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ORIGINAL ARTICLE / ARAŞTIRMA MAKALESİ

Retrospective 3-dimensional Evaluation of Skeletal and Dental Structures Following Treatment with Hybrid Hyrax-Mentoplate with Class III Elastics in Class III Patients with Vertical Growth Pattern: A Pilot Study

Dikey Büyüme Paterni Olan Sınıf III Hastalarda Sınıf III Elastiklerle Hibrit Hyrax-Mentonplak Tedavisi Sonrası İskeletsel ve Dental Yapıların Retrospektif Olarak 3 Boyutlu Değerlendirilmesi: Bir Pilot Çalışma

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ABSTRACT

Objective: The aim of the present study is to evaluate the skeletal and dental changes three-dimensionally in patients with skeletal Class III malocclusion and vertical growth pattern treated with hybrid hyrax-mentoplate and Class III elastic combination**.**

Materials and Methods: In this retrospective study, cone-beam computed tomography images of 6 patients (5 females and 1 male; Mean age: 11.9±0.9 years) who had undergone an orthopedic treatment with hybrid hyrax-mentoplate and Class III elastic combination were retrieved from the archive of Marmara University, Department of Orthodontics. Initial and post-protraction skeletal and dental parameters were investigated by using 3D SLICER version 5.0.2 software (www.slicer.org). Statistical significance was set at p<0.05.

Results: Sagittal skeletal evaluation showed statistically significant increases of 2.31° in SNA, and 2.8° in ANB (p<0.05), with no significant change in SNB (p>0.05). There were no significant changes in vertical skeletal parameters except significant decreases in FH-OP and SN-OP angles of 5.28° and 5.18°, respectively. In terms of dental changes, while a significant decrease was found in LI-OP angle (8.82°), significant increases in LI-MP angle and in overjet change were found (5.27°, 3.75 mm, respectively) (p<0.05). There were no significant changes in upper incisor parameters, UI-LI angle, and overbite (p>0.05). A significant increase was found in both SN-16M and SN-26M (5.79 mm, 4.10 mm, respectively) (p<0.05), while a significant decrease was observed in MP-36M and MP-46M measurements (1.62 mm, 2.29 mm, respectively) (p<0.05).

Conclusion: With the use of hybrid hyrax-mentoplate and Class III elastic combination, orthopedic sagittal correction can be achieved in patients presenting high angle skeletal Class III without causing any changes in facial height, and the slope of mandibular and palatal planes.

Keywords: Orthodontic Anchorage Procedures, Orthodontics-Corrective, Orthodontic Appliance Design

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ÖZ

Amaç: Bu çalışmanın amacı, hibrit hyrax-mentonplak ve Sınıf III elastik kombinasyonu ile tedavi edilen iskeletsel Sınıf III maloklüzyonlu ve vertikal yönde artmış büyüme paterni olan hastalarda meydana gelen iskeletsel ve dental değişiklikleri üç boyutlu olarak değerlendirmektir.

Gereç ve Yöntemler: Bu retrospektif çalışmada hibrit hyrax-mentonplak ve Sınıf III elastik kombinasyonu ile ortopedik tedavi görmüş 6 hastanın (5 kadın ve 1 erkek, Ortalama yaş: 11,9±0,9 yıl) Konik Işınlı Bilgisayarlı Tomografi görüntüleri, Marmara Üniversitesi Ortodonti Anabilim Dalı arşivinden alınmıştır. Başlangıç ve protraksiyon sonrası iskeletsel ve dental parametreler 3D SLICER versiyon 5.0.2 yazılımı (www.slicer.org) kullanılarak incelenmiştir. İstatistiksel anlamlılık p<0,05 olarak belirlenmiştir.

Bulgular: Sagital iskeletsel değerlendirmede SNA açısında 2,31° ve ANB açısında 2,8° istatistiksel olarak anlamlı artış bulunurken (p<0,05), SNB açısında anlamlı değişiklik bulunamamıştır (p>0,05). Vertikal iskeletsel değerlendirmede FH-OP ve SN-OP açılarında sırasıyla 5,28° ve 5,18° anlamlı azalma gözlenirken (p<0,05), diğer vertikal iskeletsel ölçümlerde anlamlı bir değişiklik bulunmamıştır (p>0,05). Dental değerlendirme parametrelerinden, LI-OP açısında 8,82° anlamlı azalma, LI-MP açısında 5,27° artış ve *overjet* değişiminde 3,75 mm anlamlı artış gözlenmiştir (p<0,05). Üst keser açıları, UI-LI açısı ve *overbite* ölçümlerinde anlamlı bir değişiklik bulunamamıştır (p>0,05). Hem SN-16M hem de SN-26M'de (sırasıyla 5,79 mm ve 4,10 mm) (p<0,05) anlamlı artış bulunurken, MP-36M ve MP-46M ölçümlerinde (sırasıyla 1,62 mm ve 2,29 mm) (p<0,05) anlamlı azalma gözlenmiştir.

Sonuç: Hibrit hyrax-mentonplak ve Sınıf III elastik kombinasyonu uygulaması ile iskeletsel Sınıf III maloklüzyonlu ve artmış vertikal büyüme paternli hastalarda, yüz yüksekliğinde değişiklik olmaksızın ve mandibular ve palatal düzlemde rotasyon gözlenmeksizin sagittal yönde ortopedik düzeltme sağlanabilmektedir.

