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Article

Cbct Evaluation of the Relationship between the Distance of the Apex of the Upper Central Tooth to the Nasal Floor and the Anterior nasal Spine with Orthodontic Vertical Direction Parameters

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Abstract: The aim of this study was to examine the relationship of the distance between the apex tip of the upper central tooth (U1A) and the anterior nasal spine (ANS) and the nasal floor (NF) with the vertical cephalometric values using cone-beam computerized tomography (CBCT). A total of 122 patients who applied to Department of Orthodontics between January 2011-June 2019 were included. On the CBCT's, distances between the U1A and the NF and ANS were measured. Statistical significance was considered as $p < 0.05$. Of 122 individuals 73.8% ($n=90$) were female and 26.2% ($n=32$) were male with an mean age of $22,8 \pm 3,3$ years. A statistically significant moderate positive correlation was found between the NF-U1A mean values and the measurements of N-Me, ANS-Me and ANS-Gn, S-Go, and N-ANS measurements ($p < 0.01$). A statistically significant positive correlation was found between the ANS-U1A mean values and Ar-Go-Me, total posterior angles, N-Me, SN/GoGn and Y-axis angle, ANS-Me and ANS-Gn ($p < 0.01$). In this study, we found that the distance of U1A from ANS and NF points was related to orthodontic vertical direction parameters. It was demonstrated that the ANS-U1A and NF-U1A points can serve as reference points for identifying the orthodontic vertical growth pattern on CBCT scans.

Keywords: orthodontic treatment; upper central; anterior nasal spine; nasal floor; CBCT; vertical growth pattern

1. Introduction

Cephalometric analysis is the most commonly used diagnostic method for patients who will undergo orthodontic treatment. With the cephalometric analysis method, the vertical, sagittal and transversal relationship of both the upper jaw and the lower jaw with respect to the skull base; the relationship of the upper and lower jaws to each other, the positions of the teeth with respect to the relevant base and each other can be evaluated [1–3]. Angle measurements have been made by creating various planes on radiographs for many years. Broadbent mentioned the growth model of the face in 1937 [4], and then Brodie introduced the method of evaluating the growth pattern of the head, brain, nose, dental arches, and lower jaw [5]. Later, Björk evaluated the cranial base and its growth. It was concluded that the vertical enlargement of the face is closely related to the growth rotation of the lower jaw [2].

One of the measurements commonly used to determine the orthogonal morphology and growth pattern of the face is the Sella-Nasion/Gonion-Gnathion (SN/GoGn) angle [3]. McNamara suggested using the Gonion-Menton/Frankfurt Horizontal Plane (GoMe/FH) angle [6]. Matilla et al. suggested looking at the Gonial angle not connected with the cranial base in orthopantomographs [7]. It is also possible to use the Y-axis angle in the classification of vertical anomalies of the face [8]. In a previous study on the distribution of the lower jaw rotation model according to the position between the sagittal jaws, it was found that the position between the sagittal jaws was independent of the vertical

growth model of the face and lower jaw rotation [6]. Evaluations with SN/GoGn, GoMe/FH, and Gonial angle norms did not give the same information in individuals with Class II and Class III deviations [9].

The Anterior Nasal Spine (ANS) point is a fixed reference point that is not affected by orthodontic tooth movements and is one of the cephalometric landmarks in the skull [10]. The A-point is the deepest point of the anterior alveolar bone recess below the ANS. Since the A-point is the alveolar bone point, it is affected by tooth movements [8]. Nasion (N) is the depression at the root of the nose corresponding to the nasofrontal suture [11]. The nasal floor (NF) and ANS are accepted as fixed reference points that do not change during orthodontic treatment.

