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Research Article

Evaluation of Facial Depth in Maxillary-Based Class III Individuals: A Cephalometric Study

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Abstract

Statement of the problem: There is a lack of data in the literature regarding the relationship between the average facial depth distance and this distance with the anterior facial height in patients exhibiting skeletal class III malocclusion originating from the maxilla.

Objective: The aim of this study is to investigate the amount of average facial depth in maxillary-based Class III cases and to evaluate the relationship between average facial depth and anterior facial height.

Materials and Methods: The study comprised 592 individuals diagnosed with Class III malocclusion, of whom 281 were female and 311 were male. The pogonion (Po), nasion (N), Frankfort Horizontal plane (FH), condylion (Co), and menton (Me) points were marked on the cephalometric radiographs of the participants. The projection of point Co to point N on the FH plane (Co'-N') was defined as the facial depth distance, while the distance between N and Me was determined as the anterior facial height distance. Subsequently, the facial depth distances of all individuals were measured. The facial depth distance was then ratioed with the anterior facial height distance in an attempt to reach standard ratios for maxillary-based Class III cases.

Results: Average facial depth distance (Co'-N') is 83 ± 7 mm. The ratio of facial depth distance (Co'-N') to anterior facial height (N-Me) (Co'-N'/N-Me) is determined to be 68 ± 5%.-When this ratio is evaluated separately according to facial heights; it is determined as 66 ± 4% in long-faced individuals, 67 ± 4% in normal-faced individuals, and 71 ± 5% in short-faced individuals.

Conclusions: The use of this ratio in cephalometric film analysis may bring a new perspective to the evaluation of maxillary Class III malocclusions.

Keywords: Cephalometric Analysis, Skeletal Class III, Malocclusion, Anterior Facial Height, Facial Depth, Jarabak Ratio

Introduction

Standard cranial radiographs are used for the identification of cranial and facial morphology, assessment and monitoring of growth and development, and evaluation of treatment outcomes in orthodontic and orthognathic surgical cases.[1,2] To date, several cephalometric analysis methods have been developed to systematically examine these radiographs.[3,4] Observing the growth and development of facial structures assists in determining the treatment method in clinical practice.[3,4] Different parts of facial structures may undergo delayed or early development, with varying growth rates, directions, and adult sizes.[5,6] The growth of the maxilla is first completed in the transverse direction, then in the sagittal direction, and finally in the vertical direction. Dental width growth ends just before the growth spurt, along with skeletal width. Active lengthening lasts longer in males than in females. Vertical alveolar growth continues throughout life.[7-9]

Factors influencing jaw growth can result in skeletal anomalies in the vertical, transverse, or sagittal planes.[10-13] The elements used to identify sagittal skeletal anomalies are the SNA, SNB, and ANB angles.[12,13] Cases with SNA angle of 82º, SNB angle of 80º, and ANB angle of 2º are considered to exhibit normal growth and development.[13] Gazilerli[12] examined 330 children from Ankara with ideal occlusion and determined that the average values for the Turkish population are 81º, 78º, and 3º for SNA, SNB, and ANB angles, respectively. When classified based on the ANB angle, cases with an ANB angle between 2±2 (0-4) are categorized as skeletal Class I; cases with an ANB angle greater than 4 degrees are classified as skeletal Class II; and cases with an ANB angle below zero are grouped as skeletal Class III anomalies.[13]

Skeletal Class III malocclusion was first described by Edward H. Angle[2] in 1899. Angle[2] defined Class III malocclusion as "mandibular protrusion, mesial occlusion of the lower teeth, and lingual inclination of the lower incisors and canines." While this definition remains valid, it is insufficient. This is because, compared to Class I cases, in Class III cases, the SNA angle decreases as a sign of maxillary retrusion, the SNB angle increases due to mandibular protrusion, the ANB angle falls to negative values, the gonial angle widens, and the mandibular plane angle becomes more vertical.[14-16] Class III cases can also arise from situations where the mandible is in its normal position and the maxilla is retrognathic.[17]

Many researchers have attempted to compare Class I and Class III cases using different parameters. However, there is almost no data in the literature regarding the relationship between average facial depth and anterior facial height in maxillary-based Class III cases. The aim of the present study is to define the distance between the condylion and nasion points projected onto the Frankfort Horizontal plane as the Facial Depth Distance (Co'-N'), determine its average values in the Turkish population, and investigate its relationship with anterior facial height to establish a ratio for future studies.