Anahtar Kelimeler: Ortodontik Tespit İşlemleri, Ortodonti-Düzeltici, Ortodontik Alet Dizaynı

INTRODUCTION

Skeletal Class III malocclusion is usually characterized by a retrognathic maxilla (Ellis III & McNamara Jr, 1984). The effectiveness of orthopedic correction with the use of face masks has been proven in growing patients; however, it is not preferred in high-angle patients due to increase of existing vertical deformity (Baccetti et al., 2000; Arman et al., 2006). Therefore, the only treatment option for patients with increased vertical growth was thought to be orthognathic surgery; which could only be performed following the cessation of growth.

Skeletal anchorage systems have been adapted to and widely used in clinical orthodontic practice in the recent years (Çetinsahin & Arman, 2005). In studies examining the application of miniplate supported face masks, it was reported that an effective maxillary protraction was obtained, and mandibular posterior rotation was less than it was caused by face mask treatment (Kircelli & Pektas, 2008; Nevzatoglu & Kucukkeles, 2014; Şar et al., 2014; Liang et al., 2021). When BAMP (Bone-Anchored Maxillary Protraction) protocol studies were reviewed, it was seen that vertical control could be achieved (De Clerck et al., 2010; Heymann et al., 2010). However, the patients examined in these studies presented normal or low angle facial pattern.

In the literature, Hybrid hyrax-mentoplate studies reported that vertical control could be achieved with this treatment protocol. Katyal et al., Tarraf et al. and Willmann et al. reported that there were no significant changes in vertical values while skeletal maxillary protraction could be successfully achieved (Katyal et al., 2016; Willmann et al., 2018; Tarraf et al., 2023). Moreover, Tarraf et al. and Willmann et al. reported that this method could be beneficial especially in patients with increased facial height (Willmann et al., 2018; Tarraf et al., 2023). Similar to previous studies, the patient group examined in these three studies had normal or low angle vertical growth patterns. To the best of our knowledge, none of these studies had investigated the efficacy of this treatment protocol in patients with high angle growth pattern so far. Hence, the aim of this study was to evaluate effects of the hybrid hyrax-mentoplate and Class III elastics combination in patients with increased vertical height in three-dimension.

MATERIALS AND METHODS

The present retrospective study was approved by the Ethical Committee of Marmara University, Faculty of Medicine (Istanbul, Turkey, 28.03.2022-09.2022.243). The inclusion criteria were as follows:

- Age range between 10-13 years,
- Skeletal Class III malocclusion due to maxillary retrognathia (coexistence of one or more; SNA<78°, N⊥A< 0 mm, Witt's< – 5 mm, ANB<0)
- High angle vertical growth pattern (GoMe-Sn angle >39°, FMA angle >25°),
- Concave profile.

The exclusion criteria were as:

- Craniofacial deformity, growth disorder or hormonal disorder,
- Missing files, routine records and cone-beam computed tomography (CBCT) data,
- Non-cooperative patients.

According to these criteria 6 patients (5 females and 1 male, Mean age: 11.9±0.9 years) were retrieved from the archive of Marmara University, Faculty of Dentistry, Department of Orthodontics and included in the present retrospective study.

According to the information obtained from the patient files, 1.7×8 mm (OrthoEasy® Pal Forestadent®, Bernhard Foerster GmbH, Pforzheim, Germany) palatal screws were inserted at the anterior palate on both sides of midpalatal suture or near the third palatal rugae as suggested by Wilmes et al. (Wilmes et al., 2011). After the placement of two orthodontic bands for maxillary first molars and abutments for palatal screws, an alginate impression (Alginate, Tropicalgin, Zhermack, Rovigo, Italy) was taken to fabricate a hybrid hyrax device. The hybrid hyrax device was secured with two fixation screws in the mouth. For the placement of mentoplates (ANCOR Orthodontics, Ankara, Türkiye), a mucoperiosteal flap was elevated. The mentoplates were placed to the anterior symphysis under local anesthesia and secured with three screws by the same surgeon (GG) (Fig. 1a and 1b).

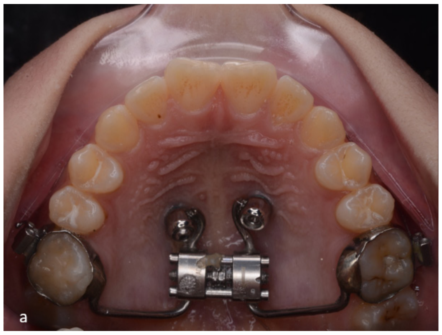

Figure 1: a) Upper occlusal photo with clear view of the hybrid-hyrax device

Figure 1: b) Intraoral frontal photo with a clear view of the mentoplate

One week of rapid maxillary expansion (RME) with the hybrid hyrax device was performed by the parents of patients by activating the screws 0.5 mm/day (1/4 turn in the morning and 1/4 turn in the evening). Following RME, orthopedic force (200-250 gr. unilaterally) was applied with Class III elastics from the hooks of molar bands of hybrid-hyrax to the hooks of the mentoplates. The orthopedic force was checked at 6-week intervals. When dental Class II canine relationship was achieved and the desired change in the profile was obtained, the treatment was terminated (6 months on average).

