Evaluation and Comparison of Cervical Spine Posture in Class II Division I Patients Treated with Twin Block Appliances, Forsus Appliances, and Bilateral Sagittal Split Osteotomy: A Cephalometric Study

Abstract

Background: It has been speculated that a change in cervical spine posture occurs due to forward repositioning of the mandible. Therefore, this study aimed to evaluate and compare the cervical spine posture in Class II division one patient treated with three different treatment modalities. **Materials and Methods:** A retrospective cohort study was conducted using pre and post-treatment lateral cephalograms of Class II Division one patients who have undergone orthodontic therapy using twin block appliance, Forsus, and bilateral sagittal split osteotomy (BSSO). This study included a total of 57 subjects comprising 19 subjects in each group. Seven cervical, three sagittal, and one vertical parameters were compared within and between each group. The data were tested using the Dependent *t*-test, One-way analysis of variance, and Tukey's *post hoc* test. **Results:** A significant difference existed between the pre- and post-treatment angular measurements within the three groups showing a change in the cervical spine posture with forward positioning of the mandible. A comparison of mean changes in angular measurements between the three groups showed a significant difference in SNA, SNB, ANB, and odontoid process tangent-cervical vertebral tangent (OPT-CVT), indicating a change in the cervical posture. **Conclusion:** OPT-CVT angle predicts a change in cervical spine posture after treatment with a significant difference in the Twin Block group ($P = 0.029$) compared to Forsus and BSSO groups. Thus, the twin block group results in a more upright craniocervical posture than the other two treatment groups.

Keywords: *Angle Class II division 1, BSS0, cephalometry, cervical spine posture, forsus, twin block*

S. S. Suji Krishna, B. Shashikumar, Roopak D. Naik

Department of Orthodontics and Dentofacial Orthopedics, Shri Dharmasthala Manjunatheshwara College of Dental Sciences and Hospital, A Constituent Unit of Shri Dharmasthala Manjunatheshwara University, Dharwad, Karnataka, India

Submitted : 11-Sep-2022
Revised : 07-May-2023
Accepted : 15-May-2023
Published : 30-Jun-2023

Address for correspondence:
Dr. S. S. Suji Krishna,
Kumari Hostel,
Shri Dharmasthala Manjunatheshwara College of Dental Sciences and Hospital,
Hubli, Dharwad - 580 009,
Karnataka, India.
E-mail: legacy.gs@gmail.com

Access this article online
Website: https://journals.lww.com/cocd
DOI: 10.4103/ccd.ccd_459_22
Quick Response Code:

Introduction

A typical cervical spine is characterized by a natural lordotic curve which gently curves forward from the base of the skull and then goes back into the top of the chest or upper back. In poor posture, the head drifts forward, resulting in hyperflexion of the lower cervical spine with the flattening of the lordosis curve and hyperextension of the upper cervical spine with a more pronounced lordosis curve.

D'Attilio[1] found a strong association between the neck posture and the sagittal structure of the face. In addition, cervical spine posture is also influenced by various factors of the body (ethnic origin, gender, age, and stature), craniofacial morphology (mostly mandibular divergence, mandibular size, and facial shape), functional factors (nasorespiratory function, temporomandibular dysfunction) and orthodontic therapy (use of removable orthodontic appliances or splints to increase vertical dimension) or the use of anterior repositioning devices for skeletal Class II children.[1]

An association between the postural inclination of the cervical spine and the position of the mandible has been reported by Duzings.[2] Angle's Class II division 1 is related to an inferior atlas position, a habitual lack of upright head posture, and lordosis of the cervical spine, in contrast to Angle's Class III. In the case of Angle's Class III, it has been demonstrated to involve a superior atlas position and kyphosis of the cervical spine.

Various studies have shown the relation between cervical posture and mandibular length; When the mandible is longer, the cervical column becomes more inclined towards the true horizontal position, and the longer the mandible straighter the

How to cite this article: Krishna SS, Shashikumar B, Naik RD. Evaluation and comparison of cervical spine posture in Class II division I patients treated with twin block appliances, forsus appliances, and bilateral sagittal split osteotomy: A cephalometric study. Contemp Clin Dent 2023;14:157-65.

cervical column, i.e., the lower the cervical lordosis angle, even in the case of adult patients with temporomandibular disorders.[3,4] There is a correlation between the cervical lordosis angle in children and adolescents to the mandibular divergence, i. e., the higher the divergence lower the cervical lordosis angle.[3]

According to Angle's classification, class II skeletal pattern is the second most common malocclusion. Class II skeletal pattern is associated with the prognathic maxilla, retrognathic mandible, or combination of both in various severities, contributed mainly by mandibular retrognathism.

