Class II, Division 2 Treatment and Mandibular Growth

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A statistical evaluation of relationships between orthodontic treatment of Class II, Division 2 malocclusion and mandibular growth and position, finding significant positive effects of treatment.

KEY WORDS: • BITE PLANE • GROWTH • MALOCCLUSION, CLASS II, DIVISION 2 • •MANDIBLE • CERVICAL TRACTION •

Reported investigations of Angle's Class II, division 2 (II^2) malocclusion (Angle 1899) are concerned mainly with cephalometric characterization (BLAIR 1952, MAJ AND LUCCHESE 1982) and approaches to treatment (SWANN 1954, TIMMONS 1972 RICKETTS ET AL. 1979, CLEALL AND BEGOLE 1982 AND EDWARDS 1983).

SWANN (1954) states that mandibular functional displacement is a factor in only an estimated one-third of all II^2 cases, but he did not state how he arrived at that figure. The "induced change" described by TIMMONS (1972) for II^1 patients may be similar to the concept of unlocking the bite, although Timmons offers other possible explanations as well. One of the principles of the Bio-progressive approach to therapy is to reduce excessive overbite before overjet correction (RICKETTS ET AL. 1979) . Ricketts believes that the progressive unlocking of the malocclusion with the Bio- progressive approach is equally applicable to the treatment of II^1 and II^2. CLEALL AND BEGOLE (1982) indicate that intrusion of the upper incisors during the initial phase of treatment may unlock the occlusion, thus aiding in the correction. To date, no investigation has identified or quantified any additional growth resulting from unlocking the bite.

The purpose of this study was to investigate whether or not unlocking the bite in II^2 cases with vertical incisors and deep overbite enhances anterior growth and/

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or repositioning of the mandible. Whether age, sex or type of treatment affected the growth and/or unlocking of the mandible were also examined.

— Material and Method —

From the case records of orthodontic patients treated at the University of Western Ontario's Graduate Orthodontic Clinic, 34 subjects (14 males and 20 females) were selected, using the following criteria:

- Clinical diagnosis of Class II, division 2 malocclusion
- Pretreatment overjet 4.0mm or less
- Pretreatment overbite 5.0mm (or 70%) or more
- Pre- and posttreatment lateral cephalographs of good quality
- Horizontal mandibular growth tendency, as demonstrated by a Frankfort/Mandibular plane angle (FH/Mp) 26° or less, and/or a Facial Axis (FA) angle 90° or more

The control sample consisted of 15 subjects (9 males, 6 females) from the Burlington Research Centre, University of Toronto, who fulfilled the same criteria applied to the treated group. None of the control subjects were treated orthodontically prior to or during the study period. Cephalometric radiographs were made serially on their birthdays.

In order to determine whether or not treatment in general had any significant effect on the growth of the mandible, 15 patients were chosen from the treated sample and matched according to sex and age (within 9 months) with one of the control subjects. This matching technique was used in an effort to separate growth effects from combined treatment and growth effects.

The 15 pairs (6 female, 9 male) were analyzed to determine changes in the cephalometric variables attributable to treatment. The results were then subjected to a paired t-test to delineate any significant differences. The 0.05 level of probability was adopted as the minimum for statistical significance. Some trends were examined further when a lower probability was due only to the small sample size.

The treated sample was analyzed to identify any forward repositioning of the mandible during treatment as demonstrated by a change in Ba–Ar.

Changes in FA and FH/Mp were recorded to determine whether the direction of growth of the mandible was altered as a result of treatment.

In an attempt to ascertain whether different types of treatment had any effect on the amount of growth of the mandible, the entire treated sample (n = 34) was subdivided by treatment type into three groups —

Group 1 was treated with extraction of permanent teeth (no males, 6 females).

Group 2 was treated by "conventional" Class II mechanics, including extraoral traction and intermaxillary elastics, without extraction (8 males, 6 females).

Group 3 was treated similarly to Group 2, but with the inclusion of a bite plane during the initial stages of treatment (6 males, 8 females).

