Evaluation of Hyoid Bone Position in Skeletal Class 3 Individuals

İskeletsel Sınıf 3 Bireylerde Hyoid Kemiğinin Konumunun Değerlendirilmesi

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ÖZ

Amaç: Bu çalışmanın amacı, iskeletsel Sınıf 3 malpozisyona sahip olan bireylerde hyoid kemiğin pozisyonunu iskeletsel olarak Sınıf 1 malpozisyonuna sahip bireylerde hiyoid kemik pozisyonunu karşılaştırmaktır.

Yöntem: Bu çalışmada İskelet Sınıf 1 ve Sınıf 3 malpozisyona sahip 90 bireyin lateral sefalometrik radyografilerinde ölçümler yapıldı. Radyografilerdeki işaretleme ve ölçümler için Vistadent OC programı kullanıldı. Çoklu grup karşılaştırmaları için tek yönlü varyans analizi (ANOVA), Post-hoc ikili karşılaştırmalar için Tukey HSD testi kullanıldı.

Bulgular: H-SN, H-FH, H-OD, HS, HA, HN, H-APW, H-PNS, H-Cd, C3-HS, H-C3-S ölçümlerinde istatistiksel düzeyde anlamlı fark bulundu. Sagital yönde normal ve retrognati grupları arasında istatistiksel olarak anlamlı düzeyde fark gözlendi ve en düşük değer retrognati grubunda saptandı. Hyoid kemiğinin gövdesi, retrognati grubundaki kızlarda proganati ve normal gruba göre daha yüksek bulundu.

Sonuç: Sınıf 1 ve Sınıf 3 iskelet paternleri, hyoid kemiğin servikal vertebra ve çene ucuna olan mesafesini etkilemez. Retrognati grubundaki kızlarda hyoid kemik, prognati grubu ve normal gruba kıyasla vertikal yönde daha yukarıda konumlanmış ve ayrıca saat yönünün tersine dönüş hareketi saptanmıştır.

Anahtar Kelimeler: *Hyoid Kemik, Maloklüzyon, Maksilla, Mandibula*

ABSTRACT

Objectives: The aim of this study is to compare the position of the hyoid bone in individuals with skeletal Class 3 malposition with the position of the hyoid bone in individuals with skeletal Class 1 position.

Methods: We measured 90 individuals lateral cephalometric radiographs who have skeletal Class 1 and Class 3 malpositions. Markings and measurements of radiographs were performed using Vistadent OC software program. One-way analysis of variance (ANOVA) was used for multiple-group comparisons and Tukey HSD test was used for Post-hoc binary comparisons.

Results: There was a statistically significant difference in the measurements of H-SN,H-FH,H-OD,HS,HA,HN,H-APW,H-PNS,H-Cd,C3-HS,H-C3-S. In the sagittal direction, a statistically significant difference was observed between the normal and retrognathie groups and the lowest value was in the retrognathie group. Hyoid bone body was found to be located higher in the girls of retrognathie group compared to the prognathie and normal group.

Conclusion: Class 1 and Class 3 skeletal patterns do not affect the distance of the hyoid bone to the cervical column and the tip of the jaw. The hyoid bone is positioned higher in the vertical direction in the girls of retrognathie group compared to the prognathie group and the normal group and also, counterclockwise rotation was seen.

Keywords: *Hyoid Bone, Malocclusion, Maxilla, Mandible*

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INTRODUCTION

The relationship between the hyoid bone and the facial skeleton is an intriguing subject. Hyoid bone position may vary depending on problems like orthodontic malpositions, abnormal swallowing, mouth breathing and malformation of face structures.

The hyoid bone, which has no physical connection with facial skeleton and cranium, is located on the anterior aspect of the neck, between the jaw tip and the larynx.[1] The position of the hyoid bone is determined by suprahyoid and infrahyoid muscles. Hyoid bone consists of a pair of larger horns called the greater cornua, a pair of smaller horns called lesser cornua and body (corpus)[2] It is a horse-shoe or U shaped small bone and has many functions; to provide the functional balance between the structures related to the mandible, larynx and head base, performing tongue functions and support for the tongue and to provide precise cranial balance by uprighting the head posture.[2]

The location of the hyoid bone that is completely suspended by the muscles varies depending on the relative length of the muscles surrounding the bone, the joint movement of the hyoid and hyoid muscles, the resistance of the elastic membranes of the larynx and the trachea and the gravitational force acting on the larynx.[2]

Treatment of malpositions causing change in the relationship between upper and lower jaw; can alter the position of the tongue and the hyoid bone and / or the dimensions of the airway.[2] At the same time, the position of the hyoid bone changes with age.[2] King, examined the location and growth of the hyoid bone from the 3rd month to the age of 16; and found that in children it was located at a level between the 3rd and 4th cervical vertebrae and above the symphysis; and was located at the level of the 4th cervical vertebra and below the symphysis in adults.[3]

The location of the hyoid bone is an important diagnostic tool in the assessment of facial types and structural aberrations, and in the detection of mouth breathing and swallowing disorders. It also plays an important role in the prognosis of orthodontic treatments and evaluating the possibility of relaps after treatment.[3]

Dinçer et al. determined that the hyoid bone was positioned posteriorly than normal in the Class II anomaly and more anteriorly in the Class III anomaly.[4] Khanna et al. showed that the hyoid bone displaced downwards and backwards in individuals with a molar relationship of Class II division 1 where the mandible was positioned posteriorly.[5]

Hyoid bone; as a bone that has no sutural, synchondral or articulating connection with other skeletal structures, has always been a subject of interest for researchers, especially in the aspect of its position. There are some studies examining positional differences of hyoid bone between Class I, II, II division I and III anomalies in the literatures.[4, 5] But we did not find a study examining and classifing class 3 anomalies according to their structural and positional differences in the literature. The aim of this study is to examine the position of the hyoid bone in individuals with skeletal Class 3 malpositions compared to individuals with skeletal Class 1 position.

MATERIALS AND METHODS

For the selection of the individuals to be included in the study, the initial digital lateral cephalometric radiographs of the individuals who were being treated in XXX University Faculty of Dentistry Orthodontics Department were examined and the individuals with the inclusion criteria were determined according to the information forms.

In the G*Power 3.1.9.2 (Franz Faul, Universität Kiel, Germany) software program, when the effect size was calculated as 0.5 effect width and $\alpha = 0.05$ significance level for ANOVA analysis, it was determined that the number of samples consisting of 22 individuals per group and total 66 individuals produced 95% power. It was considered appropriate to include more individuals to increase the strength of the study. Ethics Committee's compliance report was obtained from the Local Ethics Committee of XXX University Faculty of Medicine with the decision dated 28.12.2016 and numbered 320.

For this purpose, an orthopantomogram device (Instrumentarium OP 300, Tuusula, Finland) and radiological images obtained in natural head position and stored in the archive of the Faculty of Dentistry of XXX University were used. In this study, digital lateral cephalometric radiography images were used which were taken before treatment from the patients with skeletal Class 1 position and skeletal Class 3 malposition. While organizing the study groups, the archive records of 100 individuals were examined and the records of 10 individuals were examined and the records of 10 individuals were excluded from the study because they met the exclusion criteria.

In our research, 30 (female n: 11, male n: 19) individuals with skeletal Class III malposition with normally located upper jaw and prognathic lower jaw, 30 (female n: 19, male n: 11) (mean age: 12,40 ± 1,40) individuals with a malposition of skeletal Class III with retrognathic upper jaw and normally located lower jaw, 30 (female n: 19, male n: 11) (mean age: 13.05 ± 0.86) individuals with a skeletal class 1 position where the upper and lower jaws are normally located were included in the study. Subjects were seperated according to genders. The lateral cephalometric measurement, analysis methods and location of the hyoid bone were evaluated by using digital lateral cephalometric radiographs taken from individuals before treatment with " Vistadent OC Cephalometric Analysis Program."

Inclusion criteria:

- Individuals aged between 10-14 years,
- Normal SNA and SNB angle, 0 <ANB <4 in skeletal Class 1 position group (Normal group),[6,7]

- Decreased SNA angle, normal SNB angle, ANB <0 in the skeletal Class III malposition group (Retrognati group), [6,7]
- Increased SNB angle, normal SNA angle, ANB <0 in the skeletal Class III malposition group (Prognati group)[6,7]

are required.

