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Three-Dimensional Evaluation of Soft Tissue Changes Following Twin Block Therapy in Skeletal Class II Malocclusion with Retrognathic Mandible

Hakan DAĞ[1*], Serkan GORGULU[2]
[1]Orthodontist. PhD, Private Practice, Ergazi Mah. 1839. Cd Nu.9 A Blok D:27 Ankara, Turkey
[2]Professor, Department of Orthodontics, Gulhane Faculty of Dental Medicine, University of Health Sciences, Ankara, Turkey

Abstract: ***Introduction***: This study aims to evaluate the effects of the twin-block (TB) appliance, which is used in the treatment of skeletal Class II malocclusion with retrognathic mandible, on skeletal and dental structures using cephalometric analysis and its effects on soft tissue using 3D images obtained through a topographic scanner (stereophotogrammetry). ***Methods***: In our study, a total of 23 patients who applied to Gülhane Military Medical Academy (GATA), Department of Orthodontics—15 of whom were female and eight male—with Class II skeletal malocclusion with retrognathic mandible, were included. Patients were treated with the TB appliance for 10 months. Changes in dental and skeletal structures were analyzed via cephalometric X-rays, pre-treatment (T0), and post-treatment (T1). Soft tissues were evaluated using 3D images obtained through stereophotogrammetry equipment. Data comparison was performed using the Wilcoxon Signed Ranks test. ***Results***: In the evaluation of cephalometric analyses, 0.5° reduction in the SNA angle (P<0.001), 2° increase in the SNB angle (P<0.001), 3° reduction in the ANB angle (P<0.001), 6 mm reduction in the Wits value (P<0.001), 0.3 mm reduction in the Nv-A distance (P<0.001), and 4 mm reduction in the Nv-Pog distance (P<0.001) were determined. In the measurements obtained with 3D images through stereophotogrammetry, for sagittal dimension soft tissue parameters, 3.6 mm at pogonion (Pog) (P<0.001), 3.98 mm at sulcus inferior (Si) (P<0.001), 2.1 mm at labiale inferior (Li) (P<0.001), 1.48 mm at labiale superior (P<0.039), 1.17 mm at subnasale (Sn) (P<0.001), 1.03 mm at pronasale (Prn) (P<0.001), and 2.36 mm of forward movement at nasion (N) (P<0.001) were observed. When the vertical dimension soft tissue parameters were evaluated, an increase of 4.01 mm in the lower anterior facial height (P<0.001), 1.3 mm in the upper anterior facial height (P<0.001), and 4.3 mm in the total anterior facial height was observed. When dental parameters were examined, a reduction of 5 mm (P<0.001) and 2.5 mm (P<0.001) was determined in overjet and overbite measurements, respectively. ***Conclusion***: The TB appliance, by accelerating the mandible's forward and downward growth, proved to be an effective tool in correcting Class II skeletal malocclusion with a retrognathic mandible. The positive changes in soft tissues, accurately measured using 3D images obtained through stereophotogrammetry equipment, not only contribute to our understanding of orthodontic treatments but also inspire further research and innovation in the field.

Keywords: Twin-block, Skeletal Class II, Soft Tissue, 3D Topographic Scanner, Stereophotogrammetry.

Research Paper

***Corresponding Author:**
Hakan DAĞ
Orthodontist. PhD, Private Practice, Ergazi Mah. 1839. Cd Nu.9 A Blok D:27 Ankara, Turkey

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INTRODUCTION

The TB appliance, developed by Clark, is a functional appliance used in treating Class II malocclusions [1]. It has become popular due to its compact and simple design, ease of all-day use, and quick efficiency. Researchers have focused on its skeletal effects in many studies on the TB appliance. In contrast, studies on soft tissue are fewer in number. Morris *et al.*, examined the soft tissue changes in patients treated with Bass, Bionator, and Twin-block appliances using 3D images obtained through optical surface laser scanning (OSLS) [2]. Clinically and statistically significant changes were observed in soft tissue with all three appliances, with TB showing the most effect.

McDonagh *et al*., evaluated the effects of the TB appliance using OSLS [3]. In patients treated with the TB appliance, an increase in the lower anterior facial height was observed, and the pogonion moved 3.1 mm forward. Sharma and Lee compared lateral cephalometry and OSLS with TB and mini-block appliances [4]. Facial advancement was greater in the group where the TB appliance was used, and the pogonion point moved further forward. Both appliances showed nearly identical increases in anterior facial height.

