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Evaluation of cervical spine posture after functional therapy with twin-block appliances: A retrospective cohort study

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Evaluation of cervical spine posture after functional therapy with twin-block appliances: A retrospective cohort study

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Introduction: It has been postulated that a change in cervical posture occurs as a consequence of forward repositioning of the mandible. Therefore, the objective of this study was to compare the cervical spine posture between subjects with and without functional appliance therapy. **Methods:** A retrospective cohort study was conducted with the use of pre- and post–functional therapy cephalograms of orthodontic patients. A total of 60 subjects was composed of 2 groups of 30 subjects each: those who underwent treatment with a twin-block (TB) functional appliance and a control group selected from the Bolton-Brush Growth Study. Three sagittal and 7 cervical vertebral parameters were compared between the groups. The Wilcoxon signed-rank test was used to compare pre- and postfunctional mean angular measurements. The Mann-Whitney *U* test was used to compare the mean changes in cervical parameters between the groups. **Results:** A significant difference existed between pre- and postfunctional SNB ($P < 0.001$) and ANB ($P < 0.001$) angles, showing a change in maxillomandibular relationship. Comparison of mean changes in angular measurements between the 2 groups showed a significant difference ($P = 0.032$) in the sella-nasion to odontoid process tangent (SN-OPT) angle. The SN-OPT angle predicted that the probability of developing an altered cervical posture with the TB appliance is 2.08 times greater than without the TB appliance. **Conclusions:** SN-OPT angle can predict a change in skeletal relationships after treatment with the TB functional appliance. The TB causes the craniocervical posture to be more upright. Subjects with reduced vertical dimensions have greater change in cervical posture. (Am J Orthod Dentofacial Orthop 2019;155:656-61)

Functional appliance treatment is considered to be a valuable strategy to overcome deficient growth of the mandible. In a study by Aslam et al,[1] Class II Division 1 malocclusion had a prevalence of 41% in patients who presented for orthodontic treatment. Many of these patients are growing, and numerous functional appliances can be prescribed for the correction of skeletal relationships. Functional appliances alter the activity of various muscle groups that influence the function and position of the mandible. This generates pressure from the stretch of muscles and surrounding soft tissues, which is also known as "viscoelastic stretch."[2] The redirection of forces produced by the appliance is transmitted to the underlying skeletal tissues and brings about orthodontic and orthopedic changes.[3]

The twin block (TB) was introduced by Clark[4] in 1982. Since then, it has become the most preferred functional appliance.[5] This removable appliance owes its increasing popularity to its uncomplicated design and ease of use.[5] It consists of separate upper and lower acrylic units which position the mandible forward through interlocking occlusal bite blocks.[3,5] The 2-piece design (Fig 1) facilitates speech and mastication and has proved to be associated with good patient compliance.[2,4] Extensive research on the skeletal and dental effects of the TB[6,7] has shown varied results.[8,9] The reason for these inconsistencies could be the difficulty in beginning treatment at the maximum growth spurt and using unreliable reference lines during cephalometric analysis.[10,11]

The association between the maxillomandibular relationships, the cervical column, and head posture has been investigated in the past.[7,12] As early as 1926, Schwarz[13] observed an association between the head posture and the jaw position. The head posture is claimed to be affected by the mode of breathing and

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Fig 1. Twin-block appliance.

consequently to have effects on the craniofacial growth.[14] Gresham and Smithells[15] and Morris et al[16] revealed radiographic evidence that children who habitually lack an upright head posture have an Angle Class II malocclusion, long-face syndrome, and kyphosis of the cervical spine. In addition, Sidlauskiene et al[17] found that the dental overjet and overbite were significantly greater in patients with kyphotic posture.

Because the TB is one of the most common functional appliances prescribed to patients for dentofacial orthopedic purposes, it is necessary to evaluate its treatment effects. A survey of the pertinent literature showed many studies that have reported effects of the TB with the use of routine skeletal and dental landmarks, but none reporting the effects of the TB on cervical posture.[18,19] The objective of the present study was to compare the cervical spine posture between subjects with and without TB therapy. The null hypothesis was that no differences are observed in the cervical spine posture between the 2 groups.