Exclusion criteria

- History of orthodontic treatment
- Any systematic disease, congenital anomaly or syndrome
- The presence of surgical operation, burns and scar tissue in the head and neck region

We used, SN plane (SN), Frankfurt horizontal plane (FH), Palatal plane (PD), Occlusal plane (OD), Mandibular plane (MD), CVT plane, H-H plane (HD), SNA, SNB, ANB, H-SN, H-FH, H-PD, H-OD, H-MD, H-CVT, H-S, H-A, H-B, H-N, H-Pg, H-Cv4ia, H-APW, H-APW, H-Cv2ia, H-PNS, H-Me, H-Go, H-Cd, H-Rgn, H-C3, HD-SN, HD-FH, HD-MD, HD-OD, HD-PD, C3-H-S, H-C3-S for indicating position of the hyoid bone and dimensional and angular measurements. (Figure 1,2,3,4,5)

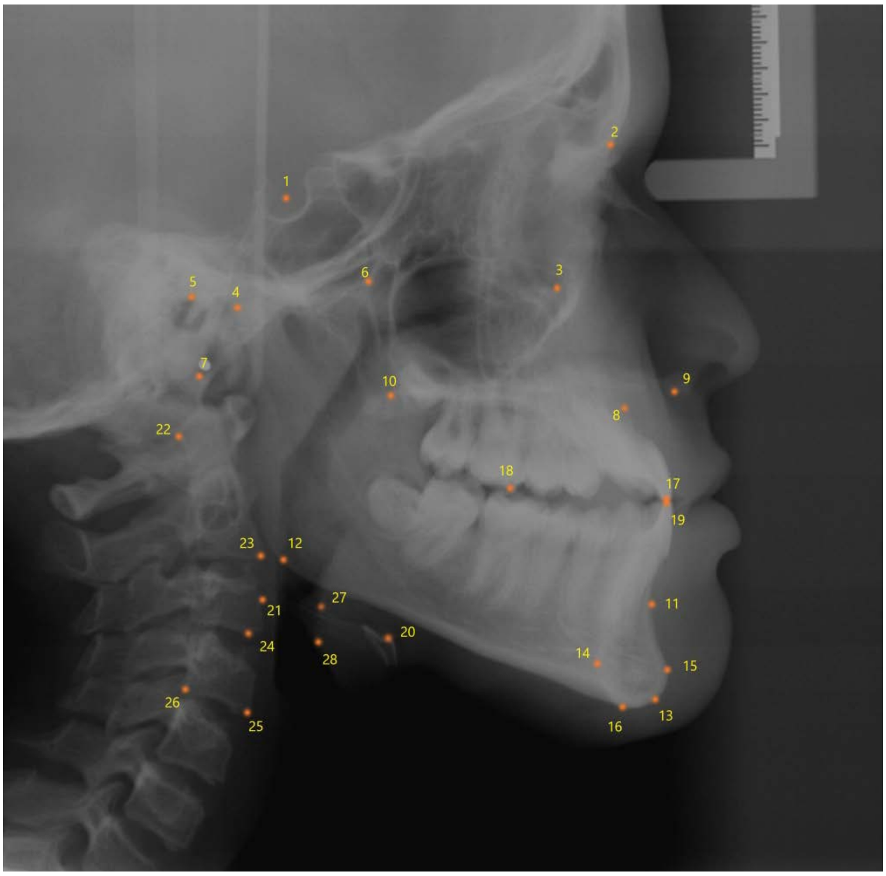

Figure 1: Landmarks Used in Lateral Cephalometric Radiography Analysis

1. Sella (S): The midpoint of Sella Tursika.[13]
2. Nasion (N): The most advanced point where the nasofrontal suture intersects with the sagittal plane.[20]
3. Orbitale (Or): The deepest point of the lower edge of the eye pit.[21]
4. Condylion (Cd): The top and most back point of the condyle head.[1]
5. Porion (Po): The middle point of the upper edge of the external ear hole.[1]
6. Pterygomaksiller fissure (Ptm): The top and back point of the pterygomaksill fissure.[20]
7. Basion (Ba): The junction between the outer edge of the clivus crane and the edge of the end of the clivus crane.[1]
8. Point A (A): The deepest point of the bone concavity extending from the spina nasalis anterior to the upper incisor in the mid oxal plane.[13]
9. Spina Nasalis Anterior (ANS): The most extreme point of bone protrusion of the maxilla at the base of the anterior opening of the nose.[1]
10. Spina Nasalis Posterior (PNS): The posterior point of the image of the hard palate in the lateral cephalometric film.[13]
11. Point B (B): The deepest point of the bone concave extending from the lower cutter to the tip of the jaw in the mid oxal plane.[2]
12. Gonion (Go): The point where the angle of the angle formed by the tangents drawn on the lower edge of the ramus mandible and the back of the mandible cuts the outer border of the lower jawbone.[13]
13. Gnathion (Gn): The most advanced and lowest point on the outer contour of the lower mandible.[13]
14. Retrognathion (Rgn): The most posterior point of the mandibular symphysis.[13]
15. Pogonion (Pg): It is the most advanced point on the outer contour of the lower mandible.[1]
16. Menton (Me): It is the lowest point on the outer periphery of the mandibular symphysis.[13]
17. U1i: is the end point of the cutting edge of the upper central thread.[1]
18. U6: Upper first molar tooth is the peak of mesiobuccal tubercle.[1]
19. L1i: The bottom point of the cutting edge of the lower central incisor.[1]
20. Hyoid (H): The top and front point of corpus of the hyoid bone.[13]
21. Hyoid-mid (H orta): The midpoint of the large horns of the hyoid bone.[1]
22. Cv2sp: The second posterior aspect of the second cervical vertebra.[1]
23. Cv2ia: This is the lowest and most prominent point of the second cervical vertebra.[1]
24. Cv3ia:: It is the lowest and most frontal point of the third cervical vertebra.[20]
25. Cv4ia: It is the lowest and most prominent point of the fourth cervical vertebra.[1]
26. Cv4ip: It is the bottom and back point of the fourth cervical vertebra.[1]
27. APW point: The point where the line joining the Cv2ia and H points crosses the anterior pharyngeal wall.[1]
28. APW (point: The point where the line joining the points Cv4ia and H crosses the anterior pharyngeal wall.[1]