3D imaging technology has been used since the 1940s to measure complex structures. Despite the numerous methods developed to date, due to lengthy imaging times, inability to produce definitive images and economic limitations, most methods have not been adopted for daily clinical use [5]. The most recent methods for acquiring 3D images are laser, structured light, and stereophotogrammetry [5, 6]. 3D images obtained using these methods are applied in various medical fields, such as facial and dental imaging, orthognathic surgery, and maxillofacial and plastic surgeries [7].

Stereophotogrammetry, a sophisticated software technique, forms a stereo pair by taking two separate photographs of the object from a distance similar to the interpupillary distance. The stereo algorithm provides the fundamental information needed to construct surface geometry accurately. After creating the 3D model, the software applies a color palette to the model, completing the imaging process. This technique, which we used in our study, is faster, more accurate, and more comfortable for patients, and allows for the detection and quantification of changes in facial soft tissue [8, 9]. The aim of our study is to examine the effects of the TB appliance on soft tissue using 3D images obtained through stereophotogrammetry.

METHOD

The study, which included 23 individuals who applied to the Gülhane Military Medical Academy Department of Orthodontics for treatment, was conducted with meticulous attention to detail. The mean age of the participants was 12.74±1.25 years, with 15 (65.2%) being female and 8 (34.8%) male. To examine the soft tissue changes following the use of the TB appliance, 3D images obtained at T0 and T1 using stereophotogrammetry equipment were compared. Skeletal and dental structures were analyzed cephalometrically. The study was conducted with the approval of the GATA Ethics Committee (25.02.14/32), ensuring the highest ethical standards were met.

The inclusion criteria for the study participants were:

1. Having skeletal Class II malocclusion with retrognathic mandible,
2. Having a dental Class II relationship,
3. An overjet of 6 mm or more,
4. Being in the pubertal growth period based on cervical vertebra analysis on cephalometric films,
5. No previous orthodontic treatment,
6. No systemic disorders.

TB appliances used in this study were fabricated in the orthodontic laboratory. Wax bites were taken with the incisors in an edge-to-edge position. All appliances included a vestibular arch and an expansion screw. The screw was activated every 5 days until sufficient expansion was achieved. Patients were recalled monthly during treatment.

To evaluate the effects of the TB appliance on soft tissue, 3D images at T0 and T1 were obtained using stereophotogrammetry. The 3dMDflex5™ device (Figure 1) in the GATA Medical Design and Production Center was used. The system comprises five cameras, eight flashes, and a connected computer. When the software is initiated, the image is captured from five camera angles (Figure 2). The patient is seated comfortably and instructed to look at a fixed point, with the Frankfurt plane aligned as horizontally as possible. While the patient gently bites on the posterior teeth and keeps the lips lightly closed, the operator clicks the capture button to complete the process. For optimal imaging, both ears should be visible. Before capturing the image, the patient should be positioned approximately 95 cm from each modular unit and within the visual range. Measurement points were marked on the obtained 3D images, and distances were calculated using the built-in caliper function [10].

