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Vertical changes in treated and untreated Class II division 1 malocclusions

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Background: Treatment-induced increases in the height of the face may be permanent.
Aims: To determine if appliance-induced increases in the heights of the upper and lower molars in girls with Class II division 1 malocclusion, and the consequential increase in the height of the face are maintained.
Methods: Ten angles and 10 distances were measured on lateral cephalometric radiographs of 11 year-old girls (Range: 8.5–14.8 years) with treated (N = 9) and untreated (N = 8) Class II division 1 malocclusions. The intervals between the initial and recall records were, on average, 12 years (Range: 7.6–15.7 years) for the girls in the treatment group, and 8 years (Range: 4–13 years) for the girls in the untreated/control group. In the treatment group eight girls were treated with the Begg appliance and Class II elastics.
Results: Upper and lower molar dentoalveolar heights in both groups increased significantly between the initial and recall visits. There were no significant differences between the molar heights in the groups at the start or at recall. Anterior face height (AFH) also increased significantly in both groups between the initial and recall visits. At recall, AFH in the treatment group was significantly greater than AFH in the control group. This finding is attributed to a similar-sized difference between the groups at the start, to the longer period between the initial and recall records in the treatment group and to lesser variation in both groups at recall. In both groups, posterior face height increased significantly between the initial and recall stages. At the conclusion of the study there were no statistically significant differences between the treated and control groups in either overjet or the inclination of the upper incisors. Relapse of the upper incisors in the treatment group and retroclination of the upper incisors in the control group reduced the initial differences between the groups. These changes are attributed to altered lip posture and increased lip pressures in adolescence. At recall, angles SNA and SNB were significantly smaller in the treatment group.
Conclusion: The heights of the upper and lower molars and the face increased in both groups. Orthodontic treatment may have no lasting effects on either the height of the face or the heights of the molars in girls with Class II division 1 malocclusion.
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Introduction

Almost 70 years ago Brodie, Downs, Goldstein and Myer[1] published the first cephalometric appraisal of patients treated with the edgewise appliance. In 12 patients with Class II division 1 malocclusions they noted that in every case the anterior end of the occlusal plane tipped downwards during treatment, opening the angle between the Bolton and occlusal planes. They reported also that following treatment the angulations of the teeth and occlusal plane tended to recover. They found Class II elastics opened the angle between the Bolton and occlusal planes and Class III elastics closed it, and a downward and backward rotation of the mandible occurred in a number of cases.

Other studies have confirmed that elevation of the molars during orthodontic treatment is accompanied by an increase the height of the face, a downward and backward rotation of the mandible and downward tipping of the anterior end of the occlusal plane, particularly if Class II elastics are used.[2–9] On one hand it has been argued that the increase in face height may be permanent and on the other hand that it is reversible.[8,10,11] The evidence is, however, inconclusive because only a few studies have used Class II division 1 malocclusion controls, the few prospective

Table I. Ages of the control and treatment groups.

	Control			Treatment		
	Mean (SD) (years)	Range Min	Max	Mean (SD) (years)	Range Min	Max
Age – initial records	11.9 (2.20)	8.5	14.8	11.7 (1.74)	9.1	14.5
Age – end of treatment				14.7 (1.59)	12.9	17.0
Retention period				1.9 (0.70)	1.0	3.1
Age – recall records	20.2 (4.02)	14.4	27.4	23.8 (2.74)	20.7	28.6
End – recall				7.2 (1.81)	5.3	10.6
Initial – recall	8.3 (2.84)	4.0	13.1	12.1 (2.66)	7.6	15.7

studies of Class II division 1 treatment have either not reported vertical changes and/or the subjects have not been followed long-term.

The aim of this retrospective study is to determine if appliance-induced increases in the heights of the molars and the consequential increase in the height of the face are maintained.

Subjects and methods

The subjects were girls with Class II division 1 malocclusions referred to the Department of Orthodontics, University of Otago between 1970 and 1981.[12] The following inclusion criteria were used:

1. Class II division 1 malocclusion[12] with an incisor overjet $\geq$ 5 mm at the initial consultation. Overjet was measured on study casts taken at the initial consultation.