CBCT images were taken before (T0: before mentoplate and hybrid-hyrax application) and after (T1: before mentoplate removal) the intervention via an Iluma Imtec Imaging Machine (3M, Ardmore, OK, USA; X-ray tube voltage: 120 kV; X-ray tube current: 1–4 mA; scanning time: 40 seconds maximum and 7.8 seconds minimum; field of view: 14.2 × 21.1 cm; voxel size: 0.0936 mm; grey scale: 14 bit); while the patients were sitting in an upright position with their Frankfort horizontal plane set parallel to the floor. Skeletal and dental changes were analyzed using 3D SLICER version 5.0.2 software (www.slicer.org) (Fedorov et al., 2012). All CBCT images were reoriented by arranging midsagittal, Frankfort horizontal and transporionic planes to match with sagittal, axial and coronal planes, respectively, which were already available in the software (de Oliveira Ruellas et al., 2016). Following the reorientation of the head, three-dimensional (3D) models were created, and skeletal and dental points were marked and checked in both CBCT slices and 3D models (Table 1 and Table 2). To create midpoints and perform measurements, “Slicer CMF” extension was used. For intraosseous landmarks, “Volume Rendering” extension was used.

Table 1. Definition of the anatomical landmarks and planes

Landmark	Abbreviation	Definition
		Dental
Molar Right	MoR	Midpoint of mesiobuccal cusps of right upper and lower first molars
Molar Left	MoL	Midpoint of mesiobuccal cusps of left upper and lower first molars
Upper Right Molar	16M	Mesial cusp tip of upper right first molar
Upper Left Molar	26M	Mesial cusp tip of upper left first molar
Lower Left Molar	36M	Mesial cusp tip of lower left first molar
Lower Right Molar	46M	Mesial cusp tip of lower right first molar
Upper Incisor Mesial	UIm	The most mesial point of upper right central incisor
Upper Incisor Distal	UId	The most distal point of upper right central incisor
Lower Incisor Mesial	LIm	The most mesial point of lower right central incisor
Lower Incisor Distal	LId	The most distal point of lower right central incisor
Line	Abbreviation	Definition
Frankfort Horizontal Line	FH	a line passes from the midpoint of Orbitales through the midpoint of Porions
Sella Nasion Line	SN	a line passes through Sella and Nasion
Palatal Plane Line	PP	a line passes through ANS and PNS
Mandibular Plane Line	MP	a line passes from the midpoint of Gonions through Menton
Occlusal Plane Line	OP	a line passes from the midpoint of MoR and MoL through the midpoint of UIm-UId (midpoint of UIm and UId) and LIm-LId (midpoint of LIm and LId)
Upper Incisor Line	UI	a line passes from the midpoint of UIm and UId through the upper right central apex
Lower Incisor Line	LI	a line passes from the midpoint of LIm and LId through the lower right central apex

Table 2. Definition of measurements

Abbreviation	Definition
Skeletal Measurements	
FH-PP (°)	pitch angle between FH line and PP line
FH-OP (°)	pitch angle between FH line and OP line
FH-MP (°)	pitch angle between FH line and MP line
SN-PP (°)	pitch angle between SN line and PP line
SN-OP (°)	pitch angle between SN line and OP line
SN-MP (°)	pitch angle between SN line and MP line
N-ANS (mm)	superoinferior component of distance between N and ANS
N-Me (mm)	superoinferior component of distance between N and Me
ANS-Me (mm)	superoinferior component of distance between ANS and Me
S-K(mm)	superoinferior component of distance between S and midpoint of GoR and GoL
Jarabak Ratio	SK / N-Me
SNA (°)	pitch angle between SN line and A point
SNB (°)	pitch angle between SN line and B point
ANB (°)	Arithmetic difference of SNA angle and SNB angle
Dental Measurements	
UI-SN (°)	pitch angle between SN line and UI line
UI-OP (°)	pitch angle between UI line and OP line
UI-PP (°)	pitch angle between UI line and PP line
LI-OP (°)	pitch angle between LI line and OP line
LI-MP (°)	pitch angle between LI line and MP line
UI-LI (°)	pitch angle between UI line and LI line
SN-16M (mm)	superoinferior component of distance between SN line and 16M
SN-26M (mm)	superoinferior component of distance between SN line and 26M
MP-36M (mm)	superoinferior component of distance between MP line and 36M
MP-46M (mm)	superoinferior component of distance between MP line and 46M
Overjet (mm)	anteroposterior component of distance between the midpoint of UIm and UId to LI and LIm
Overbite (mm)	superoinferior component of distance between the midpoint of UIm and UId to LI and LIm

Statistical Analysis

IBM SPSS Statistics (version 23, IBM Corp, Armonk, NY) software was used for statistical analyses. Due to the small number of patients, parametric assumptions could not be provided; therefore, Wilcoxon paired two-sample test was used to analyze the changes between the T0 and T1 time points. P<0.05 was considered as statistically significant. For method error evaluation, all measurements were repeated by the same author (GY) four weeks after the first tracing and intraclass correlation coefficient (ICC) was calculated.

RESULTS

ICC was found close to 1.00 for all measurements, showing that all skeletal and dental measurements can be repeated with a non-significant error that would not affect the results (P<0.001).

Sagittal evaluation showed that, while there was a statistically significant increase of 2.31° and 2.80° in SNA and ANB angles respectively (p<0.05), no significant change was found in SNB angle (Table 3 and 5). When vertical measurements were evaluated, no significant changes were found except occlusal plane angles (p>0.05), in which there were statistically significant decreases of 5.28° and 5.18° in FH-OP and SN-OP angles, respectively (p<0.05) (Table 3 and 5).

Table 3. Inital and post-treatment evaluation of skeletal changes.

