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Evaluation of Orbit Vector Relationships in Different Types of Skeletal Malocclusions

Farklı İskeletsel Maloklüzyon Tiplerinde Orbit Vektör İlişkisinin Değerlendirilmesi

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Abstract

Objective: This study aimed to determine the orbit vector relationships between different types of malocclusion supported by cephalometric analysis.

Materials and Methods: This retrospective study was conducted on 69 patients who were diagnosed with orthodontic malocclusion. Demographic information, such as age and gender, were provided from the medical records of the patients. Cephalometric analysis was performed by an expert orthodontist to determine the anteroposterior skeletal relationship. The orbit vector relationship was evaluated by digital patient photographs taken by the Frankfort horizontal plane by two different ophthalmologists.

Results: The mean age of the patients was 14.58±3.95 (range, 8-28) years. Forty-five (65.2%) of the patients were female and 24 (34.8%) were male. Positive orbit vector patients had significantly higher SNA measures and ANB readings than negative orbit vector patients (pSNA=0.014, pANB=0.001). There was no difference in orbit vector status between Class I and II malocclusion groups (p=0.580). Negative vectors were more common in the Class III group than in the Class I (p=0.039) and Class II (p=0.004) groups.

Conclusion: The majority of patients in the Class I and II groups had a positive orbit vector, whereas patients in the Class III group had a negative orbit vector relationship.

Öz

Amaç: Çalışmamızın amacı sefalometrik analizler ile desteklenmiş farklı maloklüzyon tiplerinde orbit vektör ilişkisini tanımlamaktır.

Gereç ve Yöntemler: Bu retrospektif çalışma ortodontik maloklüzyon tanısı koyulan 69 hasta ile yapıldı. Yaş ve cinsiyet gibi demografik özellikler hasta dosyalarından elde edildi. Anteroposterior iskeletsel ilişkiyi değerlendiren sefalometrik analizler ortodonti uzmanı tarafından yapıldı. Orbit vektör ilişkisi iki farklı oftalmolog tarafından Frankfurt horizontal planında çekilen dijital fotoğraflardan değerlendirildi.

Bulgular: Ortalama yaş 14,58±3,95 (aralık, 8-28) yıl idi. Hastaların 45'i kadın (%65,2), 24'ü erkekti (%34,8). Pozitif orbit vektöre sahip olgularda SNA ve ANB değerleri negatif orbit vektöre sahip olgulara göre anlamlı derecede yüksek bulundu (pSNA=0,014, pANB=0,001). Class I ve Class II maloklüzyon grupları arasında orbit vektör ilişkisi açısından bir fark yoktu (p=0,580). Ancak Class III maloklüzyon grubunda Class I (p=0,039) ve Class II'ye (p=0,004) göre daha yüksek oranlarda negatif orbit vektör saptandı.

Sonuç: Class I ve Class II maloklüzyona sahip olguların çoğunluğunda pozitif orbit vektör görülürken Class III maloklüzyona sahip olgularda negatif orbit vektörün daha fazla olduğu görüldü.

Keywords
Malocclusion, maxillary hypoplasia, orbit vector

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Introduction

The visible part of the eye includes the sclera, iris, and pupil (1). The negative orbit vector term is used to define the state that the corneal apex being in a more anterior position than the malar eminence. Negative orbit vector, unlike exophtalmos, may result from underdevelopment of the viscerocranium and manifests itself in the infraorbital and malar regions (2). Anatomical analysis has shown that visual inspection of the orbit vector can be used to classify the anterior malar prominence (3).

Functional, parafunctional, and dysfunctional harmony of all the components of the masticatory system is defined as occlusion. Aesthetically and functionally unacceptable occlusion conditions are called malocclusion (4). The World Health Organization (1987) defines malocclusion as a dental abnormality that causes deformity or affects function and requiring treatment “likely that deformity or functional deficiency is likely to impair the physical or emotional well-being of the patient” (5). Several methods of classifying malocclusions have been described. The most widely used of these is the anteroposterior skeletal classification according to the ANB angle (6). In skeletal Class I malocclusion, the position of the maxilla and mandible relative to each other is ideal while in skeletal Class II malocclusion, it may be caused by the retrognathic mandible, maxillary excess, or both. In skeletal Class III, it may be due to maxillary hypoplasia, mandibular prognathism, or both (7,8).

