ORIGINAL ARTICLE

Cephalometric evaluation of the Twin-block appliance in the treatment of Class II Division 1 malocclusion with matched normative growth data

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Cephalometric radiographs were taken before and after treatment with the Twin-block appliance on 30 consecutive patients with Class II Division 1 malocclusions. A control group was generated from published normative data such that each treated case was matched individually for age, sex, and treatment time. The cephalometric change during treatment was compared to the natural growth change in the matched control group using a Mann-Whitney U-test for statistical significance. The treatment effect was also calculated by subtracting the natural growth change from the treatment change. This was then compared to twice the method error to see if the treatment change was clinically significant. There was both a statistically and clinically significant reduction in overjet, angle ANB, increase in angle SNB, and mandibular length together with a reduction in upper incisor angle. None of the other cephalometric parameters measured showed a significant change. (Am J Orthod Dentofacial Orthop 2000;117:54-9)

The role played by functional appliances in the correction of skeletal pattern, during the treatment of Class II Division 1 malocclusion, is still controversial despite their introduction early in the century. Aelbers and Dermaut[1] reviewed the published literature on the treatment effects of activators, headgear, and Herbst appliances. They concluded that these appliances corrected sagittal discrepancies adequately but it remained questionable whether the results could be attributed to skeletal changes rather than to dentoalveolar compensation. Based on the criteria of Baumrind and Frantz[2] that the cephalometric change should be twice the method error to assume biologic significance only the Herbst appliance seemed to stimulate mandibular growth to some extent.

To assess the effects of factors that influence craniofacial growth other than appliance therapy, it is necessary to have a control group. However, there does not appear to be an ideal control group for orthodontic appliance therapy. Various authors have either used patients treated by an alternative technique,[3-9] or untreated Class II Division 1 patients,[10-13] unsuccessfully treated Class II Division 1 cases,[14] Class I patients who did not need treatment,[15-20] or a pretreatment period of observation.[21]

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Control groups have been selected from published normative data using the Bolton[22,23] and the Michigan[24,25] growth standards. However, only Valant and Sinclair[26] matched the Michigan growth standards to each individual pretreatment and posttreatment cephalometric values thus controlling precisely for age, sex, and treatment time.

It is difficult to select truly equivalent groups without random allocation of patients to control and treatment groups so that there are favorable odds that all groups are as alike as possible. This is not possible in a retrospective study and may raise ethical problems in a prospective study.[27] Whatever control group is used, it must be remembered that facial growth varies at different ages, and between the sexes. In addition, differing amounts of natural growth would result from observation times of varying lengths. Matching the control group based on the composition of the treatment group seems to be the most satisfactory alternative to randomization. Published normative data make it possible to match the study group precisely for age, sex, and treatment time as these factors are all categorized.

Very little research has been published on the Twin-block appliance despite its popularity in clinical practice. My initial evaluation[28] found an average change in angle ANB of –2.0°, which was greater than twice the method error ($2 \times 0.54 = 1.08$). However, only small groups ($n = 10$) were analyzed, and they were not matched for age, sex, or treatment time. Two recent studies have produced similar results: Lund and Sandler[29] (ANB –2.0°) and Mills and McCulloch[30] (ANB

–2.8°). The former was a prospective study on 36 patients who were not matched or randomized although there was pretreatment equivalence. The latter was a retrospective study on 28 patients who were matched for age, sex, and deep or open bite with cases selected from the Burlington growth study but not on an individual basis. Both articles reported error studies but did not compare treatment effect to the method error.

The aim of the present study was to compare the cephalometric changes in a group of successfully treated patients matched for age, sex, and treatment time from published normative standards. A net treatment effect of twice the method error would indicate a clinically significant change.

MATERIAL AND METHOD

The material consisted of 30 patients, 14 males and 16 females, with Class II Division 1 malocclusion (average age, 12 years 6 months). They were all treated with a standardized technique described by me[31] that consisted of 3 phases. First, semi-rapid maxillary expansion and alignment of the upper arch was performed. Second, correction of Class II relationships was carried out using a modification of the Twin-block functional appliance introduced by Clark[32] but with steeper bite blocks and excluding the extra-oral traction and intermaxillary elastics. Third, retention was instigated with an upper removable appliance with a very steep anterior bite plane.