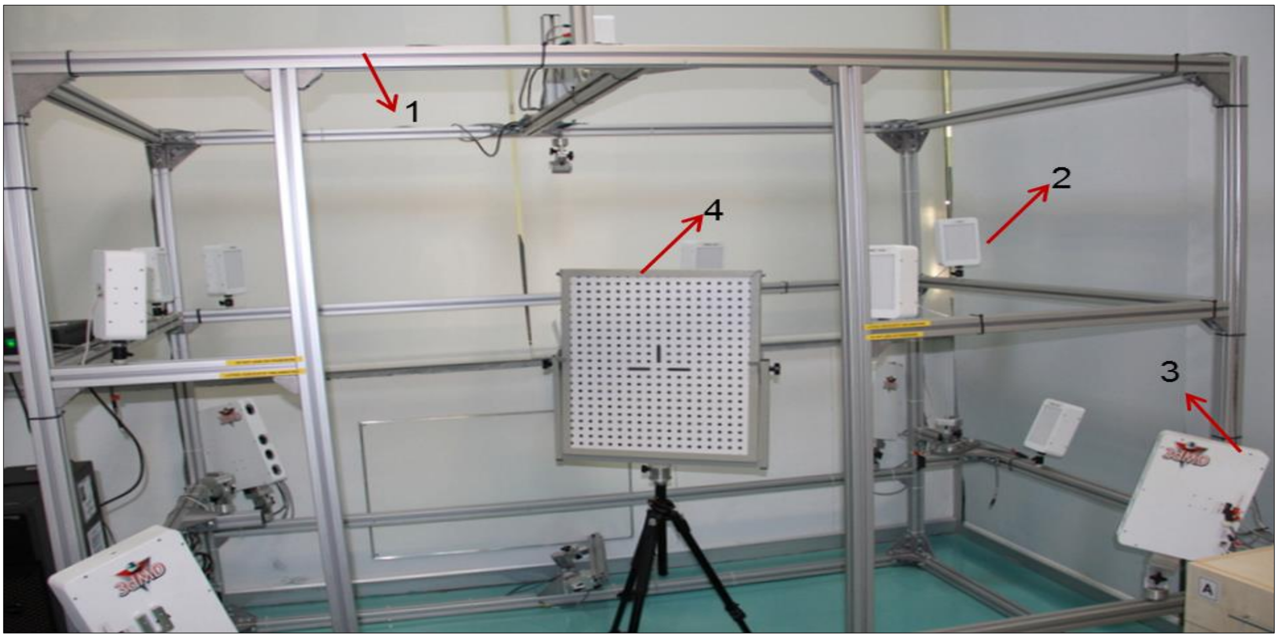

Figure 1: 1). Advanced Frame System (Robust Frame and Related Attachments and Supports) 2). External Flash 3). Modular Camera Unit 4). Calibration Kit Including Plate, Frame, and Small Tripod

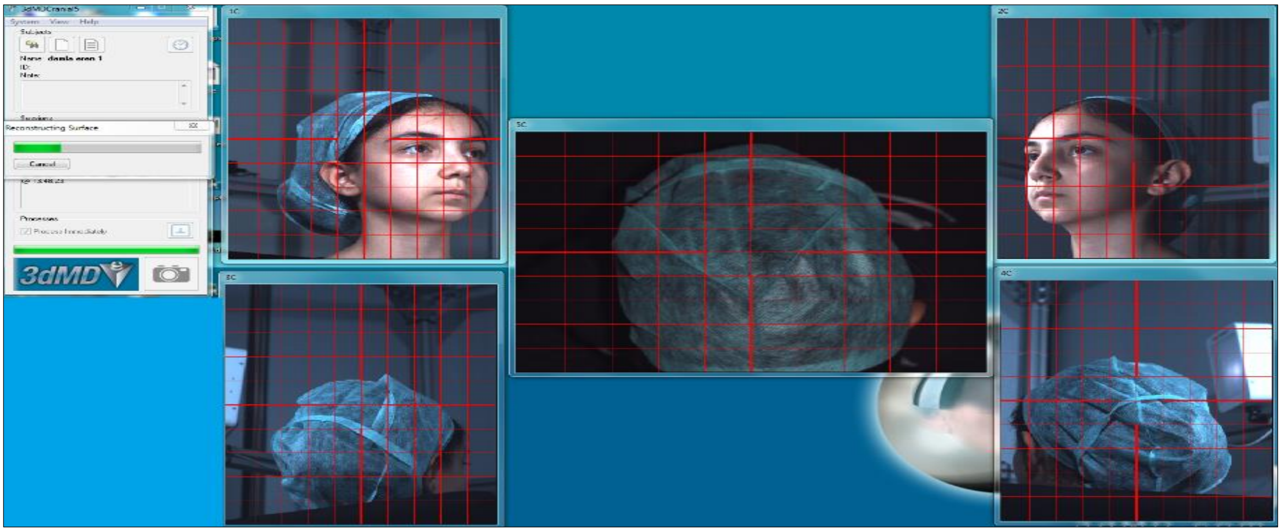

Figure 2: Display of Camera Angles on the Screen

To examine sagittal and vertical changes between T0 and T1, linear measurements between predetermined landmarks were performed (Figure 3). Sagittal changes were assessed by measuring the distances from the Tragion (Trg) to reference points, including Nasion (N), Pronasale (Prn), Subnasale (Sn), Labiale Superior (Ls), Labiale Inferior (Li), Sulcus Inferior (Si), and Pogonion (Pog). Vertical changes were evaluated with three measurements: N-Sn for upper anterior facial height, Sn-Me for lower anterior facial height, and N-Me for total anterior facial height.

