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Research Article

Assessment of Facial Depth in Skeletal Class III Cases with Mandibular Prognathism: A Cephalometric Study

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Abstract

Statement of the problem: In patients with mandibular prognathism and skeletal Class III malocclusion, there is a lack of data regarding the relationship between average facial depth and anterior facial height.

Objective: This study aims to determine the average facial depth in patients with mandibular-origin skeletal Class III malocclusion and to investigate the relationship between this measurement and anterior facial height.

Materials and Methods: A total of 626 individuals with Class III malocclusion were included in the study (292 females, 335 males). On cephalometric radiographs of the participants, the pogonion (Po), nasion (N), Frankfort Horizontal plane (FH), condylion (Co), and menton (Me) points were marked. The anterior facial height of the patients was calculated, and all participants were divided into three groups: long, average, and short. The distance where Co and N intersected the FH was defined as the 'facial depth distance' (Co-N). Finally, the ratio of the facial depth distance (Co-N) to the anterior facial height (N-Me) was calculated.

Results: A significant difference was observed in the mean ratio of Co'-N' to N-Me between long-faced individuals and short-faced individuals ($P < 0.05$). The ratio of the facial depth distance (Co'-N') to the anterior facial height (N-Me) was found to be 69% ± 5. This ratio was determined to be 68% ± 4 in long-faced individuals, 69% ± 4 in average-faced individuals, and 72% ± 5 in short-faced individuals.

Conclusions: The ratio between Co-N and N-Me may provide a new perspective in the evaluation of mandibular-origin Class III malocclusions.

Keywords: Cephalometric Analysis, Skeletal Class III, Malocclusion, Anterior Facial height, Facial Depth.

Introduction

In order to achieve optimal relationships for physiological and aesthetic harmony between facial and cranial structures, guiding the development of teeth and facial structures is within the fundamental responsibilities of orthodontics.[1,2] Determining the skeletal position of the maxilla and mandible is of great importance in the treatment of dentofacial structures and in the treatment planning of orthognathic surgical cases. Identifying the source of the problem based on the skeletal nature of malocclusion is crucial for treatment outcomes. Intervention is directed towards resolving the issue originating from whichever jaw is affected.[2,3]

Skeletal Class III malocclusion, where the relationship between the jaw structures is different from normal, is characterized by the lower jaw being positioned more forward than the upper jaw. It is mostly diagnosed using cephalometric analyses. In evaluating facial depth in skeletal Class III cases, the most commonly used cephalometric measurements so far have been the Sella-Nasion-A Point Angle (SNA Angle), Sella-Nasion-B Point Angle (SNB Angle), and A Point-Nasion-B Point Angle (ANB Angle). When the lower jaw is positioned forward, both the SNA and SNB angles increase, while the ANB angle becomes negative. The most commonly used method for determining facial depth today is measuring the distance between N and Gnathion (Gn), which is decreased in skeletal Class III cases.[4-6]

There are few studies investigating the relationship between average facial depth distance and anterior facial height in a balanced face.[7] In one of these studies, the average values of the facial depth distance, evaluated as Co-N distance, and its relationship with posterior facial height were assessed. The study found that the average facial depth distance was 85±8 mm. The ratio of this distance to the anterior facial height (N-Me) was 70±4.7% Koç[8] reported the average facial depth distance in maxillary-origin skeletal Class III cases as 83±7 mm, with a Co-N/N-Me ratio of 68%±5. In contrast, Sabuncuoğlu et al[9] found the average facial depth distance in mandibular-origin skeletal Class II cases to be 86±5 mm, with a Co-N/N-Me ratio of 69±5%.

This study aims to determine the average facial depth in patients with mandibular-origin skeletal Class III malocclusion and to investigate the relationship between this measurement and anterior facial height.

Materials & Methods

This study was approved by the Ethics Committee of Gulhane Military Medical Academy (Ankara, Turkey) and was conducted following the Helsinki Declaration of 1975. The sample size was calculated using GPower Ver. 3.00.10 (GPower, Franz Faul, Universität Kiel, Germany) software, with α=0.05 for Type I error, β=0.05 for Type II error, and a power of 0.80 (80% power), requiring a minimum of 626 patients to detect a minimum effect size of f=0.10.