The globe is located in a bone cavity called the orbit and the maxillary bone forms an essential part of the orbital floor (9). These relationships between the maxilla and mandibula affect the orbit and globe position. It is known that maxillary hypoplasia causes a negative orbit vector (3).

Furthermore, despite the existence of several orbit vector analyses in different patient groups, validation of its efficacy as diagnostic tools in relation to underlying skeletal malocclusions has not been thoroughly investigated. To the best of our knowledge, this was the first study to examine the relationship between orbital vector and different types of skeletal malocclusion. The aim of this study was to define the orbit vector relationships between different types of malocclusions supported by cephalometric analysis. The null hypothesis was selected as there is no relationship between types of malocclusion and orbit vector.

Materials and Methods

This retrospective study was conducted with 69 patients who were diagnosed with orthodontic malocclusion. The records were selected from the patients who applied between October 2015 and January 2020 in the archive of Trakya University Faculty of Dentistry, Department of Orthodontics. The research followed the Declaration of Helsinki’s principles and was authorized by the Trakya University Faculty of Medicine Dean’s Scientific Research Ethics Committee (decision number: 01/10, date: 06.01.2020). Written informed consent was obtained from all the patients before their enrollment. If the patient was under 18 years of age, informed consent was obtained from their parents.

We aimed to determine the 40% difference in the effect sizes between the groups. In our calculation by selecting the alpha value as 0.05 and the power as 0.80, we determined that at least 23 patients should be included in the study for each group.

Demographic information such as age and gender were provided from the medical records of the patients. The anteroposterior skeletal relationship was determined via cephalometric analysis. The cephalometric images were obtained with the Frankfort plane parallel to the floor and the lips relaxed. The same technician took all lateral cephalometric radiographs using the same X-ray machine (PaX-Flex; Vatech Inc. NJ). Dolphin Imaging 11.95 software was used to import digital radiographs stored as.jpeg files (Dolphin Imaging and Management Solutions, Calif, USA). The images were in grayscale format and the image characteristics were 2.232×2.304 pixels, 150 dpi, and 8 bit. Poor quality cephalograms that might interfere with anatomical point identification and craniofacial abnormalities were the exclusion criteria. Three cephalometric angular measurements were performed. The internal angle between the lines connecting sella to nasion and nasion to anterior limit of the maxillary apical base (SNA angle), the position of the mandible relative to the anterior cranial base (SNB angle), and the anteroposterior position of the mandible relative to the maxilla (ANB angle) was measured (Figure 1) (10).

