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RESEARCH ARTICLE

SEXUAL DIMORPHISM OF SKELETAL CLASS III MALOCCLUSION IN YEMENIS ADULT

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Abstract

Aim: Identification of sexual dimorphism in skeletal Class III malocclusion can help improve clinical diagnosis and orthodontic treatment. There is a continuing dispute as to the extent of sexual dimorphism in skeletal Class III malocclusion. The purpose of this study is to investigate the sexual dimorphism of cephalometric data in Class III malocclusion among Yemeni adults.

Methods: This retrospective cross-sectional study examined 144 lateral cephalographs of Class III malocclusion in Yemeni adults, including 67 men and 77 women, who ranged from 16 to 40 years. The cephalometric x-rays were digitized and traced using OrisCeph RX CE software to measure a total of 48 craniomaxillofacial variables. Descriptive statistics of data were calculated for each gender. To assess sexual dimorphisms across all cephalometric variables, the Mann-Whitney U test was employed.

Results: Most variables indicated that males exhibited greater values than females. Adult Yemeni males with Class III malocclusion had greater values in linear measurements of the cranial base, maxilla, mandible, and facial heights than female patients.

Conclusions: Sexual dimorphism exists in Yemeni adults with skeletal Class III malocclusions. The results are presented to confirm the actual variations in skeletal features between two sexes of Yemeni adults. Sexual dimorphism should be considered in clinical diagnosis, treatment planning, and orthodontic treatment.

Keywords: cephalometry, clinical diagnosis, Class III malocclusion, orthodontic treatment, sexual dimorphism.

INTRODUCTION

Class III malocclusion is the rarest type of malocclusion. The prevalence rates vary significantly between communities, with as low as 5% in Caucasians and as high as 13-19% in Asians[1,2]. Class III Skeletal malocclusion represents a convoluted discrepancy in the development of the maxilla-mandibular skeleton. It is commonly associated with adaptive changes in dental and soft tissue structures[3]. This malocclusion may be a consequence of excessive mandibular growth, inadequate maxillary growth, or both, which leads to a distinctive concave facial profile[4]. Furthermore, it is closely related to both environmental and hereditary elements that affect mandibular development[5].

Accurate diagnosis and well-designed treatment planningare essential for effective orthodontic treatment of malocclusion[6]. Lateral cephalometric radiography (LCR) is an important diagnostic tool for analyzing malocclusion, researching fields, and predicting growth. It aids orthodontists and surgeons in creating specific treatment plans to ensure optimal patient outcomes[7,8]. The first crucial step in diagnosing malocclusion and its associated craniofacial components is exploring the presence of considerable sexual dimorphism[3]. Previous studies have found sexual variations in dentoskeletal measurements related to Class III skeletal malocclusions. Lew *et al*., studied 80 LCRs of Chinese Class III malocclusion individuals and found that most of the adult women had a hypoplastic maxilla, while men had a prognathic mandible[3]. In a study involving 57 LCRs from Greek Class III malocclusions, Kavadia-T *et al*., found that males displayed more severe manifestations of malocclusion than females[9]. Several authors[10-13] have indicated gender and ethnic differences in several variables. Celebi *et al*.[14], reported similar findings when examining the sexual dimorphism of craniofacial structures in populations from Italy and Egypt. Class

III males had largerdimensional values of the face and mandible than females.

A review of previous research reveals several limitations, including small sample sizes, inclusion of growing subjects from different origins, and limited cephalometric measurements. At present, there are no studies appropriately describing cephalometric sexual dimorphisms in Class III malocclusion in the Yemeni population. Therefore, the study aimed to analyze sexual dimorphism regarding cephalometric characteristics of Class III malocclusion among Yemeni adults. A null hypothesis was formulated and examined: no sexual dimorphism in Class III malocclusion among Yemeni adults.

METHODS

This cross-sectional retrospective study received approval from the Ethical Committee of Medical Research, Sana'a University, Sana'a, Yemen (ECA/SU/ 759). The study followed the Declaration of Helsinki, and all participants gave written informed consent before enrolling. According to a confidence level of 95%, an accuracy level of 30%, a power level of 90%, and a variation of 69% for the independent variables considered in the comparator groups, the required sample size is 131 patients. A total of 144 LCRs were analyzed before treatment in this study, including 67 men and 77 women. The average age of participants was 22.1±4.67 years for men and 22.4±5.96 years for women.

Between January 2021 and February 2022, participants were recruited from individuals seeking treatment at the postgraduate orthodontic clinics of Sana'a University, in Sana'a, Yemen. True skeletal and dental Class III malocclusion was diagnosed in the clinical exam. The profile was concave in natural head posture. The mandible protruded, and the maxilla was retrognathic without functional shift. All participants were from the Yemeni heritage site. They met the eligibility criteria, which included a concave profile, anterior cross bite, Class III canine and molar relationships, and an ANB angle > -1°. Subjects with an anterior mandibular shift, previous orthodontic treatment, trauma or fracture of the jaws, general systemic disorders, orcongenital syndromes were excluded from the study.

