Cumhuriyet Dental Journal, 27(2): 118-126, 2024
DOI: https://doi.org/10.7126/cumudj.1440931

Cumhuriyet Dental Journal

| cdj.cumhuriyet.edu.tr | Founded: 1998 Available online, ISSN: 1302-5805 e-ISSN: 2146-2852 Publisher: Sivas Cumhuriyet Üniversitesi

Evaluation of the Changes in Condylion-Gonion-Menton Angle and Dentoalveolar Heights After Treatment with Removable Functional Appliances

Orhan Cicek[1-a], Hande Erener[2-b*], Yusuf Enes Unal[2-c]

[1] *Department of Orthodontics, Faculty of Dentistry, Zonguldak Bülent Ecevit University, Zonguldak, Turkiye.*
[2] *Department of Orthodontics, Faculty of Dentistry, Tekirdag Namik Kemal University, Tekirdag, Turkiye.*

**Corresponding author*

Research Article

History

Received: 21/02/2024
Accepted: 03/06/2024

ABSTRACT

Objective: Condylion-Gonion-Menton (CoGoMe) angle and dentoalveolar heights are important parameters that provide information about maxillomandibular growth and development. This study aimed to examine the changes in the CoGoMe angle and dentoalveolar heights after functional treatment and to analyze whether they are related to each other.
Materials and Methods: A total of 60 patients, 38 females (mean age 11.7 ± 0.6) and 22 males (mean age 12.6 ± 0.5), with skeletal class II division I malocclusion caused by mandibular retrognathia and treated with monoblock in the peak period were included. Linear measurements of skeletal angular and dentoalveolar heights were made on lateral cephalograms taken pre- (T0) and post-functional treatment (T1). Paired sample t test, Wilcoxon test and Spearman's rho correlation coefficient were used for statistical analyses. Statistical significance was accepted as $p<0.05$.
Results: While the CoGoMe angle increased significantly with treatment, no significant change was found in the SN/GoGn angle. While no significant change was observed in SNA angle, the increase in SNB and the decrease in ANB were found to be significant. No significant change was observed in anterior dentoalveolar heights. However, increases in posterior dentoalveolar heights were found to be significant. While there was no significant relationship between dentoalveolar heights and CoGoMe angle, dentoalveolar heights showed a positive significant relationship with each other.
Conclusions: It was observed that there was no relationship between the CoGoMe angle and dentoalveolar heights and that the CoGoMe angle was a suitable alternative to the SN/GoGn angle. Since the increases in posterior dentoalveolar heights occur at the dentoalveolar level as a result of selective grinding, it was concluded that dentoalveolar changes should not be neglected while providing skeletal correction for stability in functional orthopedic treatment.
Keywords: Cephalometry, Dentoalveolar Height, Functional, Malocclusion, Orthodontic Appliance.

Hareketli Fonksiyonel Apareylerle Tedavi Sonrası Kondilyon-Gonion-Menton Açısı ve Dentoalveolar Yüksekliklerdeki Değişikliklerin Değerlendirilmesi

Süreç

Geliş: 21/02/2024
Kabul: 03/06/2024

ÖZ

Amaç: Kondilyon-Gonion-Menton (CoGoMe) açısı ve dentoalveolar yükseklikler maksillomandibular büyüme ve gelişme hakkında bilgi sağlayan önemli parametrelerdir. Bu çalışmada fonksiyonel tedavi sonrası CoGoMe açısı ve dentoalveoler yüksekliklerde meydana gelen değişikliklerin incelenmesi ve birbirleriyle ilişkili olup olmadığının analiz edilmesi amaçlanmıştır.
Gereç ve Yöntemler: Çalışmaya mandibular retrognatiden kaynaklanan iskeletsel sınıf II bölüm I maloklüzyona sahip, pik döneminde ve monoblok ile tedavi edilen 38'i kadın (ortalama yaş 11,7 ± 0,6) ve 22'si erkek (ortalama yaş 12,6 ± 0,5) olmak üzere toplam 60 hasta dahil edildi. İskeletsel açıların ve dentoalveoler yüksekliklerin doğrusal ölçümleri, fonksiyonel tedavi öncesi (T0) ve fonksiyonel tedavi sonrası (T1) alınan lateral sefalometrik radyografilerde yapıldı. İstatistiksel analizlerde eşleştirilmiş örneklem t testi, Wilcoxon testi ve Spearman rho korelasyon katsayısı kullanıldı. İstatistiksel anlamlılık $p<0,05$ olarak kabul edildi.
Bulgular: Fonksiyonel tedavi ile CoGoMe açısında anlamlı artış gözlenirken, SN/GoGn açısında anlamlı bir değişiklik saptanmadı. SNA açısında anlamlı bir değişiklik gözlenmezken, SNB'deki artış ve ANB'deki azalma anlamlı bulundu. Anterior dentoalveolar yüksekliklerde anlamlı bir değişiklik gözlenmezken, posterior dentoalveolar yüksekliklerdeki artışların anlamlı olduğu görüldü. Dentoalveolar yükseklikler ile CoGoMe açısı arasında anlamlı bir ilişki bulunmazken, dentoalveolar yükseklikler birbirleriyle pozitif yönde anlamlı ilişki gösterdi.
Sonuçlar: CoGoMe açısı ile dentoalveolar yükseklikler arasında bir ilişki olmadığı ve CoGoMe açısının SN/GoGn açısına uygun bir alternatif olduğu görüldü. Posterior dentoalveoler yüksekliklerdeki artışların selektif möllemeler sonucu dentoalveolar düzeyde gerçekleşmesi nedeniyle, fonksiyonel ortopedik tedavide stabilite için iskeletsel düzelme sağlanırken dentoalveolar değişikliklerin gözardı edilmemesi gerektiği sonucuna varıldı.
Anahtar Kelimeler: Sefalometri, Dentoalveolar Yükseklik, Fonksiyonel, Maloklüzyon, Ortodontik Aparey.