	T0				T1				p
Parameters	Mean	SD	Min	Max	Mean	SD	Min	Max	
FH-OP (°)	9.78	2.73	5.7	12.11	4.5	2.38	2.68	8.92	0.028*
FH-PP	2.88	1.48	0.33	4.91	3.77	4.61	0.32	11.88	0.600
FH-MP (°)	31.07	1.81	28.55	33.2	29.08	2.52	25.95	32.23	0.075
SN-PP (°)	10.82	5.39	3.39	19.33	8.88	4.81	2.86	14.78	0.249
SN-OP (°)	19.42	4.29	13.29	25.8	14.24	4.94	6.66	21.17	0.046*
SN-MP (°)	40.95	2.81	37.77	45.06	39.73	4.63	35.29	47.95	0.345
N-ANS (mm)	49.23	2.51	44.4	51.61	49.96	1.13	48.66	51.39	0.345
N-Me (mm)	109.76	6.09	101.4	119.35	111.1	5.67	106.58	121.7	0.249
ANS-Me (mm)	60.53	4.7	57	69.43	61.13	6.02	57.16	73.04	0.345
Jarabak Ratio	0.6	0.06	0.52	0.7	0.6	0.05	0.5	0.66	0.917
S-K	66.71	6.19	56.92	72.51	66.98	6.87	56.21	76.85	0.753
SNA (°)	78.27	3.01	73.35	81.56	80.58	2.8	76.8	83.87	0.028*
SNB (°)	79.85	3.17	74.53	84.01	79.36	3.06	74.37	82.53	0.753
ANB (°)	-1.58	1.36	-3.48	0.32	1.22	1.84	-0.35	4.36	0.028*

Wilcoxon test statistic, Mean, SD (standard deviation), Min (minimum), Max (maximum),
*T0: Initial, T1: Post-treatment, *p<0.05*

No significant changes were observed in UI-SN, UI-OP and UI-PP angles (p>0.05) (Table 4 and 5). On the contrary, a significant increase of 5.27° in the LI-MP angle and a significant decrease of 8.82° in the LI-OP angle were found (p<0.05) (Table 4 and 5). Significant increases were found for both SN-16M and SN-26M which were 5.79 mm and 4.10 mm, respectively (p<0.05) (Table 4 and 5). In contrast, significant decreases of 1.62 mm for the MP-36M and 2.29 mm for the MP-46M were observed (p<0.05) (Table 4 and 5). Moreover, while there was a significant increase of 3.75 mm in the overjet (p<0.05), no significant change in overbite was found (p>0.05) (Table 4 and 5).

Table 4. Inital and post-treatment evaluation of dental changes.

	T0				T1				p
Parameters	Mean	SD	Min	Max	Mean	SD	Min	Max	
UI-SN (°)	109.29	7.65	99.64	118.35	109.47	6.09	100.67	118.95	0.917
UI-OP (°)	50.48	6.35	44.38	60.99	56.27	7.05	47.74	64.25	0.249
UI-PP (°)	119.72	6.77	111.06	131.09	118.66	9.51	103.55	130.93	0.345
LI-OP (°)	76.05	8.6	67.75	89.67	67.23	5.62	60.26	76.02	0.046*
LI-MP (°)	82.06	7.63	70.54	93.17	87.34	5.08	82.53	96.47	0.028*
UI-LI (°)	127.89	12.06	112.25	143.67	123.44	10.34	111.93	135.45	0.917
SN-16M (mm)	62.50	3.54	58.37	66.87	68.29	3.91	64.52	75.14	0.028*
SN-26M (mm)	63.42	4.97	58.02	71.78	67.52	3.06	64.81	73.19	0.028*
MP-36M (mm)	20.29	1.5	18.37	21.86	18.68	0.98	17.08	20.11	0.028*
MP-46M (mm)	19.98	2.16	17.17	22.72	17.69	1.60	16.28	20.10	0.028*
Overjet (mm)	-0.55	2.28	-3.37	2.08	3.19	2.15	1.18	7.32	0.028*
Overbite (mm)	-0.02	2.71	-3.63	3.8	-0.08	1.87	-2.33	2.24	0.917

Wilcoxon test statistic, Mean, SD (standard deviation), Min (minimum), Max (maximum),
*T0: Initial, T1: Post-treatment, *p<0.05*

Table 5. Skeletal and dental changes between T0 and T1

	ΔT1-T2				
Parameters	Mean	SD	Min	Max	p
FH-PP (°)	0.89	4.60	-3.97	8.61	0.600
FH-OP (°)	-5.28	3.20	– 9.36	-2.24	0.028*
FH-MP (°)	-1.99	2.02	-4.55	1.06	0.075
SN-PP (°)	-1.94	5.43	-7.98	7.93	0.249
SN-OP (°)	-5.18	5.85	-15.60	1.8	0.046*
SN-MP (°)	-1.22	2.48	-4.26	2.89	0.345
N-ANS (mm)	0.73	1.90	-1.25	4.34	0.345
N-Me (mm)	1.34	2.81	-2.84	5.18	0.249
ANS-Me (mm)	0.61	2.47	-3.47	3.61	0.345
S-K	0.27	3.54	-5.84	4.33	0.753
Jarabak Ratio	-0.01	0.04	-0.09	0.02	0.917
SNA (°)	2.31	1.64	0.34	4.87	0.028*
SNB (°)	-0.49	2.16	-4.49	1.45	0.753
ANB (°)	2.80	2.41	0.27	6.81	0.028*
UI-SN (°)	0.18	7.67	-10.33	10.90	0.917
UI-OP (°)	5.79	9.80	-6.26	17.47	0.249
UI-PP (°)	-1.06	5.73	-7.51	6.35	0.345
LI-OP (°)	-8.82	9.73	-25.05	1.25	0.046*
LI-MP (°)	5.27	6.71	1.00	18.49	0.028*
UI-LI (°)	-4.45	13.60	-31.74	3.91	0.917
SN-16M (mm)	5.79	2.78	1.57	9.23	0.028*
SN-26M (mm)	4.10	2.88	0.21	7.49	0.028*
MP-36M (mm)	-1.62	1.10	-3.30	-0.02	0.028*
MP-46M (mm)	-2.29	1.84	-5.04	9.23	0.028*
Overjet (mm)	3.75	2.90	0.08	6.06	0.028*
Overbite (mm)	-0.07	1.02	-1.56	1.30	0.917