Vertical malocclusions; is one of the most challenging cases for orthodontists in terms of difficult treatment. Therefore, information about the vertical alignment of the face has a very important place in terms of diagnosis, treatment planning and prognosis of the treatment [12]. In the literature, although there are only a few studies in which the distances of the apex of the upper central incisor (U1A) from different anatomical structures were calculated, it was stated that these distances were related to sagittal or vertical direction parameters. Therefore, we thought that the distance of U1A from NF and ANS might be related to the vertical direction parameters. The aim of the study was to examine the relationship between the distance between U1A and ANS, and U1A and NF with vertical cephalometric values on cone-beam computed tomography (CBCT) and to evaluate whether this distance can be a parameter in determining the vertical skeletal growth pattern.

2. Materials and Methods

The material of our cross-sectional retrospective study consisted of patients who applied to Van Yüzüncü Yıl University, Faculty of Dentistry, Department of Orthodontics between January 2011-June 2019. Following the planning of the study, ethics committee approval was obtained from the Ethics Committee of Van Yüzüncü Yıl University Non-Interventional Clinical Research (decision no: 2019/06-04). Demographic information, medical and dental anamnesis of the patients were obtained from the records taken in the Orthodontic Clinic before orthodontic treatment. The study was conducted in accordance with the ethical principles of the Helsinki Declaration. Skeletal class 1 (ANB: 0-4°) patients with upper inclination (UI-NA distance: 0-4 mm) and upper incisor-NA angle at norm value (UI-NA angle: 22±3°) without open-bite before orthodontic treatment, Patients aged 18 years and older and systemically healthy according to ASA classification (ASA1) were included in the study. Patients with dental anomalies such as root resorption, dental invagination, taurodontism, and dilation in their upper central incisors before treatment, individuals with cleft lip and palate, patients with low-quality radiographs, and patients who had previous orthodontic treatment were not included in the study.

Cephalometric measurements

All cephalometric x-rays were taken on the same device and by the same operator, with the lips in the resting position and the patient in the natural head position. It was paid attention to taking lateral cephalometric radiographs with the Sirona Orthophos XG imaging system under standard conditions. Determination of hard and soft tissue points and measurements were made by NemoCeph V.2017 package program. Lateral cephalometric x-rays taken at the beginning of the treatment were examined and evaluated by a single observer (SCC), and re-measurements was made on the same radiographs after 4 weeks.

Vertical cephalometric measurements used in the study are; Saddle angle (N-S-AR), Articular angle (S-Ar-Go), Gonial angle (Ar-Go-Me), sum of Posterior angles, N-Me (anterior facial height), posterior facial height (S-Go), Sella-Nasion/Gonion-Gnathion (SN/GoGn), Nasion-Anterior Nasal Spine (N-ANS), Anterior Nasal Spine-Menton (ANS-Me), Anterior Nasal Spine-Gnathion (ANS-Gn), Sella-Gonion (S-Go), Y-axis angle, Sella Nasion- Occlusal Plane (SN-OcP) values.

CBCT measurements

Individuals who received CBCT (120 kV, 130 fov, 0.300 voxel 5 mA; KaVo 3D eXam (Biberach, Germany) for different orthodontic reasons were included in the study. Measurements were made by examining the CBCT images taken before treatment. All evaluations were done by the same investigator (SÇC) and radiographs were measured again after 4 weeks. Exam vision program was used to measure the distance between U1A and ANS and NF on CBCT. NF-UA1 distance was evaluated by measuring the closest distance of the apex tip of the upper central tooth to the NF to ensure the standardisation, it was ensured that the measured line was parallel to the long axis of the tooth. The vertical distance of the horizontal line passing through the ANS point to the apex tip point of the upper central tooth was taken as a reference when measuring the distance between U1A and ANS (Figure 1).