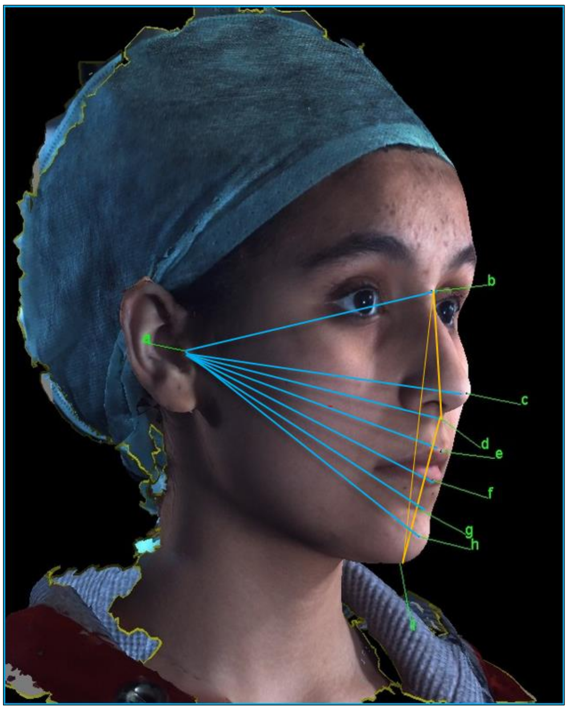

Figure 3: a). Tragion(Trg): Point located at the upper margin of the left and right tragus b). Soft tissue nasion (N): Midpoint on the soft tissue contour of the nasal root's base. c). Pronasale (Prn): Most anterior midpoint of the nasal lip d). Subnasale (Sn): Midpoint on the nasolabial soft tissue contour between the nasal columella's base and the upper lip e). Labiale superior (Ls): Midpoint of the vermilion line of the upper lip f). Labiale inferior (Li): Midpoint of the vermilion line of the lower lip g). Sulcus inferior(Si): Most posterior midpoint on the labiomental soft tissue contour defining the border between the lower lip and chin h). Soft tissue pogonion(Pog): The most anterior midpoint of the chin i). Soft tissue menton (Me): the most inferior point of the outline of the chin

To ensure accuracy, Trg-Pog and Trg-Si distances were remeasured 15 days later, and reliability was assessed using the Spearman correlation test. High consistency was observed between the initial and repeated measurements of Trg-Pog (r=0.99) and Trg-Si (r=0.99).

Several cephalometric angular and linear parameters were also analyzed to support the evaluation of 3D soft tissue data. Angular parameters included SNA, SNB, and ANB. Linear parameters included Nv-A, Nv-Pog, Wits value, overjet, and overbite.

The collected data were analyzed using SPSS 16.0 statistical software. Descriptive statistics were presented as median (min-max). Differences between measurements were compared using the Wilcoxon Signed Ranks test. P-values less than 0.05 were considered statistically significant. Measurement consistency was assessed with the Spearman correlation test.

RESULTS

The cephalometric parameters changed statistically significantly after treatment. The T0 and T1 values are presented in Table 1.

Table 1. the comparison of the patients' dental and skeletal values obtained after the use of twin-block appliance with the values of pre-treatment

Variables	T0	T1	p
SNA°	80,00(75.50-82.00)	79.50(75.00-81.00)	P<0.001
SNB°	74.00(69.00-76.00)	76.00(71.50-78.00)	P<0.001
ANB°	7.00(5.50-10.00)	4.00(2.00-5.00)	P<0.001
Wits(mm)	7.00(3.50-11.00)	1.00(-1.50-4.00)	P<0.001
Nv-A(mm)	0.00(-3.00-2.00)	-0.70(-2.50-1.00)	P<0.001
Nv-Pog(mm)	-11.00(-17.00-1.00)	-7.00(-10.00-1.00)	P<0.001
Overjet(mm)	8.00(6.00-11.00)	3.00(2.00-4.50)	P<0.001
Overbite(mm)	3.50(1.00-8.00)	1.00(-1.50-3.50)	P<0.001

The SNA value decreased from a median of 80.00° (75.50°–82.00°) at T0 to 79.50° (75.00°–81.00°) at T1 (P < 0.001). The SNB value increased from 74.00° (68.00°–76.00°) to 76.00° (71.50°–78.00°), which was statistically significant (P < 0.001). The Wits value decreased from 7.00 mm (3.50–11.00 mm) to 1.00 mm (−1.50–4.00 mm) (P < 0.001). The Nv-A distance changed from 0.00 mm (−3.00–2.00 mm) to −0.70 mm (−2.50–1.00 mm) (P < 0.001), and the Nv-Pog distance increased from −11.00 mm (−17.00–1.00 mm) to −7.00 mm (−10.00–1.00 mm), which was also statistically significant (P = 0.019).