Cephalometric radiographs

The radiographs were taken by the same radiologist utilizing a PaXFle 3D P2 cephalostat (Version 1.0.0, Vatech, Korea). While imaging, the participants were asked to keep their heads in a natural position and teeth in a centric occlusion, in addition to having their right side of the body directed toward the X-ray apparatus which was working on 85 kV and 10 mA.

Cephalometric analysis

This study employed digital LCRs recorded and stored as JPG files. The radiographs were entered into the software (OrisCeph RX CE) and standardized using a 10-mm ruler. A senior orthodontic resident, M.A.H., performed tracing of LCRs. A total of 26 cephalometric landmarks were identified, providing a comprehensive characterization of the craniofacial structures (Figure 1)[15]. This study applied 48 cephalometric craniofacial measurements, including 35 skeletal measurements and 13 dentoalveolar measurements[16,17].

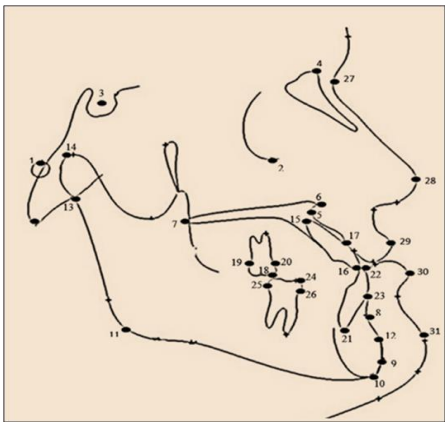


Figure 1: Anatomical landmarks used in the study.

1- porion(P), 2- orbital (Or), 3- sella(S), 4- nasion(N), 5- point-A (Subspinale), 6- anterior nasal spine (ANS), 7- posterior nasal spine(PNS), 8- point-B (Supramentale), 9-gnathion (Gn), 10-menton (Me), 11- gonion (Go),12- pogonion (Pg),13- articulare (Ar), 14- condylion (Co), 15-upper incisor tip, 16- upper incisor apex,17- upper incisor labial gingival border, 18- U6 occlusal point, 19- U6 distal point, 20- U6mesialpoint, 21- lower incisortip, 22-lower incisor apex, 23- lower incisor labial gingival border, 24- L6 occlusal point, 25- L6 distal point, 26- L6 mesial point.

Method error

A random sample of 40 LCRs was retested for tracing and analyzed after three weeks by the same examiner. Intra-examiner reliability of landmark localization was examined using intra-class correlation methods (ICC)[18]. The reliability coefficient showed that the 48 measured variables had a substantial correlation. The intra-examiner reliability variedbetween 0.892 and 0.999.

Statistical analysis

The SPSS program (Statistical Package for the Social Sciences, version 26) was used for data analysis, considering a level of significance at 5%. Descriptive statistics were calculated for the cephalometric variables in each gender. Because the Kolmogorov-Smirnov test confirmed that the data did not follow a normal distribution (p<0.05), we used the Mann-Whitney U test to compare sexual dimorphism across the cephalometric measurements.

RESULTS

This study analyzed 48 cephalometric measurements for each LCR of Class III malocclusions. This analysis found that 24 variables created a significant variance between males and females.

Relationships of the cranial base

Table 1 shows a significant sexual dimorphism in the cranial base angle (S-N-Ar), where adult class III females have a substantially greater angle (p<0.001). However, adult males demonstrated higher values in anterior and posterior cranial bases (S-N and S-Ar) when compared to adult females (p<0.001).

Table 1: Sexual dimorphism for the skeletal cranial base, maxillary, and mandibular variables with the Mann-Whitney test.