License

This work is licensed under Creative Commons Attribution 4.0 International License

[a] ortorhancicek@gmail.com https://orcid.org/0000-0002-8172-6043
[b] handeerener@hotmail.com https://orcid.org/0000-0002-8172-6043
[c] yusufenesunl@gmail.com https://orcid.org/0009-0006-7920-8024

How to Cite: *Cicek O, Erener H, Unal YE. (2024) Evaluation of the Changes in Condylion-Gonion-Menton Angle and Dentoalveolar Heights After Treatment with Removable Functional Appliances, Cumhuriyet Dental Journal, 27(2):118-126.*

Introduction

The prevalence of class II malocclusions, which are among the orthodontic anomalies with a high rate in the society, is between 11.9-13 %, and the majority of them consist of class II division I malocclusions with increased overjet.[1,2] It has been stated that these malocclusions, which have been reported to be affected by different etiologies in their development, may result from maxillary prognathia, mandibular retrognathia or both.[3] Panchez and Ruf reported that 20% of the sagittal class II malocclusions are caused by maxillary excess and 80% are caused by mandibular deficiency.[4]

The treatment performed with forces generated using circumferential tissues for the treatment of structural disorders and malpositions of the jaws is functional orthopedics, and the devices used for this purpose are called functional appliances.[5] A wide variety of functional appliances have been developed for Class II treatment. These appliances, which aim to correct the skeletal relationship by positioning the mandible in the advanced, are divided into two as removable and fixed functional appliances. Removable functional appliances have become a frequently used treatment option in skeletal class II division I patients characterized by mandibular retrognathia during the growth period, thanks to the anterior positioning of the mandible.[6] Petrovic *et al.*[7] pointed out that the growth potential of the mandible and its responsiveness to functional orthopedic treatment is strongly affected by the mandibular growth pattern.

The most well-known removable functional appliances include monoblock, twin block, bionator, activator and Frankel 2 appliances. The monoblock was designed by Robin in 1902, and the activator, considered to be the first functional appliance, was developed by Andresen in 1920. Andresen activator is one of the most widely used removable functional appliances thanks to its successful and effective treatment results.[8,9] The advantages of removable functional appliances include their removability, low cost, and easier oral hygiene.[10,11]

Condylion-Gonion-Menton (CoGoMe) angle is one of the important vertical cephalometric measurements that shows the rotational orientation of the mandible and is measured between the condylar axis (Co-Go) and the mandibular base (Go-Me).[12] The CoGoMe angle is an important measurement in functional orthopedic treatments and provides an insight about the response to Class II functional treatment and the direction of vertical growth.[13] Franchi and Baccetti reported that if the CoGoMe angle is less than 125 degrees, a positive response will be obtained to treatment with removable functional appliances, and if it is greater, it will be poor.[14]

It is important that dentoalveolar structures participate in occlusion by forming functional components of the jaws and play a role in establishing vertical jaw relations. Thus, dentoalveolar development affects the vertical features of the face, especially the different growths in the maxillofacial skeleton.[15] In addition, dentoalveolar heights are also affected by the tooth eruption and form the dentoalveolar structure when they come into contact with the opposite. Many studies have shown that the dentoalveolar segment is constantly growing and changing.[16,17] Also, dentoalveolar heights have been reported to be higher in patients with a hyperdivergent growth pattern compared to those with a normodivergent.[15]

When the literature is examined, although there are studies examining the CoGoMe angle and dentoalveolar heights[12,17-19], no study has been found in which these parameters were evaluated after functional orthopedic treatment of skeletal class II division I malocclusions. Since the skeletal and dentoalveolar changes caused by removable functional appliances are critical for orthodontists, it is important to clarify the changes occurring in the CoGoMe angle and dentoalveolar heights with functional treatment and their relationships with each other. Also, SN/GoGn angle is used to evaluate mandibular growth relative to the anterior cranial base and is a classical diagnostic parameter that should be considered before starting orthodontic treatment.[20] However, there is no similar study investigating the potential of the CoGoMe angle as an alternative to the SN/GoGn angle, which provides information about the rotational growth model and is recommended as a predictor in mandibular orthopedic treatments.[18]

Therefore, the aim of this study was to examine the changes in the CoGoMe angle and dentoalveolar heights after the treatment of patients with skeletal class II division I malocclusion in the peak period with removable functional appliances and to clarify whether there is a relationship between the CoGoMe angle and dentoalveolar heights. Additionally, the changes in CoGoMe and SN/GoGn angles will be clarified in the follow-up of mandibular growth and development with functional treatment. The alternative hypothesis of the study is that there is a significant relationship between the CoGoMe angle and dentoalveolar heights.