From a previously conducted cephalometric analysis, 626 individuals were included in the study, exhibiting the following characteristics:

-According to the McNamara analysis, the average value of Nv-A was 0 mm and the average value of Nv-Pog was +2 mm, indicating signs of mandibular-origin Class III malocclusion.

-According to the Steiner analysis, the ANB angle was 0° or less than 0°.

Of the evaluated cephalometric radiographs, 335 belonged to male patients (53.5%) and 291 belonged to female patients (46.5%). Among these, 203 radiographs (32.4%) were from individuals aged 9-13 years (Group 1), 205 (32.8%) were from individuals aged 14-20 years (Group 2), and 218 (34.8%) were from individuals aged 21 years and older (Group 3).

Acetate papers were placed on the cephalometric radiographs included in the study, and cephalometric points were marked using pencils with a precision of 0.3 mm. Drawings were made with the images centered in the case of bilateral images. All drawings and measurements were performed by the same orthodontist.

On 626 cephalometric radiographs, SNA and ANB angles were determined. Additionally, NV-A, NV-Pog, Co-A, Co-Gn, N-Me, N-ANS, ANS-Me, S-Go, ANS-Or, A-Or, B-Or, Co-Or, Go-Or, N-Or, PNS-Or, Pog-Or, PTM-Or, and Co-N distances were recorded. Subsequently, the percentages of S-Go/N-Me, Co-N/N-Me, and S-Go/Co-N ratios were calculated. Finally, N-Or/Co-N and Co-Or/Co-N ratios were determined and recorded.

Results

For statistical analysis and calculations, MS-Excel 2003 (Microsoft Corp., USA) and SPSS 15.00 (SPSS Inc., USA) software were used. Descriptive statistics were presented as the minimum and maximum values, along with the mean and standard deviation for continuous variables, and as the number of cases and percentage for categorical variables. Descriptive

statistics values for the measurements obtained from 626 cephalometric radiographs are presented in Table 1.

Table 1. Descriptive statistics for cephalometric measurements.

	Mean	Standart Deviation	Minimum	Maximum
SNA (º)	80,93	2,40	72,60	90,60
SNB (º)	82,79	2,87	75,20	93,10
ANB (º)	-1,86	1,40	-9,00	-0,10
NV-A (mm)	-0,62	2,09	-8,70	7,90
NV-Pog (mm)	2,34	3,96	-5,50	17,10
Co-A (mm)	88,67	7,15	68,50	120,13
Co-Gn (mm)	124,82	10,61	89,50	160,60
N-Me (mm)	123,73	12,67	91,31	161,51
N-ANS (mm)	55,16	5,55	39,70	73,20
ANS-Me (mm)	69,93	8,52	50,30	97,50
S-Go (mm)	78,76	10,00	54,28	110,88
ANS’-Or (mm)	17,09	3,43	10,20	32,30
A’-Or (mm)	12,68	2,89	3,90	22,90
B’-Or (mm)	13,75	5,27	0,90	29,30
Co’-Or (mm)	69,09	6,08	52,00	96,80
Go’-Or (mm)	63,33	7,60	39,80	87,50
N’-Or (mm)	15,87	2,90	7,10	25,90
PNS’-Or (mm)	32,28	4,70	20,50	54,50
Pog’-Or (mm)	16,59	5,55	2,70	32,20
PTM’-Or (mm)	35,73	4,99	25,50	87,20
S’-Or (mm)	54,82	4,80	42,40	74,80
Co’-N’ (mm)	84,90	7,17	67,40	116,70
S-Go/N-Me (%)	63,68	5,05	50,12	79,82
Co’-N’/N-Me (%)	69,05	5,43	56,26	90,48
S-Go/Co’-N’ (%)	93,87	8,00	70,00	117,70
N’-Or/Co’-N’	18,45	2,81	9,28	30,33
Co’-Or/Co’-N’	81,10	2,80	69,60	88,00