Cephalometric measurements	Total N = 144	Male N= 67	Female N= 77	Mean Diff	Median	95% Confidence Interval		*p*- value	SL
						Lower	Upper		
SN-Ar (º)	124.6±5.5	122.7±4.8	126.2±5.6	- 3.5	123	-5.2	-1.7	<0.001	***
S-N (mm)	64.4±3.5	66±3.5	63±2.7	3	64	1.9	4	<0.001	***
S-Ar (mm)	29.7±3.4	31.6±3.1	28±2.8	3.6	29	2.6	4.5	<0.001	***
SNA (º)	79±3.7	80±3.6	78.1±3.6	1.9	79.1	0.7	3.1	0.003	**
A to N Perp (FH) (mm)	- 3.2±3.4	- 2.8±4	- 3.5±2.9	- 0.7	-3	-0.5	1.8	0.465	NS
Co-ANS(mm)	77.6±5.3	80.2±4.74	75.3±4.7	4.9	77.5	3.3	6.4	<0.001	***
Co-A (mm)	77±4.9	79.5±4.4	74.9±4.2	4.6	77	3.1	6	<0.001	***
SNB (º)	82.8±3.8	84±4	81.7±3.2	2.3	82.4	1.1	3.5	<0.001	***
Facial Ang (FH-NPg) (º)	90.8±3.7	91.3±4.5	90.2±3	1.1	91	-2	2.3	0.076	NS
Facial tap (N-Gn-Go) (º)	63.2±5.1	63.2±5	63.3±5.2	- 0.1	63.7	-1.8	1.6	0.995	NS
Go-Pg (mm)	73.7±5.3	76.1±5.5	71.7±4.3	4.4	73.8	2.7	6	<0.001	***
Pg to NPerp (FH) (mm)	1.2±6.8	2.2±8	0.4±5.4	1.8	2	-0.5	4	0.077	NS
Co-Gn (mm)	112.7±7.5	116.7±6.9	109.1±6.2	7.6	112	5.5	9.8	<0.001	***
Pg - NB (mm)	0.7±1.7	0.5±1.7	0.9±1.7	- 0.4	0	-0.9	0.2	0.204	NS
Ar-Go-Me (º)	127±8.3	126.4±9.4	127.6±7.2	- 1.2	126	-4	1.5	0.150	NS
S-Ar-Go (º)	142.2±7	143.4±6.8	141±7	2.4	142.5	0.4	4.9	0.009	**
Ramus Height (Ar Go) (mm)	46.3±4.7	48.7±4.6	44.3±3.8	4.4	46	3	5.7	<0.001	***
PFH (Co-Go) (mm)	54.9±5	57.5±4.6	52.4±4.4	5.1	54.6	3.3	6.3	<0.001	***

n: number of cases, NS: non- significant, S.D: Standard deviation, Diff: Difference, S.L**:** Significant Level. * It is significant at the ($p < 0.05$) level of confidence, ** It is significant at the ($p \leq 0.01$), *** It is significant at the ($p \leq 0.001$) level of confidence.

Table 2: Sexual dimorphism for the skeletal intermaxillary variables with the Mann-Whitney test.

Cephalometric measurements	Total N= 144	Male N= 67	Female N= 77	Mean Diff	Median	95% Confidence Interval		*p*- value	SL
						Lower	Upper		
ANB (º)	- 3±2	- 3.4±2.3	- 2.7±1.8	- 0.7	-3	-1.3	0	0.047	*
NA-APg (º)	- 8.3±4.8	- 8.4±5.2	-8.1±4.6	- 0.3	-8	-1.9	1.3	0.849	NS
AB-NPg (º)	4.6±3	4.8±3.2	4.3±2.8	0.5	4	-0.4	1.5	0.320	NS
SN-NPg (º)	83.3±3.8	84.4±4.1	82.3±3.3	2.1	83	0.9	3.3	0.002	**
Co-Gn -Co-ANS (mm)	34.9±5.5	36.6±5	33.5±5.5	3.1	35	1.3	4.8	<0.001	***
AO-BO (mm)	- 8.7±3.2	- 9.2±3.4	- 8.3±3	- 0.9	-8	-1.9	0.1	0.121	NS
FMA (º)	26.2±6.3	25.6±7	26.7±5.6	- 1.1	26	-3.1	1	0.142	NS
SN-Go-Gn (º)	31.1±6.3	29.8±6.7	31.3±5.7	- 1.5	31.2	-4.6	-0.5	0.016	*
Occ Plane to SN (º)	14.5±4.6	13.2±4.7	15.6±4.3	- 2.4	14.5	-3.9	-0.9	0.005	**
Occ Plane to - FH (º)	7±4.2	6.3±4.6	7.5±3.8	-1.2	7	-2.5	0.2	0.106	NS
FH-SN (º)	8.3±9.3	7±3.2	9.4±12.4	- 2.4	7.8	-5.5	0.6	0.036	*
Y-Axis (NS-Gn) (º)	65.9±3.9	65.3±4.2	66.5±3.6	- 1.2	66	-2.4	0.1	0.058	NS
AFH (N-Me) (mm)	111.7±8	115.9±7	108.1±7	7.8	111.6	5.4	10	<0.001	***
UFH (N-ANS) (mm)	48.2±3.6	49.8±3	46.8±3.4	3	48.6	1.9	4	<0.001	***
LFH (ANS-Me) (mm)	63.7±6.5	66.3±6.3	61.4±5.8	4.9	63.1	2.9	6.9	<0.001	***
N- ANS/ N-Me %	43.2±2.7	43±2.6	43.4±2.8	- 0.4	43.1	-1.3	0.5	0.442	NS
Co-Go/ N-Me %	49.8±4.6	50.3±4.6	49.4±4.6	0.9	49.3	-0.6	2.4	0.172	NS

n: number of cases, NS: non- significant, S.D: Standard deviation, Diff: Difference, S.L**:** Significant Level. * It is significant at the ($p \leq 0.05$) level of confidence, ** It is significant at thet ($p \leq 0.01$) level of confidence, *** It is significant at the ($p \leq 0.001$) level of confidence.

