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The Impact of Twin-Block Therapy When Using the Appliance on the Measurements of the Upper Airway

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ABSTRACT

Background: The aim of this study was to evaluate the effect of twin-block appliance therapy on the dimensions of the upper airway.
Methods: The study involved 16 subjects (five girls and 11 boys) with skeletal Class II malocclusion and retrognathic mandible, who underwent twin-block therapy during or shortly after the pubertal growth peak between 2021 and 2024. Lateral cephalograms were analyzed before and after therapy for each participant using AudaxCeph and Facad software, employing Zagreb 82 MOD for classical cephalometric analysis and airway (McNamara) analysis for airway dimensions. Seventeen variables were measured in the classical analysis, and six in the airway one.
Main findings: Paired t-tests showed statistically significant increases in SNB ($p < 0.001$) and Ls:E ($p = 0.01$), and significant decreases in ANB ($p = 0.04$), Wits ($p < 0.001$), and ANPG ($p = 0.02$). Variables measured in the airway dimension analysis did not exhibit statistically significant changes after the twin-block therapy.
Principal conclusion: Twin-block therapy induced changes in skeletal and soft tissue cephalometric characteristics. An increase in the SNB angle and reductions in ANB and Wits values decreased the skeletal discrepancy between the maxilla and mandible. The reduction in the convexity angle (ANPG) suggests an improvement in the skeletal facial profile. Additionally, the increase in the distance between the upper lip and the E-line contributed to enhanced aesthetic profile features. Variables related to airway dimensions did not reveal significant changes.

Key words: airway, functional appliances, Class II, lateral cephalogram, orthodontics, twin block

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INTRODUCTION

Skeletal Class II is one of the most common orthodontic anomalies, characterized by an imbalance in the position of the upper and lower jaws. It may result from maxillary prognathism, mandibular retrognathism, or a combination of both. Key clinical features include a convex facial profile, incompetent lips, and a deep mentolabial fold. Dental characteristics often include an overjet greater than 6 mm, increased overjet, and a Class II relationship between the first molars and canines, protrusion of the upper incisors, deep bite, or crossbite. Additionally, open or deep bites, adenoid vegetations, and tonsillar hypertrophy, as well as functional disorders such as oral breathing and infantile swallowing, may be present (1–3). Severe mandibular deficiency can reduce upper airway dimensions, leading to breathing problems like snoring and obstructive sleep apnea (4). In some cases, dental compensation of Class II may occur, manifested by protrusion of the lower incisors and decreased overjet (5).

Epidemiological data indicate that skeletal Class II affects approximately 15%–20% of the population, with a higher prevalence among Caucasians (6). In general dental practice, patients with Class II malocclusion comprise approximately one third of those requiring orthodontic treatment (2). Etiologically, besides significant hereditary factors, developmental disturbances, trauma, and habits such as oral breathing or thumb sucking are important (6).

Diagnosis of Class II relies on detailed anamnesis and clinical examination, with radiological imaging – particularly lateral cephalograms – playing a crucial role in analyzing skeletal, dental, and soft tissue features in sagittal and vertical dimensions. In addition to these diagnostic procedures, study models (analog or digital) are used for gnathometric analysis and the fabrication of removable or fixed orthodontic appliances (7).

One effective treatment for this anomaly is the twin-block functional appliance, which comprises upper and lower plates that guide the mandible forward during peak pubertal growth (7). Twin-block therapy consists of an active phase lasting six to nine months and a supportive phase of an additional three to six months. The active phase primarily aims at sagittal correction of the maxilla-mandibular relationship, with secondary vertical correction of deep bite or reduced overjet. The goal of the supportive phase is to maintain the established anterior dental relationships and stabilize this relationship with complete posterior occlusion. After the main therapy, retention for six to nine months is recommended. The ultimate goal is to stimulate mandibular growth, reduce the existing discrepancy between the jaws, and improve aesthetics and function (8).

PARTICIPANTS AND METHODS

Participants

Initially, this retrospective study planned to include 22 participants in the pubertal growth peak phase or shortly after (cervical vertebral stages 3 and 4) who underwent twin-block therapy from 2021 to 2024. By the time of writing and publishing, five patients had not completed therapy, and one had dropped out. All parents/guardians provided informed consent for therapy and authorized the use of medical documentation for research purposes. Ultimately, 16 participants (five girls and 11 boys) treated with functional appliances at the orthodontic clinic, part of the Dental Medicine Department at KBC Rijeka, were included. The median age at therapy start was 12.6 years, and at therapy end, 14.0 years. The therapy duration averaged 1.4 years. Both 2D radiographs and their precise analysis were considered.