Materials & Methods

The necessary sample size for the study was calculated using GPower Ver. 3.00.10 (GPower Franz Faul, Germany) software, taking into account possible data losses. It was decided to examine cephalometric radiographs of a total of 592 individuals with maxillary skeletal Class III malocclusion, including 281 females and 311 males. The inclusion criteria for the cephalometric analysis were as follows:

-Individuals with maxillary dimensions within -10/+3 mm and mandibular dimensions within +3/-7 mm relative to the Nasion vertical plane (Nv),[18]

-Individuals with an ANB angle of 0° or less.[19]

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.

Care was taken to include cephalometric radiographs in the study that balancedly represented all three facial heights (long face, normal face, and short face) according to the vertical Jarabak ratio. The cephalometric radiographs were divided into two groups, female and male, and further subdivided into three subgroups based on age: 9-13, 14-20, and 21 years and older, taking into account growth and development.

Subsequently, acetate papers were placed on the cephalometric radiographs included in the study, and cephalometric points were marked with pens with a sensitivity of 0.3 mm. Drawings were made by aligning the images in double views.

Initially, the following points were marked on the cephalometric radiographs: Sella (S), Nasion (N), Anterior Nasal Spine (ANS), Posterior Nasal Spine, Point A (A), Point B (B), Menton (Me), Constriction Gonion (Co.Go), Orbit (Or), Pterygoid Point (PTM), Condylion (Co), Porion (Po), Pogonion (Pog), N', ANS', PNS', A', B', Pog', Ptm', S', Co', Go' (Figure 1).

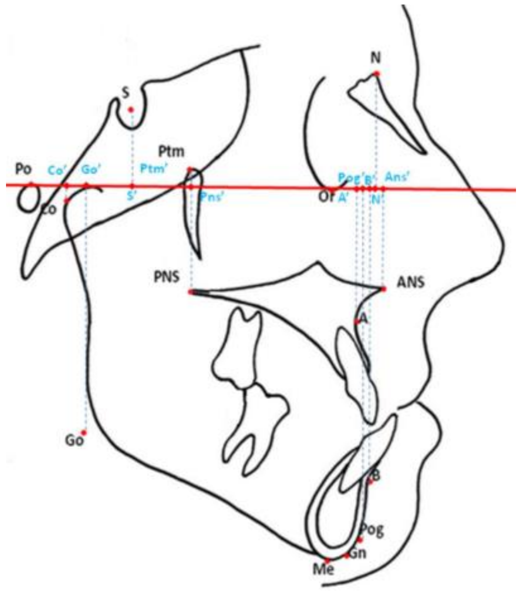

Figure 1. Anthropometric points used in cephalometric analysis.

Then, in each cephalometric radiograph, the SN, FH, and NV planes were drawn (Figure 2).

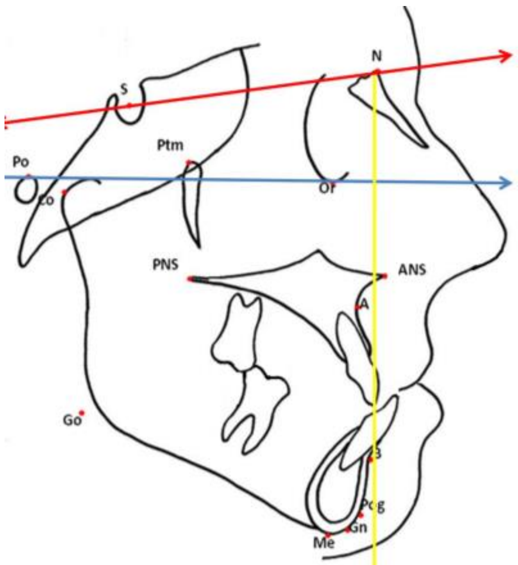

Figure 2. Planes used in cephalometric analysis.