2. Lateral cephalometric radiographs taken at the start and end of treatment, and at least five years from the end of treatment (if no retention was used) or five years from the cessation of all retention.

3. Lateral cephalometric radiographs taken at the initial consultation for the girls who did not have treatment, and at least 3.5 years after the initial consultation.

4. All radiographs were taken with the teeth in the intercuspal position.

Of the 41 girls who met these criteria 30 had been treated and 11 had not been treated. After ethical approval had been obtained attempts were made to trace the girls through School of Dentistry records, past telephone directories, family members and the New Zealand electoral roll. Eventually, nine girls who had been treated (Treatment group) and eight girls who had not been treated (Control group) were traced, and agreed to return for the recall records. In the treatment group five girls were treated with the Begg appliance and four first premolar extractions; one girl with four first premolar extractions, the Begg appliance and headgear; one girl was treated non-extraction with headgear and the Begg appliance; one girl with four first premolar extractions and removable appliances; and one girl with two upper first premolar extractions, the Begg appliance and headgear. At the initial consultation the mean ages of the girls were: Treatment group 11.7 years (SD: 1.74) and the Control group 11.9 years (SD: 2.20). The ages at each stage and the intervals between the various stages are given in Table I.

Methods

The radiographs were taken with either a Margolis cephalostat with a Meyer anode-generator (up to 1978) or a Wehmer cephalostat with an Amrad-Craig 1 anode-generator (from late 1978). Because the cephalostats had different tube-subject and subject-film distances, the enlargements of both machines were calculated from radiographs of the same wire mesh positioned midway between the ear posts. Image magnification in the Margolis cephalostat was 1.1287 and in the Wehmer cephalostat it was 1.0866. As the majority of the radiographs were taken with the Margolis equipment all linear measurements on radiographs taken with the Wehmer cephalostat were converted to the same magnification as those taken with the Margolis cephalostat. Angular dimensions were not affected by the different magnifications of the two cephalostats. No difficulty was experienced identifying which cephalostat had been used because the film sizes and images of the ear posts were different.

