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Research Article

EVALUATION OF NASAL TIP ROTATION AND PROJECTION FOLLOWING FACEMASK THERAPY

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ABSTRACT

Purpose: This study conducted retrospectively aims to assess the impact of facemask therapy on nasal tip projection and rotation in prepubertal patients with Class III malocclusion associated by maxillary deficiency.

Materials and Methods: The retrospective study included 32 patients (21 males, 12 females) with an average age of 8.34 ± 0.83, who received facemask therapy at Aydın Adnan Menderes University's Department of Orthodontics. Cephalometric radiographs were obtained pretreatment (T0) and 3 months posttreatment (T1). Nasal tip projection analysis was by the Goode method, while the rotation of the nasal tip was assessed through nasolabial angle measurements.

Results: An increase that is statistically meaningful in nasal height and length was observed post-treatment ($p < 0.001$), whereas no meaningful difference was observed in the nasolabial angle and Goode ratio ($p > 0.05$). In both females and males, nasal height and length measurements at T1 were elevated compared to the values measured at T0 ($p = 0.002$, $p = 0.001$). Based on the study's correlation analysis findings, strong positive correlations were identified between nasal length at T0 and the Goode ratio at T0 ($r=0.613$, $p<0.001$), and among nasal height at T1 and the Goode ratio at T1 ($r=0.721$, $p<0.001$).

Conclusion: The outcomes of our study demonstrate that facemask therapy supports some morphological changes in the nasal structure but has limited effects on soft tissue aesthetics.

Keywords: Facemask, Goode method, Nasolabial angle

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INTRODUCTION

In accordance with the angle classification, Class III malocclusion is characterized by the mesial positioning of the mandibular first molar relative to the maxillary first molar. The skeletal discrepancies related to Class III malocclusion is defined by retrusive maxilla, protrusive mandibula or a combination of these conditions. Approximately 60% of this anomaly originates from maxillary retrusion. Although Class III malocclusion is thought to have a genetic basis, environmental factors such as habits and mouth breathing may also contribute to its etiology (1).

Due to the negative growth pattern in patients with Class III malocclusion, early intervention is necessary. The ideal timing for skeletal treatment is during the prepubertal phase of development (1). Growth modification can be achieved through chincap appliances to restrict mandibular growth or facemask therapy to promote maxillary protraction. Early treatment improves facial aesthetics, positively impacting psychological development during childhood (2). In the postpubertal phase, camouflage or orthognathic surgery, with or without fixed orthodontic mechanics, can be applied (3). Several studies have reported noticeable effects of Class III malocclusion treatment on soft tissues. These studies show that early orthopedic treatment with facemask therapy can create positive short-term effects on soft tissue (4,5).
Since the maxilla and the nasal bone are anatomically connected by the nasomaxillary suture, maxillary protraction typically results in positional changes of the nasal bone as well. There is a direct relationship between the degree of forward movement of the maxillary complex and the positional changes of the nasal bone (6).

Projection of nasal tip is described as the anteroposterior measurement from the level of the alar fold to the nasal tip along the facial surface. Various methods have been documented in the literature to evaluating nasal tip projection (7). As the range between the nasal tip and the face increases, projection of nasal tip value also increases. One common measurement method involves calculating the ratio of the distance from the alar base to the nasal tip to the distance from the nasion to the nasal tip, known as the Goode method (8). Nasal tip rotation refers to the superior-inferior movement of the nasal tip, a dynamic that has a direct impact on the nasolabial angle. Typically, the nasolabial angle ranges from 90° to 105° in males and from 105° to 120° in females.(9).

This study aims to evaluate nasal tip projection and rotation in prepubertal patients who undergoing facemask therapy. The null hypothesis (H0) of this study is that "Facemask treatment in the prepubertal period has no effect on nasal anatomy." The alternative hypothesis (H1) is that "Facemask treatment in the prepubertal period has effect on nasal anatomy."