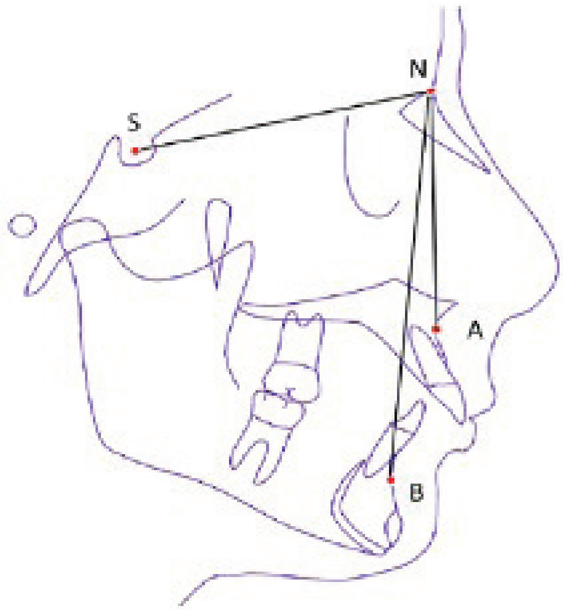

Figure 1. Cephalometric landmarks; S: sella, N: nasion, A: point A, B: point B

The patients were divided into 3 groups according to the ANB angle. ANB angle: 0-4 (°) as Class I, ANB angle >4 (°) as Class II, and ANB angle <0 (°) as Class III (6). For repeatability analysis, the x-rays of 10 patients were re-evaluated by the same investigator after 2 weeks and maloclusion classification was performed accordingly. The agreement of the first and second examinations was evaluated by Cohen's kappa test and repeatability was excellent (kappa =1.0, p<0.001). Orbit vector analysis was performed in the sagittal direction from the patient photographs. The relationship between the most anterior point of the globe to the most anterior point of the malar process was examined. Standardized photographs were taken with a DSLR camera (Nikon D7200, 105 mm Nikkor lens) which was placed at a distance of 2m from the patient. The same studio, ambient lighting, and camera were used to obtain the photographs for all patients. All images were taken with the patient's head parallel to the floor in the Frankfort plane, with the teeth in centric relation and the lips relaxed (11). All photographs were evaluated by two different ophthalmologists. Orbit vector analysis was divided into 3 groups. If the cornea projected more anteriorly than the anterior cheek mass, this was defined as a negative orbit vector. In contrast, the positive vector was defined when the globe is posterior to the most anterior projection of the malar eminence. When the anterior projection of the cornea was in line with the malar eminence, the vector is considered as neutral (Figure 2) (12). For repeatability analysis, the photos of 10 patients were reassessed by the same two investigators after 2 weeks and orbital vector classification was performed accordingly. The agreement of the first and second examinations was evaluated by Cohen's kappa test and repeatability was excellent (kappa =1.0, p<0.001).

Statistical Analysis

IBM SPSS Version 20 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Descriptive statistical data were presented as mean ± standard deviation. To test the normality of the data, Kolmogorov-Smirnov test was used. Independent t-test, one-way ANOVA, Welch ANOVA, Tukey, and Tamhane posthoc tests were used to compare quantitative variables. Chi-square was performed to compare categorical variables. The relationship between the groups was assessed using Pearson correlation analysis. Statistical significance was considered as p<0.05.

Results

The mean age of the patients was 14.5±3.9 years (range, 8-28 years). The study comprised 45 patients (65.2%) who were female and 24 patients (34.8%) who were male. No intergender difference was found in terms of SNA, SNB, ANB values, and malocclusion.

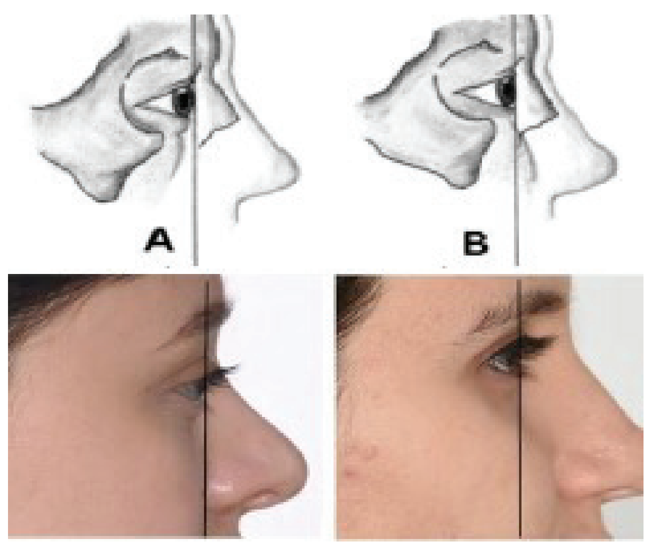

Figure 2. Schematic and photographic examples of orbital vector classification negative (A) and positive (B) orbital vector

Mean age, SNA, SNB, ANB values of of the groups were shown in Table 1. Mean ages in Class I group was 17.2±3.9 years, 12.4±1.5 years in Class II, and 14.1±4.2 years in Class III group. Female/male ratios in Class I, II, and III malocclusion patients were 18/5, 15/8, 12/11 respectively (p=0.178). Although there was no significant correlation between age and SNA (r=-0.046, p=0.706), SNB (r=0.062, p=0.612), ANB (r=-0.106, p=0.388) values, age was found to be significantly higher in patients with Class I malocclusion group compared to other malocclusion groups (p<0.001). The mean SNA value in the Class II malocclusion group was considerably higher than in the Class III malocclusion group (p=0.022). The mean SNB value was found to be significantly higher in the Class III malocclusion group than other malocclusion groups (p<0.001).