The treatment for patients with Class II division I depends on factors such as their growth pattern, growth stage, and other related aspects. The treatment is decided based on visual treatment objectives results. Various methods of treating Class II Division 1 patients include functional appliances, fixed functional appliances, camouflage therapy, and Orthodontic treatment along with Orthognathic surgery.[5] All these treatment modules approach the treatment with skeletal and dentoalveolar changes.

A valuable strategy to overcome the deficient growth of the mandible is by treating using functional appliances.[6] The mode of action of these appliances is by altering the activity of various muscle groups that, in turn, will influence the function and position of the mandible. Thereby generating pressure from the stretched muscles and surrounding soft tissues, described as Viscoelastic stretch.[6,7] The appliance then redirected these forces and transmitted them to the underlying skeletal tissues, bringing out orthodontic and orthopedic changes.[6] The Twin Block appliance designed by William J Clark in 1977 was commonly used to treat growing Class II patients with mandibular deficiency during the pubertal growth spurts.[6,8] They allow mandibular postural changes by holding the mandible forward and downward. It induces the growth of condylar cartilage, thus lengthening the mandible.[6]

The fixed functional appliance is given to patients who are noncompliant considering the facial profile, vertical height, angulation of lower incisors, severity of the problem, and when there is only a small amount of growth remaining and there is a need for mandibular advancement.[9] Among the fixed functional appliance, Forsus Fatigue Resistant Device (Forsu FRD) is the most commonly used one. It causes skeletal as well as dentoalveolar changes. While using Forsus, there is the advancement of the mandible along with a small amount of maxillary distalization. The intrusive force on maxillary molars causes a decrease in the posterior vertical dimension, and the intrusive force can intrude mandibular incisors.[5,9]

The orthodontic treatment, along with orthognathic surgery, was done in patients who required severe skeletal and dentoalveolar corrections, which cannot be accomplished by orthodontic treatment alone, and whose growth has been completed. Orthognathic surgery involves either maxillary setback with Le Fort I osteotomy, mandibular advancement by bilateral sagittal split osteotomy (BSSO), or a combination of both.[5]

So far, no studies have assessed and compared cervical spine posture changes with different treatment modalities such as Forsus and BSSO. Therefore, this study aimed to evaluate and compare the cervical spine posture in Class II division 1 patient treated with twin block appliances, Forsus appliances and BSSO.

Materials and Methods

The study protocol was approved by the institutional ethical review board of Shri Dharmasthala Manjunatheshwara University (IRB No: 2019/P/OR/64), held on November 16, 2019. The effective sample size was calculated using G*Power software (latest ver. 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The sample size was calculated according to the study by Kamal and Fida,[6] with a mean difference between the twin block and control group of 4.2 and an effect size of 1.12 and a 5% alpha error. Applying the formula concluded that 19 samples are required to attain a power of 80% with a significance level of $\alpha = 0.05$. Therefore, this study included a total of 57 patients, with 19 patients in each group. Informed consent was obtained before initiating the study from all the participants.

A retrospective cephalometric study was conducted in which pretreatment and posttreatment lateral Cephalograms of 57 patients were studied. All cephalograms had been taken with teeth in occlusion, lips at rest, and head in standard position (Frankfurt plane parallel to the horizontal plane) by an experienced technician. Samples were obtained from the patients reporting to the Department of Orthodontics and Dentofacial Orthopedics of the college for treatment; after approval from the institutional review board. Data were divided into three groups according to the treatment modality: the first group was treated with Twin block appliance, the second group was treated with Forsus FRD and three groups with BSSO.

Inclusion criteria included subjects with skeletal Class II malocclusion due to mandibular retrognathism, age group between 12 and 25 years, and subjects treated with Twin block appliances, Forsus appliances, and BSSO full cusp Class II molar, canine, and incisor relationship.

Subjects with missing teeth, spinal deformities, craniofacial syndromes, history of trauma or surgery involving facial structures, systemic disease, three-quarter cusp, half cusp, and quarter cusp molar relationship were excluded from the study.

