars were intruded (L1-MPA: -1.0 mm, U6-PP: -1.0 mm) .

Comparisons of the treatment group at removal of the Jasper Jumper (T3) with the matched cephalometric standards showed no statistically significant differences except that the mandibular incisors were proclined in the treatment group (Table 1).

Table 3
Molar and incisor changes and statistical comparison from T2 to T3 and from T1 to T4 based on anterior cranial base, maxillary, and mandibular structural superimpositions[10,11]

Measurement	T2-T3 Maxilla Mean (SD)	T2-T3 Mandible Mean (SD)	T1-T4 Maxilla Mean (SD)	T1-T4 Mandible Mean (SD)
A-P				
Total molar (mm)	-2.0 (1.2)***	1.3 (2.1)*	1.9 (2.4)***	4.7 (3.2)***
Dental molar (mm)	-2.1 (1.2)***	1.1 (2.0)	1.2 (2.1)**	2.6 (1.9)***
Skeletal molar (mm)	0.1 (0.6)	0.2 (0.9)	0.7 (1.6)	2.1 (2.2)***
Total incisor (mm)	-2.5 (1.3)***	2.1 (1.5)***	-0.4 (3.5)	4.1 (3.5)***
Dental incisor (mm)	-2.6 (1.5)***	1.9 (1.1)***	-1.2 (3.6)	1.8 (1.9)***
Skeletal incisor (mm)	0.1 (0.8)	0.2 (0.9)	0.8 (1.7)*	2.3 (2.3)***
Vertical				
Total molar (mm)	-0.3 (0.9)	0.1 (1.1)	3.0 (3.4)***	-3.3 (3.3)***
Dental molar (mm)	-0.7 (0.8)*	0.9 (0.7)***	1.8 (2.0)***	1.9 (1.6)***
Skeletal molar (mm)	0.4 (0.7)	-0.8 (1.1)*	1.2 (1.8)**	-5.2 (4.3)***
Total incisor (mm)	1.1 (1.4)*	-1.9 (1.5)***	3.0 (2.6)***	-4.8 (3.3)***
Dental incisor (mm)	0.9 (0.8)***	-1.2 (1.6)*	1.5 (1.8)***	-0.6 (2.3)
Skeletal incisor (mm)	0.2 (0.8)	-0.7 (1.5)	1.5 (1.9)***	-4.2 (3.7)***
Angulation (crown)				
Molar (°)	-4.3 (4.0)***	2.9 (4.6)*	-0.3 (3.1)	-0.2 (4.5)
Incisor (°)	-6.5 (4.9)***	8.6 (3.8)***	-1.2 (8.2)	6.5 (5.1)***

- = posterior or intruded, + = anterior or extruded
*$p<0.05$, **$p<0.01$, ***$p<0.001$

The Jasper Jumper treatment effects were also evident in the T2-T3 superimpositions (Table 3, Figure 4). On average, there was 2.0 mm of maxillary molar retraction, a result of 2.1 mm of distal molar movement and 0.1 mm of maxillary skeletal forward growth. The maxillary molars were also tipped distally (4.3 degrees) and intruded (0.7 mm). The maxillary incisors were retracted 2.5 mm due to a combination of 2.6 mm of distal incisor movement and 0.1 mm of maxillary skeletal forward growth. In addition, the maxillary incisors were tipped lingually (6.5 degrees) and extruded (0.9 mm).

In the mandible, the molars came forward an average of 1.3 mm. The protraction was accounted for by 1.1 mm of mesial molar movement and 0.2 mm of mandibular skeletal forward growth. The molars were also tipped mesially (2.9 degrees) and extruded (0.9 mm). Mandibular incisors were advanced labially 2.1 mm overall, 1.9 mm from dental change. On average, the incisors were tipped labially (8.6 degrees) and intruded (1.2 mm).

The skeletal changes determined from the superimposition data were not statistically significant for either the maxilla or the mandible during the period of Jumper treatment (Table 3).

T1-T4: Start to completion of orthodontic treatment

Cephalometric measurements from the T1 group and the matched standards were similar except for those related to the Class II selection criteria (Table 2).

Relative to the normative values, significant maxillary restraint was evident in the experimental group from T1 to T4 (Table 2). There was a very highly significant reduction in SNA angle (norm: +0.3 degrees; Jumper: -1.6 degrees) as well as the sella–A-point distance (norm: +3.0 mm; Jumper: -0.1 mm). In contrast, mandibular growth increments of the patients as indicated by the SNB angle and Ar-Pg measurements were very similar to the normative values. The net skeletal effect was evident in the reduction of the ANB angle (norm: -0.6 degrees; Jumper: -2.4 degrees). Other changes included a 2.0-degree clockwise, or opening, rotation of the occlusal plane and proclination of the mandibular incisors (L1-MPA: +5.3 degrees; L1-NB: +1.6 mm, +5.7 degrees). The U1-L1 angle decreased 4.2 degrees in the treatment group.