MATERIALS AND METHODS

This study is a retrospective investigation approved by the Non-Interventional Clinical Research Ethics Committee of Aydın Adnan Menderes University Faculty of Dentistry (approval number: 2024/18) and was conducted in accordance with the ethical standards of the Declaration of Helsinki.

The sample size was determined using version 3.1 of the G-power program, according to the study performed by Kılınç et al. (10). The effect size was set at 0.534, with a type I error rate of 0.05 and a statistical power of 0.80, a minimum of 30 individuals is required for inclusion in the study.

The study included prepubertal patients with Class III malocclusion characterized by maxillary retrusion who applied for orthodontic treatment at Aydın Adnan Menderes University Faculty of Dentistry between 2018 and 2024. The inclusion criteria for this study were as follows: patients diagnosed with Class III malocclusion characterized by maxillary deficiency, presence of anterior crossbite and in the prepubertal growth phase as determined by the cervical vertebral maturation method. Only patients who had completed the full facemask therapy protocol and had both pre-treatment (T0) and post-treatment (T1) cephalometric radiographs available were included in the study. Exclusion criteria consisted of the presence of craniofacial syndromes or systemic diseases, lack of compliance with the treatment protocol, incomplete treatment records, or a history of previous orthodontic or orthopedic treatment. All patients included in the study initially presented with anterior crossbite and achieved a positive overjet following facemask therapy.
The age range of the participants was between 7.1 and 9.6 years. All participants were in the prepubertal growth phase, which was confirmed using cervical vertebral maturation (CVM) method on cephalometric radiographs(11). The final group comprised 32 patients: 12 females (average age of 8.27 ± 0.65) and 21 males (average age of 8.38 ± 0.91).

Cephalometric radiographs were obtained using the Planmeca ProMax panoramic device (Planmeca, Helsinki,

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Finland). With the teeth in centric occlusion and the Frankfort horizontal plane parallel to the floor, the radiographs were obtained.

All cephalometric radiographs were calibrated using the Image J analysis software (version 1.51, National Institutes of Health, Bethesda, Maryland, USA). Radiographs were obtained pretreatment (T0) and 3 months posttreatment (T1). Nasal tip projection analysis was by the Goode method (10). Three reference points were determined on the cephalometric radiograph: nasion (N), the farthest forward point of the nasal tip (T), and the alar fold (A). The Goode ratio was determined by calculating the proportion of nasal height (AT) to nasal length (NT). The normal range is considered 0.55 to 0.60 (Figure 1).

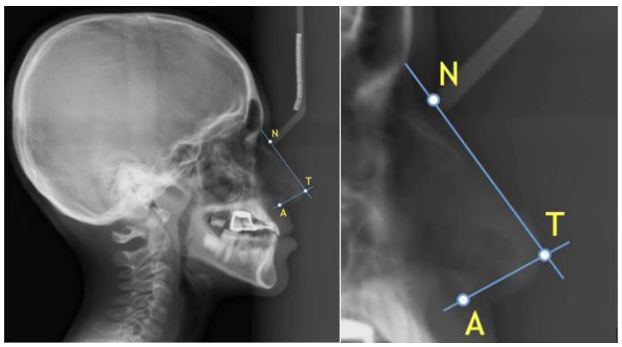

Figure 1. Linear measurements related to the nose used in the study.

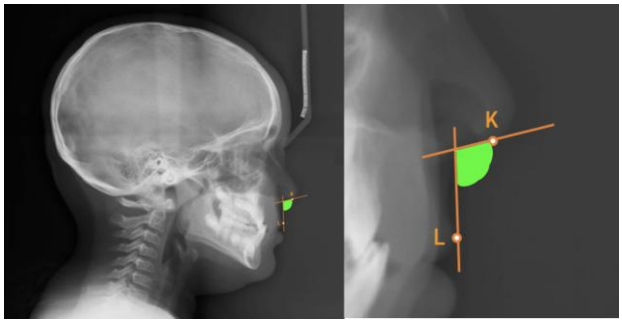

Figure 2. Nasolabial angle.