The relationship of gender, age, and SNA, SNB, ANB values with orbit vector status were presented in Table 2. There was no significant difference between orbit vector groups in terms of age, gender, and SNB value (respectively; p=0.365, p=0.436, and p=0.569).

Positive orbit vector patients had higher SNA measures and ANB values than negative orbit vector patients (p=0.014 and p=0.001, respectively). Orbit vector distributions in all malocclusion groups are shown in Table 3. There was no difference in orbit vector status between Class I and II malocclusion groups (p=0.580). In the Class III malocclusion group, however, there was a higher rate of negative vectors than both Class I (p=0.039) and Class II (p=0.004) malocclusion groups.

Discussion

The purpose of this study was to evaluate whether vector relationships can be used to diagnose and define anterior malar projection and skeletal malocclusion. In the present study, it was found that there was a higher rate of negative orbit vectors among patients with Class III malocclusion than both Class I and Class II malocclusion. Although the mean age of the Class I malocclusion group was higher than that of Class II and III, there was no correlation between age and cephalometric analysis. As skeletal Class II and Class III malocclusions are problems that need to be treated in the adolescence period, we think that the age difference from the Class I group is due to this reason. Class III malocclusion is defined as disproportionately forward growth of the mandible or inadequate maxillary development. It can be caused

Table 1. Descriptive statistics and statistical significance of the patient characteristics

	All groups (mean ± SD)	Class I (mean ± SD)	Class II (mean ± SD)	Class III (mean ± SD)	p*
Age	14.58±3.95	17.22±3.99A	12.43±1.53B	14.09±4.19B	I-II*** I-III*
SNA (°)	80.56±3.38	80.18±3.58AB	82.05±3.31A	79.44±2.81B	II-III*
SNB (°)	78.66±4.51	77.90±3.70A	75.74±3.62A	82.35±3.53B	I-III*** II-III***
ANB (°)	1.90±4.16	2.28±1.00A	6.33±1.59B	-2.90±2.28C	I-II*** I-III*** II-III***

SD: Standart deviation, *p<0.05, **p<0.01, ***p<0.001

Table 2. Relationship of gender, age, and SNA, SNB, ANB values with orbital vector status

	Positive vector	Negative vector	Neutral vector	P*
Sex (Female/Male)	32/13	11/9	2/2	NS
Age	14.91±3.74	13.65±3.17	15.50±8.70	NS
SNA (°)	81.34±3.27A	78.82±3.23B	80.45±2.89AB	P-NG*
SNB (°)	78.28±4.13	79.58±5.30	78.38±5.13	NS
ANB (°)	3.07±3.57A	-0.77±4.40B	2.10±3.81AB	P-NG***

NS: Non significant, *p<0.05, **p<0.01, ***p<0.001

Table 3. Orbital vector distributions in malocclusion groups

	Positive vector	Negative vector	Neutral vector	
Class I	16 (35.6%)	5 (25%)	2 (50%)	23
Class II	19 (42.2%)	3 (15%)	1 (25%)	23
Class III	10 (22.2%)	12 (60%)	1 (25%)	23
Total	45 (65.2%)	20 (29%)	4 (5.8%)	69

by mandibular prognathism, maxillary hypoplasia or combination of both (13). We thought that the reason for the common negative vector in Class III patients might have been due to hypoplasia in the maxilla or the incompatible growing mandible pushing the maxilla backward by mechanical action.

SNA measurements and ANB values were found to be lower in the negative orbit vector patients than in the positive vector patients. There was no significant difference between orbit vector groups in terms of age and gender. The SNA value represents the position of the anterior limit of the anterior maxillary apical base in relation to the upper craniofacial complex. The ANB value describes the anteroposterior position of the mandible relative to the maxilla. It shows the inconsistent horizontal development between the maxilla and mandible. A negative ANB value indicates retrusion of the maxilla, protrusion of the mandible, or both (10). Lower SNA values and negative ANB values were found in Class III malocclusion. Based on these findings, it can be suggested that individuals with negative orbit vectors are likely to have developmental disparities between the mandible and the maxilla.