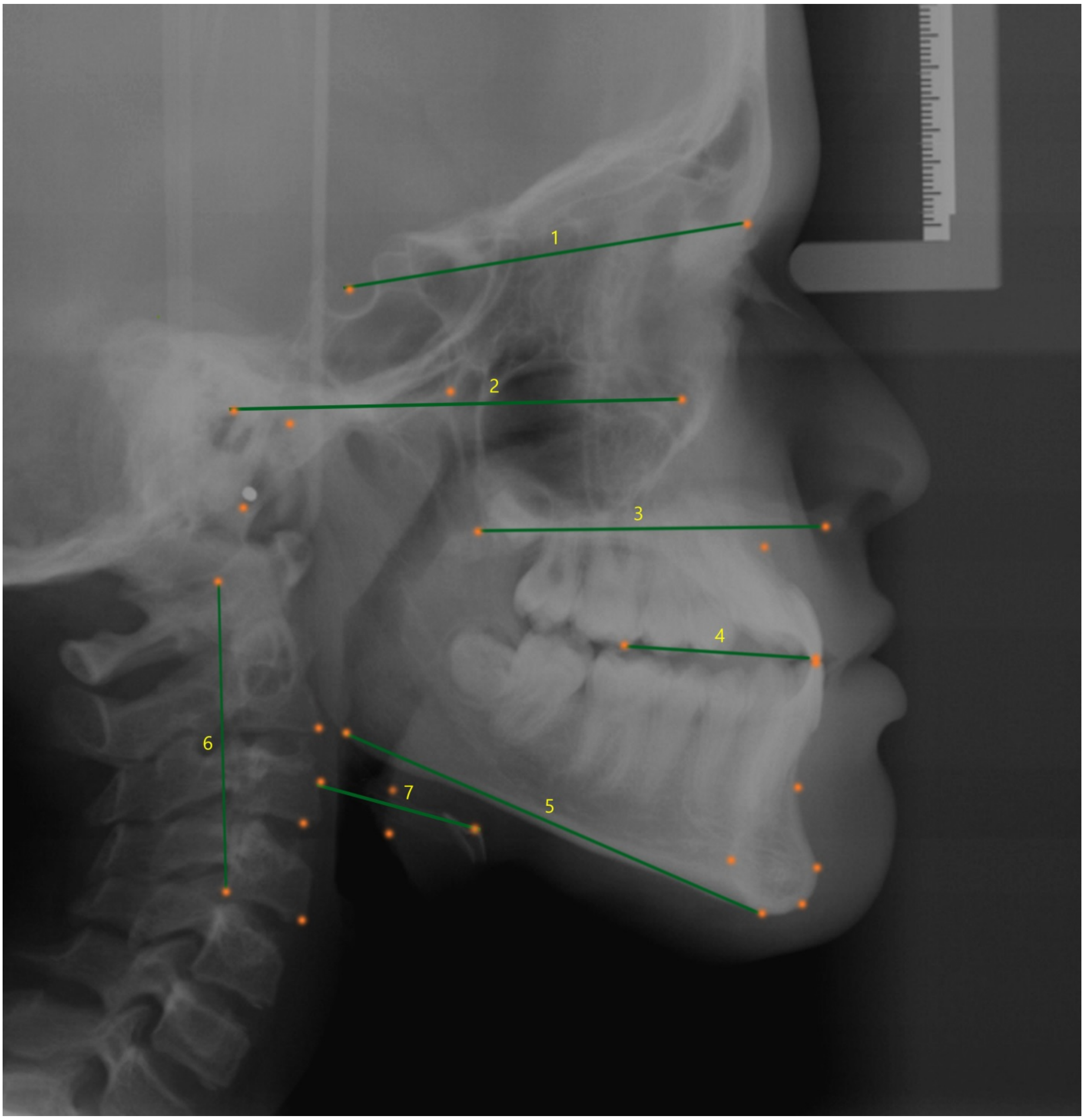

Figure 2: Planes used in our study

1. SN plane (SN): The plane passing through S and N points.[13]
2. Frankfurt horizontal plane (FH): The plane passing through Or and Po points.[13]
3. Palatal plane (PD): It is the plane passing through ANS and PNS points.[1]
4. Occlusal plane (OD): It is the plane formed by the line passing through the midpoints of the mesio-buccal tubercle peaks of the upper-lower 1. upper part and the lower-upper central cutting edges.[1]
5. Mandibular plane (MD): The plane passing through the points Go and Me.[1]
6. CVT plane: The plane passing through the points Cv2sp and Cv4ip.
7. H-H dir (HD): The plane indicating the long axis of the hyoid bone.[1]

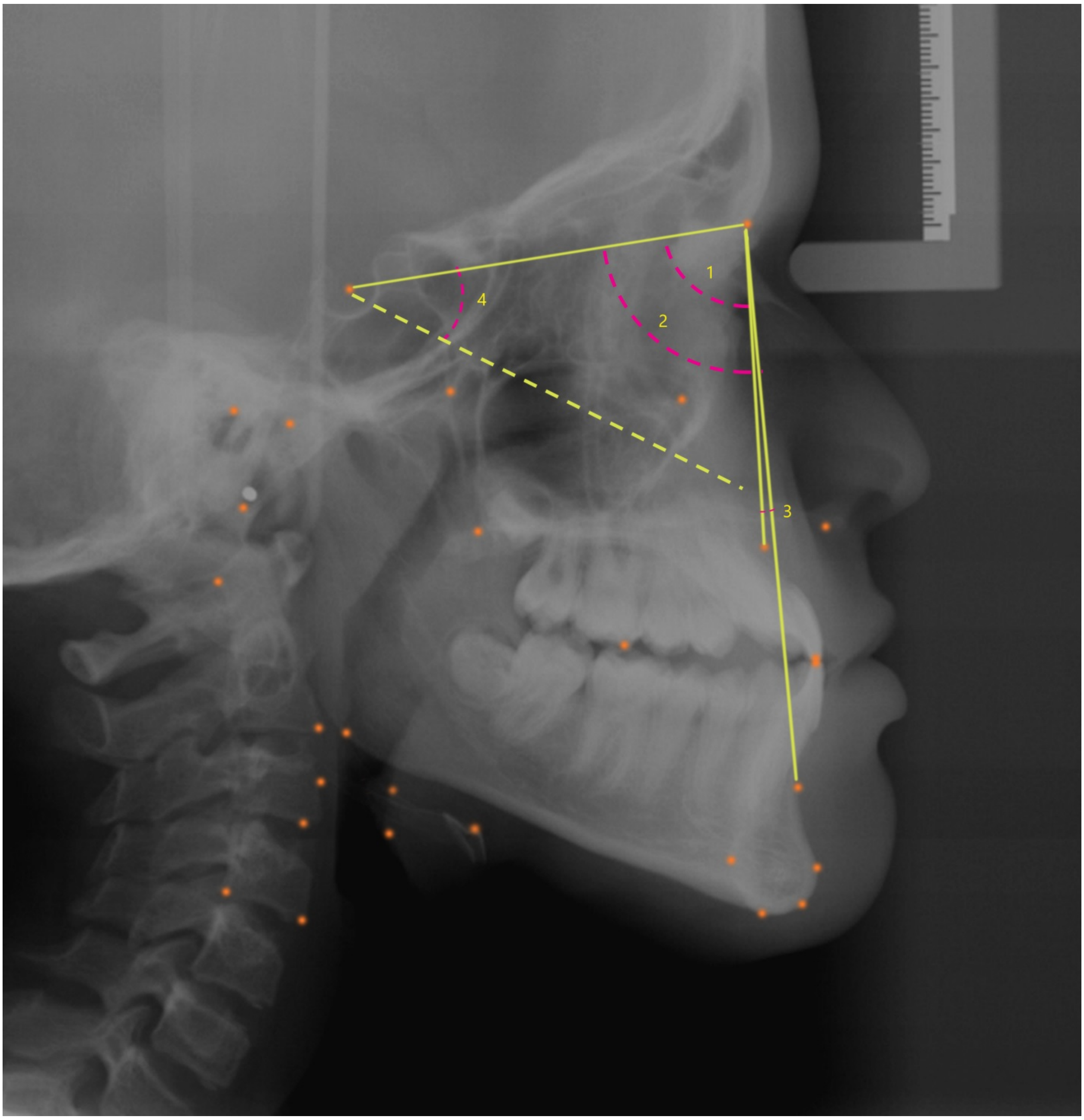

Figure 3: Craniofacial measurements

1. SNA (°): The angle between the SN plane and the NA plane.[20, 22]
2. SNB (°): This is the angle between the SN plane and the NB plane.[20, 22]
3. ANB (°): The angle between the NA and NB planes.[20, 22]