Material and Methods

The material of the retrospective study consists of patients with skeletal class II division I malocclusion who applied to Zonguldak Bülent Ecevit University, Department of Orthodontics. Ethical approval for the study was received from Zonguldak Bülent Ecevit University Non-Interventional Clinical Research Ethics Committee dated November 22, 2023, with decision number 2023/22-9.

The sample size of the study was carried out with the G*Power program (version 3.1.9.7; Franz Faul, Universität Kiel, Kiel, Germany). Accordingly, considering the mean and standard deviation values of the CoGoMe angle pre- and post-treatment and determining the two-way hypothesis (Tail(s): two), α error probability (α error probe) of 0.05 and the power of the study as 0. 95, the effect size was calculated as 0.47. Accordingly, when at least 50 samples were included, the real power of the study was calculated as 90%. The study included a total of 60 patients who met the following inclusion criterias:

- Having skeletal class II division I malocclusion caused by mandibular retrognathia (maxilla in normal skeletal sagittal position (SNA:82 ± 2) and ANB angle greater than 4 degrees)

- Having been treated with a single stage functional appliance
- Having normal or low vertical facial skeletal angle
- No prior orthodontic treatment
- Having lateral cephalometric radiographs with high resolution and good image quality
- In pre-treatment; having overjet between 5-8 mm, having treated with a single-stage removable functional appliance, having growth and development in the peak period (MP3 capping)
- In post-treatment; having overjet no more than 3 mm, having class I molar relationship, having completed growth and development (MP3 union)

Patients who did not meet at least one of these criteria were excluded from the study. The sample size by gender, age and functional treatment duration are given in Table 1.

In the first step of the study, lateral cephalometric radiographs taken from the patients' at pre- (T0) and post-functional treatment (T1) using a cephalometric X-ray device (Veraviewepocs 2D, J Morita Mfg. Corp., Kyoto, Japan) were scanned from the clinic archive. Linear and angular measurements made on these lateral cephalograms are as follows: CoGoMe, SN/GoGn, SNA, SNB and ANB skeletal angular measurements; U1/NA and IMPA dental angular measurements; maxillary anterior (MxADH) and posterior (MxPDH) dentoalveolar heights; mandibular anterior (MnADH) and posterior (MnPDH) dentoalveolar heights. After the lateral cephalometric radiographs were transferred to the NemoCeph (Nemotec, 2020, Madrid, Spain) cephalometric analysis program, all measurements were performed by the same researcher.

Table 1. Sample size, age and functional treatment duration data of the patients for gender

		Sample size (N-%)	Age (Mean ±SD)	Functional treatment duration (year)
Gender	Female	38- 63.3 %	11.7 ± 0.6	1.1 ± 0.3
	Male	22- 36.7 %	12.6 ± 0.5	1.4 ± 0.4

SD: Standard deviation, N: sample size, %: percentage

Functional orthopedic treatment protocol

A monoblock removable functional orthopaedic appliance, which is a tooth-borne passive appliance, was applied to the patients. For the production of the appliance, the occlusal bite recording measurement was taken by activating the mandible an average of 7 mm forward sagittally and 3 mm vertically. The appliance opens the bite and has lingual flanges to position the mandible anteriorly. Selective grindings made on the acrylic plate to manage the controlled eruption of the posterior teeth cause clockwise rotation in the occlusal plane, thus improving the class II molar relationship into a class I.[5] Patients were informed about the use and cleaning of the monoblock appliance and the points to be taken into consideration were explained. They were informed that the appliance should be used for 16-18 hours, except for brushing and eating.[21] Patients had control sessions at 4-6 week intervals. During the sessions for all patients, controlled eruptions were performed in the disto-occlusal direction for maxillary molar and in the mesio-occlusal direction for mandibular molars, with selective grindings (average about 2 mm) on the acrylic plate of the appliance in order to achieve Class I molar relationship. Functional orthopedic treatment was completed once it was determined that growth and development were complete on wrist X-rays.[22] Patient cooperation was evaluated by checking whether the advanced mandible relapsed to the initial position when pressure was applied to the chin. Figure 1 illustrates the pre-treatment and post-activation intraoral photographs.

Figure 1: Intraoral photographs of a patient treated with monoblock appliance; (a) lateral bite record photograph taken pre-treatment, (b) lateral bite photograph of the mandible activated advanced by applying the appliance.

Angular and linear parameters measured in the study

Skeletal measurements for maxilla and mandible in the sagittal direction:[23]

- SNA: It is the angle between the lines SN and NA. It shows the sagittal position of the maxilla relative to the anterior cranial base.

- SNB: It is the angle between the lines SN and NB. It shows the sagittal position of the mandible relative to the anterior cranial base.

- ANB: It is the angle between the lines NA and NB. It shows the sagittal position of the maxilla and mandible relative to each other.

Dental angular measurements in maxilla and mandible:

- U1/NA: It is the angle between the upper incisor line and the NA line.

- IMPA: It is the angle between the Go-Me line and the lower incisor line.

Vertical skeletal measurements:[18]

- SN/GoGn: It is the angle between the SN line and the GoGn line.