Frey (3) has described the use of the vector relationship supported by the cephalometric analysis in the visual classification of the anterior malar projection and found that those with a negative vector relationship had much less malar support than those with a positive vector relationship.

Doddamani et al. (14) evaluated anterior malar projection according to the orbit vector relationship. They concluded that orbit vector evaluation may be useful in classifying anterior malar projection and it would be useful in the diagnosis of maxillary hypoplasia. However, these studies were conducted in healthy individuals without any orthodontic conditions. In our study, we evaluated patients with malocclusion. This is the first study that evaluates and defines the relationship between the orbit vector and different types of malocclusion. While there are no significant differences in Class I and Class II patients in terms of positive and negative orbit vectors, the negative vector ratio in Class III malocclusion was found to be significantly higher than the positive vector. These data support the suggestion of Doddamani et al. (14) that the orbital vector status may be useful in the diagnosis of maxillary hypoplasia.

There are several publications in the literature on the clinical use of the orbit vector relationship.

Rajabi et al. (15) found that the majority of eyes with entropion had positive orbit vectors and a significant number of eyes with ectropion had negative orbit vectors. They proposed that the orbit vector could be a reliable factor in the prediction of the type of age-related eyelid malposition. Choi et al. (16) showed that patients with negative orbit vector relationships were more likely to develop orbital floor fractures than medial wall fractures. This knowledge indicates the importance of evaluating the orbit vector relationship in the ophthalmologic examination. In the present study, we found that the negative orbit vector relationship is more common in patients with Class III malocclusion. We suggest that the possibility of maxillary hypoplasia and malocclusion should be taken into consideration in patients with a negative orbit vector in the ophthalmological examination. This will be beneficial in the proper management of patients and preventing the conditions that may arise due to malocclusion.

Ophthalmologists by nature tend to view the globe and periocular tissues from an ophthalmologic perspective. The null hypothesis was rejected in this very study. We believe that this study may give ophthalmologists a different perspective in evaluating the relationship between the globe and the face and predicting possible pathologies that may cause it. In the case of a negative orbit vector, it may be appropriate for ophthalmologists to send patients to an orthodontic consultation to reveal whether maxillo-mandibular discrepancy exists.

The limitation of this study was that the human face, which is three-dimensional, was evaluated through two-dimensional photographs. Therefore, orbit vector analysis has become difficult in some cases. To minimize this error, the photographs were evaluated by two different ophthalmologists unaware of each other and the results were compared. For cases of conflict (2 cases), the two physicians classified the patients by evaluating the photographs together.

Conclusion

It was found that the majority of patients in Class I and II group had a positive orbit vector, whereas patients in the Class III group had a negative orbit vector relationship. These findings support that vector relationships can be used to classify anterior malar support and may be an indicator of some facial dysmorphic disorders such as maxillo-mandibular discrepancy. Patients with negative orbit vector relationships may experience severe global midface hypoplasia manifesting with Class III malocclusion and deformities of the orbits.

Ethics

Ethics Committee Approval: The research followed the Declaration of Helsinki's principles and was authorized by the Trakya University Faculty of Medicine Dean's Scientific Research Ethics Committee (decision number: 01/10, date: 06.01.2020).

Informed Consent: Written informed consent was obtained from all the patients before their enrollment. If the patient was under 18 years of age, informed consent was obtained from their parents.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: P.M., Concept: R.G., P.M., Design: R.G., P.M., M.Ö., N.Ö., Data Collection or Processing: R.G., P.M., Analysis or Interpretation: R.G., P.M., M.Ö., N.Ö., Literature Search: R.G., P.M., M.Ö., N.Ö., Writing: R.G., P.M., M.Ö., N.Ö.

Conflict of Interest: No conflict of interest was declared by the authors.

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