At the end of orthodontic treatment (T4), the smaller SNB and larger ANB angles relative to the normative values indicated a persistent Class II skeletal tendency, although the ANB angle demonstrated a trend toward the normative value (Table 2). The larger

Ar-Go-Me angle in the treatment group measured at the start of treatment persisted at the end of treatment. Dentally, the treated patients had proclined mandibular incisors and an increased interincisal angle.

Superimpositions of T1 and T4 headfilms show many statistically significant changes due to treatment effects and growth during the complete course of treatment (Table 3). The mandibular molars came forward on average 2.8 mm more than the maxillary molars. On average, the total forward maxillary molar movement was 1.9 mm, as a result of 1.2 mm of forward dental change and 0.7 mm of forward maxillary skeletal growth. Total forward mandibular molar movement was 4.7 mm due to molar protraction (2.6 mm) and forward mandibular skeletal growth (2.1 mm). The mandibular incisors were proclined an average of 6.5 degrees. The vertical skeletal and anteroposterior mandibular changes during the period of treatment were statistically significant, whereas maxillary anteroposterior changes were evident only with the incisor measures.

T2-T3 and T1-T4 group *comparisons*

Comparision of the T2-T3 treatment group at T2 (see Table 1) with the T1-T4 group at T1 (see Table 2) revealed only two significant differences. The gonial angle was 3.4 degrees greater ($p<0.01$) and the Ar-Go distance was 3.0 mm less ($p<0.05$) in the T1 group. The posttreatment comparison of T3 and T4 (see Tables 1 and 2, respectively) revealed only one significant difference. The maxillary incisor to NA distance was 1.6 mm greater ($p<0.05$) in the T4 group.

Discussion

This study used two cephalometric approaches to analyze the treatment effects of the Jasper Jumper in growing patients. One method was based on a measurement reference system that allowed comparison of subjects treated using the Jasper Jumper with age-adjusted cephalometric norms. Using this approach, the effects of growth and treatment in patients could be compared with growth changes in untreated individuals, thus permitting an evaluation of the treatment changes. The second method used anterior cranial base, maxillary, and mandibular structural superimpositions. This method allows discrimination between dental and skeletal changes. However, because there was no untreated sample analyzed in this manner, relative effects of growth versus treatment could not be evaluated. Although the validity of the superimposition method is widely accepted, several issues should be considered relative to the use of the cephalometric norms in the former method. First, the two samples differed in that the normative sample was based on a mixed population, whereas the Jasper Jumper patients were selected on the basis of a Class II malocclusion. Second, the normative values calculated in this study were based on the Michigan study[14] means, each derived from approximately 20 to 45 individuals. Use of the mean values most certainly reduced the range of normative values for each measurement relative to what the values would have been had they been measured from individuals (such as we did with the Jasper Jumper samples). The reduced variation in the adjusted normative data as reflected in the standard deviations (see norm and Jumper measurements, Tables 1 and 2) is likely to have biased the statistical analysis toward significant findings.

The validity of the overall cephalometric measurement comparison would have been improved had treatment comparisons been made

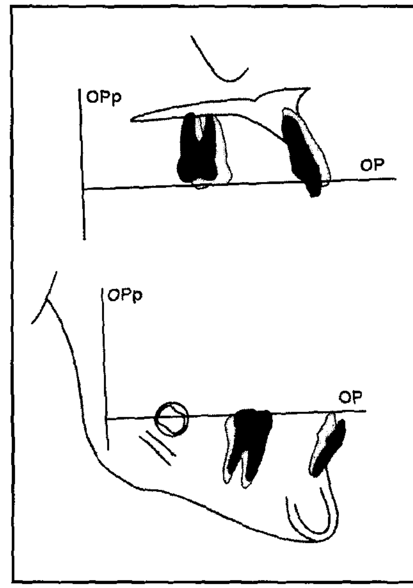

Figure 4
Diagrammatic representations of the typical dental changes occurring during Jasper Jumper treatment (T2= grey; T3= black) based on maxillary (upper drawing) and mandibular (lower drawing) structural superimpositions.[10,11] Reference planes: occlusal plane (OP); occlusal plane perpendicular (OPp).

with a matched, untreated Class II Division 1 sample of individuals. Presumably a greater standard deviation of the control group values would have resulted in lower levels of significance for a number of the statistically significant measures. Nevertheless, there are several potentially mitigating factors related to the normative values. Most of our statistically significant comparisons between norms and patients treated with the Jasper Jumper were found to be highly significant ($p<0.001$). Conversely, the presumption of an artificially reduced standard deviation for the normative data suggests that if a measure did not differ significantly in the present study (e.g., mandibular anteroposterior position), it would be even less likely to do so if individuals rather than means were to be used for control comparisons. Finally, many of the significant results relative to the norms were also evident in the superimposition data, values that did not involve norms. Nevertheless, in light of the limitations related to our use of the normative data, the statistical results in Tables 1 and 2 should be interpreted with caution.