- Condylion-Gonion-Menton (CoGoMe): It is the angle between the condylar axis line (Co-Go) and the mandibular base (Go-Me).

Measurements for dentoalveolar heights:[12]

- MxADH (Maxillary Anterior Dentoalveolar Height): It is the distance from the incisal edge of the upper central incisor to the palatal line (ANS-PNS).

- MnADH (Mandibular Anterior Dentoalveolar Height) : It is the distance from the incisal edge of the lower central incisor to the mandibular base (Go-Me).

- MxPDH (Maxillary Posterior Dentoalveolar Height): It is the distance from the top of the mesiobuccal cusp of the maxillary first molar to the palatal line (ANS-PNS).

- MnPDH (Mandibular Posterior Dentoalveolar Height): It is the distance from the top of the mesiobuccal cusp of the mandibular first molar to the mandibular base (Go-Me).

The reference lines used:

- ANS-PNS: The line between anterior nasal spina and posterior nasal spina.

- Co-Go: The line between Condylion and Gonion points.

- Go-Me: The line between Gonion and Menton points.

Skeletal and dentoalveolar height measurements investigated in the study are shown in the lateral cephalometric radiograph in Figure 2.

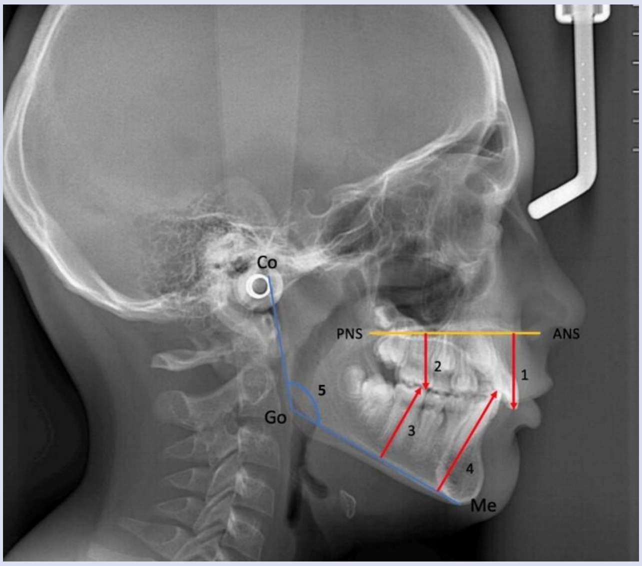

Figure 2: Skeletal and dentoalveolar height measurements; 1; Maxillary anterior dentoalveolar height, 2; Maxillary posterior dentoalveolar height, 3; Mandibular posterior dentoalveolar height, 4; Mandibular anterior dentoalveolar height, 5; Co-Go-Me angle, Co; Condylion, Go; Gonion, Me; Menton, PNS; Posterior nasal spina, ANS; Anterior nasal spina.

Statistical analysis

SPSS (Statistical Package for Social Sciences, version 26, IBM Corporation, NY, USA) program was used for statistical analysis of the data obtained in the study. Normality distribution of the data was evaluated with the one-sample Kolmogorov-Smirnov test. Intra-group comparisons of normally distributed data were made with the paired sample t test, while those with non-normal distribution were evaluated with the Wilcoxon test. The relationship between changes in CoGoMe angle and dentoalveolar height changes was evaluated with Spearman's rho correlation coefficient. The reliability test of the measurements was evaluated with Cronbach's α and two-way random effect intraclass correlation coefficients. Statistical significance level was determined as $p<0.05$.

Results

In order to evaluate intraobserver measurement reliability, excellent reliability was found between measurements made by the same investigator four weeks apart in 15 randomly selected patients (r values were between 0.901 and 0.952 for all measurements).

No significant change was found in the SNA angle with functional treatment ($p>0.05$). On the other hand, the increase in the SNB angle and the decrease in the ANB were found to be statistically significant ($p<0.05$). The SN/GoGn angle also did not change significantly with functional treatment ($p>0.05$). The decrease in the U1/NA angle and the increase in the IMPA were found to be significant ($p<0.05$). It was also found that the CoGoMe angle increased statistically significantly at T1 compared to T0 (p<0.05). It was observed that there were no significant changes in both MxADH and MnADH with treatment (p>0.05). On the other hand, MxPDH and MnPDH were found to increase significantly after treatment (p<0.05). Statistical analysis results for the comparison of measurements at T0 and T1 are given in Table 2.

There was no statistically significant relationship between changes in CoGoMe angle and changes in dentoalveolar heights after removable functional treatment (p>0.05). At T1, a moderately positive and statistically significant relationship was found between MxADH change and MxPDH, MxnADH and MnPDH changes (p<0.05). Similarly, a moderate positive significant relationship was found between MnADH change and MnPDH and MxPDH changes (p<0.05). Again, a moderate positive significant relationship was found between MnPDH change and MxPDH change (p<0.05). The results of the correlation analysis of the relationship between CoGoMe angle and dentoalveolar height changes are shown in Table 3. The scatter plots for correlation results are visually shown in Figures 3 and 4.