The normality of the data determined by measurements and the ratios calculated were examined graphically and with the Shapiro-Wilk test. Differences in distribution ratios among age groups by gender were analyzed using the chi-square test. The effects of gender and age groups on clinical measurements were evaluated using Two-Way ANOVA. If the statistical

significance of the interaction between age and gender was found, post-hoc multiple comparisons were applied with necessary statistical adjustments (such as Bonferroni correction) to identify the factors contributing to the difference. The significance of the difference between girls and boys within age groups and the significance of the difference in clinical measurements according to age within gender groups were evaluated using independent two-sample t-tests and One-Way ANOVA tests, respectively. If the result of One-Way ANOVA was found to be significant, the Tukey test was used as a post-hoc test to determine the age group(s) from which the difference originated. All values with P<0.05 were considered statistically significant.

Table 2. One-way ANOVA results.

	Age	Mean	Standard Deviation	Minimum	Maximum	P Values
NV-A	*9-13*	-1,06	1,92	-8,70	7,20	0,094
	14-20	-0,93	2,16	-8,30	5,30	
	20+	-0,10	1,99	-3,70	7,90	
NV-Pog	*9-13*	0,70	3,43	-5,00	13,30	**0,001**
	14-20	1,78	3,88	-5,50	16,10	
	20+	4,39	3,62	-4,00	17,10	
Co-A	*9-13*	88,34	7,40	71,10	120,13	0,640
	14-20	88,67	6,96	68,50	108,63	
	20+	89,00	7,10	71,80	108,73	
Co-Gn	*9-13*	122,93	11,30	98,90	160,60	**0,004**
	14-20	125,30	10,42	89,50	150,30	
	20+	126,12	9,92	97,70	148,50	
N-ANS	*9-13*	54,87	5,01	42,40	65,50	**0,001**
	14-20	54,32	5,96	39,70	69,10	
	20+	56,23	5,50	41,10	73,20	
ANS-Me	*9-13*	68,36	8,75	50,40	97,50	**0,002**
	14-20	69,11	8,62	50,30	91,50	
	20+	72,15	7,77	52,40	91,80	
S-Go	*9-13*	77,43	9,10	54,51	110,87	**0,001**
	14-20	77,11	10,00	55,56	105,09	
	20+	81,54	10,23	54,28	108,86	
ANS’-Or	*9-13*	16,98	3,27	10,30	26,10	0,835
	14-20	17,12	3,47	10,40	26,10	
	20+	17,17	3,54	10,20	32,30	
A’-Or	*9-13*	11,97	2,90	3,90	21,30	0,083
	14-20	12,42	2,94	6,70	22,90	
	20+	13,60	2,74	8,20	22,60	
B’-Or	*9-13*	11,25	4,65	0,90	27,30	**0,002**
	14-20	13,34	5,12	4,30	29,30	
	20+	16,46	4,68	7,70	29,10	

Co'-Or	*9-13*	69,08	6,16	55,50	96,80	0,744
	14-20	69,20	5,83	52,60	83,30	
	20+	69,24	6,25	52,00	82,30	
Go'-Or	*9-13*	62,85	7,55	39,80	87,50	0,509
	14-20	63,52	7,76	41,90	80,90	
	20+	63,64	7,50	40,50	77,80	
N'-Or	*9-13*	15,79	2,94	7,10	24,50	0,604
	14-20	15,90	3,03	8,10	25,90	
	20+	16,01	2,72	7,50	23,00	
PNS'-Or	*9-13*	32,17	4,60	20,90	45,40	0,843
	14-20	32,24	5,19	20,50	54,40	
	20+	32,43	4,31	20,60	43,30	
Pog'-Or	*9-13*	14,19	5,02	2,70	27,50	**0,001**
	14-20	16,16	5,51	3,40	31,10	
	20+	19,23	4,91	7,60	32,20	
PTM'-Or	*9-13*	35,78	5,06	27,40	82,60	0,173
	14-20	36,17	5,97	26,10	87,20	
	20+	36,73	4,99	25,50	46,60	
S'-Or	*9-13*	54,82	4,99	44,20	74,80	0,530
	14-20	55,09	4,77	42,80	70,80	
	20+	55,56	4,64	42,40	70,80	
Co'-N'	*9-13*	84,51	7,15	71,20	116,70	0,562
	14-20	84,96	6,93	67,40	107,50	
	20+	85,26	7,43	68,00	106,40	