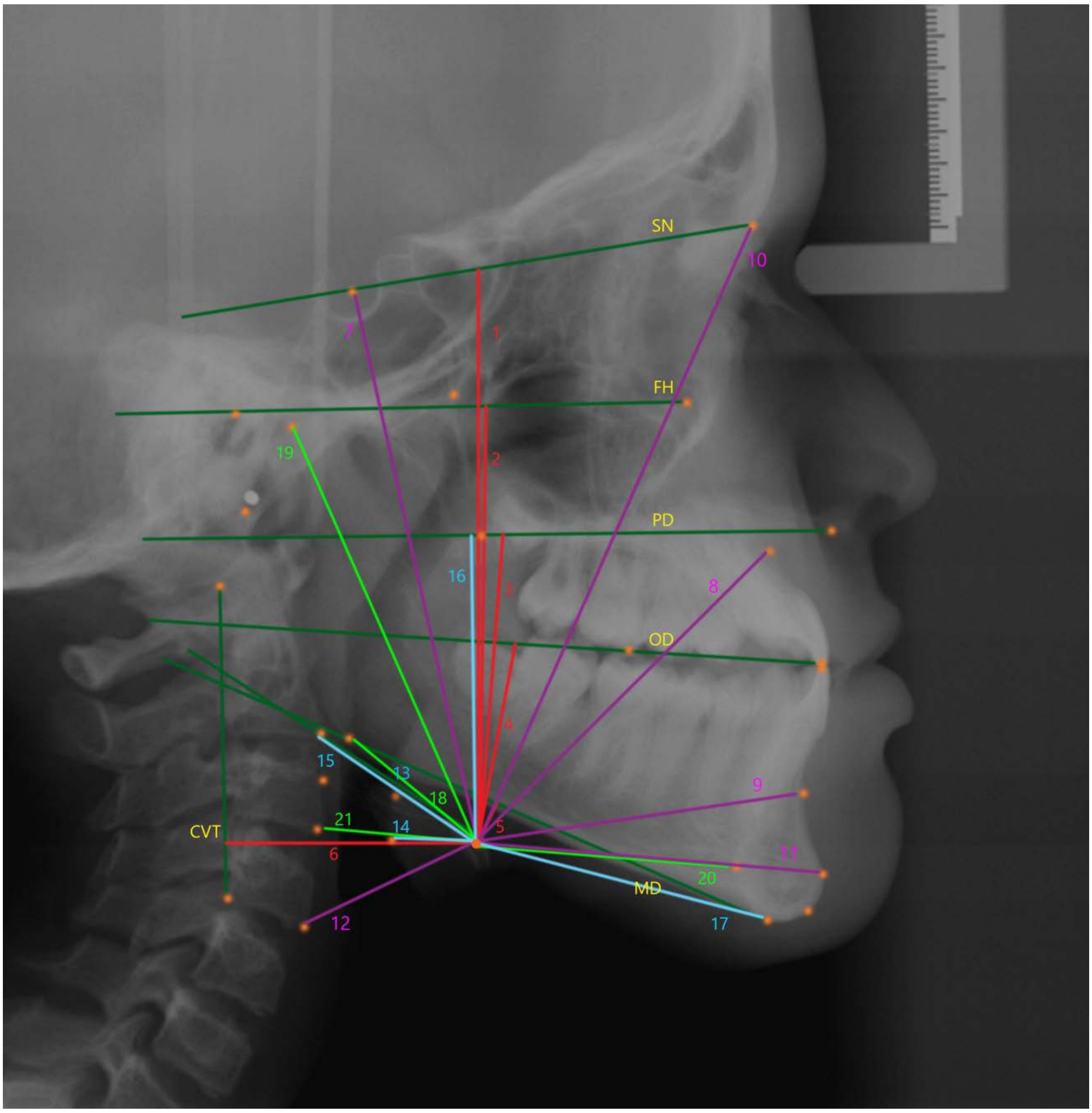

Figure 4: Dimensional measurements

1. H-SN: The vertical distance between the Hyoid point and the SN plane.[13]
2. H-FH: The vertical distance between the Hyoid point and the FH plane.[13]
3. H-PD: It is the vertical distance between the hyoid point and the palatal plane.
4. H-OD: It is the vertical distance between the hyoid point and the occlusal plane.
5. H-MD: The vertical distance between the hyoid point and the mandibular plane.[13]
6. H-CVT: It is the vertical distance of Hyoid point to the CVT plane.[1]
7. H-S (Sagittal): It is the distance between the points S and H.[22]
8. H-A: It is the distance between points A and H.[22]
9. H-B: It is the distance between points B and H.[1]
10. H-N: The distance between the N and H points.[22]
11. H-Pg: It is the distance between points Pg and H.[22]
12. H-Cv4ia: It is the distance between H and Cv4ia points.
13. H-APW: It is the distance between H and APW points.
14. H-APW is the distance between ": H and APW W points.
15. H-Cv2ia: It is the distance between the points H and Cv2ia.
16. H-PNS: It is the distance between H and PNS points.
17. H-Me: It is the distance between H and Me points.[1]
18. H-Go: the distance between H and Go points.
19. H-Cd: It is the distance between H and Cd points.
20. H-Rgn: This is the distance between the points H and Rgn.[23]
21. H-C3: It is the distance between points H and C3.

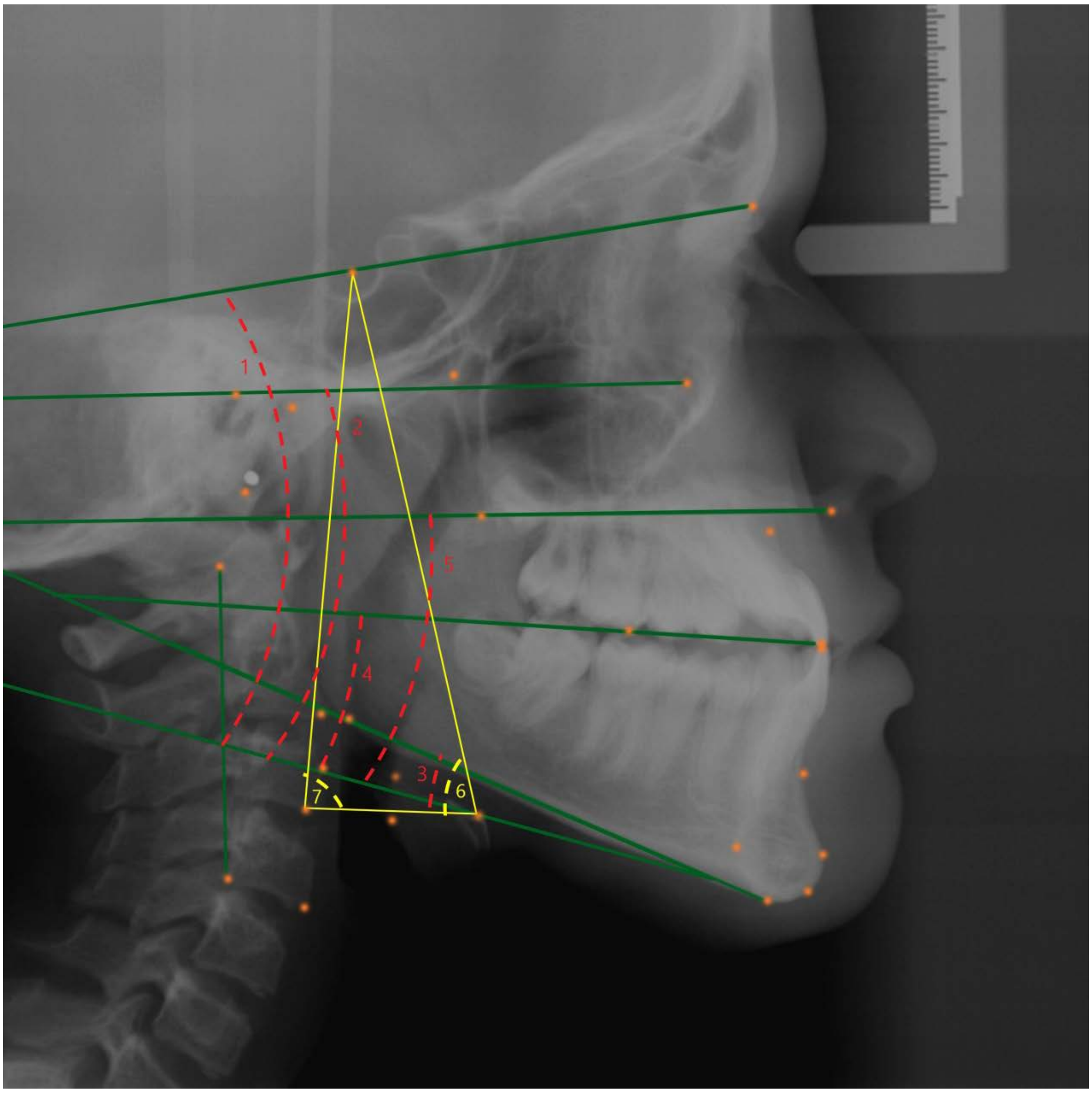

Figure 5: Angular measurements

1. HD-SN: This is the angle between HD and SN lines.
2. HD-FH: It is the angle between HD and FH.
3. HD-MD: The angle between HD and MD lines.[1]
4. HD-OD: It is the angle between HD and OD lines.[1]
5. HD-PD: This is the angle between HD and PD.[1]
6. C3-H-S: C3 is the angle between the points H and S.[23]
7. H-C3-S: H is the angle between C3 and S points.[24]

Statistical analysis

In order to evaluate the results obtained in the study, IBM SPSS Statistics Version 24 package program (Ver. 24.0, SPSS Inc., Chicago, Illinois, USA) was used. Categorical variables were summarized by “n” and “%”, continuous variables as “Mean±SD” and “Median” (Min.-Max.). Pearson Chi-Square statistical analysis was used to compare categorical variables between groups.

The homogeneity of variances in continuous variables was evaluated by Levene test. In general, it was seen that the variances were distributed homogeneously ($p>0.05$). As cephalometric measurements of normal, Prognathie and Retrognathie groups showed normal distribution, one-way analysis of variance was used. In some data, statistical differences were found as a result of the use of these two tests, and Tukey Honestly Significant Difference (HSD) test was used in post-hoc binary comparisons to evaluate the origin of this difference. Statistical significance was accepted as $p<0.05$.