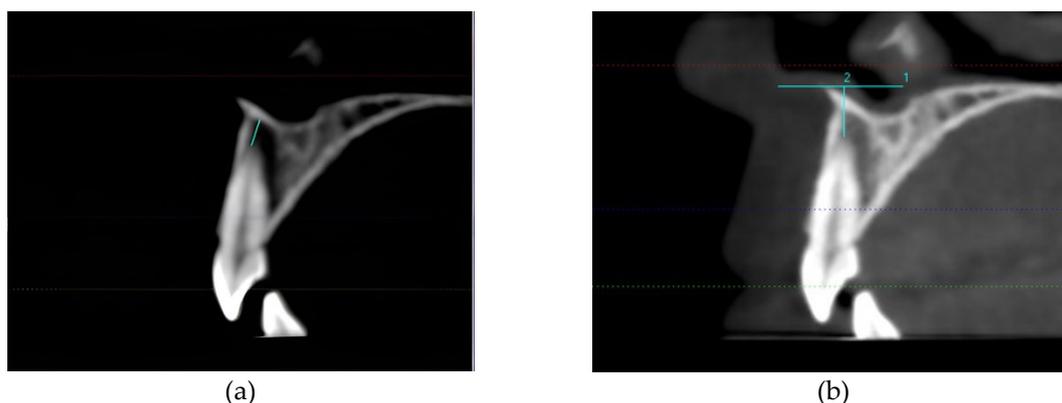


Figure 1. a) Measurements from UA1 to NF were performed parallel to the long axis of the tooth. b) The vertical distance of the horizontal line passing through the ANS point to the upper central apical point was taken as a reference when measuring the distance between U1A and ANS.

Right NF-U1A (NF- apex tip of upper right central tooth) and left NF-U1A (NB- apex tip of upper left central tooth), right ANS-U1A (ANS- apex tip of upper right central tooth) and left ANS-U1A (ANS- apex tip of upper left central tooth) distances were measured on the CBCT. NF-U1A and ANS-U1A values were obtained by calculating the mean of the right and left side measurements. ANS-Me, ANS-Gn distances and Y axis angle values of the patients were divided into 3 groups in terms of growth status. For ANS-Me distance; 63.9 mm and below was considered decreased, 64 mm to 74.9 mm was considered normal, 75 mm and above was considered increased. For ANS-Gn distance; 63.9 mm and below was considered decreased, 64 mm to 72.9 mm was considered normal, 73 mm and above was considered increased. For Y axis angle; 52.9 degrees and below was considered as decreased, 53 degrees to 66.9 degrees was considered as normal, 67 degrees and above was considered as increased.

Statistical analysis

For statistical analysis, the NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used. Descriptive statistical methods (mean, standard deviation, median, frequency, ratio, minimum, maximum) were used while evaluating the study data. The conformity of quantitative data to normal distribution was tested with Kolmogorov-Smirnov, Shapiro-Wilk tests, and graphical evaluations. Pearson Correlation Analysis was used to evaluate the relationships between variables showing normal distribution. The Student's t-test was used to compare two groups of quantitative data showing normal distribution. The Kruskal Wallis test was used for comparisons of three and more groups that did not show normal distribution, and the Bonferroni Dunn was used for pairwise comparisons. The level of significance was accepted as $p < 0.05$. The evaluation of the correlation coefficient (r) was made according to the following criteria: 0 - 0.25 very weak, 0.26 - 0.49 poor, 0.50 - 0.69 medium, 0.70 - 0.89 good, 0.90 - 1.00 very good. Post hoc power measurements were found to be above 80% in all of the significant results.

Sample size was calculated using G*Power (version 3.1.7) software, with a minimum requirement of 111 individuals. The study was conducted on 122 patients who met inclusion criteria during the time frame of the study, taking into account minimum sample size requirements.

3. Results

The ages of 122 individuals included in the study ranged from 18 to 30, with an mean age of $22,8 \pm 3,3$ years. Of 122 individuals 73.8% (n=90) were female and 26.2% (n=32) were male. Intraexaminer correlation coefficient indicated high reliability between two measurements (for CBCT measurements $r = 0,92$; for cephalometric radiography measurements $r = 0,91$).