The results from both cephalometric analyses demonstrate that the Jasper Jumper has multiple treatment effects. While many of the effects would generally be considered desirable for the correction of Class II malocclusions (e.g., bodily molar movement, reduced anterior growth of the maxilla), others would typically be considered undesirable (e.g., mandibular incisor proclination). Skeletally, in both the T2-T3 and T1-T4 treatment groups, a restraint of forward maxillary growth (SNA: 1 degree T2-T3; 2 degrees T1-T4) was the only statistically significant effect of the appliance. Reduction in forward maxillary displacement (growth) has also been found with other Class II mechanics, including headgear,[17-19] intermaxillary elastics,[20] functional appliances,[21-23] and the Herbst appliance.[15-24] Our results are similar to those of Cope and associates[3] and Stucki and Ingervall,[5] who found that the Jasper Jumper not only restrained normal growth of the maxilla when measured relative to the anterior cranial base, but tended to reverse the pattern (the maxilla moved posteriorly). On the other hand, our findings contradict those reported by Weiland and Bantleon,[4] Weiland and associates,[6] and Stucki and Ingervall (when measured relative to the occlusal plane),[5] where insignificant effects were observed on anterior maxillary growth. The contradictions may be related to a number of factors, including differences in the measurement methodology, sample characteristics (e.g., mean age 13:2 versus 11:4,[4] 10:8,[10] and 14:8;[5] permanent dentition versus mixed dentition[4,10]), sources of normative values, and differences in treatment mechanics (such as the duration of the Jumper phase of treatment).

We did not detect a significant effect on horizontal mandibular growth. These results are in agreement with those of Cope and associates,[3] but contradict the findings of Weiland and Bantleon,[4] Weiland and associates,[6] and Stucki and Ingervall,[5] where anterior mandibular growth was enhanced. The difference may be related to the factors described above for maxillary growth. With regard to patient age, in both the present study and that of Cope and associates,[3] the mean patient age was 2 to 3 years older than in the Weiland studies.[4,6] Based on results from patients treated with the Herbst appliance, Pancherz suggested that the younger the patient, the greater the potential for modification of mandibular (skeletal) growth.[24] On the other hand, the older sample of Stucki and Ingervall[5] (median 14:8 years) does not support this contention among the Jasper Jumper studies. A factor that emerges as a common denominator in this discrepancy relates to the method of measurement. Both the present study and that of Cope and associates[3] used anterior cranial base and maxillary and mandibular structural superimposition methods to determine skeletal and dental effects, whereas the conflicting studies[4-6] relied on measurements derived from anterior cranial base superimpositions alone.

Relative to other mechanics, the conflicting results mentioned above are not unique to Jasper Jumper studies. For example, with functional appliance therapy, enhanced sagittal growth of the mandible has been reported by some investigators,[21,31-34] whereas no increase was reported by others.[27,35,36] Weiland and associates found no significant difference among measures of mandibular growth in patients treated with activator, activator-headgear, and Jasper Jumpers, although growth increments tended to be greater than normal.[6] It should be noted that the possibility of anterior remodeling and relocation of the glenoid fossa, such as has been reported by Woodside and associates from animal studies,[37] was not evaluated in our study.

In the present study, the angulation of occlusal plane to sella-nasion increased in both treatment groups. However, no significant increase was found in the rotational or vertical skeletal measurements relative to cephalometric standards. In particular, the mandibular plane angle did not increase significantly in either treatment group. The opening rotation of the occlusal plane is in agreement with that of Cope and associates.[3] However, the investigators also measured a slight opening mandibular rotation in contrast with the present findings. Opening rotation of the occlusal plane is a common finding with the use of Class II elastics,[25,26] functional appliances,[22,27] and the Herbst appliance.[24] Increased vertical facial dimension has been reported with the use of Class II elastics,[20,28] functional appliances,[21,29,30] and the Herbst appliance.[15,21,24] Consistent with the force vectors produced when the Jumpers are activated, the lack of vertical skeletal changes in the present study may relate to the significant maxillary molar intrusion demonstrated with the superimpositions, the decrease in maxillary molar eruption reflected in the upper-molar-to-palatal-plane measurement, and the opening rotation of the occlusal plane.