In order to examine the method error, measurements were repeated on 30 randomly selected individuals at least 1 week later and Paired Sample test statistical analysis was performed.

RESULTS

No significant difference was found in the error level measurements (p> 0.05).

The mean SNA of the retrognathie group was found to be significantly different from the normal group and the mean of the prognathie group; the mean SNB of the prognathie group were significantly different from the mean of the normal group and the retrognathie group; there was a statistically significant difference between the ANB mean values of the normal group and the mean ANB of the retrognathie group (p<0.05). In binary comparisons; there was a significant difference between normal and retrognathie group and retrognathie and prognathie groups for the value of SNA. (Table 1)

When the mean distribution of H-SN, H-FH, H-PD, H-OD, H-MD, H-CVT values according to the groups of boys and girls were examined; there was a statistically significant difference between normal group and girls of retrognathie group in terms of mean H-SN and H-OD values (p<0.05) (Table 2). The mean H-SN and H-OD values of the normal group were higher than the other groups in both boys and girls.

When the mean distribution of HS, HA, HB, HN, H-Pg, H-Cv4ia, H-APW, H-PNS, H-Me, H-Go, H-Cd, H-Rgn, H-C3 values are examined according to the groups; H-S, H-A, H-N, H-APW, H-PNS and H-Cd values were significantly different between the groups (p<0.05) (Table 3). There was a statistically significant difference in H-S measurements between normal and retrognathie groups as a result of multiple comparisons (p=0.048). The mean H-S values of the normal group were higher than the other groups.

Table 1: Distribution of H-SN, H-FH, H-PD, H-OD, H-MD, H-CVT values according to the groups

	Normal	Retrognathie	Prognathie	F	p	Binary comparisons		
	Mean±SD Min.-Max.	Mean±SD Min.-Max.	Mean±SD Min.-Max.			1-2	1-3	2-3
H-SN	95,35±7,63 79,6-111,9	88,89±9,45 77,1-112	92,62±11,65 72,3-136	3.345	***0,040***	0,031	0,522	0,303
H-FH	75,3±6,61 62,3-91,8	70,32±7,99 57,4-89,2	71,47±9,29 55,7-104	3.164	***0,047***	0,048	0,160	0,845
H-PD	54,07±4,69 44,1-64,3	50,5±6,31 37,9-64,3	51,59±7,21 39-73,8	2.641	0,077	0,070	0,271	0,771
H-OD	37,47±4,49 29,9-48	31,61±8,7 2-45,8	35,24±5,61 26-50,1	6.178	***0,003***	0,002	0,385	0,085
H-MD	10,89±3,28 5,1-16,8	13,09±15,94 2-94,7	13,45±5,81 5,4-35,3	0,581	0,562	0,670	0,582	0,989
H-CVT	45,09±4,29 36,2-52,1	43,8±9,27 34,8-89,3	44,62±4,98 32,8-58	0,298	0,743	0,727	0,959	0,878

SD: standard deviation; Min: minimum; Max: maximum; p<0.05*, p<0.01**, p<0.001***

Table 2: Distribution of mean H-SN, H-FH, H-PD, H-OD, H-MD, H-CVT values of male and female individuals according to the groups

		Normal	Retrognathie	Prognathie	F	P	Binary comparisons		
		Mean±SD	Mean±SD	Mean±SD			1-2	1-3	2-3
H-SN	Female	95,12±8,64	88,44±8,57	90,18±5,18	3.492	***0,039***	0,035	0,243	0,833
	Male	95,76±5,86	89,67±11,21	94,03±14,07	0,815	0,450	0,446	0,918	0,590
H-FH	Female	75,17±7,52	70,44±7,38	70,06±4,41	2.904	0,065	0,098	0,136	0,989
	Male	75,53±4,99	70,1±9,33	72,28±11,24	0,923	0,406	0,379	0,639	0,816
H-PD	Female	53,78±4,77	50,48±5,76	50,08±3,6	2.819	0,070	0,113	0,133	0,976
	Male	54,56±4,74	50,54±7,47	52,47±8,63	0,800	0,457	0,424	0,741	0,775
H-OD	Female	37,72±4,49	31,89±9,65	35,69±4,4	3.386	***0,042***	0,035	0,725	0,330
	Male	37,04±4,68	31,11±7,18	34,97±6,31	2.636	0,085	0,076	0,656	0,238
H-MD	Female	11,55±2,84	15,33±19,63	14,98±7,84	0,466	0,630	0,643	0,764	0,997
	Male	9,75±3,8	9,24±4,08	12,57±4,24	2.929	0,066	0,952	0,177	0,093
H-CVT	Female	44,76±4,48	42,08±2,94	44,55±4,18	2.626	0,083	0,095	0,989	0,224
	Male	45,67±4,09	46,77±14,78	44,67±5,5	0,205	0,815	0,953	0,951	0,801

SD: standard deviation; p<0.05*, p<0.01**, p<0.001***

Table 3: Distribution of mean H-S (Sagittal), H-A, H-B, H-N, H-Pg, H-Cv4ia, H-APW, H-APW'', H-Cv2ia, H-PNS, H-Me, H-Go, H-Cd, H-Rgn, H-C3 values according to groups

	Normal Mean±SD Min.-Max	Retrognathie Mean±SD Min.-Max.	Prognathie Mean±SD Min.-Max	F	p	Binary comparisons 1-2	1-3	2-3
H-S (Sagittal)	96,22±8,83 79,6-114,2	90,11±8,83 77,1-111	93,66±11,68 72,1-136	2,9	0,06	0,048	0,577	0,348
H-A	68,04±4,83 58,8-76,3	62,91±5,92 54,5-74,9	65,39±10,03 48,7-96,4	3,736	0,028	0,021	0,339	0,387
H-B	45,07±5,26 35,3-54,1	44,16±3,86 36,6-53	46,77±6,77 36-69	1,787	0,174	0,79	0,451	0,156
H-N	115,28±6,93 101,2-131,2	107,74±8,72 94,9-128	107,07±13,19 87-157	6,284	0,003	0,012	0,006	0,963
H-Pg	45,24±5,21 34,8-56	45,38±3,66 38,1-52,1	45,52±7,33 34-69,4	0,02	0,981	0,994	0,979	0,995
H-Cv4ia	35,87±3,85 28,2-41,7	36,65±3,03 30,7-46,1	35,5±5,39 26,4-50,1	0,588	0,558	0,753	0,937	0,54
H-APW	21,01±4,59 14,8-30,1	18,43±3,11 11,5-23,9	19,63±5,33 11-31	2,529	0,086	0,069	0,458	0,548
H-APW''	18,55±4,42 11-29,1	15,83±2,93 12-22,1	16,08±5,34 2-29,3	3,589	0,032	0,046	0,076	0,974
H-Cv2ia	35,28±6,14 23,7-50,1	35,94±5,03 25,4-43,6	32,42±9,75 0,1-43	1,996	0,142	0,933	0,284	0,151
H-PNS	54,66±4,4 43,8-65,3	50,46±7,68 39,2-64,8	52,73±7,72 40-73,9	2,878	0,062	0,049	0,516	0,401
H-Me	38,99±5,98 28,7-53,4	40,6±4,44 30,1-48,9	40,61±6,83 30-62,8	0,766	0,468	0,536	0,532	1
H-Go	32,45±4,96 22,1-41,8	28,56±8,12 1,5-41,8	30,1±6,56 18,1-44,2	2,583	0,081	0,068	0,363	0,648
H-Cd	84,75±6,3 75-98,2	79,48±6,76 68,2-96,7	80,25±9,92 60-110	3,957	0,023	0,029	0,073	0,923
H-Rgn	31,7±4,98 21,1-40,6	33,14±3,62 26,6-41,2	34,52±6,04 21,9-44,2	2,395	0,097	0,507	0,079	0,533
H-C3	40,01±4,82 31,2-51,1	36,63±6,78 8,1-45,8	38,8±5,7 28,8-50	2,609	0,079	0,068	0,699	0,322

SD: standard deviation; Min: minimum; Max: maximum; p<0.05*, p<0.01**, p<0.001***

When the mean distribution of H-Cd, H-Rgn, H-C3HS (Sagittal), HA, HB, HN, H-Pg, H-Cv4ia, H-APW, H-CW2, H-PNS, H-Me, H-Go, values were examined according to groups of boys and girls, there was a statistically significant difference between the groups in terms of mean H-A, H-N and H-CD values of girls (p<0.05). After the post hoc Tukey analysis was performed to find out which groups presented the difference, a statistically significant difference was found in the H-A and H-CD means between normal group and retrognathie group. A statistically significant difference was found between the H-N means of the normal group and retrognathie and prognanthie group (Table 4). H-A, H-N and H-CD means of the normal group were higher than the other groups.