Lateral cephalograms will be taken with the help of a cephalostat with rigid head fixation such that the Frankfurt horizontal plane is parallel to the floor and with a 165 cm film-to-tube distance. Then the cephalograms will be traced manually with a 0.3 mm lead pencil on matte acetate paper on an illuminator. Angular readings were measured with a protractor. The cervical spine posture in the pre-treatment and post-treatment cephalograms was evaluated by obtaining three sagittal, one vertical, and seven cervical parameters. The sagittal parameters: SNA, SNB, and ANB are measured to determine any change in the skeletal relationships in the anteroposterior dimension. The SN-GoGn is measured to determine the changes in the vertical dimensions. Then the odontoid process tangent (OPT) is drawn through the most posteroinferior point on the C2, and the anterior and inferior angles created with sella-nasion (SN), palatal plane (PP), and mandibular plane (Sn-GoGn) are measured to determine any change in the upper cervical posture. To determine any change in the middle cervical posture, the cervical vertebral tangent (CVT) is drawn through the most posteroinferior point on the C4 vertebra, and the anterior and inferior angles created with the planes as mentioned above and the angle between OPT and CVT are measured [Figure 1]. These measurements will be obtained from the pre- and post-treatment cephalograms of all the three groups. Then the readings will be evaluated and compared.

Statistical analysis

The obtained data were analyzed statistically with the software Statistical Package for Social Sciences (SPSS) version 21.0 (IBM Technology Corporation, NY, U.S.A). The statistical tests were the Dependent *t*-test, one-way analysis of variance (ANOVA), and Tukey's *Post hoc* test. Paired *t*-tests were used to compare the mean difference between two related variables. One-way ANOVA is used to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups. The one-way ANOVA compares the means of different cephalometric readings between the Twin Block, Forsus, and BSSO treatment groups and determines whether any of those means are statistically significantly different. Tukey's *post hoc* test was used to determine which specific groups differed from each other.

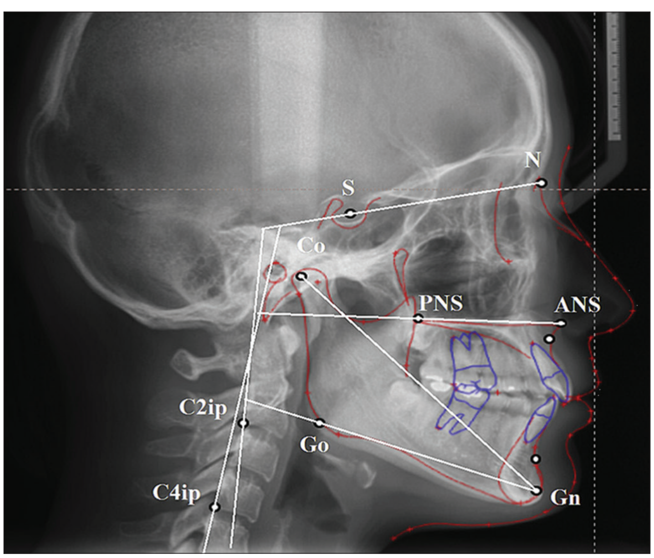

Figure 1: Cephalometric planes[6]

Results

Comparison of cephalometric readings before and after the treatment of Twin-block, Forsus, and BSSO are shown in Tables 1-3, respectively. According to paired *t*-test, In Upper cervical posture, the SN-OPT, PP-OPT, and

Table 1: Comparison of different cephalometric readings before and after the treatment of twin-block

Paired samples statistics					
	n	Mean	SD	*t*	*P*
Sagittal					
SNA					
Pretreatment	19	83.37	3.09	2.882	0.01*
Posttreatment	19	83.05	2.93		
SNB					
Pretreatment	19	75.68	2.94	−15.782	0.001*
Posttreatment	19	80.79	2.82		
ANB					
Pretreatment	19	7.68	1.83	16.922	0.001*
Posttreatment	19	2.32	0.58		
Vertical					
SN-Go-Gn					
Pretreatment	19	28.74	3.77	−4.083	0.001*
Posttreatment	19	30.11	3.74		
Cervical					
Upper cervical posture					
SN-OPT					
Pretreatment	19	104.26	7.75	12.283	0.001*
Posttreatment	19	96.53	6.68		
PP-OPT					
Pretreatment	19	99.05	6.28	8.527	0.001*
Posttreatment	19	91.58	4.98		
MP-OPT					
Pretreatment	19	83.11	9.50	10.129	0.001*
Posttreatment	19	77.11	9.39		
Middle cervical posture					
OPT-CVT					
Pretreatment	19	3.84	1.12	−15.24	0.001*
Posttreatment	19	8.68	1.86		
SN-CVT					
Pretreatment	19	98.74	5.93	−13.011	0.001*
Posttreatment	19	105.47	6.39		
PP-CVT					
Pretreatment	19	93.53	3.96	−15.334	0.001*
Posttreatment	19	100.68	4.07		
MP-CVT					
Pretreatment	19	78.26	6.38	−14.325	0.001*
Posttreatment	19	84.26	5.58		