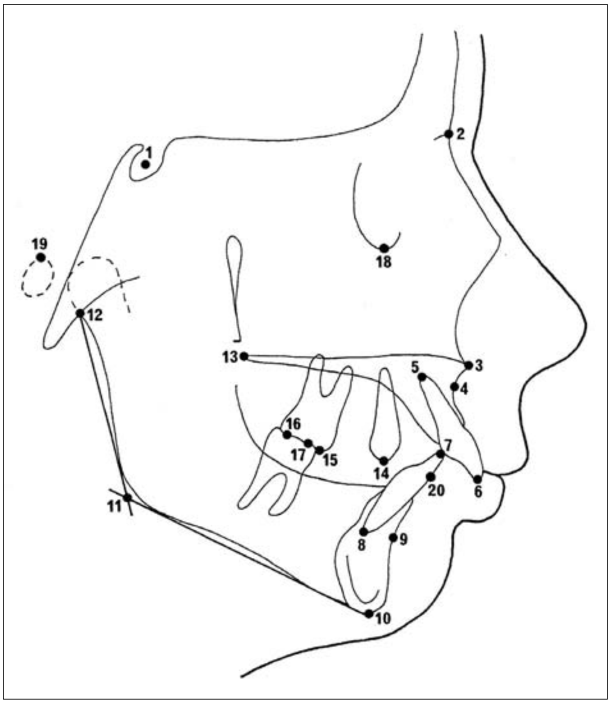

Figure 1. Reference points and measurements.
SNA: sella-nasion-A point (1-2-4)
SNB: sella-nasion-B point (1-2-9)
ANB: A point-nasion-B point (4-2-9)
MxL/MnL: ANS-PNS/Me-Go (3-13/10-11)
FH/MxL: Or-Po/ANS-PNS (18-19/10-11)
FH/MnL: Or-Po/Me-GO (18-19/10-11)
OL/MxL: ANS-PNS/U6DCT-PMCT (14-16/3-13)
OL/MnL: U6DCT-PMCT/Me-GO (14-16/10-11)
UI/MxL: UIA-UIE/ANS-PNS (5-6/3-13)
LI/MnL: LIE-LIA/Me-Go (7-8/10-11)
Overjet: UIE-LL (6-20)
Overbite: LIE-LL (7-20)
UIperp/MxL: UIE perp/ANS-PNS (6/3-13)
U6perp/MxL: U6MCT perp/ANS-PNS (15/3-13)
LIperp/MnL: LIE perp/Me-Go (7/10-11)
L6perp/MnL: LIE perp/ANS-PNS (17/10-11)
AFH: N-Me (2-10)
PFH: S-Go (1-11)
UIperp/OL: UIE perp/U6DCT-PMCT (6/14-16)
LIperp/OL: LIE perp/U6DCT-PMCT (7/14-16)

The coordinates of the reference points shown in Figure 1 were digitised directly three times with a reflex metrograph. The cursor was moved several centimetres away from each point between digitisations. The means of the three digitisations were used to calculate the measurements described in the legend to Figure 1.

To estimate the errors in the method of measurement, 10 radiographs were randomly selected from the Control and Treatment groups and digitised using the methods described above. The same radiographs were redigitised eight days later. The combined errors in identification of the reference points and digitisation were calculated with Dahlberg's formula, and differences between the two sets of measurements with the paired *t*-test.[13] Significant differences at the 5 per cent level of significance were found for the variables: OL/MxL, OL/MnL, and the perpendicular distance from the incisal edge of the upper incisor to the maxillary plane (UIperp/MxL). The mean difference for OL/MxL was 0.81 degree (SEM difference: 0.17 degree), for OL/MnL it was –0.65 degree (SEM difference: 0.24 degree) and for UIperp/MxL it was 0.20 mm (SEM difference: 0.11 mm). In agreement with Baumrind and Frantz,[14] we consider that large dental restorations affected our ability to locate the reference points for the occlusal plane consistently. The significant finding for the upper incisor dentoalveolar height (UIperp/MxL) may be due to a slight shift in location of the reference points for this dimension. In spite of these differences we consider that the method of measurement met the requirements of the study. Poor definition on the films taken with the older Margolis equipment did not allow us to use stable anatomical structures.

Comparisons between the Initial, End and Recall measurements in the Treatment sample were carried out in two steps: an analysis of variance was used to determine if any statistically significant differences ($p < 0.05$) occurred between the same measurements at the three stages. Duncan's new multiple range tests were then carried out to determine whether the significant differences occurred between the Initial – End, End – Recall and/or Initial – Recall stages. Comparisons within the Control group were carried out with paired *t*-tests, and between the Control and Treatment groups with *t*-tests for unpaired data. The 0.05 level of probability was used in all tests.

Results

The means and standard deviations of the variables together with the comparisons within and between the groups are given in Table II. The groups significantly different with Duncan's multiple range test are indicated by letters.

Control group

Initial – Recall

No statistically significant differences were found between the angular measurements at the initial and recall stages. There were, however, statistically significant increases in upper molar dentoalveolar height

Table II. Comparison of the cephalometric variables in the control and treatment groups.