There was a statistically significant difference between the groups in terms of H-Rgn means of male subjects (p<0,05). In the post hoc Tukey analysis, there was a statistically significant difference in the H-Rgn means between the normal group and prognathie group (Table 4). Prognathie group H-Rgn means were higher than the other groups.

When the mean angular measurement values of three different groups are examined, distributions were found to be normal. Therefore, one-way analysis of variance (ANOVA) was performed. As a result of this analysis, a statistically significant difference was found between three groups. In addition to ANOVA, Tukey HSD test was used to find out which groups the difference was caused by. When the mean distribution of HD-SN, HD-FH, HD-MD, HD-OD, HD-PD, C3-H-S, H-C3-S values were examined, according to the groups; C3-H-S and H-C3-S values were significantly different between the three groups (p <0.05) (Table 5).

There was a statistically significant difference between the normal and retrognathie groups (p=0.001) and between the retrognathie and prognothie groups (p=0.010) in the C3-H-S measurements (Table 5). The C3-H-S value of the retrognathie group was higher than the other groups.

There was a statistically significant difference between the normal and retrognathie groups (p=0.010) and between the retrognathie and prognathie groups (p=0.006) (Table 5). Prognathie group H-C3-S value was higher than the other groups.

When the distribution of mean HD-SN, HD-FH, HD-MD, HD-OD, HD-PD, C3-H-S, H-C3-S values according to the groups of boys and girls were examined, there was a statistically significant difference between the groups in terms of C3-H-S and H-C3-S means (p<0.05). There was statistically significant difference between C3-H-S means of the between normal group and retrognathie group and between retrognathie and prognathie group. (Table 6). Among male and female subjects, the C3-H-S value of the retrognathie groups was higher than in the other groups.

Variations between T0 and T1 measurements in method error measurements were evaluated by Paired Sample t test statistical analysis. No statistically significant difference was found in all measured values (p>0.05) (Table 7).

Table 4: Distribution of mean H-S (Sagittal), H-A, H-B, H-N, H-Pg, H-Cv4ia, H-APW, H-APW'', H-Cv2ia, H-PNS, H-Me, H-Go, H-Cd, H-Rgn, H-C3 values of male and female individuals according to groups

		Normal	Retrognathie	Prognathie	F	P	Binary comparisons		
		Mean±SD	Mean±SD	Mean±SD			1-2	1-3	2-3
H-S (Sagit-tal)	Female	95,49±8,77	90,06±7,81	91,48±5,54	2,434	0,099	0,091	0,37	0,88
	Male	97,47±9,21	90,2±10,79	94,93±14,07	1,033	0,366	0,347	0,845	0,563
H-A	Female	69,23±4,59	62,84±5,73	68,05±8,62	5,67	***0,006***	0,006	0,867	0,073
	Male	66±4,75	63,03±6,53	63,85±10,67	0,373	0,691	0,689	0,781	0,964
H-B	Female	47,3±4,76	44,56±3,43	47,09±6,09	1,917	0,159	0,175	0,992	0,331
	Male	41,23±3,69	43,45±4,6	46,58±7,28	3,069	0,058	0,649	0,053	0,347
H-N	Female	115,07±8,26	107,76±8,2	104,91±8,22	6,414	***0,003***	0,023	0,006	0,634
	Male	115,65±4,04	107,7±9,98	108,32±15,44	1,615	0,212	0,276	0,251	0,99
H-Pg	Female	46,94±4,56	45,26±3,23	46,85±4,97	0,895	0,416	0,442	0,999	0,58
	Male	42,3±5,14	45,59±4,47	44,75±8,44	0,72	0,493	0,497	0,609	0,943
H-Cv4ia	Female	36,72±3,79	36,27±3,12	37,75±5,93	0,454	0,638	0,939	0,787	0,612
	Male	34,41±3,67	37,32±2,89	34,19±4,72	2,298	0,114	0,222	0,989	0,116
H-APW	Female	20,04±4,71	18,54±2,66	19,73±4,78	0,706	0,499	0,491	0,977	0,72
	Male	22,67±4,06	18,25±3,91	19,58±5,75	2,41	0,103	0,099	0,231	0,754
H-APW''	Female	17,92±4,18	15,69±3,11	16,06±6,85	1,237	0,3	0,3	0,537	0,975
	Male	19,65±4,82	16,07±2,71	16,08±4,46	2,933	0,065	0,124	0,076	1
H-Cv2ia	Female	35,16±5,73	36,19±4,67	31,05±11,27	1,969	0,151	0,893	0,277	0,139
	Male	35,49±7,1	35,52±5,82	33,22±8,98	0,442	0,646	1	0,722	0,716
H-PNS	Female	54,09±4,52	50,52±7,45	52,9±5,21	1,748	0,185	0,166	0,858	0,547
	Male	55,63±4,22	50,36±8,42	52,63±9	1,246	0,299	0,27	0,577	0,728
H-Me	Female	41,62±5,23	40,47±3,81	40,77±4,25	0,326	0,723	0,712	0,873	0,983
	Male	34,45±4,31	40,83±5,57	40,52±8,06	3,518	***0,04***	0,074	0,052	0,992
H-Go	Female	31,65±5,05	28,08±8,04	28,72±6,34	1,498	0,234	0,233	0,48	0,966
	Male	33,84±4,69	29,39±8,59	30,89±6,72	1,223	0,306	0,29	0,497	0,831
H-Cd	Female	84,82±6,79	79,74±5,71	79,41±6,79	3,865	***0,028***	0,047	0,076	0,99
	Male	84,62±5,66	79,05±8,57	80,74±11,5	1,012	0,373	0,364	0,535	0,885
H-Rgn	Female	33,75±3,83	33,18±3,14	35,75±5,03	1,573	0,218	0,894	0,372	0,2
	Male	28,17±4,89	33,06±4,5	33,81±6,57	3,666	***0,035***	0,12	0,032	0,936
H-C3	Female	39,49±5,05	35,56±7,66	39,05±5,68	2,088	0,136	0,145	0,982	0,319
	Male	40,92±4,46	38,47±4,66	38,65±5,86	0,809	0,453	0,52	0,492	0,995

SD: standard deviation; p<0.05*, p<0.01**, p<0.001***

Table 5: Distribution of mean HD-SN, HD-FH, HD-MD, HD-OD, HD-PD, C3-H-S, H-C3-S values according to groups

	Normal	Retrognathie	Prognathie	F	p	Binary comparisons		
	Mean±SD Min.-Max	Mean±SD Min.-Max	Mean±SD Min.-Max			1-2	1-3	2-3
HD-SN	30,8±8,73	29,76±6,69	26,45±6,38	2.879	0,062	0,848	0,062	0,193
	10,4-46,4	17,6-50,4	12,7-39,4					
HD-FH	19,85±7,16	16,53±6,66	19,32±6,74	2.023	0,138	0,153	0,952	0,262
	4,8-34,8	9,8-38,4	4,8-30,4					
HD-MD	5,28±5,67	7,55±4,23	6,92±6,63	1.313	0,274	0,264	0,496	0,901
	-9-13,5	0-15,5	0,5-27,5					
HD-OD	36,7±132,43	11,66±5,7	12,79±5,97	1.022	0,364	0,418	0,451	0,998
	0,7-737	1,3-30,2	0,8-25,2					
HD-PD	22,81±9,3	19,67±5,85	20,98±7,69	1.248	0,292	0,263	0,630	0,791
	1,2-40,1	11,1-38,1	3-36,3					
C3-H-S	64,53±8,09	73,07±8,54	66,29±9,75	7.847	***0,001***	0,001	0,721	0,010
	48-92	57,8-103,1	48,7-96,9					
H-C3-S	89,04±10,26	81,26±9,8	89,58±10,3	6.352	***0,003***	0,010	0,977	0,006
	62,4-110	53,1-102,6	58,7-108,9					

SD: standard deviation; Min: minimum; Max: maximum; p<0.05*, p<0.01**, p<0.001***

Table 6: Distribution of mean HD-SN, HD-FH, HD-MD, HD-OD, HD-PD, C3-H-S, H-C3-S values of male and female individuals according to groups