*Statistical significance set at 0.05. *n*: Number of samples; SD: Standard deviation; SN: Sella-nasion; OPT: Odontoid process tangent; PP: Palatal plane; CVT: Cervical vertebral tangent

Table 2: Comparison of different cephalometric readings before and after the treatment of Forsus

Paired samples statistics	*n*	Mean	SD	*t*	*P*
Sagittal					
SNA					
Pretreatment	19	80.89	3.00	4.975	0.001*
Posttreatment	19	80.32	2.85		
SNB					
Pretreatment	19	74.74	2.56	−21.534	0.001*
Posttreatment	19	78.16	2.79		
ANB					
Pretreatment	19	6.16	0.69	25.055	0.001*
Posttreatment	19	2.11	0.32		
Vertical					
SN-Go-Gn					
Pretreatment	19	28.47	2.20	−9.816	0.001*
Posttreatment	19	30.63	2.45		
Cervical					
Upper cervical posture					
SN-OPT					
Pretreatment	19	100.21	8.38	12.684	0.001*
Posttreatment	19	96.47	8.44		
PP-OPT					
Pretreatment	19	93.42	9.23	5.418	0.001*
Posttreatment	19	90.11	10.38		
MP-OPT					
Pretreatment	19	80.16	12.08	8.473	0.001*
Posttreatment	19	77.42	12.36		
Middle cervical posture					
OPT-CVT					
Pretreatment	19	5.89	1.52	−10.819	0.001*
Posttreatment	19	10.58	2.29		
SN-CVT					
Pretreatment	19	99.68	4.56	−8.612	0.001*
Posttreatment	19	105.74	3.49		
PP-CVT					
Pretreatment	19	93.05	6.73	−9.534	0.001*
Posttreatment	19	98.53	6.69		
MP-CVT					
Pretreatment	19	77.63	7.59	−8.563	0.001*
Posttreatment	19	83.00	7.33		

*Statistical significance set at 0.05. *n*: Number of samples; SD: Standard deviation; SN: Sella-nasion; OPT: Odontoid process tangent; PP: Palatal plane; CVT: Cervical vertebral tangent

MP-OPT readings were statistically significantly lower values after treatment. Whereas in middle cervical posture, OPT-CVT, SN-CVT, PP-CVT, and MP-CVT readings were statistically significantly higher values after treatment in all three groups ($P < 0.05$), signifying there was improvement and development of natural curvature in cervical spine posture in addition to the sagittal skeletal improvement in all the three groups.

Comparison of cephalometric readings between Twin Block, Forsus, and BSSO treatment groups before treatment are shown in Table 4. Before treatment, one-way ANOVA shows a statistically significant difference in SNA, SNB, ANB, and OPT-CVT cephalometric readings between the Twin Block, Forsus, and BSSO treatment groups. When comparing the Twin block treatment group to the Forsus group before treatment, Tukey's Posthoc analysis shows statistically significant higher SNA cephalometric readings in the Twin block treatment group (Mean difference = 2.47; $P = 0.022$). Similarly, SNB cephalometric reading displayed statistically significant lower cephalometric readings in the BSSO treatment group when compared to the Twin block group (Mean difference = 3.47; $P = 0.001$) and Forsus group (Mean difference = 2.53; $P = 0.019$) before the treatment. Before treatment, BSSO treatment groups had statistically significantly higher ANB cephalometric readings than Twin block treatment groups (Mean difference = −2.11; $P = 0.001$) and Forsus treatment groups (Mean difference = −3.63; $P = 0.001$), whereas Forsus groups had statistically significantly lower ANB cephalometric readings than Twin block treatment groups (Mean difference = 1.53; $P = 0.006$) Before any treatment, cephalometric readings in the BSSO treatment groups showed statistically significant higher OPT-CVT readings than the Twin block and Forsus treatment groups. Similarly, when compared to the Twin block treatment group, the Forsus treatment group had statistically significantly higher OPT-CVT readings.

Table 5 compares cephalometric readings between Twin Block, Forsus, and BSSO treatment groups after treatment. It shows a statistically significant difference in SNA ($F = 5.13$; $P = 0.009$), SNB ($F = 4.38$; $P = 0.017$), ANB ($F = 3.93$; $P = 0.025$), and OPT-CVT ($F = 3.52$; $P = 0.036$) cephalometric readings between the Twin Block, Forsus, and BSSO treatment groups. Tukey's posthoc analysis revealed that after treatment with the Twin block and Forsus treatment groups, the Twin block group had statistically significantly higher SNA cephalometric readings than the Forsus treatment group (Mean difference = 2.74; $P = 0.007$). ANB cephalometric readings revealed similar results (Mean difference = 2.63; $P = 0.013$). Compared to the Forsus group, the BSSO treatment group had a statistically significant higher ANB reading. The OPT-CVT readings were statistically significantly higher in the Twin block treatment group when associated with the Forsus treatment group.