In Group 1 (the extraction group), the overbite was decreased with archwire levelling mechanics. In Group 2, the bite was unlocked by increasing the overjet, and in Group 3 the overbite was decreased and overjet increased. Although treatment was similar in Groups 2 and 3, it was postulated that the bite plane used in Group 3 would unlock the bite more efficiently and accomplish a greater treatment effect.

The cephalometric measures for the entire treated sample were analyzed for sex differences.

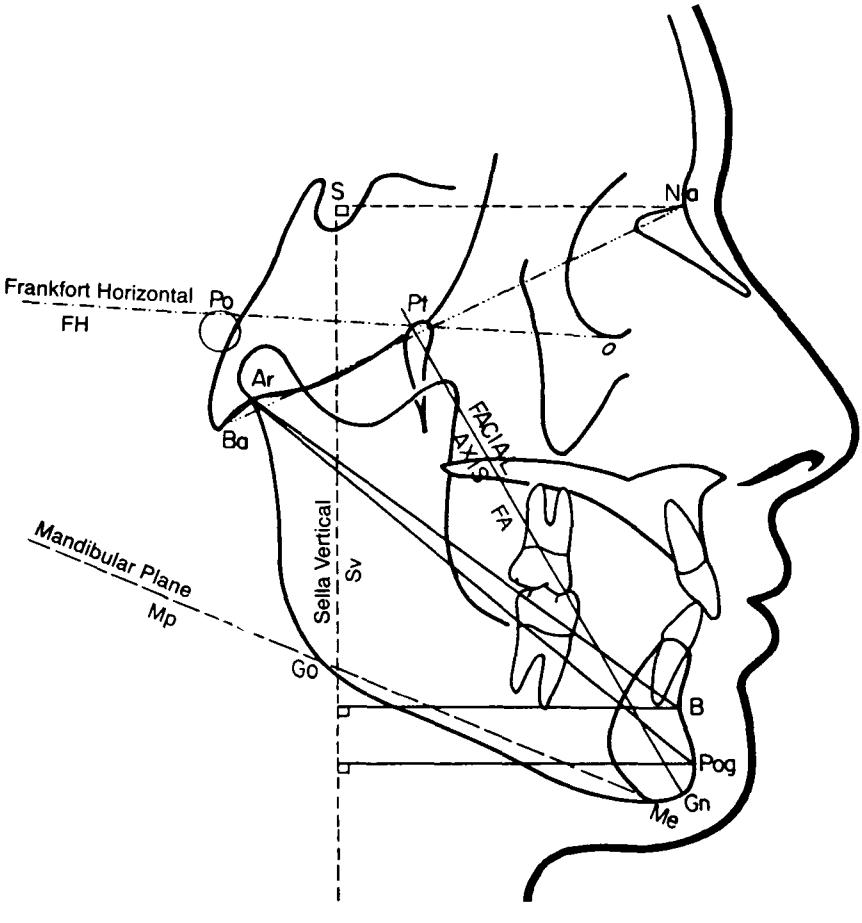

Fig. 1 Cephalometric landmarks, planes and measurements

The three treatment groups were then divided by sex in order to identify any sex differences. Each group was analyzed to determine changes in Ar–B and Ar–Pog per year of treatment.

Results for the males were subjected to a simple t-test for significance because there were only two types of treatment. Results for the females were analyzed by an analysis of variance since there were three types of treatment, and a t-test comparison was also done to compare the nonextraction (headgear plus bite plane) treatments with the extraction treatment.

The sample was further divided into "good growers" and "poor growers." The Ar–Pog measurement increased in the male good growers at 2.0mm/yr of treatment or more. These groups were analyzed for any discernible tendencies related to age or type of treatment.

Radiographic and Measuring Techniques

Cephalometric landmarks are those defined by RIDLO ET AL. (1979) AND GUGINO (1971) and are shown in Fig. 1. Articulare was used as one of the endpoints in the

measurement of mandibular length because of the difficulty in accurately identifying condylion on lateral cephalographs.

The radiographic enlargement factor for the lateral headfilms used in the treated sample was calculated to be 9.7%, and in the control group it was 9.8% (Popovich 1982). Corrections were not made because of this close similarity.