The distribution of patients' gender was not found to be statistically significant in any age group (t=1.208, P=0.293). When the effect of gender on angular measurements was examined, no statistically significant difference was found in the mean angular measurements (SNA, SNB, ANB) between genders (P=0.426, P=0.353, P=0.564). When the effect of gender on metric measurements was examined, it was observed that all metric measurement averages except for Co-A, Co-Gn, N-Me, ANS-Me, S-Go, and Co-N distances were statistically similar between males and females (P=0.001, P=0.003, P=0.001, P=0.004, P=0.001, P=0.001, P=0.004).

When the effect of age on angular measurements was examined, it was observed that the mean angular measurements of SNB and ANB showed statistically significant differences according to age groups (P=0.004, P=0.002). When the effect of age on metric measurements was examined, it was found that all metric measurement averages (NV-A, Co-A, ANS-Or, A-Or, Co-Or, Go-Or, N-Or, PNS-Or, PTM-Or, S-Or, Co-N) increased with age, but there was no statistically significant difference between age groups. It was determined that all other

measurement averages showed statistically significant differences between age groups (Table 2).

The combined effects of age and gender on measurements were examined using Two-way ANOVA (Direction 1: Gender effect, Direction 2: Age effect). All established two-way interaction models were found to be statistically significant (P<0.001). However, among the variables, only the interaction effect of age and gender on NV-Pog, N-Me, N-ANS, ANS-Me, and Pog-Or was found to be statistically significant. The significance of the difference in NV-Pog, N-Me, N-ANS, ANS-Me, and Pog-Or averages between girls and boys within age groups and between age groups within gender groups was examined. In cases aged 14-20 years, males were found to have significantly larger averages of NV-Pog, N-Me, N-ANS, ANS-Me, and Pog-Or compared to females (P=0.002, P=0.001, P=0.015, P=0.007, P=0.013).

In males, significant differences were observed among different age groups in NV-Pog, N-Me, N-ANS, ANS-M, and Pog-Or values (P=0.006, P=0.011, P=0.047, P=0.035, P=0.001). However, in females, no statistically significant differences were found in NV-Pog, N-Me, N-ANS, ANS-Me, and Pog-Or averages among age groups.

When the distribution of Co-N/N-Me ratios, which represent the depth of the face relative to the anterior facial height, was examined across different facial heights (long face, normal face, short face), it was found that the Co-N/N-Me values of at least one class were statistically different from the others (P<0.001). To determine which facial height group(s) contributed to the difference in the Co-N/N-Me ratio, the Tukey test was applied as a post-hoc test. The difference in the Co-N/N-Me ratio averages between long-faced and short-faced individuals was statistically significant (P<0.05), while the difference between normal-faced individuals and both long-faced and short-faced individuals was not statistically significant (P=0.133, P=0.061). When the distribution of Co-N/N-Me distances was examined according to age and gender, taking facial height into account, it was observed that the averages of the measurements were not statistically different (P>0.05).