Regarding occlusal parameters, overjet decreased significantly from 8.00 mm (6.00–11.00 mm) to 3.00 mm (2.00–4.50 mm) (P < 0.001), and overbite decreased from 3.50 mm (1.00–8.00 mm) to 1.00 mm (−1.50–3.50 mm) (P < 0.001).

Soft tissue measurements using caliper distances on 3D images also showed statistically significant changes, which were consistent with the cephalometric findings. The measurements are shown in Table 2.

In sagittal soft tissue measurements, the Trg-Pog distance increased from 126.30 mm (112.18–146.09 mm) to 129.90 mm (116.64–147.65 mm) (P < 0.001). The Trg-Si distance increased from 122.38 mm (112.12–132.23 mm) to 123.49 mm (114.00–134.77 mm) (P = 0.039). The Trg-Li distance increased from 122.45 mm (112.54–136.60 mm) to 124.60 mm (114.30–139.41 mm) (P < 0.001). The Trg-Ls distance increased from 122.51 mm (112.12–142.56 mm) to 123.99 mm (114.00–140.12 mm) (P < 0.001). The Trg-Sn distance rose from 119.42 mm (110.13–139.34 mm) to 120.59 mm (111.63–137.54 mm) (P < 0.001). The Trg-Prn distance increased from 129.37 mm (118.96–148.32 mm) to 130.40 mm (121.76–148.60 mm) (P < 0.001). The Trg-N distance increased from 116.61 mm (107.60–132.68 mm) to 118.97 mm (112.30–133.25 mm) (P < 0.001).

Table 2: The comparison of the patients' 3D soft tissue values obtained after the use of twin-block appliance with the values of pre-treatment

Variables	T0	T1	p
Trg-Pog(mm)	126.30(112.18-146.09)	129.90(116.64-147.65)	P<0.001
Trg-Si(mm)	119.00(108.90-136.29)	122.98(111.54-136.60)	P<0.001
Trg-Li(mm)	122.45(112.54-136.60)	124.60(114.30-139.41)	P<0.001
Trg-Ls(mm)	122.51(112.12-142.56)	123.99(114.00-140.12)	P<0.001
Trg-Sn(mm)	119.42(110.13-139.34)	120.59(111.63-137.54)	P<0.001
Trg-Prn(mm)	129.37(118.96-148.32)	130.40(121.76-148.60)	P<0.001
Trg-N(mm)	116.61(107.60-132.68)	118.97(112.30-133.25)	P<0.001
N-Me(mm)	106.44(96.52-119.39)	110.76(97.75-126.70)	P<0.001
N-Sn(mm)	48.32(42.83-59.20)	49.67(42.96-63.60)	P<0.001
Sn-Me(mm)	61.91(38.60-72.00)	65.92(40.91-78.43)	P<0.001

In vertical measurements, the N-Me distance increased from 106.44 mm (96.52–119.39 mm) to 110.76 mm (97.75–126.70 mm) (P < 0.001). The N-Sn distance increased from 48.32 mm (42.83–59.20 mm) to 49.67 mm (42.96–63.60 mm) (P < 0.001). The Sn-Me distance increased from 61.91 mm (38.60–72.00 mm) to 65.92 mm (40.91–78.43 mm) (P < 0.001).

Discussion

Traditionally, diagnostic assessments and evaluations of treatment outcomes in orthodontics have relied on dental casts, cephalometric films, and intraoral and extraoral photographs. However, conventional 2D imaging methods have limitations, particularly in representing 3D anatomical structures [11]. These limitations include variations in head positioning, camera angle, and the inability to capture depth, all of which may affect measurement reliability [8].

Stereophotogrammetry overcomes many of these issues by enabling the rapid acquisition of accurate 3D images without requiring patient repositioning. The method is non-invasive, reproducible, and allows for direct angular and linear measurements within its software. It also eliminates additional processing, enhancing data accuracy and reliability [8]. Unlike structured light and laser methods—which are slower and more sensitive to patient motion—stereophotogrammetry captures images simultaneously using multiple cameras within 1/250 seconds. These features support its superiority, especially in dynamic settings like orthodontic documentation [5, 8, 12].