Consecutively treated cases were chosen on the basis of the selection criteria of Knight.[15] First, an overjet >6 mm, second, ANB angle >4°, and third, availability of before and after cephalometric radiographs. None of the cases selected had congenital syndromes or obvious asymmetry nor had any prior appliance therapy. I treated all cases to successful completion in terms of occlusal result and overjet reduction.

The date of the pretreatment and posttreatment cephalometric radiographs was used to calculate the treatment time and age of the patient at the start of treatment. This information was then used to generate a control group by matching each individual case from published normative data for age, sex, and observation time. Thus for each set of pretreatment and posttreatment cephalometric measurements taken from the patient, an equivalent set was derived from the normative data tables controlled for age, sex, and observation time.

The normative data published by Bhatia and Leighton[33] derived from London school children was chosen because of its nearest geographic proximity.

Cephalometric tracings were taken from the radiographs and the following points recorded (Fig 1): S, Sella; A, Subspinale; ANS, Anterior Nasal Spine; N, Nasion; B, Supramentale; PNS, Posterior Nasal Spine; Go, Gonion; Me, Menton; Ar, Articulare; Po, Pogonion; Co, Condylion.

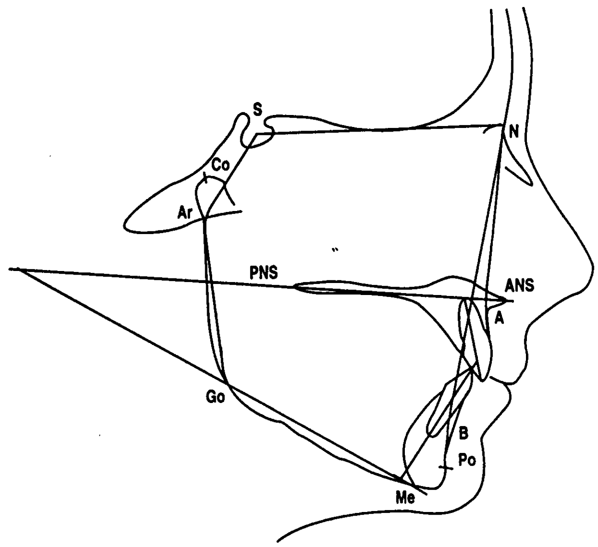

Fig 1. Cephalometric points, planes, angles, and distances recorded.

The radiographs were traced in a random order by one operator in order to reduce bias. The angles measured were SNA, SNB, ANB, UI upper incisor long axis to maxillary plane (ANS-PNS), LI lower incisor long axis to mandibular plane (Me-Go), MM (maxillary mandibular planes angle) and II (angle between the long axes of the upper and lower incisors). In addition, Björk's polygon angles, NSAr, SArGo, and ArGoMe, were measured, as was the overjet. The linear distances measured were Ar-A, Ar-B, Ar-Po, Co-A, Co-B, Co-Po. From the cephalometric measurements before and after treatment (Table I), the change during treatment was calculated for the Twin-block appliance and control groups (Table II). For each cephalometric parameter a Mann Whitney U-test was used to detect any differences that can be attributed to factors other than chance. A nonparametric Mann Whitney U-test was chosen because the data was nonhomogeneous and may not have been normally distributed.

The tracings were repeated on 20 of the original 60 cephalometric radiographs selected by random number tables. The error of the method was determined by the formula:

$$ME = \sqrt{\frac{\Sigma d^2}{2\,(n\text{-}1)}}$$

d = difference between measurements pairs
n = number of pairs

Table I. Cephalometric parameters before and after treatment

	Twin-block group				*Control group*			
	Before		*After*		*Before*		*After*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
SNA	82.2	3.2	81.6	3.4	80.1	0.4	80.4	0.4
SNB	75.8	3.4	77.8	3.7	77.4	0.5	78.0	0.4
ANB	6.4	1.3	3.8	1.7	2.7	0.5	2.4	0.5
MM	23.9	6.4	24.0	6.5	27.9	1.1	26.9	1.0
UI	119.2	8.5	104.9	8.6	109.4	0.3	109.5	0.5
LI	96.3	6.9	97.0	7.6	90.8	0.8	90.7	1.0
II	121.3	12.3	134.8	10.8	132.1	2.0	133.2	2.3
OJ	10.5	1.9	3.2	0.7	3.7	0.4	3.5	0.3
NSAr	125.8	4.0	126.2	4.2	124.5	0.7	124.9	0.7
SArGo	138.4	6.6	138.2	6.7	140.6	0.6	140.5	0.5
ArGoMe	126.6	6.6	127.2	6.8	130.0	0.9	129.0	0.7
Ar–A	90.7	5.8	93.1	5.1	79.9	1.9	82.1	2.2
Ar–B	94.3	4.9	100.7	4.3	88.5	2.5	91.5	2.4
Ar–Po	103.5	5.3	109.9	5.8	97.5	3.2	101.4	2.9
Co–A	92.1	6.2	94.9	6.6	80.8	2.0	83.0	1.8
Co–B	100.2	5.2	106.7	5.4	93.4	2.6	96.4	2.2
Co–Po	110.2	5.4	117.3	5.9	103.3	3.3	107.3	2.9

Table II. Change in cephalometric parameters during treatment

	Twin-block group		*Control group*		*Mann Whitney U value*	*Probability P >*	*Treatment effect*	*Method error*	*2 × ME*	*Clinical significance*
	Mean	*SD*	*Mean*	*SD*						
SNA	–0.60	1.04	0.28	0.23	3.90	.001	–0.88	0.49	0.98	×
SNB	2.00	1.39	0.57	0.39	5.15	.001	1.43	0.43	0.84	✔
ANB	–2.60	1.33	–0.31	0.27	5.83	.001	–2.29	0.51	1.02	✔
MM	0.07	1.57	–0.96	0.54	3.22	.001	1.03	1.16	2.32	×
UI	–14.37	8.81	0.06	0.47	6.21	.001	–14.31	1.23	2.46	✔
LI	1.13	5.22	–0.16	0.74	0.81	NS	1.39	1.19	2.38	×
II	13.47	9.74	1.05	1.10	5.12	.001	12.42	1.95	3.90	✔
OJ	–7.20	1.96	–0.24	0.16	6.65	.001	–6.96	0.51	1.02	✔
NSAr	0.40	3.19	0.44	0.30	0.65	NS	–0.04	0.92	1.84	×
SArGo	–0.20	4.92	–0.08	0.45	0.33	NS	–0.12	1.16	2.32	×
ArGoMe	0.63	2.90	–0.99	0.57	2.60	.01	1.62	1.55	3.10	×
Ar–A	2.40	2.90	2.20	1.40	0.10	NS	0.24	0.69	1.38	×
Ar–B	6.40	3.90	3.00	1.90	3.67	.001	3.39	0.71	1.42	✔
Ar–Po	6.60	4.50	3.90	2.40	2.09	.05	2.66	0.54	1.08	✔
Co–A	2.80	3.60	2.20	1.40	0.26	NS	0.60	1.16	2.32	×
Co–B	6.40	4.50	3.00	2.00	3.54	.001	3.43	0.93	1.86	✔
Co–Po	7.20	5.20	4.00	2.50	2.77	.01	3.15	1.21	2.42	✔

The error variance was then compared with the biologic variance of the total material and expressed as a percentage (Table III). It was concluded that the error of the method was comparable to that of other cephalometric studies and less than 10% of the biologic variation.

The magnification of the cephalometric radiographs was 8.76%, which was close to the 8.89% reported for the normative data.[33]

RESULTS

Using the Mann Whitney U-test, the change during treatment in the Twin-block group was compared to the natural growth change in the matched control group derived from normative data.

The treatment effect was calculated by subtracting the natural growth from the treatment change. This was then compared to twice the method error (ME) to see if the treatment change was clinically significant (Table II).

The overjet was reduced during treatment by over 7 mm and this was significant ($P > .001$), and the treatment effect was greater than 2ME.