Angles were measured with a protractor calibrated in 0.5° increments. Linear measurements were made with a modified dial caliper calibrated to 0.1mm. Twenty films chosen randomly from the treated group were traced twice at different times and analyzed to determine the measurement error; an acceptable level of error was found.

— Results —

Results are presented in Tables 1-5.

A major interest was whether changes occurring during treatment resulted from growth alone or from a combination of growth and treatment. Table 2 indicates that Ar-Pog and FA increased significantly more in the treated patients, indicating a positive treatment effect. No statistically significant difference was found in the measurements Sv-B, Sv-Pog, Ar-B, Ba-Ar and FH/Mp.

Ba-Ar, the measure of mandibular repositioning, increased from 0.5mm/yr to 1.6mm/yr of treatment in 26% of the treated cases, but it was also found to decrease more than 0.5mm/yr of treat-

Table 1

Treated Sample
Pretreatment Cephalometric Means

Females

	Bite Plane		Headgear		Extractions		Total	
	$\bar{x}$(n=8)	S.D.	$\bar{x}$(n=6)	S.D.	$\bar{x}$(n=6)	S.D.	$\bar{x}$(n=20)	S.D.
FH/Mp	17.3	3.0	20.5	4.4	21.3	3.1	19.5	3.8
FA	93.6	4.1	91.7	3.7	89.6	2.4	91.8	3.8
Ar-B	96.2	3.4	95.4	7.2	92.0	7.7	94.7	6.1
Ar-Pog	107.8	3.9	103.2	8.1	101.9	8.9	104.6	7.2
Sv-B	53.6	4.6	49.8	8.1	48.2	3.9	50.9	5.9
Sv-Pog	55.3	4.9	50.0	10.1	47.7	4.2	51.4	7.2
Ba-Ar	11.1	4.5	11.8	3.2	10.5	2.4	11.2	3.4

Males

	Bite Plane		Headgear		Total	
	$\bar{x}$(n=6)	S.D.	$\bar{x}$(n=8)	S.D.	$\bar{x}$(n=14)	S.D.
FH/Mp	20.8	3.2	23.4	4.4	22.3	4.0
FA	93.1	3.4	90.6	1.1	91.6	2.6
Ar-B	95.8	2.7	97.4	3.9	96.7	3.4
Ar-Pog	106.9	3.7	107.5	4.0	107.2	3.7
Sv-B	54.4	3.9	49.5	5.5	51.6	5.3
Sv-Pog	55.5	4.3	49.4	6.4	52.0	6.3
Ba-Ar	10.3	0.9	12.8	1.8	11.9	2.0

ment in 14.8% of the treated cases. The remainder of the treated cases changed less than 0.5mm/yr, and the overall mean change was not statistically significant (Table 5).

Males and females were evaluated separately because significant sex differences were seen in the treated sample for four of the seven variables (Table 5).

Mean changes in FH/Mp and FA are also shown in Table 5. The FA mean showed a small decrease in treated males and females, while mean FH/Mp showed a small increase in both sexes. The FA decreased more than 0.5°/yr of treatment in 35% of treated cases, increased in 12% and remained the same in 53%. The FH/Mp angle decreased more than 0.5° per year of treatment in 17% of treated cases, increased in 21% and remained unchanged in 62%.

The t-test comparison between the two male treatment groups showed no statistical difference. Table 3 indicates that in males the average length of the mandible from Ar–Pog increased an average of 3.82mm/yr in the bite plane group and 3.33mm/yr in the headgear group.

The analysis of variance test comparing the three female treatment groups showed no significant difference among them (Table 4), nor was any significant difference observed between the extraction and nonextraction (headgear and bite plane) groups. Mandibular length from Ar–Pog also increased significantly more than in the untreated controls, but not as much as in the males. Table 4 shows that there was almost a millimeter difference between the mean change of Ar–Pog for the female headgear group (1.91mm/yr) and the female extraction group (.94mm/yr), with the female bite plane group an intermediate 1.46mm annual increase.