Discussion

This research study evaluated and compared the cervical spine posture in Class II division 1 patients treated with Twin block appliance, Forsus appliance, and BSSO.

The relationship between the maxillo-mandible cervical spine and head posture has been studied. Schwarz, in 1926, observed a relationship between the head posture and the jaw position. The head posture is observed to be affected by the mode of breathing and consequently affects craniofacial growth.[6]

Table 3: Comparison of different cephalometric readings before and after the treatment of bilateral sagittal split osteotomy

Paired samples statistics	*n*	Mean	SD	*t*	*P*
Sagital					
SNA					
Pretreatment	19	82.00	2.11	Nil	Nil
Posttreatment	19	82.00	2.11		
SNB					
Pretreatment	19	72.21	2.82	−27.89	0.001*
Posttreatment	19	79.37	2.61		
ANB					
Pretreatment	19	9.79	1.62	27.89	0.001*
Posttreatment	19	2.63	0.76		
Vertical					
SN-Go-Gn					
Pretreatment	19	30.47	3.86	−3.284	0.004*
Posttreatment	19	32.11	3.36		
Cervical					
Upper cervical posture					
SN-OPT					
Pretreatment	19	103.00	6.25	7.608	0.001*
Posttreatment	19	98.16	5.96		
PP-OPT					
Pretreatment	19	95.58	6.64	16.988	0.001*
Posttreatment	19	92.05	6.54		
MP-OPT					
Pretreatment	19	76.63	10.02	10.751	0.001*
Posttreatment	19	73.21	9.32		
Middle cervical posture					
OPT-CVT					
Pretreatment	19	7.79	3.22	−2.456	0.024*
Posttreatment	19	9.84	2.46		
SN-CVT					
Pretreatment	19	102.95	7.58	−11.516	0.001*
Posttreatment	19	107.74	8.01		
PP-CVT					
Pretreatment	19	96.95	8.26	−17.186	0.001*
Posttreatment	19	101.37	8.36		
MP-CVT					
Pretreatment	19	77.37	6.77	−7.971	0.001*
Posttreatment	19	82.05	7.74		

*Statistical significance set at 0.05. *n*: Number of samples; SD: Standard deviation; SN: Sella-nasion; OPT: Odontoid process tangent; PP: Palatal plane; CVT: Cervical vertebral tangent

The quadrant theorem of Guzay[6] explains the influence of muscle attachments to the cervical vertebrae (C2) in the developing vertical growth pattern. This theory states that when the mandible moves downward, it generates a pulling force, loosening the muscles around C2. Similarly, moving up generates pressure, which results in the muscles tightening around C2.[6,10]

Evaluation and comparison of changes in cervical spine posture in skeletal class II Division 1 patients with appliances that cause mandibular advancement, such as twin block appliance, Forsus appliance, and mandibular advancement through the surgical procedure via BSSO, were investigated in this clinical study. Besides the skeletal improvement in the sagittal plane, an increase in the cervical curvature angle was also observed.

The effect of a few functional appliances on head posture was investigated and reported in the past. This study is the first to offer insight into how different mandible advancement treatment modalities affect the cervical spine's posture.

There is a close link between the morphological development of the upper and middle segment of the spine to the facial development. It was reported that in skeletal Class II subjects, a more lordotic curve of the cervical spine is related to the greater extension of the cervical column.[11] Furthermore, the upper cervical spine mediates the head and trunk, forming a functional inter-related system.[11]

In his study, Kamal and Fida.[6] noted this exciting relationship between C2 and the mandible, which was explained by the significant differences between the SN-OPT and MP-CVT angles in subjects from the Bolton–Brush Growth Study group. Furthermore, he concluded in his study that the SN-OPT angle could predict a change in skeletal relationships after treatment with the TB functional appliance. The TB causes the craniocervical posture to be more upright.

A significant correlation between the angle ANB and their Modified Cervical Angle (OPT/CVT) has been reported by Hosseinzadeh Nik and Janbaz Aciyabar,[12] and this association emphasizes the relation between the posture of the cervical column and the skeletal class.

In their study, Smailienė *et al.*[13] analyzed postural body change in class II malocclusion subjects with TB appliance which showed a straightening of the back profile, and all measurements during the treatment showed a statistically significant reduction.

Tecco *et al.*[14] showed that functional therapy with Frankel regulation appliance (FR2), which causes forward repositioning of the mandible in skeletal class II, seems to increase the cervical lordosis angle due to the inclination of the upper segment backward and extension of the head on the cervical column.