The angle ANB showed a statistical significant reduction ($P > .001$) again with a treatment effect greater than 2ME, which was mainly due to a statisti-

Table III. Experimental error

Variable	Method error	Error variance	Sample mean	Standard deviation	Total variance	Error variance % ÷ Total variance
SNA	0.49	0.24	81.87	3.32	11.00	2.18
SNB	0.43	0.19	76.77	3.66	13.37	1.42
ANB	0.51	0.26	5.10	1.98	3.92	6.63
MM	1.16	1.35	23.93	6.41	41.11	3.28
UI	1.23	1.51	112.05	11.14	123.98	1.22
LI	1.19	1.42	96.67	7.21	51.96	2.73
II	1.95	3.80	128.07	13.32	177.49	2.14
OJ	0.51	0.26	6.85	3.91	15.32	1.70
NSAr	0.92	0.85	126.03	4.07	16.58	5.12
SArGo	1.16	1.35	138.30	6.58	43.23	3.12
ArGoMe	1.55	2.40	126.90	6.63	43.92	5.46
Ar–A	0.69	0.48	91.88	5.55	30.78	1.56
Ar–B	0.71	0.50	97.48	5.61	31.44	1.59
Ar–Po	0.54	0.29	108.18	13.30	176.76	0.16
Co–A	1.16	1.35	93.47	6.50	42.19	3.20
Co–B	0.93	0.87	104.93	13.33	177.79	0.49
Co–Po	1.21	1.46	113.78	6.64	44.17	3.31

cally significant increase in angle SNB. There was a small but statistically significant reduction in angle SNA, but the treatment effect was less than 2ME. These findings were substantiated by length measurements with no significant maxillary change (Ar-A, Co-A) over control growth data but statistically and clinically significant increase in mandibular length (Ar-B, Co-B, Ar-Po, Co-Po).

The upper incisor angulation was significantly reduced with the interincisal angle correspondingly increased, both treatment effects greater than 2ME. There was no significant change in the lower incisor angulation.

The MM angle remained virtually unchanged during treatment but decreased in the control group and the difference was statistically significant, but the treatment effect was less than 2ME. A similar situation arises with angle ArGoMe. There was no significant change in angles NSAr or SArGo.

DISCUSSION

Angular measurements reflect changes in shape whereas linear measures reflect changes in size. Angular changes between cephalometric planes are unaffected by magnification due to divergence of the x-ray beam unlike linear measurements. However, the magnification factors were similar for the study patients and normative data.

Reidel's analysis with angles SNA and SNB was considered to be the method of choice to assess anteroposterior dental base relationship. Because this is the most commonly used method, it was possible to compare the results of the present study with those of previous authors. Mills[34] considered points A and B to be essentially deep alveolar points that may be changed by movement of the underlying apices of incisor teeth. Most authors, however, neglect to measure incisor angulations in order to assess dentoalveolar as well as skeletal changes.

The angle ANB can be influenced by factors other than dental base relationship, most notably, the rotation of both jaws relative to the cranial base, the anteroposterior position of point N relative to point B, the vertical distance N to B and A to B. However, these factors remain constant for each case before and after treatment and only exert an influence when making comparisons between different individual cases and not when measuring change within the same case. The maxillary mandibular planes angles and the angles of the cranial base did not change significantly throughout the present study.

The method error for condylion was greater than articulare as previously reported.[1] Although the latter point is more difficult to define, it is a more valid point to measure for mandibular length because it includes the condylar growth center.

Any retrospective study is likely to introduce bias by producing an inflated view of treatment outcome. Only successfully treated cases were included in the study because as with most retrospective studies the patients who failed to complete treatment did not have a final cephalometric radiograph. This is believed to exaggerate the magnitude of treatment response because it cannot be assumed that patients who defaulted would have responded to treatment in the same way as successfully treated cases. Bias can also creep into prospective trials as a result of the loss to follow up after randomization has taken place[35];

there are also ethical problems in selecting control groups. The differences in outcome between the treated patients and the normative growth data were attributed to the effects of treatment rather than to preexisting differences because they were matched for confounding variables, that is, age, sex, and observation period.