*Wilcoxon test statistic, Mean, SD (standard deviation), Min (minimum), Max (maximum), T0: Initial, T1: Post-treatment, *p<0.05*

DISCUSSION

Many treatment approaches have been reported for the orthopedic treatment of skeletal Class III malocclusion; however, most of them are not suitable to be used in patients with high angle vertical pattern due to the resulting downward and backward rotation of the mandible. It is an established fact that face mask treatment produces posterior rotation of the mandible (Baccetti et al., 2000; Westwood et al., 2003; Arman et al., 2006).

Various treatment protocols have been suggested in the literature to overcome this problem. In a study by Şar et al., it was reported that applying forces to face mask from anchoring miniplates placed on the lateral walls of apertura priformis significantly reduced the clockwise rotation of the mandible (Şar et al., 2011). Still, there are also some studies reporting that a similar treatment approach would cause an increase in vertical facial values (Kircelli & Pektas, 2008; Kaya et al., 2011).

In an attempt to minimize vertical changes, some researchers suggested maxillary protraction that is achieved using the hybrid-hyrax appliance as an anchorage unit with face mask (Nienkemper et al., 2013; Ngan et al., 2015; Nienkemper et al., 2015; Maino et al., 2018). In a study where altramec protocol was used, it was stated that there was no significant change in the vertical facial values (Maino et al., 2018). However, there are other studies which state that this method also caused an increase in vertical values (Nienkemper et al., 2013; Ngan et al., 2015; Nienkemper et al., 2015). In all these studies, the groups of patients investigated were composed of individuals presenting normal vertical facial pattern.

With the introduction of BAMP protocol, it was reported in the first publications that following treatment, while vertical control was provided in most of the cephalometric values of the patient groups, some vertical values were increased (De Clerck et al., 2009; Heymann et al., 2010). On the other hand, there are also studies reporting that counterclockwise rotation of the mandible was observed in patients treated with the BAMP protocol (De Clerck et al., 2010; Eid et al., 2016).

Studies on hybrid hyrax-mentoplate protocol, which is a relatively new method, indicate that clockwise rotation does not occur in the mandible in individuals with a normal vertical pattern (Katyal et al., 2016; Willmann et al., 2018; Tarraf et al., 2023). Only one study have investigated the effects of this treatment protocol in patients with increased vertical values so far, in which a MARPE (Miniscrew-Assisted Rapid Palatal Expansion) system was used as maxillary anchorage (Facio-Umaña et al., 2021). No studies were found in the literature evaluating the dental and skeletal effects of hybrid hyrax-mentoplate combination in high angle patients.

While traditional lateral cephalometric analysis neglects the mediolateral axis, frontal cephalometric radiographs neglect the postero-anterior dimension (Rossini et al., 2011). On the other side, in the present study, 3D variables that we measured on the available CBCT data, which was used for the surgical procedure, provided more reliable data, as it eliminated distortion such as overlapping of anatomical structures and magnification problems that make it difficult to obtain accurate measurements on 2D images (Leung et al., 2010; Özbilen et al., 2021).

One week rapid maxillary expansion was done in order to enhance treatment outcome by activating surrounding sutures. There are many studies which suggest that rapid maxillary expansion increases the effectiveness of maxillary protraction by increasing cellular activity in the circummaxillary sutures (Kapust et al., 1998; Baccetti et al., 2000; Saadia & Torres, 2000; Tortop et al., 2007)

The patients included in the study were in the 10-13 years old range, which is more than recommended maximum age for standard facemask treatment; however this age group is compatible with the literature in terms of age group for bone-anchored maxillary protraction (BAMP) protocol (Merwin et al., 1997; Sung & Baik, 1998; Yüksel et al., 2001).

A significant increase of 2.31° was found in the SNA angle in the present study; which indicates an anterior movement of the maxilla. In other studies using the same technique as our study, Katyal et al. found an increase of 2.1° and Willman et al. found an increase of 2.23° in SNA angle (Katyal et al., 2016; Willmann et al., 2018) similar to our results. In another study a 4.26° increase was found in SNA angle (Tarraf et al., 2023), which is higher than the present study. The reason for this difference may lie in treating younger patients, longer treatment duration and variation in patient numbers.

With a similar treatment technique, Facio-Umaña et al. found a 4.08° increase in SNA angle (Facio-Umaña et al., 2021). The reason why more increase were reported in this study might be the use of more and longer screws in the MARPE system and also the different expansion protocol.

On the other hand, Miranda et al. reported an increase of 1.47° in the SNA angle (Miranda et al., 2021), which was less than reported in the present study. Although the treatment duration was longer in their study, the differences between two studies in terms of SNA angle change might be attributed to the use of miniscrews as mandibular anchorage in their study instead of miniplates as in the present study.

If the results of the studies carried out with the BAMP protocol were evaluated, Eid et al. and Elnagar et al. reported 2.8° and 5.65° increases in SNA angle, respectively (Eid et al., 2016; Elnagar et al., 2016). The slight difference between our study and the study of Eid et al. may be due to the differences in elastic force which was higer in their study (Eid et al., 2016). However, the increase in SNA angle was dramatically high in the study of Elnagar et al. which may be related with the longer duration of orthopedic force application (Elnagar et al., 2016).