MATERIAL AND METHODS

A retrospective cohort was conducted with the use of pre– (PF1) and post– (PF2) functional therapy cephalograms of orthodontically treated patients. A comparison or unexposed group was selected as a control from the Bolton-Brush Growth Study.[20] The sample size was calculated with the use of OpenEpi software. Tecco et al[21] reported that the mean value for the sella-nasion to the odontoid process tangent (SN-OPT) angle in patients treated with the Frankel II appliance was 87.5 ± 3° compared with 83.3 ± 4.5° in the control group. Keeping the power of the study as 90% and alpha as 0.05, it was calculated that at least 28 subjects were required in each group. A total of 60 subjects were included in this study. Because sex is an effect modifier, equal numbers of male (n = 15) and female (n = 15) patients were included in each group. The mean age of subjects in the exposed group was 11.8 ± 1.5 years and in the unexposed group was 11.6 ± 2.0 years.

Table I. Pretreatment severity of Class II molar relationships between the groups

Severity	*Control*	*Twin block*
Full cusp	30	30
Three-quarter cusp	–	–
Half cusp	–	–
Quarter cusp	–	–

All subjects presenting at the orthodontic clinics of our university hospital with skeletal Class II malocclusion (ANB >5°) due to mandibular retrognathism (SNB <78°), with full cusp Class II molar, canine, and incisor relationships, and in their pubertal growth spurt (CS3) were included in this study. Those subjects who had extracted or missing teeth, craniofacial syndromes, history of trauma or surgery involving facial structures, or a systemic disease that affects the growth and development were excluded.

The control group was taken from the Bolton-Brush Growth Study and was matched with experimental subjects on the basis of skeletal age, sex, molar relationships (Table I), and SNB and ANB angles. Cephalograms (T_1) were matched between a subject serving as a control and a subject in the exposed group. Subsequently, a cephalogram (T_2) of the same individual was evaluated after TB appliance therapy. Both groups showed a circumpubertal stage of skeletal growth (CS3) at T_1 as reported by Baccetti et al.[22] Each subject's chronologic age and cervical stage were recorded. The mean duration of TB treatment was 11.83 ± 1.8 months. All subjects were instructed to wear the appliance for a minimum of 20 hours/day except during eating, brushing, and contact sports. Compliance with the TB therapy was monitored by recording the wear time as reported by the patient and his or her parents on every visit, the wear of the appliance, the reduction of overjet of at least 1 mm between the most proclined incisor at monthly intervals and the observation of the pterygoid effect. If there wasn't a reduction in overjet and absence of these factors for 2 consecutive months, it indicated a failure to wear the appliance. TB appliance therapy was considered to be successful when a class I molar relationship was achieved and patients then underwent a PF2 cephalogram.

All cephalograms were taken with rigid head fixation and a 165 cm film to tube distance with the use of an Orthoralix R9200 (Gendex-Kavo, Milan, Itay). Cephalograms were traced manually with a 0.5-mm lead pencil on acetate sheets on an illuminator. Angular readings were measured with the help of a protractor.

The PF1 and PF2 cephalograms were evaluated for 3 sagittal, 1 vertical, and 7 cervical parameters. The sagittal parameters, SNA, SNB, and ANB, were measured to determine any change in the skeletal relationships in the anteroposterior dimension. The SN-GoGn was measured to determine changes in the vertical dimension. The odontoid process tangent (OPT) was drawn through the most posteroinferior point on the second cervical vertebra (C2). The anterior and inferior angles created with sella-nasion (SN), palatal plane (PP), and mandibular plane (SN-GoGn) were measured to determine any change in the upper cervical posture. The cervical vertebral tangent (CVT) was drawn through the most posteroinferior point on the fourth cervical vertebra (C4). The anterior and inferior angles created with the aforementioned planes and the angle between OPT and CVT were used to determine any change in the middle cervical posture (Fig 2).

To test intraexaminer reliability, 30 radiographs were randomly selected, retraced, and remeasured by the principal investigator. The intraclass correlation coefficient showed a high degree of correlation between the 2 readings (Table II).

Data were entered and analyzed in SPSS for Windows (version 20.0; SPSS, Chicago, Ill). Descriptive statistics were used for the calculation of mean age. The Shapiro-Wilk test was applied to determine the normality of the data, which showed a nonnormal distribution. The Wilcoxon signed-rank test was used to compare PF1 and PF2 means in both the groups. The Mann-Whitney *U* test was used to compare the mean changes between the 2 groups. The probability of altered cervical posture after TB therapy was also calculated.