Inclusion criteria: participants of both sexes with skeletal Class II, retrognathic mandible, overjet >6 mm, ANB angle >2.5°, Wits >2.5 mm, Class II relationship of first molars and canines, and first-time orthodontic patients. Additionally, they needed to have lateral cephalograms taken before and after therapy.

Exclusion criteria: hypodontia, as well as temporomandibular joint diseases, obstructive airway disorders, craniofacial syndromes,

congenital malformations, severe facial asymmetries, or systemic diseases affecting facial morphology.

Methods

Cephalometric analysis

Sixteen lateral cephalograms from patients before and after twin-block therapy were analyzed. Each cephalogram was obtained using the same device at the Department of Dental Medicine, KBC Rijeka. A single researcher performed the analysis with AudaxCeph software (Ljubljana, Slovenia) for classical cephalometry, and Facad software (Ilexis AB, Linköping, Sweden) for airway analysis. The Zagreb 82 method, with additional measurements of the mandibular and condylar angles, was utilized for classical analysis, while the McNamara airway analysis was employed for airway dimensions. Calibration was performed before each measurement. The reference landmarks for classical cephalometry are shown in Figure 1. Thirteen parameters were defined and listed in Table 1.

For airway analysis (McNamara), the reference points and lines are listed in Table 2 and shown in Figure 2.

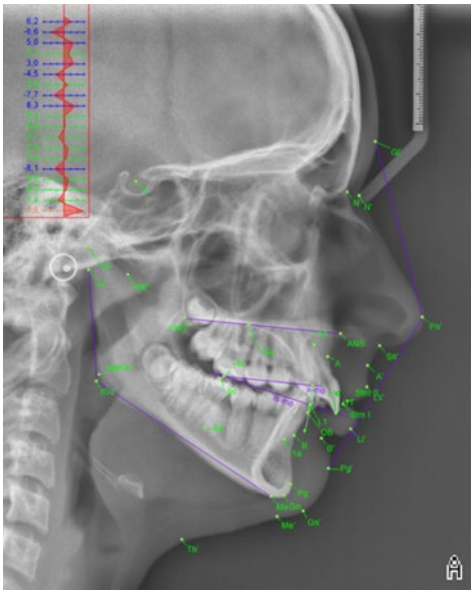

Figure 1. Reference cephalometric points used in the Zagreb 82 cephalometric analysis.

Table 1. Variables measured in the Zagreb 82 cephalometric analysis

Variable	Meaning
SNA	Sagittal position of the maxilla relative to the anterior cranial base
SNB	Sagittal position of the mandible relative to the anterior cranial base
ANB	Sagittal relationship between mandible and maxilla
Wits	Linear measurement of skeletal class
ANPG	Angle of facial skeletal convexity
SN:NL	Relationship between cranial base and nasal line
IntermaxAngle	Intermaxillary angle
SArGo	Articular angle
MeGoAr	Mandibular angle
Bjork	Bjork polygon
NSGn	Y angle
sn:gogn	Angle between cranial base and mandibular plane
CondylAngle	Condylar angle
U1Mx1	Inclination of upper incisors to maxillary skeletal base
L1Md1	Inclination of lower incisors to mandibular skeletal base
Ls:E1	Distance from upper lip to Ricketts' E-line
Li:E1	Distance from lower lip to Ricketts' E-line

Statistical analysis

For the statistical analysis, the Statistical Package for the Social Sciences (SPSS; version 26.0, IBM Corporation, Armonk, New York, USA) software was used. The comparison of 17 cephalometric characteristics and six parameters of the airway before and after treatment was performed with a paired t-test, with the significance level set at $p < 0.05$. The correlation between variables was determined utilizing Pearson's correlation coefficient.