No significant change was found in the SNB angle in the present study which was consistent with previous literature findings (Katyal et al., 2016; Willmann et al., 2018; Tarraf et al., 2023). Moreover, in the present study, there was a significant increase of 2.8° in ANB angle. In the literature, Katyal et al., Willmann et al., and Tarraf et al. found increases of 1.9°, 2.54°, and 5.25° in ANB angle, respectively, where the treatment protocols were the same as in the present study (Katyal et al., 2016; Willmann et al., 2018; Tarraf et al., 2023). Since none of these studies have found significant change in SNB angle, the difference in ANB angle depends on the change of SNA angle. Many studies have found an increase in ANB angle, as in this present study, and almost all are due to increases in SNA angle (Eid et al., 2016; Elnagar et al., 2016; Facio-Umaña et al., 2021).

In terms of vertical measurements, no significant changes were found in SN-MP and FH-MP angles; which means there was no significant rotation of the mandibular plane. Katyal et al., Willman et al. and Tarraf et al. also reported no significant change in SN-MP angle which supports our results (Katyal et al., 2016; Willmann et al., 2018; Tarraf et al., 2023). Although there are methodological differences, Eid et al. and Elnagar et al. also found the same results for SN-MP angle as in the present study (Eid et al., 2016; Elnagar et al., 2016). Miranda et al. compared the hybrid hyrax-miniscrew combination with the conventional hyrax-miniscrew group and reported an increase of 0.95° in the FH-MP angle(Miranda et al., 2021). However, it should be noted that there is a methodological difference between this studies and our study.

According to the findings of the present study, there was no significant change in SN-PP angle which is parallel with the study of Willman et al. (Willmann et al., 2018). On the contrary, Katyal et al. reported a 0.8° significant decrease, which may not be clinically significant (Katyal et al., 2016). In the studies where the BAMP protocol was applied, Elnagar et al., Eid et al., and De Clerck et al. reported that no significant rotation was observed in the maxilla when compared to the control group (De Clerck et al., 2010; Eid et al., 2016; Elnagar et al., 2016). Although there are many studies supporting our result plane (Willmann et al., 2018, De Clerck et al., 2010; Eid et al., 2016; Elnagar et al., 2016), there is a study reporting rotation in the palatal (Katyal et al., 2016). Various researchers have described different anatomical points for the center of resistance of the maxilla. That is because, the location of the center of resistance of maxilla cannot be determined exactly and it cannot be clearly identified extraorally. Also, the applied elastics cannot pass through the center of resistance of the maxilla due to anatomical limitations. Inability to determine the exact location of the resistance center of the maxilla may cause rotation in the palatal plane after treatment with different techniques.

No significant change was observed in any of the vertical measurements and also Jarabak ratio. Since no significant clockwise rotation was observed in the mandible, these results are consistent with other findings in this present study.

Significant increases were found in SN-16M and SN-26M which showed upper molar extrusion. Moreover, significant decreases found in MP-36M and MP-46M indicated the intrusion of lower molars. Although the upper molars were attached to the skeletal anchor unit, extrusion may have occurred due the vectorial force of the Class III elastics. Also, it was written in the patient files that composite blocks were made on the lower first molars in order to avoid contact in the anterior region during anterior traction. This may be the reason for the significant intrusion of lower molars over the time. When the literature was reviewed, no information was found evaluating the vertical movements of molar teeth in patients who were treated with the current technique. was applied. In the present study, in terms of vertical measurements, significant changes were seen only in SN-OP and FH-OP angles, as 5.18° and 5.28° of decreases, respectively, showing counterclockwise rotation of the occlusal plane. Within the lights of these findings, one may conclude that the movement of the molar teeth caused the counterclockwise rotation of the occlusal plane.

No significant changes were observed in UI-SN and UI-PP angles in the present study. This is in concordance with the other studies using either the same or similar treatment protocols (De Clerck et al., 2010; Elnagar et al., 2016; Katyal et al., 2016; Willmann et al., 2018; Facio-Umaña et al., 2021; Tarraf et al., 2023). On the other hand, Eid et al. reported significant increases in these angles and explained with occlusal interferences formed by the contact of the upper incisors with the lower incisors during maxillary protraction (Eid et al., 2016). Singer et al. also reported that retroclination occurred for the same reason in the case report they published (Singer et al., 2000). In the present study, in patients with the possibility of occlusal interference, occlusion was opened with bite raisers until the contact disappeared. This could be the reason why significant protrusion or retrusion was not observed in the UI-SN and UI-PP angles.

A statistically significant increase of 5.27° was found in the LI-MP angle. Different from our result, Katyal et al., Willmann et al. and Tarraf et al. reported no significant change in LI-MP (Katyal et al., 2016; Willmann et al., 2018; Tarraf et al., 2023). When the previous studies using similar technique was evaluated, while some of them reported significant protrusion in the lower incisors as in the present study, some others reported no significant movement (Cevidanes et al., 2010; De Clerck et al., 2010; Eid et al., 2016; Elnagar et al., 2016). Şar et al. suggested that the hooks of mandibular miniplates could reduce the lower lip pressure, showing lip bumper effect; which might be the reason of lower incisor protrusion (Şar et al., 2014).

UI-LI angle did not change significantly in the present study. Katyal et al. also reported no significant change in UI-LI angle. However, Eid et al., stated a significant increase in UI-LI angle which might have occurred as a result of significant protrusion in the upper incisors (Eid et al., 2016).