Variables	Control (N=8)			Treatment (N=9)			Control vs Treatment	
Angles	Initial Mean (SD)	Recall Mean (SD)	*p**	Initial Mean (SD)	End Mean (SD)	Recall Mean (SD)	Initial *p*†	Recall *p*†
SNA	82.3 (4.08)	81.8 (2.01)	> 0.05	80.6 (3.74)	79.4 (4.47)	78.9 (2.94)	> 0.05	< **0.05**
SNB	77.3 (3.02)	77.0 (1.26)	> 0.05	75.3 (3.53)	73.9 (4.00)	74.2 (2.53)	> 0.05	< **0.05**
ANB	5.0 (1.46)	4.8 (1.78)	> 0.05	5.3 (2.48)	5.4 (3.05)	4.8 (3.02)	> 0.05	> 0.05
MxL/MnL	27.1 (3.69)	25.8 (3.70)	> 0.05	28.9 (4.42)	29.4 (4.65)	26.2 (6.57)	> 0.05	> 0.05
FH/MxL	2.5 (2.25)	3.3 (1.96)	> 0.05	1.8 (1.68)	1.6 (1.03)	2.4 (1.25)	> 0.05	> 0.05
FH/MnL	26.5 (4.09)	23.9 (4.48)	> 0.05	27.2 (4.17)	29.9 (3.36) **b**	24.9 (6.36) **b**	> 0.05	> 0.05
OL/MxL	13.0 (3.69)	10.9 (2.83)	> 0.05	15.4 (3.09) **a**	20.5 (4.62) **a,b**	14.3 (4.88) **b**	> 0.05	> 0.05
OL/MnL	14.1 (5.24)	14.8 (3.81)	> 0.05	13.4 (3.13)	9.2 (5.48)	11.9 (6.35)	> 0.05	> 0.05
UI/MxL	114.1 (4.88)	110.6 (4.48)	> 0.05	119.7 (4.87) **a,c**	100.4 (8.30) **a**	107.8 (9.60) **c**	< **0.05**	> 0.05
LI/MnL	98.5 (6.48)	101.9 (4.45)	> 0.05	97.5 (9.11)	97.8 (6.43)	97.2 (8.00)		> 0.05
Distances								
Overjet	8.6 (2.60)	6.9 (2.99)	> 0.05	11.4 (2.68) **a.c**	3.5 (1.60) **a**	5.8 (2.58) **c**	< **0.05**	> 0.05
Overbite	4.2 (2.11)	3.3 (2.06)	> 0.05	5.2 (1.89) **a**	2.6 (1.38) **a,b**	4.8 (1.75) **b**	> 0.05	> 0.05
U1perp/MxL	27.8 (2.75)	30.3 (2.20)	> 0.05	28.7 (2.45) **c**	30.6 (2.39)	31.8 (2.11) **c**	> 0.05	> 0.05
U6perp/MxL	20.6 (2.83)	24.2 (1.72)	< **0.05**	22.0 (2.47) **a,c**	24.2 (2.15) **a**	26.0 (2.02) **c**	> 0.05	> 0.05
LIperp/MnL	39.2 (3.19)	41.8 (3.25)	> 0.05	42.0 (3.50)	41.2 (3.08)	43.6 (3.51)	> 0.05	> 0.05
L6perp/MnL	28.9 (1.75)	32.5 (1.00)	< **0.05**	30.1 (2.59) **a,c**	33.0 (2.20) **a**	34.0 (2.80) **c**	> 0.05	> 0.05
N-Me	113.8 (4.28)	123.1 (2.77)	< **0.05**	117.4 (8.07) **a.c**	125.2 (4.48) **a**	127.7 (5.48) **c**	> 0.05	< **0.05**
S-Go	72.0 (6.09)	79.7 (3.80)	< **0.05**	74.2 (4.03)	78.7 (3.04)	83.8 (9.04) **c**	> 0.05	> 0.05
UIperp/OL	0.9 (2.90)	0.7 (2.30)	> 0.05	3.7 (1.83)	3.8 (2.25)	1.5 (2.71)	**< 0.05**	> 0.05
LIperp/OL	2.9 (1.64)	2.1 (2.02)	> 0.05	5.3 (1.13)	4.6 (2.24)	4.5 (2.24)	**< 0.05**	< **0.05**

* Paired *t*-test
† Unpaired *t*-test
The letters indicate groups significantly different at $p < 0.05$ with Duncan's multiple range test

(U6perp/MxL), the lower molar dentoalveolar height (L6perp/MnL), anterior face height (AFH) and posterior face height (PFH). AFH and PFH increased by 9.3 mm and 7.7 mm respectively (Table II).

Treatment group

Initial – End of treatment

During treatment the upper incisors were tipped palatally (UI/MxL), and the occlusal plane – maxillary plane angle (OL/MxL) increased significantly from 15.4 degrees to 20.5 degrees. There were five statistically significant differences between the linear measurements at the Initial and End stages (Table II). During treatment the overjet and overbite were reduced 7.9 mm and 2.6 mm respectively, and the perpendicular heights of the upper (U6perp/MxL) and lower (L6perp/MnL) molars increased 2.2 mm and 2.9 mm respectively. The AFH increased 7.9 mm during treatment.