Analysis of those treated subjects deemed to have responded particularly well to treatment failed to reveal any consistent patterns or trends.

— Discussion —

Growth Comparisons

This study appears to indicate that unlocking the bite through routine treatment procedures enhances the forward growth of the mandible by an average of approximately 1.5mm/yr over untreated subjects with II[2] malocclusions.

Growth was evaluated by matching each treated subject with an untreated subject. Changes seen in excess over

Table 2

Paired t-tests
Comparing Treatment Patients with Controls

	$\bar{d}$	df	t	p
FH/Mp	+0.23	14	0.46	<.5
FA	−1.14	14	2.75	† .02
Ar-B	+1.43	14	1.96	.1
Ar-Pog	+2.04	14	3.52	† .01
Sv-B	−0.06	13	0.09	<.5
Sv-Pog	+0.83	13	1.03	.5
Ba-Ar	+1.24	14	1.61	.2

$\bar{d}$ — Mean Difference between treated and control pairs
df — Degrees of Freedom † - Significant Difference

Table 3

Comparison of Treatment Types for Males

		Bite Plane $\bar{x}$ Yr–Mo	S.D. Mo	Headgear $\bar{x}$ Yr–Mo	S.D. Mo	t	p	Riolo Atlas
Age at start		14–9	15	12–5	10			13
Treatment time		2–2	10	2–2	13			2
Change mm	Ar-B	5.44	1.8	4.66	2.5			3.9
	Ar-Pog	7.62	2.7	6.70	3.4			5.5
Annual change	Ar-B	2.72	1.1	2.40	1.4	.70	NS	2.0
	Ar-Pog	3.82	1.8	3.33	1.8	.29	NS	2.8

Table 4

Comparison of Treatment Types for Females

		Bite Plane $\bar{x}$ Yr–Mo	S.D. Mo	Headgear $\bar{x}$ Yr–Mo	S.D. Mo	Extraction $\bar{x}$ Yr–Mo	S.D. Mo	F ratio	p	Riolo Atlas
Age at start		13–11	32	12–9	16	14–0	30			13
Treatment time		2–2	10	2–0	4	2–1	10			2
Change mm	Ar-B	2.44	3.2	4.47	2.6	0.92	1.5			3.3
	Ar-Pog	3.43	3.2	3.52	1.6	1.48	2.5			3.7
Annual change	Ar-B	1.08	1.2	2.32	1.5	0.65	1.2	2.9	NS	1.7
	Ar-Pog	1.46	1.4	1.91	1.2	0.94	1.6	0.8	NS	1.9

Table 5

Sex Differences in Treated Sample

	Males $\bar{x}$	SD	Females $\bar{x}$	SD	df	t	p
FH/Mp	0.10	0.78	0.14	0.82	32	0.14	NS
FA	−.23	0.90	−.39	0.58	32	0.62	NS
Ar–B	2.56	1.22	1.32	1.39	32	2.64	.02
Ar–pog	3.54	1.73	1.50	1.37	32	3.78	.001
Sv–B	0.83	1.14	0.02	0.98	32	2.25	.05
Sv–Pog	1.21	1.31	0.08	1.08	32	2.76	.01
Ba-Ar	0.18	0.83	0.10	0.66	25	0.28	NS

growth in the untreated subjects are attributed to the treatment. The amount of mandibular growth in the treated patients, as measured by Ar–Pog, was significantly greater ($p < .01$) than in the untreated subjects matched for occlusion and age.

Table 3 shows that the males averaged from 0.5mm to 1.0mm more growth per year (depending on the treatment used) than the averages for untreated cases reported by RIOLO ET AL. (1974). However, the females treated with headgear did not grow as much as the females in that study.

Sex differences were significant for the four measures Ar–B, Ar–Pog, Sv–B and Sv–Pog as seen in Table 5. The measures employing Pog (Ar–Pog and Sv–Pog) showed higher levels of significance than those measures using B, possibly due to the increase in prominence of Pogonion in males.