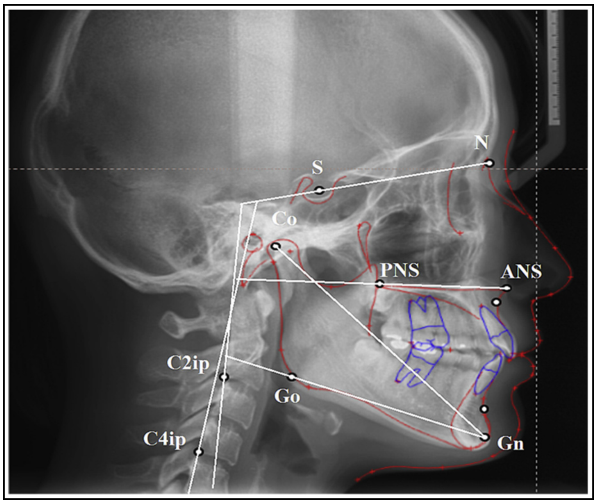

Fig 2. Cephalometric planes.

Table II. Intraexaminer reliability, median (interquartile range)

Parameter	1st reading (n = 30)	2nd reading (n = 30)	ICC
SNA°	82.0 (79-83.2)	81.0 (78.7-82.2)	0.979
SNB°	75.0 (72.7-77.0)	75.0 (72.0-77.0)	0.965
ANB°	6.0 (5.0-8.0)	6.0 (5.0-8.0)	0.873
SN-OPT°	104.0 (99.0-110.0)	104.0 (99.0-110.0)	0.953
MP-OPT°	73.5 (70.0-80.2)	72.5 (69-80.5)	0.788
PP-OPT°	98.0 (94.7-102.2)	96.0 (92.0-100.2)	0.978
SNCVT°	104.5 (100.7-113.5)	103.0 (100.0-110.0)	0.985
PP-CVT°	100.0 (95.0-106.2)	99.5 (95.7-105.2)	0.962
MP-CVT°	76.5 (71.5-82.2)	75.5 (70.5-82.0)	0.997
OPT-CVT°	5.0 (3.0-7.2)	4.0 (2.0-6.2)	0.954

ICC, Intraclass correlation coefficient.

RESULTS

The PF1 angular measurements did not show a significant difference between sexes, so results were not stratified accordingly.

The medians and interquartile ranges of PF1 and PF2 linear and angular sagittal and cervical angular measurements are presented in Table III. The PF1 and PF2 sagittal values, ie, SNB and ANB, showed a significant difference (P <0.001) in the exposed group. A significant difference existed between the T1 and T2 readings for the SN-OPT angle ($P = 0.033$) and MP-CVT angle ($P = 0.013$) in the unexposed group.

The change in the PF1 and PF2 values are presented in Table IV. A significant difference was found between SNB (P <0.001), ANB (P <0.001), and SN-OPT ($P = 0.032$).

The probabilities of developing an altered cervical posture with different angular measurements are presented in Table V.

DISCUSSION

This study was conducted to determine the cervical spine posture between subjects with and without TB therapy. Khoja et al[7] reported an improvement in the sagittal skeletal relationships with the TB owing to an increase in the mandibular length. Aglarci[23] investigated the effects of the TB on the sagittal skeletal dimensions and the cervical posture. The results showed a significant difference between the PF1 and PF2 SNB, ANB, and OPT/CVT angles, indicating an improvement in sagittal relationships and an increase in cervical curvature. Ohnmeiß et al[24] also found a significant difference between the PF1 and PF2 ANB values. Similarly, a significant difference in the SNB and ANB angles in PF1 and PF2 indicated an improvement in the sagittal relationships in this study. Furthermore, a comparison of the changes in angular measurements between the groups also showed a significant difference. This establishes

Table III. Comparison of the groups, median (interquartile range)