Table 2. Defined points and lines used for measuring the dimensions of the upper airway

Points and lines	Meaning
S	Sella turcica
Ba	Point at the inferior part of the occipital bone
PNS	Spina nasalis posterior
H	Point on the posterior edge of the foramen magnum
AD2	Adenoid upper point
AD1	Adenoid lower point
SPs	Upper soft palate dorsum
PPW-s	Posterior pharynx wall, superior point
APW-mand	Anterior pharynx wall, at mandible
PPW-i	Posterior pharynx wall, inferior point
SBa line	Line defined by points S and Ba
BaPNS line	Line defined by points Ba and PNS
SBa line | PNS	Line perpendicular to the SBa line passing through PNS

Table 3. Variables measured in the airway dimension analysis (airway – McNamara)

Variables	Meaning
Upper airway	Distance between points AD2 and PNS
Upper adenoid	Distance between points H and AD2
Lower airway	Distance between points AD1 and PNS
Lower adenoid	Distance between points Ba and AD1
Upper pharynx	Minimum distance between point SPs and the nearest point on the posterior pharyngeal wall (PPW-s)
Lower pharynx	Minimum distance between point APW-mand and the nearest point on the posterior pharyngeal wall (PPW-i)

Descriptive statistics, including mean values and standard deviations (SDs), were used to describe the basic characteristics of the samples. The reliability of measurements was assessed utilizing the intraclass correlation coefficient (ICC) to ensure measurement consistency and accuracy. The normality of the distribution of measured variables was tested with the Kolmogorov-Smirnov test.

In measuring the dimensions of the upper airway, six variables were used: upper and lower airway, upper and lower adenoids, and the upper and lower pharynx. Table 3 presents these parameters and their meaning

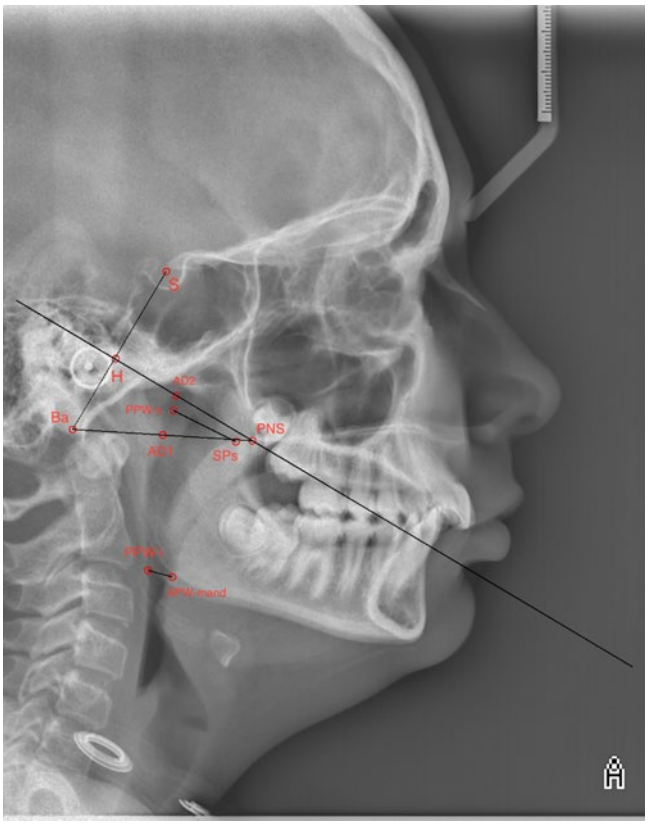

Figure 2. Placement of the defined points and lines used in measuring the dimensions of the airways.

RESULTS

The Kolmogorov-Smirnov normality test indicated that all measured variables were normally distributed ($p > 0.05$).

Using the ICC, high reliability was established for all measured variables (ICC > 0.9), except for the upper adenoid, where the reliability was good (ICC = 0.856). The measurement reliability test was performed by repeated measurements of all variables on 10 randomly selected lateral cephalograms from the main sample, before and after therapy, with measurements repeated seven days after the initial measurements by the same examiner.

Standard statistical values, such as mean values for classical cephalometric analysis and for

airway dimension analysis, are visible in the descriptive statistics in Tables 4 and 5.

The Pearson correlation coefficient shows a high statistically significant correlation ($p < 0.05$) between all pairs of variables in the classical cephalometric analysis before and after therapy, except for the variables Ls:E1 and Ls:E2 ($p = 0.775$) and Li:E1 and Li:E2 ($p = 0.759$), which did not demonstrate significant correlation before and after therapy.