End of treatment – Recall

There were three significant differences between the end of treatment and recall stages: the Frankfort – mandibular planes angle (FH/MnL) decreased 4.9 degrees; the occlusal plane – maxillary plane angle (OL/MxL) decreased 6.2 degrees; overbite increased 2.1 mm.

Initial – Recall

The inclination of the upper incisors to the maxillary plane (UI/MxL) remained significantly less at the recall stage in spite of a 7 degree relapse after treatment. By contrast, there were six significant linear differences. The mean overjet difference between the initial and recall stages was 5.6 mm. The upper incisor dentoalveolar height (UIperp/MxL) increased 3.1 mm, and the upper (U6perp/MxL) and lower molar (L6perp/MnL) dentoalveolar heights increased 4.0 mm and 3.9 mm respectively. The AFH increased 10.3 mm and the posterior face height (PFH) increased 9.6 mm.

Control vs Treatment

Initial stage

The upper incisors in the treatment group were significantly more proclined, the overjet was significantly larger, the upper incisors (UIperp/OL) were significantly below the occlusal plane and the lower incisors (LIperp/OL) were significantly above the occlusal plane compared with the control group.

Recall stage

There were only two significant angular differences between the groups at this stage. Angles SNA and SNB were significantly smaller in the treatment group compared with the control group (Table II). The standard deviations in both angles at recall were less than those found initially. There were also two significant linear differences between the two groups: AFH was significantly greater in the treatment group, and the lower incisors were above the occlusal plane (LIperp/OL) to a greater extent than in the control group.

Discussion

We set out to determine if the increase in the height of the face that invariably occurs when the molars are extruded during orthodontic treatment, was permanent, or whether it was 'reversible'.[10] That is to say, the upper and lower molars and the mandible end up in the positions they would have occupied, had treatment not been carried out. We followed a group of 11 year-old girls with untreated Class II division 1 malocclusions for 8 years, and a similar-aged group of girls with treated Class II division 1 malocclusions for 12 years. After taking into account several differences at the outset, the age difference at the conclusion of the study (the treatment group were three years older than the control group) and the lesser amounts of variation at the conclusion of the study, it appears that the upper and lower molars and mandible ended up in the positions they would have occupied had treatment not been carried out. The ages of the girls at the start were similar. It would appear that orthodontic treatment may have no lasting effects on either the vertical height of the face or the vertical heights of the molars in girls with Class II division 1 malocclusion.

This study was very small because of the difficulties we had finding patients that met the inclusion criteria, who could be located many years after their initial consultation and then persuaded to return for records. Because it was a small study it did not have much power to detect differences between the groups. The small numbers made it impossible for us to adjust for obvious differences, such as the length of follow-up. But in spite of the size of the study we did find some statistically significant differences at recall, which we will discuss below. The subjects were not randomly allocated to the groups at the outset so the possibility of some selection bias cannot be ruled out.

In longitudinal cephalometric investigations it is essential to keep errors to a minimum so that they do not overwhelm the changes being measured. The main errors can arise from repositioning an individual in the cephalostat on different occasions, from combined errors of identification of the reference points and from the measurements made. Difficulties in identifying the landmarks are considered the source of greatest errors in cephalometric investigations. It was not possible to check the repositioning errors because the lateral cephalometric radiographs had been taken over a 12 year period by different people using two cephalostats. However, positioning errors are generally small in relation to the variation found between different individuals and the variation when the same individual is followed longitudinally.

We investigated the errors in identification and measurement by remeasuring 10 randomly selected radiographs. We attributed two of the three significant differences to the difficulty we had in locating the reference points for the occlusal plane because the teeth concerned had large restorations.[14] The third finding we attributed to a slight shift when constructing the planes to measure the height of the incisal edge of the upper incisor from the occlusal plane. All measurements were taken directly off the films without an intervening tracing. Where a reference point proved difficult to locate we used other radiographs belonging to the subject to aid identification of the point in question. This procedure probably reduced the error variance within individuals, and as it was not used for all reference points systematic errors will be negligible.