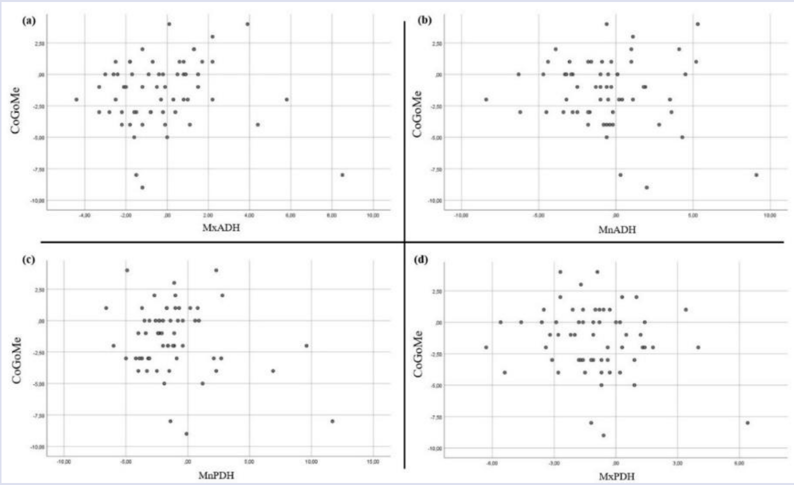

Figure 3: The scatter plots of correlations between the differences in CoGoMe angle and in dentoalveolar heights changes. Scatter plots: (a) for Maxillary Anterior Dentoalveolar Height, (b) for Mandibulary Anterior Dentoalveolar Height, (c) for Mandibulary Posterior Dentoalveolar Height (c), (d) for Maxillary Posterior Dentoalveolar Height.

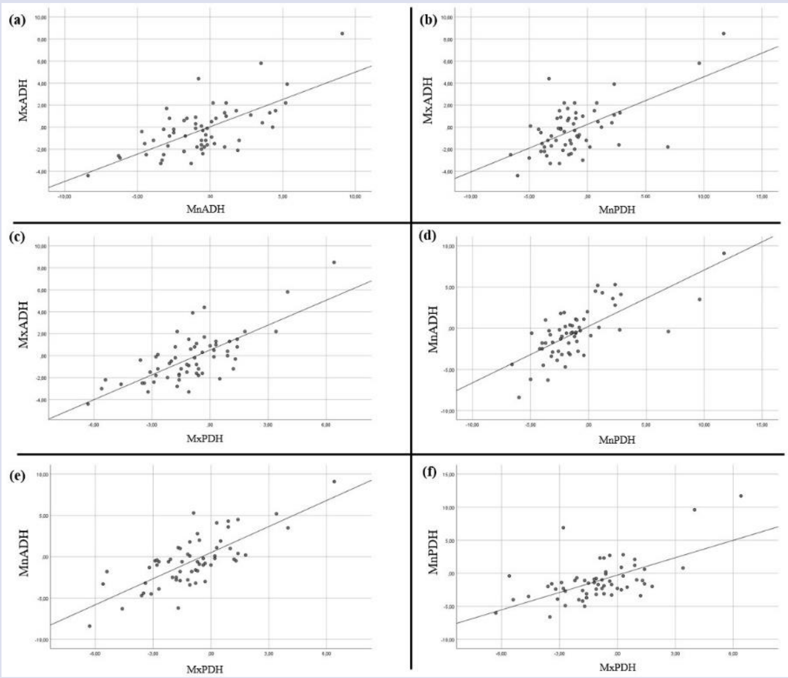

Figure 4: The scatter plots of correlations between the differences in dentoalveolar heights changes. Scatter plots: (a) for the between maxillary and mandibular anterior dentoalveolar height changes, (b) for the between maxillary anterior and mandibular posterior dentoalveolar height changes, (c) for the between maxillary anterior and posterior dentoalveolar height changes, (d) for the between mandibular anterior and posterior dentoalveolar height changes, (e) for the between mandibular anterior and maxillary posterior dentoalveolar height changes, (f) for the between mandibular and maxillary posterior dentoalveolar height changes.

Table 2. Statistical analysis results for angular and linear measurements

		T0	T1	p
SNA	Mean±SD	80.88 ± 2.70	80.13 ± 2.36	0.279 W
	Median	81	80	
SNB	Mean±SD	75.05 ± 2.64	77.98 ± 2.36	**<0.001 * P**
	Median	75	78	
ANB	Mean±SD	5.88 ± 1.05	3.15 ± 1.08	**<0.001 * W**
	Median	6	4	
SN/GoGn	Mean±SD	31.70 ± 5.87	32.18 ± 5.64	0.385 W
	Median	31.5	30.5	
U1/NA	Mean±SD	32.46 ± 3.43	29.85 ± 3.43	**<0.001 * W**
	Median	32	30	
IMPA	Mean±SD	91.48 ± 4.42	94.35 ± 4.39	**<0.001* W**
	Median	91	94	
CoGoMe	Mean±SD	124.06 ± 6.09	125.46 ± 5.60	**<0.001* W**
	Median	123.5	125	
MxADH	Mean±SD	26.46 ± 3.29	26.71 ± 2.76	0.407 P
	Median	26.4	26.7	
MnADH	Mean±SD	37.41 ± 3.77	37.98 ± 3.46	0.158 P
	Median	36.6	37.5	
MxPDH	Mean±SD	20.64 ± 2.60	21.65 ± 2.24	**<0.001 * P**
	Median	20.4	21.8	
MnPDH	Mean±SD	26.52 ± 3.45	27.69 ± 2.76	**<0.001 * W**
	Median	26.05	27.65	