Ohnmeiß *et al.*,[2] in their study of the therapeutic effects of functional appliances on spine posture, concluded that the dens axis and atlas were verticalized as the dens moved closer to the sphenoid-occipital complex during the skeletal advancement of the mandible.

In the present study, it is observed that there is an improvement in the cervical spine posture with the use of oral appliances such as twin block and Forsus and also with

Table 4: Comparison of different cephalometric readings between twin block, Forsus and bilateral sagittal split osteotomy treatment groups before treatment

	One-way-ANOVA					Tukey's *Post hoc*		
	n	Mean	SD	*F*	*P*	Multiple comparisons	Mean difference	*P*
Sagittal								
SNA								
Twin block	19	83.37	3.09	3.804	0.028*	Twin block versus Forsus	2.47	0.022*
Forsus	19	80.89	3.00			Twin block versus BSSO	1.37	0.29
BSSO	19	82.00	2.11			Forsus versus BSSO	−1.11	0.44
SNB								
Twin block	19	75.68	2.94	7.934	0.001*	Twin block versus Forsus	0.95	0.55
Forsus	19	74.74	2.56			Twin block versus BSSO	3.47	0.001*
BSSO	19	72.21	2.82			Forsus versus BSSO	2.53	0.019*
ANB								
Twin block	19	7.68	1.83	29.463	0.001*	Twin block versus Forsus	1.53	0.006*
Forsus	19	6.16	0.69			Twin block versus BSSO	−2.11	0.001*
BSSO	19	9.79	1.62			Forsus versus BSSO	−3.63	0.001*
Vertical								
SN-Go-Gn								
Twin block	19	28.74	3.77	1.983	0.148	Twin block versus Forsus	0.26	0.97
Forsus	19	28.47	2.20			Twin block versus BSSO	−1.74	0.26
BSSO	19	30.47	3.86			Forsus versus BSSO	−2.00	0.17
Cervical								
Upper cervical posture								
SN-OPT								
Twin block	19	104.26	7.75	1.447	0.244	Twin block versus Forsus	4.05	0.23
Forsus	19	100.21	8.38			Twin block versus BSSO	1.26	0.86
BSSO	19	103.00	6.25			Forsus versus BSSO	−2.79	0.49
PP-OPT								
Twin block	19	99.05	6.28	2.726	0.074	Twin block versus Forsus	5.63	0.06
Forsus	19	93.42	9.23			Twin block versus BSSO	3.47	0.33
BSSO	19	95.58	6.64			Forsus versus BSSO	−2.16	0.65
MP-OPT								
Twin block	19	83.11	9.50	1.78	0.178	Twin block versus Forsus	2.95	0.67
Forsus	19	80.16	12.08			Twin block versus BSSO	6.47	0.15
BSSO	19	76.63	10.02			Forsus versus BSSO	3.53	0.56
Middle cervical posture								
OPT-CVT								
Twin block	19	3.84	1.12	15.902	0.001*	Twin block versus Forsus	−2.05	0.013*
Forsus	19	5.89	1.52			Twin block versus BSSO	−3.95	0.001*
BSSO	19	7.79	3.22			Forsus versus BSSO	−1.89	0.024*
SN-CVT								
Twin block	19	98.74	5.93	2.451	0.096	Twin block versus Forsus	−0.95	0.88
Forsus	19	99.68	4.56			Twin block versus BSSO	−4.21	0.10
BSSO	19	102.95	7.58			Forsus versus BSSO	−3.26	0.24
PP-CVT								
Twin block	19	93.53	3.96	1.992	0.146	Twin block versus Forsus	0.47	0.97
Forsus	19	93.05	6.73			Twin block versus BSSO	−3.42	0.25
BSSO	19	96.95	8.26			Forsus versus BSSO	−3.89	0.17
MP-CVT								
Twin block	19	78.26	6.38	0.084	0.92	Twin block versus Forsus	0.63	0.96
Forsus	19	77.63	7.59			Twin block versus BSSO	0.89	0.92
BSSO	19	77.37	6.77			Forsus versus BSSO	0.26	0.99

*Statistical significance set at 0.05. *n*: Number of samples; SD: Standard deviation; BSSO: Bilateral sagittal split osteotomy; SN: Sella-nasion; OPT: Odontoid process tangent; PP: Palatal plane; CVT: Cervical vertebral tangent; ANOVA: Analysis of variance

Table 5: Comparison of different cephalometric readings between twin block, Forsus and bilateral sagittal split osteotomy treatment groups after treatment