Nasal Height (AT): The anteroposterior distance between the alar fold of the nose and the farthest forward point of the nasal tip point of the nasal tip in the sagittal plane.

Nasal Length (NT): The anteroposterior distance from the nasion to the the farthest forward point of the nasal tip in the sagittal plane.

$$\text{The nasal tip projection ratio (Goode method)} = \frac{\text{Nasal Height (AT)}}{\text{Nasal Length (NT)}}$$

The nasolabial angle (NLA) values pretreatment (T0) and posttreatment (T1) were measured by utilizing cephalometric radiographs. NLA is a parameter used to evaluate nasal tip rotation. It is defined by drawing a tangent to the nasal columella (K) and another tangent to the upper lip's border (L). The intersection of these lines at the subnasale point forms the nasolabial angle. The normal range for the NLA is considered 95° to 110° (12). All analyses and measurements were conducted by the same investigator (O.U.) (Figure 2).

Statistical Analysis

SPSS v26 software (IBM Corporation, Armonk, NY, USA) was used for statistically analyses. The normality of quantitative variables was evaluated using the Kolmogorov-Smirnov test. Descriptive statistical analyses for quantitative variables are reported as mean ± standard deviation or median (25th-75th percentiles), and for qualitative variables as counts (%). Comparisons between independent groups were conducted using either independent samples t-tests or Mann-Whitney U tests, depending on the data distribution. The chi-square independence test was used to analyze relationships between qualitative variables. Pearson correlation was employed to assess the relationships between quantitative variables. A p-value of <0.05 was regarded as statistically meaningful.

RESULTS

Upon evaluating the demographic characteristics of the individuals included in this study were assessed, the majority of the participants were male (n = 21, % 65.6), while females accounted for a smaller proportion (n = 11, % 34.4). The average age of male patients was 8.38 ± 0.91, and for female patients, it was 8.27 ± 0.65. The mean age of all individuals was 8.34 ± 0.83 (Table 1).

Table 1. Demographic characteristics of the patients in the study

Gender	n (%)	Male	21 (65.6)
		Female	11 (34.4)
Age	Mean±SD	Male	8.38±0.91
		Female	8.27±0.65
		Total	8.34±0.83

Descriptive statistics are presented as mean ± standard deviation.

When nasal measurements, nasolabial angle and Goode ratio findings at T0 and T1 were analyzed, significant increases in nasal height and nasal length were observed in males at T1 in comparison to T0 (p=0.001; p=0.011). There was no statistically notable difference was observed between T0 and T1 regarding the Goode ratio and nasolabial angle measurements (p=0.255; p=0.317) (Table 2). For females, nasal height and nasal length at T1 were

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significantly higher than at T0 (p=0.002; p=0.005). No notable difference in Goode ratio and nasolabial angle between T0 and T1 (p=0.327; p=0.093) (Table 2). Overall, nasal height and nasal length at T1 were significantly higher than at T0 (p<0.001; p<0.001). No notable difference was found in Goode ratio and nasolabial angle measurements between T0 and T1 (p=0.148; p=0.116) (Table 2).

Table 2. Comparison of nasal measurements, Goode ratio, and nasolabial angle at T0 and T1

		Facemask T0	Facemask T1	p*
Male (n=21)	Nasal Height	17.99±2.43	20.18±2.80	***0.001***
	Nasal Length	40.71±5.16	44.32±5.59	***0.011***
	Goode Ratio	0.44±0.05	0.46±0.05	0.255
	Nasolabial Angle	107.37±11.40	105.81±11.90	0.317
Female (n=11)	Nasal Height	17.68±2.61	19.60±3.24	***0.002***
	Nasal Length	41.02±4.39	44.29±3.07	***0.005***
	Goode Ratio	0.43±0.08	0.44±0.09	0.327
	Nasolabial Angle	103.17±17.20	101.20±16.34	0.093
Total (n=32)	Nasal Height	17.88±2.46	19.98±2.92	***<0.001***
	Nasal Length	40.82±4.84	44.31±4.81	***<0.001***
	Goode Ratio	0.44±0.06	0.45±0.07	0.148
	Nasolabial Angle	105.93±13.54	104.22±13.51	0.116