P: Paired-t test / W: Wilcoxon test / T0: pre-treatment / T1: post-treatment / *p*: significance value / *: $p < 0.05$
MxADH: Maxillary Anterior Dentoalveolar Height / MnADH: Mandibulary Anterior Dentoalveolar Height / MxPDH: Maxillary Posterior Dentoalveolar Height / MnPDH: Mandibulary Posterior Dentoalveolar Height

Table 3. Correlation analysis results of the relationship between CoGoMe angle and dentoalveolar height change amounts

		CoGoMe	MxADH	MnADH	MnPDH	MxPDH
CoGoMe	Spearman rho	1	0.172	-0.058	-0.018	-0.117
	p		0.189	0.661	0.892	0.374
MxADH	Spearman rho		1	0.576	0.422	0.649
	p			**<0.001 ***	**<0.001 ***	**<0.001 ***
MnADH	Spearman rho			1	0.670	0.687
	p				**<0.001 ***	**<0.001 ***
MnPDH	Spearman rho				1	0.494
	p					**<0.001 ***
MxPDH	Spearman rho					1

T0/T1 difference: amount of pre- and post-treatment differences / *p*: significance value / *: $p < 0.05$
MxADH: Maxillary Anterior Dentoalveolar Height / MnADH: Mandibulary Anterior Dentoalveolar Height / MxPDH: Maxillary Posterior Dentoalveolar Height / MnPDH: Mandibulary Posterior Dentoalveolar Height

Discussion

In our study, we examined whether the CoGoMe angle and dentoalveolar heights changed and were related to each other after removable functional orthopedic treatment in patients with Class II division I malocclusion. We found that the CoGoMe angle and posterior dentoalveolar heights in the maxilla and mandible increased significantly with functional treatment. We also found that there was no correlation between the CoGoMe angle and dentoalveolar heights, but dentoalveolar heights showed a significant positive correlation with each other. According to these results, the alternative hypothesis of our study was rejected.

Digital cephalometric radiographs enable fast, accurate and easy diagnosis and follow-up. For this reason, software developed for digital cephalometric analysis that allows measurements on these radiographs has increased considerably.[24] The usability and accuracy of Nemoceph, one of the widely used programs for this purpose, has been reported.[25] However, it has disadvantages such as incorrect head posture and two-dimensional (2D) image magnification.[24] With the development of cone beam computed tomography (CBCT), which eliminated these disadvantages, three-dimensional (3D) imaging began to be used more widely to replace 2D images. However, although CBCTs produce lower radiation exposure than conventional CTs, they create higher radiation exposure than 2D dental radiographs.[26] Considering the follow-up radiographs needed during the long-term treatment of adolescents receiving orthodontic treatment, the potential for adverse effects from receiving CBCT, which will result in exposure to high doses of radiation, is quite high.[24,27,28] For this reason, in our study, the Nemoceph analysis program was used to obtain reliable and repeatable measurements on 2D lateral cephalometric radiographs.

The CoGoMe angle is an important angle related to mandibular rotation, independent of the anterior cranial base, and its evaluation is important for growth and development monitoring.[12] Dentoalveolar heights are also an important segment in skeletal vertical growth. D'Antò *et al.*[18] investigated the distribution of the CoGoMe angle in a patient population from Southern Italy and the relationship of this angle with vertical and sagittal cephalometric parameters. Contrary to our study, they reported that skeletal sagittal differences did not affect CoGoMe angle and that this angle was associated with vertical facial type. In our study, we found that the CoGoMe angle increased significantly with skeletal mandibular advancement. We think that this is due to sagittal and vertical skeletal changes in the repositioned and advanced mandible. Also, no relationship was observed between CoGoMe angle and dentoalveolar heights.

The average CoGoMe angle measured by growth monitoring by Franchi and Baccetti[14] was reported to be 125.5 degrees. In their study, they reported that the CoGoMe angle is a cephalometric measurement that determines the response to functional treatment before treatment. In our study, we found the average value of the CoGoMe angle to be 124.06 degrees at T0 and significantly increased to 125.46 degrees at T1. In contrast, changes in SN/GoGn angle were not significant. Thus, the significant increases in the CoGoMe angle with functional orthopedic treatment revealed that this angle is an important angular parameter for growth and development monitoring and could be preferred over the SN/GoGn angle in functional treatment.

Martina *et al.*[29] evaluated the relationship between changes in posterior dentoalveolar heights and craniofacial heights. They reported that posterior dentoalveolar heights were positively affected by the change in lower facial heights. In our study, no significant changes were observed in anterior dentoalveolar heights at T1 compared to T0. This situation is thought to be due to the fact that the eruption of the incisors, which is the determinant of the anterior dentoalveolar height, is controlled by the appliance's acrylic plate. However, we found that posterior dentoalveolar heights increased significantly in both jaws after functional treatment. It is thought that this is due to allowing the extrusion of the molars with the selective grindings made on the acrylic plate to create a clockwise rotation in the occlusal plane in order to obtain a class I molar relationship.