	ANOVA					Tukey's *Post hoc*		
	n	Mean	SD	*F*	*P*	Multiple comparisons	Mean difference	*P*
Sagittal								
SNA								
Twin block	19	83.05	2.93	5.131	0.009*	Twin block versus Forsus	2.74	0.007*
Forsus	19	80.32	2.85			Twin block versus BSSO	1.05	0.45
BSSO	19	82.00	2.11			Forsus versus BSSO	−1.68	0.13
SNB								
Twin block	19	80.79	2.82	4.383	0.017*	Twin block versus Forsus	2.63	0.013*
Forsus	19	78.16	2.79			Twin block versus BSSO	1.42	0.26
BSSO	19	79.37	2.61			Forsus versus BSSO	−1.21	0.37
ANB								
Twin block	19	2.32	0.58	3.931	0.025*	Twin block versus Forsus	0.21	0.51
Forsus	19	2.11	0.32			Twin block versus BSSO	−0.32	0.23
BSSO	19	2.63	0.76			Forsus versus BSSO	−0.53	0.02*
Vertical								
SN-Go-Gn								
Twin block	19	30.11	3.74	1.955	0.151	Twin block versus Forsus	−0.53	0.87
Forsus	19	30.63	2.45			Twin block versus BSSO	−2.00	0.15
BSSO	19	32.11	3.36			Forsus versus BSSO	−1.47	0.35
Cervical								
Upper cervical posture								
SN-OPT								
Twin block	19	96.53	6.68	0.345	0.71	Twin block versus Forsus	0.05	1.00
Forsus	19	96.47	8.44			Twin block versus BSSO	−1.63	0.76
BSSO	19	98.16	5.96			Forsus versus BSSO	−1.68	0.75
PP-OPT								
Twin block	19	91.58	4.98	0.335	0.717	Twin block versus Forsus	1.47	0.82
Forsus	19	90.11	10.38			Twin block versus BSSO	−0.47	0.98
BSSO	19	92.05	6.54			Forsus versus BSSO	−1.95	0.71
MP-OPT								
Twin block	19	77.11	9.39	0.956	0.391	Twin block versus Forsus	−0.32	1.00
Forsus	19	77.42	12.36			Twin block versus BSSO	3.89	0.49
BSSO	19	73.21	9.32			Forsus versus BSSO	4.21	0.43
Middle cervical posture								
OPT-CVT								
Twin block	19	10.58	2.29	3.529	0.036*	Twin block versus Forsus	1.89	0.029*
Forsus	19	8.68	1.86			Twin block versus BSSO	−1.16	0.25
BSSO	19	9.84	2.46			Forsus versus BSSO	0.74	0.57
SN-CVT								
Twin block	19	105.47	6.39	0.745	0.48	Twin block versus Forsus	−0.26	0.99
Forsus	19	105.74	3.49			Twin block versus BSSO	−2.26	0.51
BSSO	19	107.74	8.01			Forsus versus BSSO	−2.00	0.59
PP-CVT								
Twin block	19	100.68	4.07	0.956	0.391	Twin block versus Forsus	2.16	0.58
Forsus	19	98.53	6.69			Twin block versus BSSO	−0.68	0.95
BSSO	19	101.37	8.36			Forsus versus BSSO	−2.84	0.39
MP-CVT								
Twin block	19	84.26	5.58	0.484	0.619	Twin block versus Forsus	1.26	0.84
Forsus	19	83.00	7.33			Twin block versus BSSO	2.21	0.59
BSSO	19	82.05	7.74			Forsus versus BSSO	0.95	0.91

*Statistical significance set at 0.05. *n*: Number of samples; SD: Standard deviation; BSSO: Bilateral sagittal split osteotomy; SN: Sella-nasion; OPT: Odontoid process tangent; PP: Palatal plane; CVT: Cervical vertebral tangent; ANOVA: Analysis of variance

BSSO procedure in addition to the improvement achieved in the sagittal relation as there is a significant difference existed between the pretreatment and posttreatment angular measurements within the three groups.

Comparison of mean changes in angular measurements among the three groups showed a significant difference in SNA, SNB, ANB, and OPT-CVT, indicating a change in the cervical posture indicating more uprighting of cervical spine posture in subjects using twin block appliance than the other two treatment modalities. While comparison among the three groups the significant difference in the OPT-CVT angle in twin block subjects indicates that there is more of improvement in the middle segment of the cervical column in these subjects, suggesting that the advancing of the mandible seems to influence the increase in cervical curvature angle because of the backward inclination of the middle segment of the cervical column in twin block group as the appliance is prescribed during the phase of growth modulation, it utilizes the surrounding neuromuscular forces to bring about orthopedic and orthodontic changes thereby causing mandibular displacement and repositions the mandible in a forward position allowing the muscles to stretch and thereby influencing the position of the cervical vertebrae as described by the Quadrant theorem of Guzay contribute to more skeletal effects unlike in Forsus where there is more of dental effect than skeletal effects, whereas in BSSO there is no growth alteration it is just surgical reposition of the mandible in the correction of class II Division 1 patients. Compared to Forsus and BSSO treatment modalities, twin block treatment provides more physiological changes where the occlusal forces are transmitted through the dentition, which provides a constant proprioceptive stimulus to influence the growth rate.