Then, the Co-Pog, Nv-A, Nv-Pog, ANS'-O, N'-O, PNS'-O, A'-O, B'-O, Pog'-O, PTM'-O, S'-O, Go'-O, and Co'-O distances were measured (Figure 3).

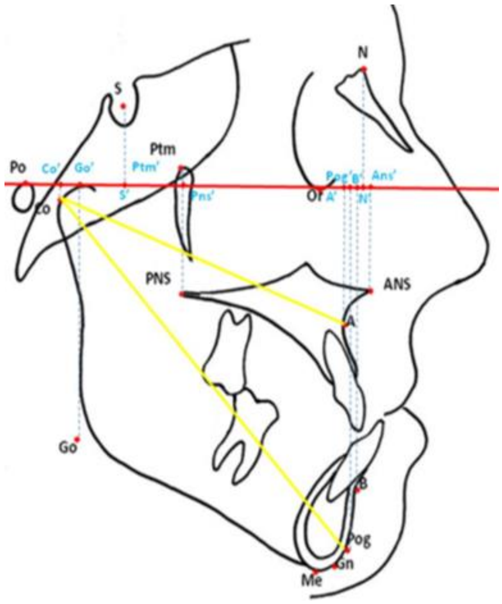

Figure 3. Distance measurements made in cephalometric analysis.

Following the distance measurements, the SNA, SNB, and ANB angles were measured (Figure 4).

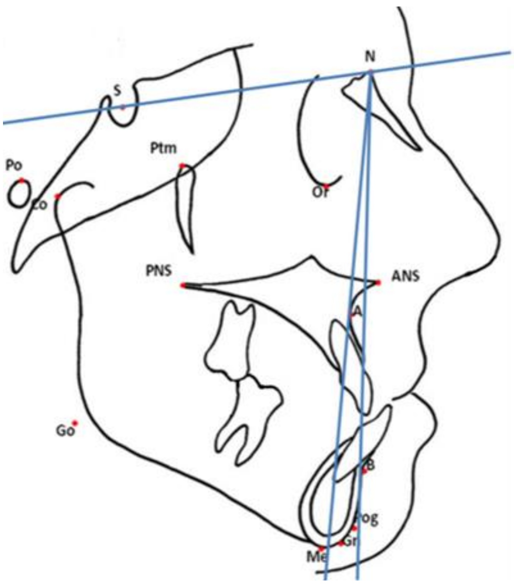

Figure 4. Angular measurements performed in cephalometric analysis.

Finally, ratios (S-Go/N-Me, Co'-N'/N-Me, S-Go/Co'-N', N'-O/Co'-N', and Co'-O/Co'-N') were established among the distances of interest in the study, and the calculations were completed.

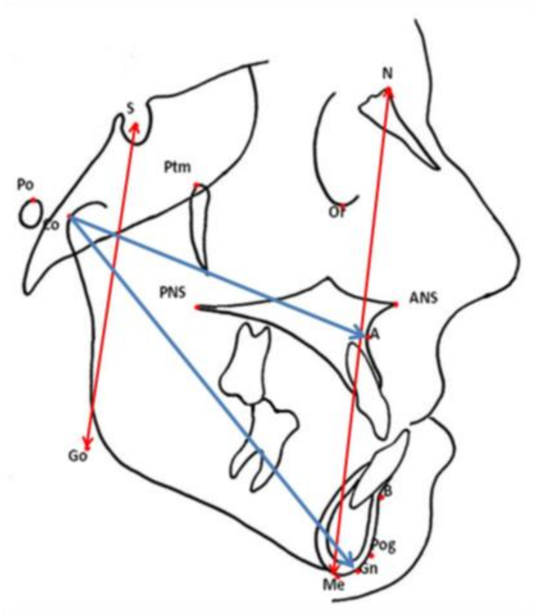

Figure 5. Ratios calculated in the study.

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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