**: Dependent samples t test. Descriptive statistics are presented as mean ± standard deviation.*

The correlation analysis findings of the study showed that estrong positive correlations were found between nasal length at T0 and Goode ratio at T0 (r=0.613, p<0.001) and between nasal height at T1 and Goode ratio at T1 (r=0.721, p<0.001). Additionally, a nearly perfect correlation was observed between the nasolabial angle at T0 and T1 (r=0.903, p<0.001). Positive correlations were found between nasal length at T0 and nasal height at T1 (r=0.437, p=0.012) and between nasal length at T0 and nasal length at T1 (r=0.447, p=0.010). A significant positive relationship was identified between age and the Goode ratio at T1 (r=0.611, p<0.001). These results indicate significant and distinct relationships between the variables. (Table 3).

Table 3: Results of correlation analysis. r: Pearson correlation coefficient

		T0 Nasal Height	T0 Nasal Length	T0 Goode Ratio	T0 Nasolabial Angle	T1 Nasal Height	T1 Nasal Length	T1 GoodeRatio	T1 Nasolabial Angle
T0 Nasal Length	r	**0.437**							
	p	**0.012**							
T0 Goode Ratio	r	**0.613**	**-0.434**						
	p	**<0.001**	**0.013**						
T0 Nasolabial Angle	r	0.296	-0.173	**0.412**					
	p	0.100	0.344	**0.019**					
T1 Nasal Height	r	**0.653**	0.186	**0.477**	0.289				
	p	**<0.001**	0.309	**0.006**	0.108				
T1 Nasal Length	r	0.241	**0.447**	-0.179	-0.046	**0.370**			
	p	0.184	**0.010**	0.326	0.803	**0.037**			
T1 Goode Ratio	r	**0.456**	-0.154	**0.604**	0.334	**0.721**	**-0.370**		
	p	**0.009**	0.400	**<0.001**	0.061	**<0.001**	**0.037**		
T1 Nasolabial Angle	r	0.172	-0.303	**0.394**	**0.903**	0.147	-0.042	0.190	
	p	0.348	0.092	**0.026**	**<<0.001**	0.423	0.820	0.297	
Age	r	**0.431**	**0.578**	-0.098	-0.008	0.298	**0.611**	-0.160	-0.051
	p	**0.014**	**0.001**	0.593	0.967	0.097	**<<0.001**	0.383	0.780

DISCUSSION

The primary concern of individuals with Class III malocclusion is facial aesthetics. Improvements in facial appearance, especially during adolescence, can positively influence patients' self-esteem, appearance, and psychological well-being (4). When evaluating the facial profile, excessive protrusion or retrusion of the jaw and lips can negatively affect aesthetics. Factors such as the nasal projection, nasolabial angle, lip position, and mentolabial sulcus are important to preserve facial aesthetics. The nasolabial angle is characterized as the angle between the lower edge of the nose and the upper edge of the lip, is a critical measure for determining facial balance. The ideal range for this angle is between 90° and 95° in males, and 95° to 115° in females. (13).

In this study, a decrease in the nasolabial angle was observed in both males and females after treatment. However, this change was not statistically significant. This result is similar to the findings of Sertan et al. (14) and Kılıçoğlu and Kırlıç (5), who also found no statistically significant changes in the nasolabial angle before and

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following facemask therapy. Similarly, Celikoğlu et al. (15) observed no meaningful changes in nasolabial angle measurements pre-treatment and post-treatment in groups with and without rapid maxillary expansion using facemask therapy. In contrast, Xu et al. (16) observed an average decrease of 5.62° in the nasolabial angle, which was statistically significant, in patients undergoing maxillary protraction therapy.