In the literature, there are many studies on sagittal skeletal and dental changes that occur with the functional treatment of class II malocclusions.[21,30,31] Dikmen *et al.*[30] observed a decrease in SNA and ANB angles and an increase in SNB angles after functional treatment of class II malocclusions. Additionally, they found both the decrease in U1/NA angle and the increase in IMPA significant. Similarly, in their study investigating the dentofacial effects of functional therapy, Küçükönder *et al.*[31] found the decrease in SNA and ANB angles and the increase in SNB angle significant and observed retroclination in the maxillary incisors and proclination in the mandibular incisors. In our study, we did not find the decrease in SNA angle significant with functional treatment. This is due to the difference in the sample due to the inclusion of patients with a normal sagittal position of the maxilla and the forward displacement of the hard tissue point A, which is affected by the retroclination of the maxillary incisors. However, the increase in the SNB angle, the decrease in the ANB angle, retroclination in the maxillary incisors and proclination in the mandibular incisors were found to be significant.

Laranjo and Pinho[17] stated that dentoalveolar heights are effective in posterior and anterior facial heights and mandibular rotation. They found that maxillary posterior dentoalveolar heights had a strong positive correlation with anterior and posterior facial heights. They also stated that patients with increased dentoalveolar heights had increased vertical growth and the mandible grew in a way that made posterior rotation. In our study, it was observed that maxillary and mandibular posterior dentoalveolar heights increased with the CoGoMe angle at T1, and vertical growth occurred with posterior rotation of the mandible. Additionally, although there were no significant changes in anterior dentoalveolar heights at T1, changes in all dentoalveolar heights were positively significantly correlated with each other.

Ardani *et al.*[32] examined the relationship between dentoalveolar heights and skeletal vertical growth patterns in Indonesian patients with class I malocclusion. They found that maxillary and mandibular posterior dentoalveolar heights were positively correlated with SN/GoGn angle, which are vertical cephalometric measurements. In our study, we found that maxillary and mandibular posterior dentoalveolar heights increased after functional treatment, but this was not related to the CoGoMe angle. We also found that although the SN/GoGn angle increased, this was not significant, but there were significant increases in the CoGoMe angle. It is thought that the differences between the studies are due to the different inclusion criteria of the sample.

The limitations of this study are that multiple comparisons with the literature cannot be made entirely due to the lack of an equivalent study with a similar sample and that the remaining mandibular growth after the post-peak period cannot be monitored long-term. Other limitations include the unequal distribution of male and female patients and the vertical inclusion of only hypodivergent and normodivergent individuals. Furthermore, the effect of different growth patterns could not be evaluated due to the lack of knowledge regarding the distribution of hypodivergent and normodivergent patients in the study group. Therefore, there is a need to plan further studies that include long-term stability follow-ups in appropriate sample groups. With the presented study, important results have been revealed on lateral cephalometric radiographs regarding the changes in the CoGoMe angle and dentoalveolar heights, which are reliable[19,33] and which provide orthodontists with an insight into the level of possible skeletal and dentoalveolar changes expected in the functional treatment of skeletal class II division I malocclusions.

Conclusions

The alternative hypothesis of the study was rejected. The following conclusions were obtained in the research:

- There is no relationship between CoGoMe angle and dentoalveolar heights. On the other hand, the significant positive relationship between changes in dentoalveolar heights was due to changes in dentoalveolar levels.
- In the advanced and repositioned mandible with functional treatment, the eruption of the molars with selective grinding on the acrylic plate and the clockwise rotation in the occlusal plane caused by this resulted in both a class I molar relationship and an increase in posterior dentoalveolar heights. Therefore, orthodontists should not only focus on skeletal correction for stability in functional orthopedic treatment, but should also consider changes at the dentoalveolar level.
- Finally, since significant changes were observed in the CoGoMe angle compared to the SN/GoGn angle with functional treatment, the CoGoMe angle is a suitable alternative to the SN/GoGn angle in monitoring mandibular rotational growth and development changes with functional treatment.

Acknowledgements

The authors declared that this study has received no financial support.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Alogaibi YA, Murshid ZA, Alsulimani FF, et al. Prevalence of malocclusion and orthodontic treatment needs among young adults in Jeddah city. J Orthodont Sci. 2020;9(3).

2. Namdar P, Shiva A, Lal Alizadeh F, et al. Prevalence of dental malocclusions among 12-14-year-old students in East Mazandaran. Iran J Pediatr Dent. 2021;16(2):58-69.

3. Jena AK, Duggal R, Parkash H. Skeletal and dentoalveolar effects of Twin-block and bionator appliances in the treatment of Class II malocclusion: a comparative study. Am J Orthod Dentofac Orthop. 2006;130(5):594-602.

4. Pancherz H, Ruf S. The Herbst appliance: research-based updated clinical possibilities. World J Orthod. 2000;1(1):17.

5. Proffit, WR, Fields Jr HW, Sarver DM. Contemporary Orthodontics. 5 th ed. Missouri: Mosby Inc., an affiliate of Elsevier Inc; 2013.

6. McNamara Jr JA. Components of Class II malocclusion in children 8–10 years of age. Angle Orthod. 1981;51(3):177-202.

7. Petrovic A, Lavergne J, Stutzmann J. Tissue-level growth and responsiveness potential, growth rotation and treatment decision. Science and clinical judgment in orthodontics. 1986;Monograph 19:249.