The same analysis for variables measured in the airway analysis revealed that all pairs of variables were statistically significantly correlated ($p < 0.05$), except for the lower adenoid ($p = 0.076$) and the lower pharynx ($p = 0.298$).

There is a statistically significant difference in the results of the paired t-test for the SNB angle, with the first measurement (mean = 77.15, SD = 3.26) and the second measurement (mean = 78.57, SD = 3.07); $t(15) = -4.39$, $p < 0.001$.

A statistically significant difference was also observed for the ANB angle between the first (mean = 4.60, SD = 1.70) and second measurements (mean = 3.95, SD = 1.51); $t(15) = -2.30$, $p = 0.04$.

Similarly, a significant difference was found in Wits measurement: first (mean = 2.67, SD = 2.63) vs. second (mean = 1.21, SD = 3.02); $t(15) = 3.49$, $p < 0.001$.

The ANPG angle also showed a significant change: first (mean = 7.26, SD = 4.34) vs. second (mean = 5.76, SD = 3.61); $t(15) = 2.69$, $p = 0.02$.

The Ls:E value significantly increased from first (mean = 1.37, SD = 0.99) to second measurement (mean = 3.48, SD = 2.57); $t(15) = -3.14$, $p = 0.01$.

In conclusion, according to the paired t-test results for the classical cephalometric variables, as seen in Table 6, SNB ($p < 0.001$) and Ls:E ($p = 0.01$) significantly increased, while variables such as ANB ($p = 0.04$), Wits ($p < 0.001$), and ANPG ($p = 0.02$) significantly decreased. Other variables did not change significantly.

Variables measured in the airway dimension analysis did not show statistically significant changes after twin-block therapy, as depicted in Table 7.

Table 4. Standard statistical values for classical cephalometric analysis

	AS	N	SD	AS SD
SNA1	81.742	16	4.1344	1.0336
SNA2	82.521	16	4.1355	1.0339
SNB1	77.146	16	3.2600	0.8150
SNB2	78.570	16	3.0690	0.7673
ANB1	4.596	16	1.7019	0.4255
ANB2	3.951	16	1.5108	0.3777
Wits1	2.673	16	2.6258	0.6564
Wits2	1.211	16	3.0242	0.7560
ANPG1	7.258	16	4.3401	1.0850
ANPG2	5.757	16	3.6101	0.9025
SN:NL1	9.329	16	3.1916	0.7979
SN:NL2	9.604	16	3.1773	0.7943
MxMdKut1	19.230	16	5.5160	1.3790
MxMdKut2	18.091	16	5.5143	1.3786
SArGo1	144.211	16	6.7586	1.6896
SArGo2	144.108	16	6.1374	1.5344
MeGoAr1	120.568	16	7.6255	1.9064
MeGoAr2	120.072	16	6.6394	1.6599
Bjork1	388.559	16	5.9751	1.4938
Bjork2	387.695	16	5.7002	1.4250
NSGn1	65.168	16	4.5575	1.1394
NSGn2	65.033	16	4.5225	1.1306
sn:gogn1	25.898	16	5.9039	1.4760
sn:gogn2	25.247	16	5.5244	1.3811
CoGoMe1	117.953	16	7.7576	1.9394
CoGoMe2	118.018	16	6.6420	1.6605
U1Mx1	113.568	16	7.9240	1.9810
U1Mx2	113.540	16	4.9960	1.2490
L1Md1	98.277	16	7.8657	1.9664
L1Md2	100.275	16	5.4708	1.3677
Ls:E1	1.373	16	0.9932	0.2483
Ls:E2	3.481	16	2.5721	0.6430
Li:E1	1.744	16	1.4363	0.3591
Li:E2	2.647	16	1.8881	0.4720

Table 5. Descriptive statistics of measured variables in airway analysis before (1) and after (2) therapy

	$\bar{X}$	SD	Mean of Std
Upper airway 1	16.32	3.52	0.88
Upper airway 2	17.62	3.93	0.98
Upper adenoid 1	11.89	3.83	0.96
Upper adenoid 2	11.59	3.33	0.83
Lower airway 1	21.44	4.14	1.04
Lower airway 2	21.61	4.04	1.01
Lower adenoid 1	24.35	3.48	0.87
Lower adenoid 2	24.51	4.66	1.16
Upper pharynx 1	11.73	4.38	1.09
Upper pharynx 2	12.14	3.27	0.82
Lower pharynx 1	11.21	2.77	0.69
Lower pharynx 2	10.20	2.64	0.66