Relationship of NF-U1A and cephalometric measurements

There was no statistically significant relationship between NF-U1A and NS-AR, S-Ar-Go, Ar-Go-Me, Sum of angles, SN/GoGn and SN-OcP measurements ($p > 0,05$). A statistically significant moderate positive correlation was found between NF-U1A and N-Me, ANS-Me and ANS-Gn measurements ($r = 0,547$; $r = 0,585$; $r = 0,611$; $p < 0,01$, respectively). A statistically significant weak positive correlation was found between NF-U1A and S-Go and N-ANS measurements ($r = 0,372$; $r = 0,338$; $p < 0,01$, respectively). A statistically significant very weak positive correlation was found between NF-U1A and Y-axis angle measurements ($r = 0,219$; $p < 0,05$, respectively), (Table 1).

Relationship of ANS-U1A and cephalometric measurements

A statistically significant weak positive correlation was found between ANS-U1A and Ar-Go-Me, the sum of posterior angles, N-Me, SN/GoGn and Y-axis angle measurements ($r = 0,287$; $r = 0,311$; $r = 0,384$; $r = 0,297$; $r = 0,311$, $p < 0,01$, respectively). A statistically significant moderate positive correlation was found between ANS-U1A and ANS-Me and ANS-Gn measurements ($r = 0,534$; $r = 0,531$; $p < 0,01$, respectively) (Table 1).

Table 1. Relationship of Cephalometric Measurements with NF-U1A and ANS-U1A.

Vertical Direction Parameters	NF-U1A		ANS-U1A	
	r	p	r	p
N-S-AR	-0,065	0,476	0,017	0,853
S-Ar-Go	0,030	0,740	-0,068	0,458
Ar-Go-Me	0,099	0,278	0,287	0,001**
Sum of posterior angles	0,098	0,284	0,311	0,001**
N-Me	0,547	0,001**	0,384	0,001**
S-Go	0,372	0,001**	0,131	0,150
SN/GoGn	0,064	0,484	0,297	0,001**
N-ANS	0,338	0,001**	0,079	0,388
ANS-Me	0,585	0,001**	0,534	0,001**
ANS-Gn	0,611	0,001**	0,531	0,001**
Y axis angle	0,219	0,015*	0,311	0,001**
SN-OcP	-0,163	0,073	0,082	0,369

r: Pearson Correlation Coefficient **p<0,01 *p<0,05.

The distribution of ANS-Me, ANS-Gn and Y-axis angle levels is shown in (Table 2).

Table 2. Distribution of ANS-Me, ANS-Gn and Y-Axis Angle levels.

	Levels	n	%
ANS-Me	Decreased (≤ 63.9)	66	54,1
	Norm (64-74.9)	49	40,2
	Increased (≥ 75)	7	5,7
ANS-Gn	Decreased (≤ 63.9)	76	62,3
	Norm (64-72.9)	36	29,5
	Increased (≥ 73)	10	8,2
Y Axis Angle	Decreased (≤ 52.9)	3	2,4
	Norm (53-66.9)	100	82
	Increased (≥ 67)	19	15,6

Evaluation of ANS-U1A and NF-U1A measurements according to ANS-Me

A statistically significant difference was found between NF-U1A measurements according to ANS-Me levels ($p=0.001$; $p<0.01$). As a result of the paired comparisons; The NF-U1A measurements of the groups with increased and normal ANS-Me levels were higher than the decreased group ($p=0.001$; $p=0.001$; $p<0.01$, respectively). No statistically significant difference was found between the NF-U1A measurements of the groups with increased and normal ANS-Me levels ($p>0.05$). A statistically significant difference was found between ANS-U1A according to ANS-Me levels ($p=0.001$; $p<0.01$). As a result of the paired comparisons; The ANS-U1A measurements of the groups with increased and normal ANS-Me levels were higher than the decreased group ($p=0.002$; $p=0.001$; $p<0.01$, respectively). No statistically significant difference was found between the ANS-U1A measurements of the groups with increased and normal ANS-Me levels ($p>0.05$), (Table 3).