Discussion

Although it is a highly important parameter, there has been no consensus on any cephalometric measurement for facial depth to date.[11,12] This current study is one of the first attempts to address this lack of data in the field, aiming to discuss several cephalometric points and distances that could be agreed upon. In one of the few previous studies, the CC point (projection of Ptm onto the FH plane), which is considered a more stable point than the Co

point to determine the posterior border of facial depth, was proposed but not widely accepted.[12] In another study[13], taking the Co-A distance as the effective midface length proved effective in selecting the Co point as the posterior border point of facial depth. The Co point is quite challenging to mark on cephalometric radiographs. In this study, the metallic recording rings on earbuds were removed to facilitate marking and improve radiographic quality.[13,14] The ANS, N, A, B, and Pog points were evaluated to determine the anterior border of facial depth in this study. The ANS point is affected by maxillary rotation, the A point is influenced by both maxillary rotation and the inclination of maxillary incisor roots, the Pog point is affected by mandibular rotation, and the B point is influenced by both mandibular rotation and the inclination of mandibular incisor roots. These points were not preferred because they are directly affected by treatment. The N point, on the other hand, was preferred due to its ease of detection and being the anterior and median point of the face, despite its minimal forward and upward movement with growth and development.[15,16]

In the present study, the anatomical Po point was considered as the posterior border of the Frankfort Horizontal (FH) plane, which was accepted as the reference plane, and the Or point was taken as the anterior border.[17,18] This choice was made because marking the Po point radiographically is difficult, while the Or point is both stable and easily identifiable.[17,18]

The results of the present study are in complete agreement with previous studies that found the facial depth distance to be greater in males than in females.[19,20] However, the results of this study indicate that in skeletal Class III cases, the Co-N distance does not increase with age, which is consistent with the findings of Koç's[8] study. While some previous studies in the sagittal plane of the face have reported an increase in facial depth distance with age, these studies have used points A and B as references.[21-23]

The results obtained from the study showed that the lower anterior facial height (ANS-Me), upper anterior facial height (N-ANS), and the total anterior facial height (N-Me) can significantly vary with age. When both gender and age were considered together, N-Me, N-ANS, and ANS-Me distances were found to be statistically significant. The statistical significance in all three parameters is due to an increase in these distances with age in males. These findings are fully consistent with some previous studies conducted in Class I cases.[24-26]

It has been suggested that the rotation of the mandible that occurs during growth and development is associated with condylar growth, facial sutures, and vertical development of the alveolar structure.[27] Vertical development of the facial sutures and alveolus, if less than the

vertical development in the condyle, may lead to anterior rotation of the mandible; otherwise, it may result in posterior rotation.[26-28] When the anterior facial height was evaluated according to gender, a significant increase in favor of males was observed (P<0.05). Consistent with our findings, a study reported a similar male predominance in anterior facial height.[26-28] However, Bibby[29], who conducted cephalometric analyses on craniofacial morphology patterns, reported that there was little difference between males and females in craniofacial morphology, except for posterior facial height. In the present study, no difference was found according to gender, but a statistically significant difference was observed according to age. Björk[30] reported that vertical growth lasts longer and is greater in magnitude than sagittal growth. Nanda[21] reported that vertical growth is completed earlier in females than in males. The observed difference in the present study may be attributed to the delayed completion of vertical growth in males.

The findings of the present study are consistent with studies reporting an increase in lower facial height with age.[24,31] Cevidanes et al[31] suggested that this increase in posterior facial height may be due to growth in the condyle and an increase in ramus height. However, Koç[8] did not observe a significant increase with age in the S-Go distance. He attributed this to the higher number of long-faced individuals in the 9-13 age group compared to those over 20 years old.[8]

In the present study, the lack of statistical difference between the ratios of the anterior part of facial depth to total facial depth (N-Or/Co-N) and the ratios of the posterior part of facial depth to total facial depth (Co-Or/Co-N) may be explained by the similarity in the changes observed in N-Or and Co-Or distances to those in Co-N distance. In a previous study, Duyar[32] reported a significant resemblance between the growth of facial length and facial width.

Conclusion

In Class III skeletal cases, the average facial depth distance (Co-N) ranges from 85 ± 5 mm, and the ratio between the facial depth distance (Co-N') and the anterior facial height (N-Me) (Co-N/N-Me) is approximately %69 ± 5. This ratio varies among individuals with long faces (%68 ± 4), normal faces (%69 ± 4), and short faces (%72 ± 5).

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