8. Wahl N. Orthodontics in 3 millennia. Chapter 9: functional appliances to midcentury. Am J Orthod Dentofac Orthop. 2006;129(6):829-833.

9. Baccaglione G, Rota E, Ferrari M, et al. Second class functional treatment: Andreasen activator vs twin block. Int J Clin Pediatr Dent. 2020;13(2):144-149.

10. El-Huni A, Salazar FBC, Sharma PK, et al. Understanding factors influencing compliance with removable functional appliances: a qualitative study. Am J Orthod Dentofac Orthop. 2019;155(2):173-181.

11. Franchi L, Alvetro L, Giuntini V, et al. Effectiveness of comprehensive fixed appliance treatment used with the Forsus Fatigue Resistant Device in Class II patients. Angle Orthod. 2011;81(4):678-683.

12. Valletta R, Rongo R, Pango Madariaga AC, et al. Relationship between the Condylion–Gonion–Menton angle and dentoalveolar heights. Int J Environ Res Public Health. 2020;17(9):3309.

13. Cozza P, Baccetti T, Franchi L, et al. Mandibular changes produced by functional appliances in Class II malocclusion: a systematic review. Am J Orthod Dentofac Orthop. 2006;129(5):599. e591-599. e512.

14. Franchi L, Baccetti T. Prediction of individual mandibular changes induced by functional jaw orthopedics followed by fixed appliances in Class II patients. Angle Orthod. 2006;76(6):950-954.

15. Tallgren A, Solow B. Age differences in adult dentoalveolar heights. Eur J Orthod. 1991;13(2):149-156.

16. Shaikh A, Fida M. Dentoalveolar heights in skeletal class I normodivergent facial patterns. J Coll Physicians Surg Pak. 2012;22(1):5-9.

17. Laranjo F, Pinho T. Cephalometric study of the upper airways and dentoalveolar height in open bite patients. Int Orthod. 2014;12(4):467-482.

18. D'Antò V, Pango Madariaga AC, Rongo R, et al. Distribution of the condylion-gonion-menton (cogome^) angle in a population of patients from southern Italy. Dent J. 2019;7(4):104.

19. Islam ZU, Shaikh AJ, Fida M. Dentoalveolar heights in vertical and sagittal facial patterns. J Coll Physicians Surg Pak. 2016;26(9):753-757.

20. DeVincenzo JP. Changes in mandibular length before, during, and after successful orthopedic correction of Class II malocclusions, using a functional appliance. Am J Orthod Dentofac Orthop. 1991;99(3):241-257.

21. Tümer N, Gültan AS. Comparison of the effects of monoblock and twin-block appliances on the skeletal and dentoalveolar structures. Am J Orthod Dentofac Orthop. 1999;116(4):460-468.

22. Mardiati E, Soemantri ES, Halim H. Determination of the duration of various pubertal growth stages in Indonesian boys and girls using hand-wrist radiographs. J World Fed Orthod. 2018;7(4):146-149.

23. Cortese M, Pigato G, Casiraghi G, et al. Evaluation of the oropharyngeal airway space in class II malocclusion treated with mandibular activator: a retrospective study. J Contemp Dent Pract. 2020;21(6):666-672.

24. Li C, Teixeira H, Tanna N, et al. The reliability of two-and three-dimensional cephalometric measurements: A CBCT study. Diagnostics. 2021;11(12):2292.

25. Mitra R, Chauhan A, Sardana S, et al. Determination of the comparative accuracy of manual, semi-digital, and fully digital cephalometric tracing methods in orthodontics. J Dent Def Sect. 2020;14(2):52-58.

26. Benn DK, Vig PS. Estimation of x-ray radiation related cancers in US dental offices: Is it worth the risk? Oral Surg Oral Med Oral Pathol Oral Radiol. 2021;132(5):597-608.

27. Kapetanović A, Oosterkamp BC, Lamberts AA, et al. Orthodontic radiology: development of a clinical practice guideline. Radiol Med. 2021;126:72-82.

28. Yeh J-K, Chen C-H. Estimated radiation risk of cancer from dental cone-beam computed tomography imaging in orthodontics patients. BMC Oral Health. 2018;18:1-8.

29. Martina R, Farella M, Tagliaferri R, et al. The relationship between molar dentoalveolar and craniofacial heights. Angle Orthod. 2005;75(6):974-979.
30. Dikmen F, Bolat E. Comparison of The Effects of Monoblock and Twin Block Appliances in Class II Division 1 And Class II Division 2 Patients. Suleyman Demirel University Journal of Health Sciences. 2020;11(3):311-321.
31. Küçükönder A, Doruk C. Evaluation of the effects of monoblock and twin Force appli-ances on the dentofacial System. Int J Oral Dent Health. 2019;5:078.
32. Ardani IGAW, Pratiknjo IS, Djaharu'ddin I. Correlation between dentoalveolar heights and vertical skeletal patterns in class I malocclusion in ethnic Javanese. Eur J Dent. 2021;15(2):210-215.
33. Kucera J, Marek I, Tycova H, et al. Molar height and dentoalveolar compensation in adult subjects with skeletal open bite. Angle Orthod. 2011;81(4):564-569.