Because small differences can become statistically significant if standard deviations are low or numbers in the study are high, a clinically significant change was based on the criterion suggested by Baumrind and Franz[2] that the treatment effect should be at least twice the method error and exceed 1° or 1 mm. In fact, the significant treatment changes were all large relative to the control group.

The present study demonstrated that the Twin-block appliance reduced the overjet by a combination of upper incisor tipping and bodily correction of the dental base relationship. The main effect was upper incisor retroclination (–14.37°) but the angle ANB correction (–2.6°) was also clinically significant. The correction of ANB was mainly due to increase in SNB (+2.0°) with a small reduction in angle SNA (–0.6°) due to restraint of forward maxillary growth. Thus the so-called headgear effect was purely minimal and not clinically significant. It would seem that the Twin-block appliance not only results in forward positioning of the mandible but also lengthening as shown by the linear measurements (Ar-B, +6.4 mm; Co-B, +6.43 mm; Ar-Po, +6.57 mm; Co-Po, +7.17 mm).

Although similar results were reported by Lund and Sandler[29] and Mills and McCulloch,[30] they both found significant lower incisor proclination during treatment that did not occur during the present study. This can easily be explained by the use of ball clasps or acrylic labial bow that provide less rigid retention in the lower labial segment than Southend clasps. As in the present study, Lund and Sandler[29] achieved significant upper incisor retraction using an upper labial bow in contrast to Mills and McCulloch[30] who did not use a labial bow and found little change in upper incisor position. All 3 studies show that differences in outcome appear to be related to appliance design.

Although the Twin-block appliance produced a clinically significant improvement in the Class II dental base relationship, it was not completely corrected to the Class I control group values. Hansen and Pancherz[23] found mandibular retrognathism still existed after Herbst appliance treatment relative to ideal Bolton standards. Growth is not therefore totally normalized, the overjet being corrected by varying degrees of dentoalveolar compensation to make up for the incomplete dental base correction. The improved response of the Herbst and Twin-block appliances is probably due to the fact that both these appliances are worn 24 hours a day. This allows the continuous application of forces that are known to produce the most favorable biologic response.

CONCLUSIONS

1. The Twin-block appliance reduced the Class II dental base relationship to a degree that was both statistically and clinically significant.
2. The correction of the Class II dental base relationship was greater than that reported for the Andresen and Fränkel appliances and comparable to that reported for the Herbst appliance.
3. The dental base relationship was not reduced completely to Class I values but there was some dentoalveolar compensation largely due to upper incisor retraction.
4. The improved response of the Twin-block (and Herbst) appliances over other functional appliances was considered to be due to the fact that they are worn 24 hours a day.