Table 3. Evaluation of ANS-U1A and NF-U1A measurements according to ANS-Me Levels.

	ANS-Me Levels	NF-U1A	ANS-U1A
Decreased (≤ 63.9)	<i>n</i>	66	66
	<i>Min-Max</i>	1,1-10,1	1,5-10
	<i>Mn±Sd</i>	4,57±1,84	4,86±1,91
Norm (64-74.9)	<i>n</i>	49	49
	<i>Min-Max</i>	2,2-11,4	1-11
	<i>Mn±Sd</i>	6,94±2,13	6,80±2,15
Increased (≥ 75)	<i>n</i>	7	7
	<i>Min-Max (Median)</i>	5,5-10,8	5-12,2
	<i>Mn±Sd</i>	8,06±2,35	8,54±2,70
	<i>^ap</i>	0,001**	0,001**

^aKruskal Wallis Test ** $p<0,01$.

Evaluation of ANS-U1A and NF-U1A measurements according to ANS-Gn

A statistically significant difference was found between NF-U1A measurements according to ANS-Gn levels ($p=0.001$; $p<0.01$). As a result of the paired comparisons; The NF-U1A measurements of the groups with increased and normal ANS-Gn levels were higher than the decreased group ($p=0.001$; $p=0.001$; $p<0.01$, respectively). No statistically significant difference was found between the NF-U1A measurements of the groups with increased and normal ANS-Gn levels ($p>0.05$). A statistically significant difference was found between ANS-U1A measurements according to ANS-Gn ($p=0.001$; $p<0.01$). As a result of the paired comparisons; the ANS-U1A measurements of the groups with increased and normal ANS-Gn levels were higher than the decreased group ($p=0.001$; $p=0.001$; $p<0.01$, respectively). No statistically significant difference was found between the ANS-U1A measurements of the groups with increased and normal ANS-Gn levels ($p>0.05$), (Table 4).

Table 4. Evaluation of ANS-U1A and NF-U1A measurements according to ANS-Gn Levels.

ANS-Gn Levels		NF-U1A	ANS-U1A
Decreased (≤ 63.9)	<i>n</i>	76	76
	<i>Min-Max</i>	1,1-9,3	1,5-10
	<i>Mn±Sd</i>	4,76±1,88	5,01±1,88
Norm (64-72.9)	<i>n</i>	36	36
	<i>Min-Max</i>	2,2-11,4	1-11
	<i>Mn±Sd</i>	7,03±2,19	7,00±2,36
Increased (≥ 73)	<i>n</i>	10	10
	<i>Min-Max</i>	5,5-10,8	5-12,2
	<i>Mn±Sd</i>	8,30±2,08	8,11±2,33
	<i>^ap</i>	0,001**	0,001**

^aKruskal Wallis Test ** $p < 0,01$.

4. Discussion

It is a general view that the norm values of cephalometric analyses differ according to races [13–15]. It was determined that some dimensional measurement norm values used in Tweed analysis do not fit the Turkish race [16]. Gazilerli has created a new form of Steiner analysis for our society in Turkish children aged 13-16 [17]. In the study of İşimer et al. [18], the gonial angle norm value in Turkish society was found to differ by nearly 10 degrees according to Björk measurements [19]. For these reasons, racial characteristics should also be taken into consideration while performing cephalometric evaluation.

Tsunori et al. reported that facial types regarding morphological characteristics are an important factor to be considered in orthodontic treatment because the facial type influences growth prediction of the maxillofacial system in the anchorage system that is used during treatment [20]. Ligthelm-Bakker et al. found a negative correlation between the growth rate of the upper anterior facial height and the lower anterior facial height, suggesting that some children show accelerated growth at the lower facial height compared to the upper facial height, and vice versa [21]. Janson et al. confirmed an anterior ratio is a tool that can be used in orthodontic diagnosis, rather than using only numerical vertical measurements [22].