The nose keeps developing forward and downward until reaching adulthood. It has been reported that the nasal tip moves forward by approximately 1 mm per year (17). Nanda et al. (17) observed rapid growth in nasal height between ages 7 and 8, followed by slower growth between ages 8 and 11, and accelerated growth between ages 14 and 17. In the present study, the nasal tip shifted anteriorly and slightly inferiorly in all treatment groups.

A retrospective study by Yavuz et al. (18) on adolescents and young adults, it was reported that early facemask therapy demonstrated efficacy in both age groups; however, its impact was more pronounced in young adults compared to adolescents. Similarly, a study conducted by Kim et al. (19) examining the impact of age on facemask therapy reported more pronounced treatment changes in younger patients. These findings suggest that facemask therapy is more effective in younger patients but shows reduced efficacy in those older than 10 years. In the present study, the average age of the participants was 8.34 ± 0.83, which is consistent with similar studies (20,21), allowing for early intervention and the benefits of biological growth advantages.

Different methods have been employed to assess nasal tip projection (7,22). The Goode method, one of these methods, calculates projection of the nasal tip ratio by examining on the relationship between nasal height and nasal length (Figure 1). In our study, the Goode method was used to evaluate projection of the nasal tip. Reyneke and Ferretti (23) indicated that nasal aesthetics could be evaluated using the Goode method in their study focusing on soft tissue facial aesthetics. Nasal aesthetics are a significant focus in aesthetic assessments since they can be influenced by orthodontic treatment and orthognathic surgery. Rhinoplasty can be considered a component of orthognathic surgical treatment planning, allowing for the management of potential adverse aesthetic outcomes during surgery (23). Several studies have assessed nasal aesthetics using the Goode method after rhinoplasty (7,22,24). Elbestar et al. (25) compared the Goode and Byrd methods for evaluating nasal tip projection after rhinoplasty and reported that the Goode method provided more reliable and accurate results. Similarly, Kılınç et al. (10) used the Goode method to assess nasal tip projection after orthognathic surgery, while Ingels et al. (24) applied it following rhinoplasty procedures. Conversely, Ahmed et al. (26) proposed that the Crumley 1 method could be a more applicable option. These findings highlight the widespread use of the Goode method in evaluating nasal projection after various treatment techniques. To our knowledge, there is no other study has used the Goode method in patients undergoing facemask therapy, making our study a unique contribution to the field of orthodontics. Therefore, the null hypothesis of this study, "Facemask treatment in the prepubertal period has no effect on nasal anatomy." was rejected.

CONCLUSION

Our study assessed the effects of facemask therapy on projection and rotation of nasal tip in prepubertal individuals with Class III malocclusion. The findings suggest that facemask therapy supports certain morphological changes in the nasal structure, but its impact on soft tissue aesthetics is limited. Early intervention takes advantage of the biological growth potential during the development phase, enhancing the effectiveness of both orthodontic and orthopedic treatments. Therefore, initiating treatment during the prepubertal phase may be critical for achieving long-term success in both aesthetic and functional outcomes.

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None

Authorship contributions
Surgical and medical practices OU, concept OU, collecting design OU and MGC, data collection of processing OU, analysis of interpretation OU and MGC, literature search OU, writing OU and MGC.

Data availibity statement
The data that support the findings of this study are available from the corresponding author, [MGC], upon reasonable request.

Declaration of competing interest
The authors deny any conflicts of interest related to this study.

Ethics
This study was approved by Ethics Committee of Aydin Adnan Menderes University, Faculty of Dentistry

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Noninvasive Clinic Ethics Committee (Approval date: 25.12.2024.; Number:2024/18.)

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