Our results show that the Class II correction produced by the Jasper Jumpers was due largely to dentoalveolar changes. In the maxillary arch, the molars were retracted, intruded, and tipped distally. Cope and associates also found that the maxillary molars underwent significant posterior tipping and relative intrusion.[3] The dental effects resemble, in part, those described with other Class II mechanics. Distal movement of maxillary molars has been reported with cervical headgear[19,38,39] and the Herbst appliance.[15,24,40] Inhibited vertical maxillary dentoalveolar growth has been demonstrated using a variety of functional appliances.[21,33,40,41] It is well established that Class II molar correction is facilitated when maxillary molar eruption is inhibited and mandibular molar vertical and mesial eruption is encouraged. This mechanism has been described with functional appliances,[35,35,41] Class II elastics,[26] and the Herbst appliance.[15,24,40] Measurements from the T2 to T3 superimpositions showed that the total mandibular molar mesial movement was significant and almost entirely dentoalveolar. Significant retroclination of maxillary incisors was observed during the active Jumper phase in the T2-T3 treatment group. This finding is in agreement with previous Jasper Jumper[3-11] and functional appliance studies.[21,23,33]

Consistent with previous studies, molars in the mandibular arch were protracted, extruded, and tipped mesially, while the incisors were proclined and intruded.[3-6] The incisor proclination, evident in the superimpositions and in measured changes of the mandibular incisor during the T2-T3 and T1-T4 treatment periods accounted for the decreased interincisal angle at T4. Mandibular incisor proclination has also been observed with functional[21,23,33,36] and Herbst appliances.[15,24,40] Taking into account the apparent dentoalveolar versus skeletal effects of the appliance, it should be noted that although the mandibular incisor angulation may not be ideal based on cephalometric means,[14,42] the proclination may in part represent a necessary dentoalveolar compensation attendant to the persistent underlying skeletal base discrepancy.[43-45]

Comparison of the measurements from the T2-T3 and T1-T4 samples indicates that a number of the active treatment effects of the Jasper Jumper appliance are reversed after the Jumpers are removed. Although caution is indicated in interpreting these results because the data is cross-sectional, similar observations have recently been described by Stucki and Ingervall.[5] Notably, the maxillary and mandibular molars that were tipped from T2 to T3 were uprighted in the finishing stages of treatment, and maxillary incisors that were upright at T3 had a normal inclination at T4. Because the patients remained in the banded and bonded appliance after the Jumpers were removed, the suggested changes could be attributed to an expression of the orthodontic appliances' prescription. In addition, a component of the correction may be due to the tendency toward dental relapse as demonstrated in the Jasper Jumper case study by Mills and McCulloch.[9] The untoward effects of the Jumper on the molars and incisors (resembling those described in the present study) were found to reverse following removal of the Jumpers, although no brackets or archwires had been placed.[9] Similarly, long-term follow up of patients treated with the Herbst appliance demonstrated that, while significant dental relapse occurs relative to skeletal landmarks, dental arch relationships tend to remain stable by a continual process of dentoalveolar compensation.[46] Presumably, cuspal interdigitation maintains the dental arch relationship.[45,46] In the present study, despite the apparent axial molar changes after the Jumpers were removed, Class I dental relationships were maintained during treatment. In the future, a more definitive determination of the treatment effects of the Jasper Jumper will rely on long-term posttreatment analyses of dental and skeletal relationships.

Conclusions

This study documented a number of treatment effects attendant to a Class II correction using the Jasper Jumper appliance. During the interval of Jumper use, cephalometric structural superimpositions demonstrated that correction of the anteroposterior molar discrepancy (mean: 3.3 mm) was due to significant dental movements (3.2 mm, 97%) and relatively small alterations in the skeletal growth pattern (0.1 mm, 3%). Bodily anteroposterior molar movement was found, along with significant molar tipping. The maxillary molars were intruded and the mandibular molars were extruded. The mandibular incisors were proclined and intruded, while the maxillary incisors were retroclined and extruded. These dental changes resulted in an opening rotation of the occlusal plane without an opening rotation of the mandibular plane. Skeletally, the patients showed restraint of forward maxillary growth and no significant change in horizontal mandibular growth. The results suggest that during orthodontic finishing (following removal of the Jumper springs), molar tipping and maxillary incisor retroclination were reversed, whereas proclination of the lower incisors remained. Because the transverse maxillary molar dimension was controlled during treatment, changes in this dimension were not analyzed. Beyond the issue of increased compliance, the potential advantage of the Jasper Jumper over a variety of other Class II mechanics is the ability to correct Class II dental discrepancies relatively rapidly without significantly increasing vertical or rotational skeletal growth patterns. Further study will be needed to establish the long-term stability of Class II corrections achieved with the Jasper Jumper appliance.

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