In our study, a statistically significant increase of 3.75 mm was found in overjet. Katyal et al. also reported a 2 mm of increase (Katyal et al., 2016). In their studies, it was stated that 3/16, 3.5 oz. elastics were used throughout the entire treatment. Since force will decrease using the same diameter elastic during the forward movement of the maxilla; this could be the reason why they found smaller increase in overjet. Tarraf et al. reported 4.12 mm increase in overjet (Tarraf et al., 2023). Although they reported a value close to the change we found, methodological differences (longer expansion duration, different age group, different number of patients) may be why they found a greater increase in overjet compared to our study. In the literature, following similar treatment protocols, Elnagar et al. reported 7.11 mm, De Clerck et al. reported 3.7 mm and Cevidanes et al. reported 3.7 mm overjet increase. The variation in results may again be due to methodological differences.

No statistically significant change was found in the measurement of overbite. Katyal et al. and Tarraf at. al. did not report any significant change in overbite measurement, parallel to the present study (Katyal et al., 2016; Tarraf et al., 2023). When similar studies were evaluated, contrary to our results, while Elnagar et al. found significant decrease, De Clerck et al. found significant increase in overbite change (De Clerck et al., 2010; Elnagar et al., 2016). The fact that the overbite measurement can be influenced not only by the rotation of the mandible but also by the incisor angles, might be the reason for the differences in the literature.

CONCLUSION

Hybrid hyrax-mentoplate and Class III elastics combination provides sagittal skeletal correction without increasing the facial height in patients with skeletal Class III malocclusion with high angle vertical growth pattern. However, counterclockwise rotation of the occlusal plane was observed as a result of the treatment in the present study, which may be due to extrusion of the upper molars and intrusion of the lower molars. Moreover, while this treatment protocol did not cause a significant change in the upper incisor angles, it created a significant increase in the lower incisor angles.

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Conflicts of interest

None to declared.

REFERENCES

1. Arman, A, TU Toygar and E Abuhijleh. Evaluation of maxillary protraction and fixed appliance therapy in Class III patients. Eur J Orthod. 2006;28(4):383-392.
2. Baccetti, T, L Franchi and JA McNamara Jr. Treatment and posttreatment craniofacial changes after rapid maxillary

expansion and facemask therapy. Am J Orthod Dentofacial Orthop. 2000;118(4):404-413.