*Std – standard deviation

Table 6. Results of the paired t-test for variables from the classical cephalometric analysis

	Differences in paired samples			
	$\bar{X}$	SD	t	p
SNA1-SNA2	-0.78	1.56	2.00	0.06
SNB1-SNB2	-1.42	1.30	4.39	0.00
ANB1-ANB2	0.64	1.12	2.30	0.04
Wits1-Wits2	1.46	1.68	3.49	0.00
ANPG1-ANPG2	1.50	2.23	2.69	0.02
SN:NL1-SN:NL2	-0.27	2.02	0.54	0.59
IntrmxAng1-IntrmxAng2	1.14	2.70	1.69	0.11
SArGo1-SArGo2	0.10	3.38	0.12	0.90
MeGoAr1-MeGoAr2	0.50	5.76	0.34	0.74
Bjork1-Bjork2	0.86	3.25	1.07	0.30
NSGn1-NSGn2	0.13	1.35	0.40	0.70
sn:gogn1-sn:gogn2	0.65	3.04	0.86	0.40
CondylAngle1-CondylAngle2	-0.06	5.97	0.04	0.97
U1Mx1-U1Mx2	0.03	5.13	0.02	0.98
L1Md1-L1Md2	-2.00	4.84	1.65	0.12
Ls:E1-Ls:E2	-2.11	2.68	3.14	0.01
Li:E1-Li:E2	-0.90	2.28	1.59	0.13

Table 7. Results of the paired t-test for variables from the airway analysis

	$\bar{X}$	SD	t	p
Upper airway1-Upper airway2	-1.30	2.57	-2.03	0.06
Upper adenoid1-Upper adenoid2	0.29	2.27	0.52	0.61
Lower airway1-Lower airway2	-0.17	4.05	-0.17	0.87
Lower adenoid1-Lower adenoid2	-0.16	4.36	-0.14	0.89
Upper pharynx1-Upper pharynx2	-0.41	2.99	-0.54	0.59
Lower pharynx1-Lower pharynx2	1.01	3.25	1.24	0.23

*ss – sample size

DISCUSSION

In this study, the effects of twin-block appliance therapy on cephalometric variables in patients with Class II malocclusion were analyzed. The results of the paired t-test showed significant increases in the SNB and Ls:E variables, while variables such as ANB, Wits, and ANPG demonstrated significant decreases. Other variables did not exhibit major changes. These findings suggest that twin-block therapy effectively influenced certain skeletal and soft tissue parameters.

Comparing these results with previous research reveals some similarities and differences. The increase in the SNB angle after twin-block therapy aligns with findings from works such as Çoban Büyükbayraktar and Camcı (2023), Ghodke et al. (2014), and Jena et al. (2013), indicating a sagittal forward movement of the mandible, which reduces the skeletal discrepancy between the mandible and maxilla (9–11). Vertical cephalometric parameters did not change significantly post-therapy and, as such, did not affect masking or highlighting sagittal changes. The distance from the reference point of the upper lip (Ls) and Ricketts' aesthetic line (Ls:E) increased significantly, contributing to an improved profile appearance and reduced upper lip protrusion. Most others support a statistically

significant increase in the Ls:E distance, such as those by Varlik et al. (2008), Khoja et al. (2016), and Baysal and Uysal (2013) (12–15). All these studies utilized control groups, which further reinforces their findings.

Conversely, some present contradictory results – for example, Luo and Fang (2005) conducted measurements similarly but did not observe statistically significant changes in the Ls:E distance (16). Additionally, a systematic review by Flores-Mir and Major (2006) concluded that two-dimensional measurement methods, such as lateral cephalograms, are not optimal for evaluating soft tissue, which may explain the conflicting results (17).