REFERENCES

1. Aelbers CMF, Dermaut LR. Orthopedics in orthodontics: part 1, fiction or reality: a review of the literature. Am J Orthod Dentofacial Orthop 1996;110:513-9.
2. Baumrind S, Frantz RC. The reliability of head film measurements: 1. landmark identification. Am J Orthod 1971;60:111-27.
3. Parkhouse RC. A cephalometric appraisal of cases of Angle's Class II Division 1 malocclusion treated by the Andresen appliance. Trans Br Soc Stud Orthod 1969;55:61-70.
4. Weinberger TW. Extra-oral traction and functional appliances: a cephalometric comparison. Br J Orthod 1973;1:35-9.
5. Cohen AM. Skeletal changes during the treatment of Class II/I malocclusions. Br J Orthod 1983;10:147-53.
6. Creekmore TD, Radley LJ. Fränkel appliance therapy: orthopaedic or orthodontic? Am J Orthod 1983;83:89-108.
7. Gianelly AA, Brosnan P, Martignoni M, Bernstein L, Mandibular growth, condyle position, and Fränkel appliance therapy. Angle Orthod 1983;53:131-42.
8. Gianelly AA, Arena SA, Bernstein LA. A comparison of Class II treatment changes noted with the light wire edgewise and Fränkel appliances. Am J Orthod 1984;86:269-76.
9. Owen AH. Maxillary incisolabial responses in Class II Division 1 treatment with Fränkel and Edgewise. Angle Orthod 1986;56:67-87.
10. Derringer K. A cephalometric study to compare the effects of cervical traction and Andresen therapy in the treatment of Class II Division 1 malocclusions. Part 1: skeletal changes. Br J Orthod 1990;17:33-46.
11. Trayfoot J, Richardson A, Angle Class II Division 1 malocclusions treated by the Andresen method. Br Dent J 1968;124:516-9.
12. Wieslander L, Lagerström L, The effect of activator treatment on Class II malocclusions. Am J Orthod 1979;75:20-6.
13. Calvert TFJ. An assessment of Andresen therapy on Class II Division 1 malocclusion. Br J Orthod 1982;9:149-53.
14. Ahlgren J, Laurin C. Late results of activator treatment: a cephalometric study. Br J Orthod 1976;3:181-7.
15. Knight H. The effects of three methods of orthodontic appliance therapy on some commonly used cephalometric angular variables. Am J Orthod Dentofacial Orthop 1988;91:213-24.
16. Wieslander L. The effect of orthodontic treatment on the concurrent development of the craniofacial complex. Am J Orthod 1963;49:15-27.
17. Stockli OW, Dietrich UC. Sensation and morphogenesis: experimental and clinical findings following forward displacement of the mandible. Trans Eur Orthod Soc 1973;49:435-42.
18. Luder HU. Effects of activator treatment: evidence for the occurrence of two different types of reaction. Eur J Orthod 1981;3:205-22.
19. Luder HU. Skeletal profile changes related to two patterns of activator effects. Am J Orthod 1982;81:390-6.
20. Moore RN, Dubois LM, Boice PA, Igel KA. The accuracy of measuring condylion location. Am J Orthod Dentofacial Orthop 1989;95:344-7.
21. Demisch A. Effects of activator therapy on the craniofacial skeleton in Class II Division 1 malocclusion. Trans Eur Orthod Soc 1972;48:295-310.

22. Pancherz H. A cephalometric analysis of skeletal and dental changes contributing to Class II correction in activator treatment. Am J Orthod 1984;85:125-34.
23. Hansen K, Pancherz H. Long-term effects of Herbst treatment in relation to normal growth development: a cephalometric study. Eur J Orthod 1992;14:285-95.
24. Kerr WJS, Ten Have TR, McNamera JA. A comparison of skeletal and dental changes produced by Function Regulators (FR-2 and FR-3). Èur J Orthod 1989; 11:235-42.
25. Mamandras AH, Allen LP. Mandibular response to orthodontic treatment with the Bionator appliance. Am J Orthod Dentofacial Orthop 1990;97:113-20.
26. Valant JR, Sinclair PM. Treatment effects of the Herbst appliance. Am J Orthod Dentofacial Orthop 1989;95:138-47.
27. Reed RT. Orthodontic research. Br Dent J 1990;168:231.
28. Trenouth MJ. A comparison of Twin-block, Andresen, and removable appliances in the treatment of Class II Division 1 malocclusion. Funct Orthod 1992;9:26-31.
29. Lund DI, Sandler PJ. The effects of Twin-blocks: a prospective controlled study. Am J Orthod Dentofacial Orthop 1998;113:104-10.
30. Mills CM, McCulloch KJ. Treatment effects of the twin block appliance: a cephalometric study. Am J Orthod Dentofacial Orthop 1998;114:15-24.
31. Trenouth MJ, A functional appliance system for the correction of Class II relationships. Br J Orthod 1989;16:169-76.
32. Clark WJ. The Twin-bock traction technique. Eur J Orthod 1982;4:129-38.
33. Bhatia SN, Leighton BC. A manual of facial growth: a computer analysis of longitudinal cephalometric growth data. Oxford: Oxford University Press; 1993.
34. Mills JRE. The effect of functional appliances on the skeletal pattern. Br J Orthod 1991;18:267-75.
35. Tulloch JFC, Phillips C, Koch G, Proffit WR. The effect of early intervention on skeletal pattern in Class II malocclusion: A randomized clinical trial. Am J Orthod Dentofacial Orthop 1997;111:391-400.