		Normal	Retrognathie	Prognathie	F	P	Binary comparisons		
		Mean±SD	Mean±SD	Mean±SD			1-2	1-3	2-3
HD-SN	Female	30,66±7,8	30,54±7,23	25,51±7,76	1.930	0,157	0,999	0,182	0,197
	Male	31,04±10,55	28,43±5,7	26,99±5,6	1.082	0,349	0,679	0,316	0,861
HD-FH	Female	19,97±6,47	16,66±7,1	18,51±7,27	1.096	0,343	0,311	0,843	0,760
	Male	19,64±8,55	16,32±6,15	19,79±6,56	0,948	0,396	0,517	0,998	0,403
HD-MD	Female	6,24±4,45	7,52±4,46	8,89±8,91	0,762	0,472	0,771	0,447	0,804
	Male	3,62±7,26	7,59±4,01	5,77±4,78	1.507	0,235	0,206	0,545	0,648
HD-OD	Female	12,51±7,15	11,91±6,1	13,77±7,76	0,256	0,775	0,961	0,879	0,756
	Male	78,49±218,49	11,25±5,2	12,22±4,79	1.420	0,254	0,348	0,275	1.000
HD-PD	Female	22,11±9,21	19,45±6,26	21,56±9,92	0,520	0,598	0,592	0,984	0,783
	Male	24,03±9,77	20,05±5,35	20,64±6,34	1.033	0,366	0,406	0,435	0,975
C3-H-S	Female	64,45±8,99	70,21±6,8	66,41±6,78	2.697	0,078	0,066	0,783	0,403
	Male	64,65±6,64	78,01±9,26	66,22±11,3	6.591	***0,003***	0,007	0,906	0,008
H-C3-S	Female	89,71±10,59	82,12±9,75	86,74±8,98	2.803	0,071	0,058	0,711	0,444
	Male	87,88±10,04	79,76±10,17	91,22±10,87	4.195	***0,023***	0,178	0,680	0,017

SD: standard deviation; p<0.05*, p<0.01**, p<0.001***

Table 7: Mean distribution of method error measurements of individuals

	T0		T1		t	p
	Mean±SD	Min.-Max.	Mean±SD	Min.-Max.		
H-SN	88,01±7,32	79,0-101,0	87,50±6,99	78,2-100,4	1.731	*0,117*
H-FH	69,23±5,94	61,2-78,8	69,23±5,20	63,2-78,0	0,000	*1.000*
H-PD	49,16±3,65	44,0-55,1	50,00±3,49	44,8-55,2	-1.562	0,153
H-OD	32,26±4,55	25,2-38,0	31,92±4,60	18,7-49,8	0,740	*0,478*
H-MD	10,17±3,04	6,4-15,4	10,34±2,58	6,9-14,1	-0,307	0,766
H-CVT	44,78±4,68	36,6-54,4	44,23±4,49	38,1-53,8	1.120	*0,292*
H-S (Sagittal)	89,61±7,95	79,0-103,0	88,94±8,11	77,9-100,9	1.439	*0,184*
H-A	61,50±5,24	54,5-71,9	61,30±5,08	55,3-70,4	0,591	*0,569*
H-B	44,36±3,82	39,6-51,2	43,92±3,58	39,3-49,4	1.157	*0,277*
H-N	104,88±8,41	95,0-121,0	105,44±8,13	94,8-119,3	-1.440	0,184
H-Pg	45,07±3,51	40,01-51,3	45,08±3,60	38,7-50,5	-0,025	*0,981*
H-Cv4ia	36,78±5,76	31,0-50,1	36,58±5,58	30,2-48,9	0,530	*0,609*
H-APW	20,03±2,74	17,8-24,0	20,68±3,11	17,8-25,1	-0,299	0,772
H-APW″	15,87±3,30	10,0-21,0	15,98±3,01	11,4-20,8	-2.127	*0,062*
H-Cv2ia	38,04±4,41	31,2-43,6	37,26±4,08	30,01-42,9	1.919	*0,087*
H-PNS	48,87±5,60	40,5-56,2	48,42±5,47	40,1-56,0	0,930	*0,377*
H-Me	41,54±3,49	36,1-46,4	41,92±3,01	37,1-46,1	-0,971	*0,357*
H-Go	28,65±3,81	23,0-36,2	29,18±3,69	25,1-37,4	-1.416	*0,190*
H-Cd	78,68±5,57	71,2-88,0	78,39±5,09	71,1-87,3	0,801	*0,444*
H-Rgn	33,01±2,92	30,04-40,0	32,83±3,26	29,9-41,7	0,429	*0,678*
H-C3	39,01±5,35	32,0-50,0	38,7±5,50	33,1-51,4	0,553	0,593
HD-SN	32,63±7,75	17,9-46,0	31,79±7,42	18,6-44,9	2.048	*0,071*
HD-FH	20,21±8,49	10,0-34,8	20,22±7,29	12,0-31,9	-0,019	*0,985*
HD-MD	7,53±3,90	2,4-13,5	7,12±3,79	12,1-14,0	1.229	*0,250*
HD-OD	16,42±5,11	7,5-25,2	16,46±4,82	8,9-24,7	-0,097	*0,925*
HD-PD	25,51±8,61	15,1-39,2	25,05±8,05	16,5-37,8	1.244	*0,245*
C3-H-S	72,61±11,28	58,7-96,0	73,14±10,35	61,6-97,3	-1.194	*0,263*
H-C3-S	83,31±11,64	54,3-108,9	83,52±11,84	57,4-98,2	2.448	*0,608*
SNA	79,93±1,92	77,0-82,2	79,58±1,66	77,0-81,5	-0,531	*0,127*
SNB	81,36±3,0,7	76,3-85,0	81,27±2,81	78,1-85,1	0,239	0,817
ANB	-1,43±2,74	-4,6-3,7	-1,69±2,08	-4,2-2,0	0,559	0,590

SD: standard deviation; Min: minimum; Max: maximum; p<0.05*, p<0.01**, p<0.001***

DISCUSSION

When the literature was examined, it was seen that the studies on the evaluation of the position of the hyoid bone were performed in adult and child subjects.[2, 4, 8, 9, 10 11] In this study, individuals between the ages of 10-14 who are receiving orthodontic treatment actively are included. Our study group is competent with the groups of previous studies.[2, 4, 8, 9, 10, 11] In many previous studies, individuals of both genders were included in the study groups and possible effect of the gender on the location of hyoid bone was not questioned.[1, 12, 13, 14, 15, 16] Therefore, subjects were separeted according to genders.

In order to determine the presence of individual variants, the error control test is performed and any statistically significant error is detected in the cephalometric markings and measurements applied to determine the position of the hyoid bone. (Table 7).

It has been shown that the natural head position and the position of the hyoid bone may change in individuals with orthopedic or orthognathic treatment history. In particular, It has been reported that the change of the position of the mandible and tongue can change … the natural head position and hyoid position, and changes in functions such as chewing, swallowing and breathing also directly affect these structures.[14, 17, 18] King, in his study in which was evaluated the positional changes of hyoid bone in the same individual, found that the hyoid bone was positioned backward in the extension position of the head and forward in the flexion position.[3] For this reason, x-rays taken in the natural head position were used in our study to ensure standardization.

Since we have not encountered a study that differentiates and examines Class 3 anomalies according to their structural and positional differences in the literature, in this retrospective study, two study groups consisting of individuals with skeletal Class 3 malposition are included. One group included individuals with retrognathic maxilla and normal positioned mandible whereas the other group included individuals with prognathic mandible and normal positioned maxilla. Control group consisted of individuals with normal Class 1 relation. Thus, the position of the hyoid bone in individuals with skeletal Class 3 malposition originating from different jaw aberrations could be compared with the control group.

Horizontal and vertical distance measurements and angular measurements are performed to determine the location of the hyoid bone. The increase in the horizontal distance means that the hyoid bone is positioned forward, while the increase in the vertical distance means that the hyoid bone is positioned lower.