Angle	Twin block (n = 30) T1	Twin block (n = 30) T2	P	Control (n = 30) T1	Control (n = 30) T2	P
Sagittal parameters						
SNA°	81.0 (79.8-84.0)	82.0 (79.8-84.0)	0.196	83.0 (80.0-86.0)	83.0 (80.0-85.2)	0.936
SNB°	75.0 (73.0-77.0)	75.0 (73.0-77.0)	<0.001†	77.0 (75.0-77.0)	77.0 (74.0-77.0)	0.379
ANB°	6.5 (5.0-8.0)	5.0 (3.0-6.0)	<0.001†	6.0 (5.0-7.0)	5.5 (5.0-7.0)	0.641
Vertical parameter						
Sn-GoGn°	32.5 (28-36)	31.0 (28-35)	0.618	29.0 (23-30)	29.0 (23-32)	0.119
Upper cervical parameters						
SN-OPT°	105.0 (100.0-110.5)	104.0 (100.0-110.0)	0.386	95.0 (88.0-101.5)	97.0 (93.0-103.5)	0.033*
PP-OPT°	97.0 (94.8-101.0)	95.5 (92.5-103.3)	0.665	90.5 (88.0-97.0)	92.0 (88.0-94.2)	0.287
MP-OPT°	73.0 (67.0-80.0)	73.5 (69.0-79.0)	0.222	71.0 (67.2-78.0)	70.0 (68.0-78.0)	0.138
Middle cervical parameters						
SN-CVT°	104.5 (100.8-113.0)	106.0 (102.8-114.8)	0.683	100.0 (96.7-108.2)	100.0 (97.2-108.0)	0.396
PP-CVT°	99.0 (94.8-107.0)	99.5 (95.8-104.0)	0.544	92.0 (91.0-94.2)	93.0 (90.0-95.5)	0.275
MP-CVT°	75.0 (72.0-83.0)	78.0 (70.0-80.0)	0.793	73.0 (66.7-77.2)	72.5 (69.5-81.2)	0.013*
OPT-CVT°	5.0 (3.8-7.0)	5.0 (4.0-6.9)	0.558	4.0 (2.0-4.2)	3.0 (3.0-4.0)	0.676

*$P \leq 0.05$; †$P < 0.001$; Wilcoxon signed-rank test.

Table IV. Cephalometric changes, median (interquartile range)

Parameter	Twin block (n = 30)	Control (n = 30)	P
Sagittal parameters			
SNA°	0.0 (−1.3 to 0.25)	0.0 (0.0 to 0.2)	0.236
SNB°	−2.0 (−3.0 to 1.0)	0.0 (0.0 to 0.0)	<0.001*
ANB°	1.5 (1.0-3.0)	0.0 (−0.2 to 0.0)	<0.001*
Vertical parameter			
SN-GoGn°	0.0 (−3.0 to 2.0)	0.0 (0.0 to 0.0)	0.853
Upper cervical parameters			
SN-OPT°	1.0 (−3.5 to 5.0)	0.0 (−1.2 to 11.2)	0.032*
PP-OPT°	2.0 (−3.3 to 6.0)	0.0 (−5.2 to 2.2)	0.805
MP-OPT°	−0.5 (−7.3 to 2.3)	0.0 (−5.5 to 0.2)	0.189
Middle cervical parameters			
SN-CVT°	0.0 (−5.0 to 3.3)	0.0 (−4.0 to 0.2)	0.417
PP-CVT°	0.0 (−4.0 to 3.3)	0.0 (−0.5 to 2.0)	0.994
MP-CVT°	0.0 (−6.0 to 5.0)	1.5 (0.0-5.2)	0.153
OPT-CVT°	0.0 (−3.3 to 2.0)	0.0 (−1.0 to 1.0)	0.770

*$P < 0.001$; Mann-Whitney U test.

Table V. Probability of change in cervical posture after TB appliance therapy

Cervical parameter	Group	Beyond norm	Within norm	Relative risk
PP-OPT°	TB	16	14	3.20
	Control	05	25	
SN-OPT°	TB	25	05	2.08
	Control	12	18	
MP-OPT°	TB	28	02	1.06
	Control	28	02	
SN-CVT°	TB	20	10	1.81
	Control	11	19	
PP-CVT°	TB	14	16	3.50
	Control	04	26	
MP-CVT°	TB	25	05	1.03
	Control	13	17	
OPT-CVT°	TB	10	20	1.43
	Control	07	23	

that the faltering growth of the mandible had significantly improved relative to the maxilla and cranial base and emphasizes the consistent treatment success with the TB appliance. However, the success has been seen as a combination of inconsistent skeletal and dentoalveolar effects. This indicates the need for an alternate quantification of the improvement in skeletal relationships.[25,26]