Elevation of the upper and lower molars during treatment was accompanied by a significant increase in anterior face height. Anterior face height was also significantly greater in the treatment group, as compared with the control group, at recall. Some might argue that this difference was evidence of an appliance-induced permanent increase in face height, but there were some notable differences between the groups at recall. Firstly, anterior face height was 3.5 mm longer (but not significantly so) in the treatment group at the start, secondly the treatment group was, on average, 3.5 years older than the control group at recall, and thirdly there was less variation within the groups at recall which would increase the probability of finding a significant difference between the two groups.

In agreement with other studies the overbite was reduced during treatment, but relapsed after treatment.[5,7,15–17] Bearing in mind that anatomically stable landmarks could not be used, the increase in overbite appears to be due to continued vertical development of the upper and lower incisors relative to the occlusal and maxillary planes. The overbite reduced slightly, but not significantly so, in the control group. There was no significant difference in overbite between the two samples at recall.

During treatment the upper incisors were retroclined 19 degrees and the overjet reduced 8 mm. Following treatment, however, the upper incisors proclined 7 degrees and the overjet increased 2.2 mm. Similar changes during and following treatment have been reported by others.[1,6,15,16,18–20] At the start of the study, both the overjet and the inclinations of the upper incisors to the maxillary plane were significantly larger in the treatment group than in the control group. Therefore, the absence of any statistically significant differences in either overjet or the inclination of the upper incisors at recall was unexpected, particularly as the upper incisors were retracted during treatment. A number of small changes in the angulations of both upper and lower incisors appear to have combined to produce these findings. Changes in the inclinations of both upper and lower incisors in the control group reduced the overjet approximately 2 mm, whereas the upper incisors relapsed 2.2 mm in the treatment group: in only one subject was the overjet less at recall than at the end of treatment and in eight girls it relapsed. In view of these changes it is not surprising that there was no significant difference in overjet at the recall stage. In the control group the upper incisors retroclined 3.5 mm between initial and recall, and the lower incisors proclined about 3.5 mm. It has been reported that the upper incisors retroclined and the lower incisors proclined naturally in children with untreated Class II division 1 malocclusions.[21,22]

Several investigators have observed that in many adolescents lip posture changes from ‘lips apart’ to ‘lips together’.[23,24] It is postulated that as a lip seal developed labial to the upper incisors they would be retroclined by pressure from the lower lip, and the lower incisors would be free to procline because they would no longer be subjected to pressure from the lower lip.

Although there was no significant difference between the SNA angles in the treatment and control groups at the start of the study, this angle was significantly smaller in the treatment group at recall. Palatal movement of point A, and slightly lesser variation in both groups at recall would account for this finding. Point A would be expected to move palatally in the six subjects who had their upper incisors torqued palatally.[6,25] There was a small, but statistically significant difference in angle SNB at recall. This finding is less easily explained as the lower incisors were not torqued lingually in the treatment group, but the lesser variation in both groups at recall may account for this finding.

During treatment, the lower molars were extruded slightly more than the upper molars (2.9 mm and 2.2 mm respectively) and the anterior end of the occlusal plane was tipped downwards 5 degrees. Following treatment however, the upper molars erupted more than the lower molars, 1.8 mm and 1.0 mm respectively. The vertical ‘recovery’ of the molars after treatment lends support to the notion that each molar has a separate potential for vertical development/eruption.[26,27] Continued vertical development of the teeth and the alveolar process throughout life provides a mechanism for adjustment of molar heights after treatment.[27,28]

Conclusions

1. Orthodontic treatment may have no lasting effects on the vertical heights of the molars, incisors and faces of 11 year-old girls with Class II division 1 malocclusion.

2. The increase in overbite post-treatment appeared to be due to continued vertical development of the upper incisors relative to the maxillary and occlusal planes and relapse of the lower incisors.

3. Altered lip posture in adolescence and altered soft tissue pressures on the teeth may be responsible for retroclination of the upper incisors in the untreated individuals, with a consequential reduction in the overjet.

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