The statistically significant reduction in the skeletal class angle (ANB) and Wits appraisal as linear measures of class contribute to decreasing the discrepancy between the upper and lower jaws, bringing their relationship closer to Class I. The increase in the SNB angle, indicating a sagittal forward shift of the mandible, appears to be the primary cause of the reduction in skeletal class. Supporting this, the mean SNA angle (maxillary prognathism) increased after twin-block therapy, implying no inhibition of maxillary growth. Similar findings are reported by Vinoth et al. (2013), who observed significant changes such as increased SNB and decreased ANB angles, with a reduction in the mean SNA angle post-treatment, though not statistically significant (18). In Çoban Büyükbayraktar and Camcı's work (2023), in addition to decreased ANB and increased SNB, there was a significant reduction in SNA, which might suggest minimal yet significant maxillary growth inhibition (10). The significant decrease in Wits measurement aligns with other studies' results (30).

A significant reduction in the convexity angle of the skeletal facial profile (ANPG) was observed, supporting a decrease in facial convexity. The literature review reveals some discrepancies: some studies report a significant decrease, while others suggest an increase in the convexity angle (10, 19).

Although no statistically significant changes were observed in the inclination of the upper and lower incisors relative to the maxillary and mandibular bases, a tendency toward retrusion of the upper incisors and protrusion of the lower incisors was noted, indicating that twin-block therapy also affects the dentoalveolar level. Most research in this review confirms statistically significant dental changes, supporting this conclusion (15).

Variables measuring airway dimensions did not show significant differences after therapy. Çoban Büyükbayraktar and Camcı (2023) measured three variables (upper and lower adenoids and lower airway) on 18 lateral cephalograms, and found no significant changes post-treatment with the same appliance (10). Conversely, Vinoth et al. (2013) reported a statistically significant increase in the dimension of the lower pharynx, along with increases in the upper pharyngeal width and bony part of the nasal pharynx, although these results are not directly comparable due to different measurement reference points (18). Verma et al. observed significant increases in upper pharyngeal dimensions after twin-block therapy across all three experimental groups, with no change in the lower pharynx (20). A systematic review by Kannan et al. supports the view that many previous studies are contradictory and that further research is needed to evaluate the impact of twin-block therapy on airway parameters (4).

One limitation of this study is the lack of a control group, which prevents definitive conclusions about whether observed changes are solely due to the functional appliance or also involve growth and developmental factors.

Additionally, the use of lateral cephalograms is limited because it cannot detect transverse dimension changes or airway shape in cross-section. While cone-beam computed tomography (CBCT) imaging offers volumetric and detailed structural analysis, it involves higher radiation exposure. Future works should consider evaluating the most effective functional appliances with dynamic magnetic resonance imaging (MRI), which allows for

analysis of airway dynamics during different phases of respiration. Although CBCT provides volumetric and skeletal data, MRI is considered superior for airway assessment due to better soft tissue and volumetric visualization during breathing phases (4).

Further research should also investigate the long-term effects of functional appliance therapy to provide a more comprehensive understanding of its influence on cephalometric parameters over time.

CONCLUSION

In this study, the twin-block appliance reduced skeletal discrepancy between the maxilla and mandible. A statistically significant increase in the mandibular prognathism angle resulted in a more favorable anterior position of the mandible relative to the maxilla. Angular and linear values defining skeletal class (ANB and Wits) contributed to a significant reduction of Class II malocclusion. No significant influence on the maxilla was observed. The significant increase in the upper lip distance and Ricketts' aesthetic line (Ls:E) demonstrates the appliance's effect on soft tissues and contributes to a more harmonious facial appearance. Cephalometric analysis did not show an impact on sagittal airway dimensions.

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CONFLICT OF INTEREST

None to declare.

AUTHORS' CONTRIBUTIONS

VK conceived and designed the study; AS, SC, and DŠP collected the data; AS and SC analyzed the data; VK and DŠP interpreted the results; AS and DŠP prepared the figures; AS drafted the manuscript; VK and DŠP edited and revised the manuscript; VK approved the final version of the manuscript.

ETHICAL BACKGROUND

Institutional review board statement: The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the Faculty of Dental Medicine, University of Rijeka (protocol code 12-23, June 19, 2023), as well as by the Ethics Committee of the Clinical Hospital Center Rijeka (December 22, 2022).

Informed consent statement: Written informed consent was obtained from all participants included in the study.

Data availability statement: The datasets generated and analyzed during the current study are not publicly available as the research is ongoing and includes identifiable information. Data access requests may be directed to visnja.katic@fdmri.uniri.hr.