These findings are in agreement with those of EDWARDS (1983), who studied treatment effects in a group of mixed II^1 and II^2 patients. His use of all untreated Class II subjects (both II^1 and II^2) from the Burlington Growth Study as a control group limits the comparisons that can be made; however, he reported that the mean mandibular length of his treated group increased significantly more than the untreated group (0.5mm/yr in boys and 0.4mm/yr in girls).

In the present study the annualized mean difference in mandibular length increase between the fifteen matched pairs was approximately 1.0mm/yr over the treatment period. Edwards also found that orthodontic treatment of low-angle cases, particularly in males, resulted in significantly more mandibular growth than in the controls, and suggested that this may be due to the large number of II^2 cases in the low angle group.

Mandibular Repositioning

RICKETTS ET AL. (1979) report the expected posterior growth shift of Ba to be approximately 1.0mm/yr, recommending repositioning the mandible posteriorly by the same amount in growth forecasts to maintain a constant distance from Ba–Ar. SEWARD (1981) also reports an unchanging distance between Basion and Articulare. Any forward repositioning of the mandible can therefore be expected to result in an increase in the Ba–Ar measurement. During treatment, Ba–Ar increased an average of 0.18mm/yr in the males and 0.10mm/yr in the females (Table 5), which is not significant. Nevertheless, the increase in Ba–Ar was more than 0.5mm/yr in 26% of the treated cases.

One might speculate that in some cases Ba–Ar could increase during treatment as a result of unlocking the mandible, or it may be only a temporary shift. The fact that approximately one-quarter of the cases in the present study appeared to reposition forward is in approximate agreement with Swann's estimate of one-third (SWANN 1954).

The error in the method used to measure Ba–Ar was slightly larger than the average increases seen over the treatment period, hence the possibility of mandibular repositioning must be viewed with caution.

Growth Direction

One of the treatment objectives in deep-bite forward-growing cases is to inhibit closure of the bite. Treatment is often successful in opening the bite, and opening of the bite in treatment of II^2 malocclusions in the present study is shown by a nonsignificant mean increase in FH/Mp and a decrease in the facial axis angle. The facial axis angle increased in only 12% of the treated subjects, but in 67% of the control subjects. Treatment was

associated with an opening of the bite in 35% of the treated cases, compared to 6% of the control sample; nevertheless, the difference did not meet the criterion of statistical significance.

Of the four cephalometric measures used to indicate the relative anteroposterior size of the mandible, only Ar-B and Ar-Pog showed differences which may have resulted from treatment. The relative anteroposterior position of the chin in relation to the cranial base (Sv-B and Sv-Pog). failed to show significant changes during treatment because the mandible rotated open in 35% of the treated cases, compared to 6% in the untreated controls. Since FH/Mp was small to begin with, an increase was sought during treatment. An increase in FH/Mp was seen in 21% of the treated patients.

CLEALL AND BEGOLE (1982) suggest that II[2] malocclusions should be treated with "minimal buccal segment extrusion except that required to offset anterior growth rotation and a short lower face height". The findings from the present study support Cleall and BeGole's proposal. By maximizing extrusion in the buccal segments, hence opening the bite, the growth and/or repositioning of the mandible would be expressed in a more vertical direction as opposed to a horizontal direction.

On the other hand, LITT AND NIELSEN (1984) described the results of extraction and nonextraction treatment in one set of identical twin boys in which both types of treatment resulted in significant forward rotation of the mandible and anterior direction of growth. Results from the present study show that a majority of treated cases (88%) either stayed the same or exhibited divergent rotation of the mandible sufficient to open the bite or inhibit closing of the bite.

Treatment Comparisons

The apparently best treatment results, on average, were obtained with treatment incorporating a bite plane for the males, and headgear for the females. However, the differences between the treatment groups were statistically insignificant under the adopted criteria.

The fact that the female bite plane group in the present study did not grow as well as the headgear group is difficult to explain, as one would expect the opposite to occur as it did for the males. It is speculated that the females in the bite plane group may have completed the majority of their growth by the time treatment was undertaken (GRABER 1972). One may also speculate that the unexpected finding that the bite plane in the female treatment group was not as efficient at unlocking the bite as it was in the male treatment group may be due to differences in musculature.