Maxillary anterior teeth are important not only in achieving dental and facial aesthetics but also in physiological functions such as pronunciation and chewing [23–27]. Therefore, determining the three-dimensional (3D) position of the maxillary incisors is an integral part of orthodontic diagnosis, and treatment planning and various biomechanical treatment methods are used to achieve the ideal incisor position. Vertical malocclusions; is one of the most challenging cases, often not achieving desired aesthetic results with treatment and post-treatment relapse. Therefore, information about the vertical alignment of the face has a very important place in terms of diagnosis, treatment planning and prognosis of the treatment [12]. In the literature, although there are only a few studies in which the distances of U1A from different anatomical structures were calculated, it was stated that these distances were related to sagittal or vertical direction parameters. Therefore, we thought that the distance of U1A from NF and ANS might be related to the vertical direction parameters.

The study of Cho et al. reported that the anteroposterior distance between the maxillary central incisor roots and the incisive canal was approximately 5-6 mm. It has been reported that the evaluation of the proximity of the incisive canal to the maxillary incisors, in addition to its dimensional, may be helpful in cases where a significant amount of maxillary retraction is planned [28].

In a study examining the correlation coefficients of GoGn/SN, Gonial angle, and GoMe/FH measurements used in the vertical classification of the face, they reported that these 3 angles that show the vertical direction position in individuals with hyperdivergent structure support each other [29]. In our study, it was observed that as the distance of U1A from ANS and NF increased, the ANS-Gn, ANS-Me, N-Me distances, and Y-axis angles increased and correlated with each other.

In their study, Gracco et al. reported that in the upper incisors, the face type was statistically significantly associated with both the thickness of the alveolar bone and the distance between the root apex and the lingual cortex [30]. In our study, the vertical evaluation parameters N-Me, ANS-Me, ANS-Gn, and Y-axis angle measurements; were observed to be positively correlated with the distance of U1A from ANS and NF.

Sadek et al. in their study in which they examined alveolar bone thickness and height on CBCT, reported that patients with increased vertical dimensions had greater anterior dentoalveolar height in both maxilla and mandible without significant difference in posterior alveolar height [31]. Patients with different vertical direction dimensions were also evaluated in our study. Similar to the results of the studies of Sadek et al. it was observed that the distance of the examined parameter, U1A, from ANS and NF, increased in patients with increased lower anterior facial height.

Enoki et al. in their study examining the dental-skeletal dimensions together with the variations in lower facial height in individuals in the growth and development period [32], In our study, similar to the results of the studies of Enoki et al., it was observed that the distance of the examined parameter, U1A, from ANS and NF increased in patients with increased lower anterior face height. Also in this study, it was observed that as the distance between U1A and NF increases, N-Me, ANS-Me, ANS-Gn, S-Go and N-ANS distances and Y-axis angle increase; as the distance between U1A and ANS increases, ANS-Gn ANS-Me, N-Me distances, Ar-Go-Me, SN/GoGn, Y-axis angle and the sum of posterior angles increase.

The limitations of the study include the small number of patients with increased growth direction in group comparisons made according to the ANS-Me and ANS-Gn growth direction model during statistical evaluations. In addition, comparisons could not be made between the Y axis angle groups in terms of NF-U1A and ANS-U1A because the numbers in the groups formed for the Y axis angle, which is another growth direction parameter, were not statistically sufficient and appropriate.

5. Conclusions

In this study, It was observed that the distance between U1A and ANS and between U1A and NF was higher in individuals with normal lower anterior facial height values than individuals with decreased lower anterior facial height. We found that the distance of U1A from ANS and NF points was related to vertical direction parameters, it was concluded that these parameters could be used as a determining factor in vertical growth. In this study, it was demonstrated that the ANS-U1A and NF-U1A points can serve as reference points for identifying the orthodontic vertical growth pattern on CBCT scans. Further studies with different populations, different case groups and larger sample sizes are needed to support these results.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data of the study is available and archived and protected by the authors.

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Conflicts of Interest: The authors declare no conflict of interest.

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