3. Cevidanes, L, T Baccetti, L Franchi, JA McNamara Jr and H De Clerck. Comparison of two protocols for maxillary protraction: bone anchors versus face mask with rapid maxillary expansion. Angle Orthod. 2010;80(5):799-806.
4. Çetinsahin, A and A Arman. Application of implants for orthodontic anchorage. Turk J Orthod. 2005;18(1):77-89.
5. De Clerck, H, L Cevidanes and T Baccetti. Dentofacial effects of bone-anchored maxillary protraction: a controlled study of consecutively treated Class III patients. Am J Orthod Dentofacial Orthop. 2010;138(5):577-581.
6. De Clerck, HJ, MA Cornelis, LH Cevidanes, GC Heymann and CJ Tulloch. Orthopedic traction of the maxilla with miniplates: a new perspective for treatment of midface deficiency. J Oral Maxillofac Surg. 2009;67(10):2123-2129.
7. de Oliveira Ruellas, AC, C Tonello, LR Gomes, MS Yatabe, L Macron, J Lopinto, ve ark. Common 3-dimensional coordinate system for assessment of directional changes. Am J Orthod Dentofacial Orthop. 2016;149(5):645-656.
8. Eid, OM, AA-F Ramadan, MA Nadim and TA-B Hamed. Maxillary protraction using orthodontic miniplates in correction of Class III malocclusion during growth. J World Fed Orthod. 2016;5(3):100-106.
9. Ellis III, E and JA McNamara Jr. Components of adult Class III malocclusion. J Oral Maxillofac Surg. 1984;42(5):295-305.
10. Elnagar, MH, E Elshourbagy, S Ghobashy, M Khedr and CA Evans. Comparative evaluation of 2 skeletally anchored maxillary protraction protocols. Am J Orthod Dentofacial Orthop. 2016;150(5):751-762.
11. Facio-Umaña, JA, J Chaurand and PI Gonzalez-Luna. Early class III treatment with maxillary protraction-miniscrew-assisted rapid palatal expansion (MARPE) and mandibular miniplates. Ann Oral Maxillofac Surg. 2021;4(1):100-151.
12. Fedorov, A, R Beichel, J Kalpathy-Cramer, J Finet, J-C Fillion-Robin, S Pujol, ve ark. 3D Slicer as an image computing platform for the Quantitative Imaging Network. Magn Reson Imaging. 2012;30(9):1323-1341.
13. Heymann, GC, L Cevidanes, M Cornelis, HJ De Clerck and JC Tulloch. Three-dimensional analysis of maxillary protraction with intermaxillary elastics to miniplates. Am J Orthod Dentofacial Orthop. 2010;137(2):274-284.
14. Kapust, AJ, PM Sinclair and PK Turley. Cephalometric effects of face mask/expansion therapy in Class III children: a comparison of three age groups. Am J Orthod Dentofacial Orthop. 1998;113(2):204-212.
15. Katyal, V, B Wilmes, M Nienkemper, M Darendeliler, W Sampson and D Drescher. The efficacy of Hybrid Hyrax-Mentoplate combination in early Class III treatment: a novel approach and pilot study. Aust Orthod J. 2016;32(1):88-96.
16. Kaya, D, I Kocadereli, B Kan and F Tasar. Effects of facemask treatment anchored with miniplates after alternate rapid maxillary expansions and constrictions; a pilot study. Angle Orthod. 2011;81(4):639-646.
17. Kircelli, BH and ZÖ Pektas. Midfacial protraction with skeletally anchored face mask therapy: a novel approach and preliminary results. Am J Orthod Dentofacial Orthop. 2008;133(3):440-449.
18. Leung, CC, L Palomo, R Griffith and MG Hans. Accuracy and reliability of cone-beam computed tomography for measuring alveolar bone height and detecting bony dehiscences and fenestrations. Am J Orthod Dentofacial Orthop. 2010;137(4):109-119.
19. Liang, S, F Wang, Q Chang and Y Bai. Three-dimensional comparative evaluation of customized bone-anchored vs tooth-borne maxillary protraction in patients with skeletal Class III malocclusion. Am J Orthod Dentofacial Orthop. 2021;160(3):374-384.
20. Maino, G, Y Turci, A Arreghini, E Paoletto, G Siciliani and L Lombardo. Skeletal and dentoalveolar effects of hybrid rapid palatal expansion and facemask treatment in growing skeletal Class III patients. Am J Orthod Dentofacial Orthop. 2018;153(2):262-268.
21. Merwin, D, P Ngan, U Hagg, C Yiu and SH Wei. Timing for effective application of anteriorly directed orthopedic force to the maxilla. Am J Orthod Dentofacial Orthop. 1997;112(3):292-299.
22. Miranda, F, JC da Cunha Bastos, AM Dos Santos, G Janson, JRP Lauris and D Garib. Dentoskeletal comparison of miniscrew-anchored maxillary protraction with hybrid and conventional hyrax expanders: A randomized clinical trial. Am J Orthod Dentofacial Orthop. 2021;160(6):774-783.
23. Nevzatoglu, S and N Kucukkeles. Long-Term Results of Rapid Maxillary Expansion and Facemask: Long-Term of Regular Protraction. Turk J Orthod. 2014;27(2):51-62.
24. Ngan, P, B Wilmes, D Drescher, C Martin, B Weaver and E Gunel. Comparison of two maxillary protraction protocols: tooth-borne versus bone-anchored protraction facemask treatment. Prog Orthod. 2015;16(1):26.
25. Nienkemper, M, B Wilmes, L Franchi and D Drescher. Effectiveness of maxillary protraction using a hybrid hyrax-facemask combination: a controlled clinical study. Angle Orthod. 2015;85(5):764-770.
26. Nienkemper, M, B Wilmes, A Pauls and D Drescher. Maxillary protraction using a hybrid hyrax-facemask combination. Prog Orthod. 2013;14(1):5.
27. Özbilen, EÖ, HN Yılmaz and YB Acar. Does Alt-RAMEC protocol and facemask treatment affect dentoalveolar structures? A 3-dimensional study. Angle Orthod. 2021;91(5):626-633.
28. Rossini, G, C Cavallini, M Cassetta and E Barbato. 3D cephalometric analysis obtained from computed tomography. Review of the literature. Ann Stomatol (Roma). 2011;2(3-4):31-39.
29. Saadia, M and E Torres. Sagittal changes after maxillary protraction with expansion in class III patients in the primary, mixed, and late mixed dentitions: a longitudinal retrospective study. Am J Orthod Dentofacial Orthop. 2000;117(6):669-680.
30. Singer, SL, PJ Henry and I Rosenberg. Osseointegrated implants as an adjunct to facemask therapy: a case report. Angle Orthod. 2000;70(3):253-262.

31. Sung, SJ and HS Baik. Assessment of skeletal and dental changes by maxillary protraction. Am J Orthod Dentofacial Orthop. 1998;114(5):492-502.
32. Şar, Ç, A Arman-Özçırpıcı, S Uçkan and AC Yazıcı. Comparative evaluation of maxillary protraction with or without skeletal anchorage. Am J Orthod Dentofacial Orthop. 2011;139(5):636-649.
33. Şar, Ç, Z Şahinoğlu, AA Özçırpıcı and S Uçkan. Dentofacial effects of skeletal anchored treatment modalities for the correction of maxillary retrognathia. Am J Orthod Dentofacial Orthop. 2014;145(1):41-54.
34. Tarraf, NE, O Dalci, K Dalci, AT Altug and MA Darendeliler. A retrospective comparison of two protocols for correction of skeletal Class III malocclusion in prepubertal children: hybrid hyrax expander with mandibular miniplates and rapid maxillary expansion with face mask. Prog Orthod. 2023;24(1):3.
35. Tortop, T, A Keykubat and S Yuksel. Facemask therapy with and without expansion. Am J Orthod Dentofacial Orthop. 2007;132(4):467-474.
36. Westwood, PV, JA McNamara Jr, T Baccetti, L Franchi and DM Sarver. Long-term effects of Class III treatment with rapid maxillary expansion and facemask therapy followed by fixed appliances. Am J Orthod Dentofacial Orthop. 2003;123(3):306-320.
37. Willmann, JH, M Nienkemper, NE Tarraf, B Wilmes and D Drescher. Early Class III treatment with Hybrid-Hyrax-Facemask in comparison to Hybrid-Hyrax-Mentoplate–skeletal and dental outcomes. Prog Orthod. 2018;19(1):42.
38. Wilmes, B, M Nienkemper, B Ludwig, CH Kau and D Drescher. Early Class III treatment with a hybrid hyrax-mentoplate combination. J Clin Orthod. 2011;45(1):15-21.
39. Yüksel, S, TT Üçem and A Keykubat. Early and late facemask therapy. Eur J Orthod. 2001;23(5):559-568.

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