Limitations

The limitation of this study was that only a 2-dimensional view of a 3-dimensional object could be obtained in a lateral cephalogram. Hence, a 3-dimensional study like CBCT would have given more accurate results than the lateral cephalogram; the samples in this study were not randomized, and which are generally accepted as the best possible trial design when addressing therapeutic effects and the Examination was made only on the sagittal plane, rotational or sideways components of the cervical spine changes are still unknown.

Scope of further studies

Further studies in the same field can be done to assess the effect of these treatment options in patients with cervical spine deformities; studies can be conducted to assess the changes in the cervical spine posture in rotational and sideways components, and long-term follow-up studies can be conducted to assess the stability of the changes acquired with different treatment options.

Conclusion

The study compared and evaluated the cervical spine postural changes in Class II division I patients who underwent orthodontic treatment under different treatment modalities such as Twin Block, Forsus, and BSSO.

The conclusion of the study can be put forth as follows. There is a significant difference in the upper and middle cervical posture between the pretreatment and post-treatment in all three groups. The decrease in the SN-OPT angle in the posttreatment, when compared to pretreatment, shows an uprighting and development of natural curvature of the spine with an improvement in the mandibular length. When comparing the three groups using Tukey's *post hoc* test, it showed that Twin Block shows a statistically significant difference when compared to the other two groups as it improves the middle cervical spine posture in addition to the improvement in the sagittal relationship between the maxilla and mandible when compared to the Forsus and BSSO group. The twin block causes the craniocervical posture to be more upright when compared to Forsus and BSSO group.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. D'Attilio M, Caputi S, Epifania E, Festa F, Tecco S. Evaluation of cervical posture of children in skeletal class I, II, and III. Cranio 2005;23:219-28.
2. Ohnmeiß M, Kinzinger G, Wesselbaum J, Korbmacher-Steiner HM. Therapeutic effects of functional orthodontic appliances on cervical spine posture: A retrospective cephalometric study. Head Face Med 2014;10:7.
3. Tecco S, Festa F. Cervical spine curvature and craniofacial morphology in an adult Caucasian group: A multiple regression analysis. Eur J Orthod 2007;29:204-9.
4. Tauheed S, Shaikh A, Fida M. Cervical posture and skeletal malocclusions – Is there a link? J Coll Med Sci Nepal 2019;15:5-9.
5. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. 5th ed. St Louis. Mo: Mosby Elsevier; 2007.
6. Kamal AT, Fida M. Evaluation of cervical spine posture after functional therapy with twin-block appliances: A retrospective cohort study. Am J Orthod Dentofacial Orthop 2019;155:656-61.
7. Bishara SE, Ziaja RR. Functional appliances: A review. Am J Orthod Dentofacial Orthop 1989;95:250-8.
8. Gill D, Sharma A, Naini F, Jones S. The twin block appliance for the correction of Class II malocclusion. Dent Update 2005;32:158-68.
9. Vogt W. The Forsus Fatigue Resistant Device. J Clin Orthod. 2006;40:368-77.
10. Sandoval C, Díaz A, Manríquez G. Relationship between craniocervical posture and skeletal class: A statistical multivariate approach for studying class II and class III malocclusions. Cranio

2021;39:133-40.
11. Aglarci C. Evaluation of cervical spine posture after functional therapy with twin-block appliances. J Orthod Res 2016;4:8.
12. Hosseinzadeh Nik T, Janbaz Aciyabar P. The relationship between cervical column curvature and sagittal position of the jaws: Using a new method for evaluating curvature. Iran J Radiol 2011;8:161-6.
13. Smailienė D, Intienė A, Dobradziejutė I, Kušleika G. Effect of treatment with twin-block appliances on body posture in class II malocclusion subjects: A prospective clinical study. Med Sci Monit 2017;23:343-52.
14. Tecco S, Farronato G, Salini V, Di Meo S, Filippi MR, Festa F, *et al.* Evaluation of cervical spine posture after functional therapy with FR-2: A longitudinal study. Cranio 2005;23:53-66.