CRAGG (1983) reported an average 2.04mm/yr increase in mandibular length, as measured from Ba to B, in 40 untreated males 9-16 years old with Class I or Class II malocclusion and large overbites. The males in the present study whose treatment included a bite plane grew an average 3.82mm/yr, and those treated without a bite plane grew 3.33mm/yr (Table 3). Again, treatment appears to have facilitated growth of the mandible to a small degree.

Increases in mandibular length, however small, are important when one considers that other authors have indicated that the mandible does not grow more than normal even with treatment utilizing functional appliances (HARVOLD AND VARGERVIK 1971, AND PANCHERZ 1984).

Statistically significant differences in mandibular length between different female treatment groups were not found.

Although the increase in mandibular length for the extraction group was the smallest of any of the three treatment groups, several points might be noted. Treatment commenced for the extraction group at approximately 14 years of age. By this time, most of the growth in the females was probably completed. Also, the pretreatment length of the mandible is considerably smaller in the extraction group than in the other two treatment groups, suggesting that the mandible in the extraction groups tended to grow less and to be smaller than in the other two treatment groups (Table 1).

The 12yr–16yr age range is a more active growth period for males than it is for females (GRABER 1972). It can be hypothesized that if growth facilitates treatment response, the variations in mandibular growth obtained with different forms of treatment may be explained, at least in part, by the ages at which the treatment was begun. Mean age for initiating headgear treatment was 12yr 6mo for the males and 12yr 9mo for the females; for bite plane treatment it was 14yr 9mo for the males and 14yr for the females. Extraction treatment for the females also began at an average age of 14. The best treatment results were seen when treatment took place during a period of more active growth for males (14yr 9mo) and females (12yr 9mo), which is in agreement with HÄGG AND TARANGER (1982).

Patient cooperation was not taken into account, and this can have a large effect on the outcome of treatment. Future studies utilizing larger samples should eliminate bias caused by variations in patient cooperation.

The observations from this study do appear to show that the II^2 mandible is often locked back, and that treatment which incorporates an unlocking effect on the bite during an active growth period can allow the mandible to grow or be repositioned forward much more than if treatment were not undertaken.

— Summary —

The objective of this study was to determine whether or not unlocking the bite in Class II, division 2 malocclusions would promote anterior growth and/or repositioning of the mandible.

The anteroposterior size of the mandible in 34 treated patients originally exhibiting II^2 characteristics was compared to that in an untreated control group of 15 II^2 subjects. It was found that the mandible grew forward significantly more in the treated subjects than in the controls.

The mandible was found repositioned forward more than 0.5mm/yr of treatment in 27% of the treated subjects. In 35% of the treated subjects the direction of mandibular growth became more vertical, possibly due to opening of the bite with treatment. The different types of treatment studied showed small but statistically insignificant differences in mandibular growth.

Although not statistically significant, it appeared that the mandibles in the female extraction group were smaller before treatment and grew less with treatment than in the other two treatment groups.

— Conclusions —

- The amount of mandibular growth for treated subjects was significantly greater than in the untreated controls, with a mean difference of approximately 1.5mm/yr. Thus, treatment appeared to enhance the growth of the mandible in the cases studied .

- Approximately one-fourth of the treated sample exhibited 0.5mm or more anterior repositioning of the mandible, suggesting that the mandible is indeed locked posteriorly in at least some cases of II[2] malocclusion.
- The direction of growth of the mandible was changed in approximately half of the treated patients;
  - 12% grew more horizontally
  - 41% grew more vertically.
- No statistically significant differences for mandibular length among the various treatment groups could be demonstrated.
- The pretreatment size and subsequent growth of the mandible in the female extraction group was slightly less than for the other two treatment groups, but the differences were not statistically significant.

The authors wish to thank Dr. James M. Wanklin for his assistance with the statistical aspects of the study.

The control sample was from the Burlington Growth Centre, University of Toronto, which was supported by funds from - National Health Grant #605-7-299 - Province of Ontario Grant PR33 - and The Varsity Fund.

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