Fromm and Lundberg compared the position of the hyoid bone between adult individuals with normal occlusion and mandibular protrusion and stated that there was no significant difference between the two groups in the vertical position of the hyoid bone but hyoid bone was positioned significantly more anteriorly in women with mandibular prognathie. They suggested that changes in hyoid bone position were associated with mandibular changes.[19] H-SN, H-FH, H-PD, H-OD, H-MD measurements of the vertical position of the hyoid bone were examined. In terms of H-SN, H-FH and H-OD, a statistically significant difference was found between the normal and retrognathie groups. The lowest values of these measurements were observed in the retrognathie group. This means that in the individuals with skeletal Class 3 malpositions originated from maxillary retrognathia, the body of the hyoid bone is closer to the plane of the SN, the FH plane and the occlusal plane. Thus, the hyoid bone in the retrognathie group is located higher than the normal group. There was no difference between normal and prognathie groups in the vertical position of hyoid bone as Fromm and Lundberg stated in their study.[19,20]

Grant reported that the position of the hyoid bone was not affected by Class I, II and III malocclusions and that the hyoid bone position was only determined by the musculare.[21] In our study, no statistically significant difference was found in H-Me, H-Pg, H-Rgn, H-B distances between the retrognathie and prognathie groups and the normal group, which are the values about the distance of the hyoid bone to the jaw tip.

In previous studies, Sayın and Ceylan reported that, as ANB angle increases the hyoid bone moved away from the cervical column and on the contrary, as angle decreased the bone positioned closer to column.[20, 22] In our study, unlike the other studies, H-CVT, H-Cv4ia, H-Cv2ia, H-C3 measurement values which describe the distance of hyoid bone from the cervical column did not differ significantly between the groups. The reason of this result may be due to the absence of a group with a large ANB angle in our study. According to the results of our study, it is seen that ANB angle has no effect on the hyoid bone-cervical column distance.

Tsaous Chasan, by using radiographs of Class I (30 individuals), Class II (20 individuals) and Class III (8 individuals) malocclusion individuals whose lateral cephalometric films were obtained regularly for 3 years, aimed that to determine the positional and spatial changes of hyoid bone in the growth period in different malocclusions.[2] According to the findings of this study; CV4ia-H, CV2ia-H, APW-H and APW''-H measurements measurements showing the distance of the hyoid bone to the anterior pharyngeal wall showed a linear increase with development in all groups, while the highest value was observed in the Class III group, which indicated hyoid bone was positioned anteriorly due to the mandibular prognothie.

The observed value in Class II group being more than Class I group were interpreted as increasing H-cervical vertebrae distance in order to maintain airway maintenance due to mandibular retrognathie. In our study, no significant difference was found between the groups in terms of H-Cv4ia, H-Cv2ia, H-APW measurements. According to the findings of our study, it is not possible to say that the hyoid bone is located anteriorly in the prognothie group. In terms of H-APW'' measurement value, a statistically significant difference was found between the normal and retrognathie groups and the lowest value was found in the retrognathie group. The reason of this result is probably due to the counterclockwise rotation of the hyoid bone body in the retrognathie group.[23]

Urzal et al., said that the hyoid bone is angularly counterclockwise rotated in the retrognathie group and in the the prognothie and normal group clockwise rotation was seen when three groups were compared.[24]

Dinçer et al.[4], stated that the hyoid bone was located posteriorly than normal in the Class II division 1 malocclusions and anteriorly in the Class III anomaly. He also found that among the malocclusion groups, the hyoid bone position was located the highest in the Class III group. Researchers reported a significant difference in At-H, H-CVT, AH and NH, H-OP values among Class I and Class II groups, and in At-H, H-OP, AH, NH values in Class I and Class III.[18] Similarly, in terms of H-N values, a significant difference was found between normal and retrognathie and between normal and prognothie groups, and the highest H-N values were found in the normal group. A significant difference between the normal and retrognathie groups in terms of H-A value which describes the sagittal position of the hyoid bone was seen and retrognathie group presented the lowest value. Orientation of the nasomaxillary complex and placement of important sketelal landmarks like A and N point in skeletal Class 3 individuals, might be the reason of this finding. In addition, counterclockwise rotation seen in the retrognathie group and anterior placement seen in prognathie group might be the factors.

Marsan et al[15]. evaluated head posture and hyoid bone position in adult Class III malocclusion group. In this study, which was conducted on Turkish individuals consisting of 39 girls and 30 boys, the distances between the hyoid bone and Cv4ia, Cv4ip, Cv2ia, Bolton, Articulare, ANS were found to be less in girls than in boys. In our study, no statistically significant difference was found between the groups in terms of Cv4ia and Cv2ia values of boys and girls.

Adamidis et al[25]. in Class I and Class III groups, in their studies stated that AH measurement was statistically different between Class I and Class III groups in mouth closed position and the lowest value was in Class III group. They also stated that in individuals with Class III malocclusion, the hyoid bone positioned more anteriorly in males in both open and closed mouth position, and the angle between hyoid bone plane and the mandibular plane was considerably reduced. Not having the same results in girls group was explained as girl were more conscious about prognathic mandibulae look even if their early years and exhibit a different head posture in order to camouflage.

In our study; Although the H-A measurement shows a statistically significant difference only between the normal group and girls of retrognathie group, the lowest value in the retrognathie group can be interpreted as the orientation of point A due to the positioning of the maxilla. However in our study, the fact that HD-MD angle measurement did not show a significant difference between the groups and did not show similarity with the findings of the mentioned study suggesting that the girls tend to camouflage their prognathic mandible.

A statistically significant difference was observed in H-PNS and H-Cd measurements which give information about the vertical position of the hyoid bone, between the normal and retrognathie groups and the lowest value was found in the retrognathie group. Based on these findings, it can be said that the hyoid bone body is located higher in the retrognathie group. Lowest value of H-PNS measurement presented by the retrognathie group can be attributed to sagittal and vertical development of maxilla. In terms of H-Go measurement value, no statistically significant difference was observed between the groups. In the study conducted by Tsaous Chasan, H-Go size was highest in the Class III group.[2]

In the study conducted by Tsaous, the angle of HD-SN showed statistically no significant increase in Class I and III groups and a decrease in Class II group. Similarly, HD-MD, HD-OD, HD-PD and HD-NBa angles were the lowest in Class II group. The angle of HD-NBa showing the angular relationship between the hyoid bone and the posterior head base decreased in the Class I and II groups during the three year follow-up period and increased in the Class III group. These findings showed that the hyoid bone and the angular relations between the anterior and posterior head bases and the occlusal and palatal planes were different in the malocclusion groups. In our study, no statistically significant difference was observed between the groups in terms of HD-SN, HD-FH, HD-MD, HD-OD, HD-PD measurement values which are the angular measurements of hyoid bone.

Şahin and Uydaş[26] evaluated the relationship between hyoid bone position and head posture in adult women and men. They examined the lateral cephalometric films of 38 female and 38 male adult individuals with skeletal Class I ideal occlusion, taken in natural head position and reported that the hyoid bone positioned significantly anteriorly and inferiorly in males, but no significant difference was observed between the genders in terms of natural head position. Although there are different opinions, many researchers have reported that the hyoid bone position does not affected by gender.[9, 22, 27] However in our study, like Ceylan's study, it was shown that hyoid bone is positioned higher in girls.[21] This is probably due to the way of construction of the study groups which included individuals with different skeletal structures and ages.

The effects of ethnic origin on morphology are a known fact. However, the civilizations located along the historical silk road between the slavic origin located above the equator and the far north have mixed with each other throughout history and genetic differences have decreased. While the individuals involved in this study who lives in Turkey[4,20,22], on the other hand considering other studies on people living in the Greece[25], Portugal[24], Sweden[19] and US[21]; there is no evidence that this situation could significantly affect the position of the hyoid bone, which is not directly related to any bone. Studies in which working groups that include individuals with similar morphologies, gender and age should be constructed in order to obtain more likely results on this subject

CONCLUSION

Class 1 and Class 3 skeletal patterns do not affect the distance of the hyoid bone to the cervical column and the tip of the jaw. The hyoid bone is positioned higher in the vertical direction in the girls of retrognathie group compared to the prognathie group and the normal group and also, counterclockwise rotation was seen. The position of the hyoid bone is very important for the prognosis and stability of orthodontic treatment in terms of the functions of suprahyoid and infrahyoid muscle groups. This situation shows us that any change or difference in the tooth and face systems cause adaptive and compensatory effects on all environmental structures and therefore we should consider these mechanisms in every intervention performed on the maxillofacial area.

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Compliance with Ethical Standards

Conflict of interest: The authors have no conflicts of interest to declare.

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Ethical Committee Approval: The study protocol was approved by the Health Research Ethics Board of İzmir Katip Çelebi University, School of Medicine (protocol number: 320). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed consent: A written informed consent was obtained from each participant.

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