In a systematic review by Flores-Mir and Major [13], evidence regarding facial soft tissue changes following twin-block (TB) therapy in Class II Division 1 patients was found inconclusive, primarily due to the lack of 3D imaging and methodological inconsistencies. In contrast, more recent studies using 3D imaging have demonstrated measurable improvements in the soft tissue profile after TB therapy [2, 4].

Sharma and Lee [4] reported a 4.5 mm increase in the Trg–Pog distance following TB treatment using 3D imaging. Consistently, our study observed a 3.6 mm increase. Similarly, studies using 2D methods by Quintão *et al*., [14] and Varlık *et al*., [15], reported forward movements of the pogonion by 3.24 mm and 4.58 mm, respectively.

Forward movement of the Si point has also been documented by Varlık *et al*., [15], McDonagh *et al*., [3], and Quintão *et al*., [14], with values ranging from 3.24 mm to 4.5 mm. Our findings, showing a 3.98 mm increase, align well with these results. Similarly, an increase of 2.1 mm in Trg–Li distance in our study indicates forward movement of the lower lip, which has been attributed to mandibular advancement. While our observed changes are slightly lower than those reported by Sharma and Lee (5.1 mm), Varlık *et al*., (3.2 mm), and McDonagh *et al*., (3.4 mm), this could be due to different reference points and methodologies.

The adaptive response of the upper lip to incisor retraction remains debated. Some authors reported upper lip retraction associated with incisor retraction [14-16], while others found no significant changes [2, 15, 17]. In our study, a 1.48 mm increase in Trg–Ls distance suggests a slight forward movement of the upper lip. This finding aligns with Sharma and Lee [4], who observed forward movement of the upper lip despite concurrent incisor retraction.

Regarding the Prn point, Quintão *et al*., [14], reported a non-significant forward movement of 2.57 mm. Our study found a 1.03 mm increase. We also noted forward shifts of 1.17 mm at the Sn point and 2.36 mm at the N point, consistent with expected growth during adolescence.

Vertical changes due to functional treatment remain controversial. Some studies indicate increased vertical dimensions [3, 4, 18], while others report no significant effect [19]. Sharma and Lee [4] and McDonagh *et al*., [3], reported increases of 3.2 mm and 3.6 mm in anterior facial height, respectively. Our findings exceed these values, with an increase of 4.3 mm in total anterior facial height, 1.3 mm in upper, and 4 mm in lower anterior facial height. These results may reflect differences in patient selection criteria, particularly related to initial vertical dimensions and bite block configuration.

Our skeletal findings support the soft tissue changes. A 2° increase in SNB angle and a 4 mm reduction in Nv–Pog distance reflect forward mandibular displacement, reinforcing the facial soft tissue adaptation.

The maxillary effects of functional treatment are also debated. Some studies suggest inhibition of maxillary growth [20], while others report no effect [21]. Our study showed a 0.5° decrease in SNA angle and a −0.3 mm change in Nv–A distance, supporting the hypothesis of restrained maxillary development [18, 22, 23].

Sagittal relationships, evaluated using the ANB angle and Wits appraisal, significantly improved. The ANB angle decreased by 3.0° and the Wits value by 6 mm, supporting mandibular advancement and consistent with changes in the SNB, SNA, and Nv–Pog measurements.

Post-treatment reductions in overjet (5 mm) and overbite (2.5 mm) agree with previous findings [18, 24–27]. The treatment protocol involved full-time appliance use for seven months and nighttime use for three months, totaling 10.03 ± 0.62 months. Nighttime usage was emphasized during the retention phase due to growth hormone peaks during sleep [28].

In accordance with Aelbers and Dermaut [29], our study did not analyze sex-based differences, as sex differentiation was not a criterion for treatment evaluation.

In Conclusion

- The use of the twin-block appliance resulted in significant soft tissue changes consistent with underlying skeletal modifications.
- Forward displacement of the pogonion and sella points in the sagittal plane was observed.
- Vertical dimensions, notably lower anterior facial height, increased following treatment.
- These changes were effectively measured using advanced 3D imaging, highlighting its value in orthodontic diagnostics and outcome evaluation.

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