The physiologic change in the cervical posture varies in different individuals. Müller[27,28] claimed that the mandible acts in close harmony with a chain of muscles to control the position of the head in space and stated that craniofacial growth is evaluated more objectively from the occipital structures at the junction between skull and trunk. The cervical posture is dependent on interactions within the musculoskeletal system and physiologic growth processes and there is a close anatomic relationship between the cervical spine and the mandible.[29] In addition, the cervical spine has shown an association with the size of the mandible, craniofacial morphology,and mandibular divergence.[30-33]

Björk[34-36] and Bjork and Skieller[37,38] were the first to describe the rotation of the maxilla and the mandible during human growth and development. They described it in terms of either a forward or backward rotation. The influence of muscle attachments to the cervical vertebrae (C2) in the developing vertical growth pattern have been explained by the quadrant theorem of Guzay.[39] It states that when the mandible moves downward, it generates a pulling force, loosening the muscles around C2. Likewise, when moving up, it generates pressure which tightens the muscles around C2. This means that an occlusion with a decreased vertical dimension will aggravate muscle tension around C2 when the mouth is closed.[39]

This interesting relationship between C2 and the mandible can be explained by the significant differences found between the SN-OPT and MP-CVT angles in subjects from the Bolton-Brush Growth Study. There was a significant increase noted in the SN-OPT angle between the T1 and T2 values of the unexposed group which indicates a change in the upper cervical posture making it more forwardly inclined with a retrognathic mandible. Compared with the exposed group, the decrease in the SN-OPT angle shows that there is an uprighting and development of a natural curvature of the spine with an improvement in the mandibular length.

The mean values of the mandibular plane angle in the unexposed group indicate that the selected subjects had skeletal Class II malocclusion due to mandibular retrognathism and a reduced vertical dimension. With the compelling evidence above,[35-39] it can be clearly determined that these subjects would definitely have a greater physiologic change in their cervical posture, which is represented by the significant difference found between the MP-CVT angles taken at T_1 and T_2. The mean values of the mandibular plane angle in the exposed group indicate that a majority of the subjects had a normal vertical growth pattern, therefore no significant differences were noted in the PF1 and PF2 cervical parameters. Whereas Agalrci[23] found a significant difference between the OPT-CVT angles, indicating a change in the middle cervical posture, Ohnmeiß et al[24] did not find a significant difference between the cervical parameters. We found a significant difference in the mean change of the SN-OPT angle, which can be interpreted as an uprighting of the upper cervical posture. There was no significant change noted in the middle cervical posture in the exposed group (from T_1 to T_2), and the mean change between the groups also was nonsignificant.

The probability of altering the cervical posture with the use of the TB appliance was assessed using the measurements of the cervical parameters. The probability of altering the upper cervical posture was predicted with the use of the SN-OPT angle to be 2 times greater than without TB therapy. Although the results show many of the other parameters to be suggestive of an altered cervical posture, the results should be interpreted with caution because the other statistical evidence contradicts these findings.

The comparison group exhibited a normal physiologic forward inclination of the cervical posture which was significantly different from the intervention group who revealed a change to a more upright posture in the duration of appliance therapy. Although a comparison group was used in this study, it is based on a historical sample of the white population and makes a poor standard of comparison. A single-center study based on a 2-dimensional imaging technique, manual tracing of cephalometric landmarks, and measurements are all limitations of this study. These deficiencies can be overcome by obtaining a comparison group of individuals from the local population and using a 3-dimensional imaging technique.

CONCLUSIONS

This study was conducted to determine the cervical spine posture between subjects with and without TB therapy. We rejected the null hypothesis based on the following results:

1. The TB improves the sagittal relationships between the maxilla and mandible.
2. The TB causes the craniocervical posture to be more upright.
3. Subjects with Class II malocclusion due to mandibular retrognathism with a reduced vertical dimension have a greater forward inclination of the craniocervical posture.
4. The SN-OPT angle can predict a skeletal change in the maxillomandibular relationships.

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