REFERENCES

1. Guo R, Tian Y, Li X, Li W, He D, Sun Y. Facial profile evaluation and prediction of skeletal class II patients during camouflage extraction treatment: a pilot study. Head Face Med. 2023;19(1).
2. Lone IM, Zohud O, Midlej K, Proff P, Watted N, Iraqi FA. Skeletal Class II malocclusion: from clinical treatment strategies to the roadmap in identifying the genetic bases of development in humans with the support of the collaborative cross mouse population. J Clin Med. 2023;12(15).
3. Bittencourt Neto AC, Saga AY, Pacheco AAR, Tanaka O. Therapeutic approach to Class II, division 1 malocclusion with maxillary functional orthopedics. Dental Press J Orthod. 2015;20(4):99-125.
4. Kannan A, Sathyanarayana H, Padmanabhan S. Effect of functional appliances on the airway dimensions in patients with skeletal class II malocclusion: a systematic review. J Orthod Sci. 2017;6:54-64.
5. Kim JE, Mah SJ, Kim TW, Kim SJ, Park KH, Kang YG. Predictors of favorable soft tissue profile outcomes following Class II twin-block treatment. Korean J Orthod. 2018;48(1):11-22.
6. Proffit WR, Sarver HWFDM. Contemporary orthodontics. Eur J Orthod. 2014;35.
7. Rischen RJ, Breuning KH, Bronkhorst EM, Kuijpers-Jagtman AM. Records needed for orthodontic diagnosis and treatment planning: a systematic review. PLoS One. 2013;8(11).
8. Pinheiro F. Twin block functional therapy: applications in dentofacial orthopedics. Am J Orthod Dentofacial Orthop. 2015;147(5).
9. Jena AK, Singh SP, Utreja AK. Effectiveness of twin-block and Mandibular Protraction Appliance-IV in the improvement of pharyngeal airway passage dimensions in Class II malocclusion subjects with a retrognathic mandible. Angle Orthod. 2013;83(4):728-34.
10. Çoban Büyükbayraktar Z, Camcı H. Dentoalveolar, skeletal, pharyngeal airway, cervical posture, hyoid bone position, and soft palate changes with Myobrace and twin-block: a retrospective study. BMC Oral Health. 2023;23(1).
11. Ghodke S, Utreja AK, Singh SP, Jena AK. Effects of twin-block appliance on the anatomy of pharyngeal airway passage (PAP) in class II malocclusion subjects. Prog Orthod. 2014;15(1):68.

12. Varlik SK, Gultan A, Tumer N. Comparison of the effects of Twin Block and activator treatment on the soft tissue profile. Eur J Orthod. 2008;30(2):128-34.
13. Khoja A, Fida M, Shaikh A. Cephalometric evaluation of the effects of the twin block appliance in subjects with class II, division 1 malocclusion amongst different cervical vertebral maturation stages. Dental Press J Orthod. 2016;21(3):73-84.
14. Baysal A, Uysal T. Soft tissue effects of twin block and Herbst appliances in patients with Class II division 1 mandibular retrognathy. Eur J Orthod. 2013;35(1).
15. Daokar S, Sharma M. A systematic review of skeletal, Dental and soft tissue treatment effects of twin block appliance. Orthod J Nepal. 2020;10(1).
16. Luo Y, Fang G. Effect of twin-block appliance in the treatment of Class II and division I malocclusion: a cephalometric study in 12 patients. Shanghai Kou Qiang Yi Xue. 2005;14(1).
17. Flores-Mir C, Major PW. Cephalometric facial soft tissue changes with the twin block appliance in Class II division 1 malocclusion patients: A systematic review. Angle Orthod. 2006;76.
18. Vinoth S, Thomas A, Nethravathy R. Cephalomteric changes in airway dimensions with twin block therapy in growing Class II patients. J Pharm Bioallied Sci. 2013;5(5):25.
19. Har Zion G, Katzhendler E, Bader Farraj A, Rabin M, Einy S. Evaluating the effects of Carriere Motion Appliance and twin block appliances in Class II correction—a retrospective study. Dent J (Basel). 2024;12(5):119.
20. Verma G, Tandon P, Nagar A, Singh G, Singh A. Cephalometric evaluation of hyoid bone position and pharyngeal spaces following treatment with twin block appliance. J Orthod Sci. 2012;1(3):77.