Skeletal relationships of the maxilla

Sexual dimorphism was found in maxillary measurements in relation to the cranial base for individuals with Class III malocclusion. The females had a posterior positioned maxilla assessed by SNA ($p \leq 0.05$) and significantly shorter maxillary lengths (Co-ANS), shorter mid face lengths (Co-A) ($p<0.001$), and shorter upper facial heights (UFH), measured by N-ANS ($p<0.001$) (Table 1).

Skeletal relationships of the mandible

Sexual dimorphism was noted in the sagittal measurements of the mandible in relation to the cranial base in Class III malocclusion adults. Males showed more substantial mandibular prognathism as measured by the SNB angle ($p \leq 0.001$). The mandibular unit length (Co-Gn) and mandibular base length (Go-Pg) in males were larger than in females ($p \leq 0.001$).

The study found that male subjects displayed greater chin prognathism, with a statistically substantial variance noted only in the facial plane angle (SN-NPg) ($p \leq 0.001$). An increase in the measurement of ramus height (Ar-Go) was present in males compared to females ($p<0.001$). The facial angle (FH-N-Pg), gonial angle (Ar-Go-Me), and facial taper angle (N-Gn-Go) showed no significant sexual dimorphism in Class III malocclusion adults (Table 1).

Intermaxillary relationships

Sexual dimorphism is presented in the sagittal intermaxillary relationships according to the ANB angle and Co-Gn: CoA-NS (mm). There was a statistically significant decrease in both ANB angle ($p<0.05$) and Co-Gn: CoA-NS ($p<0.001$) in females compared to males. The convexity angle (NA-APg), AB-NPg angle, and Wits Appraisal (AO-BO) (mm) did not show any important distinctions.

A substantial distinction was found in TAFH (N-Me), UAFH (N-ANS), and LAFH (ANS-Me) analysis, showing smaller vertical maxillomandibular measurements in female individuals. The articular angle (S-Ar-Go) was higher in men than in women (p<0.05). Females had greater angular measures, including the mandibular plane angle (SN-GoGn) (p≤0.05), the angle of the occlusal plane to S-N plane (p<0.001), and the gonial angle (Ar-Go-Me) (Table 2).

Maxillary dentoalveolar relationships

All variables were used to measure maxillary dentoalveolar position, and angulation described more protrusion of the upper incisors in adult Class III males, where the variance for the angle U1-SN was statistically considerable (p≤ 0.05) (Table 3).

Mandibular dentoalveolar relationships

All measurements used to evaluate mandibular dentoalveolar position and angulation described greater protrusion of the lower incisors in adult male subjects; however, this difference was only statistically significant for L1 Protrusion (L1-APg) (mm) (p≤ 0.05). The study found that male patients exhibited higher values in intermaxillary dental relationships, with statistically significant differences observed only for the overjet variable (p≤ 0.01) (Table 3).

Table 3: Sexual Dimorphism for the maxillary and mandibular dentoalveolar variables with the Mann-Whitney test.

Cephalometric measurements	Total N= 144	Male N= 67	Female N= 77	Mean Diff	Median	95% Confidence Interval		*p*- value	SL
						Lower	Upper		
U1-SN (º)	107.8±6.7	109±6.9	106.6±6.3	2.4	108	0.3	4.6	0.028	*
U1-NA (º)	28.7±6.3	28.9±6.3	28.5±6.3	0.4	28.8	-1.7	2.5	0.705	NS
U1-FH (º)	117.7±7	117.5±7.4	116.6±6.8	0.9	116	-1.4	3.2	0.458	NS
U1-NA (mm)	7.6±2.1	7.7±2	7.4±2.3	0.3	7	-0.4	1	0.380	NS
IMPA (L1-MP) (º)	82.9±7.4	83±7	82.8±7.8	0.2	83	-2.2	2.7	0.813	NS
L1-NB (º)	19.5±6.4	19.7±6.1	19.3±6.7	0.4	19.1	-1.6	2.6	0.659	NS
L1-APg (º)	24.1±5.2	24.3±4.5	24±5.7	0.3	23.8	-1.4	2	0.655	NS
FMIA (L1-FH) (º)	70.9±7.8	71.4±8.3	70.5±7.3	0.9	71	-1.7	3.4	0.527	NS
L1-NB mm	4.2±1.9	4.5±1.9	4±1.8	0.5	4	-0.1	1	0.113	NS
L1 Prot (L1-APg) (mm)	5.8±2.4	6.2±2.3	5.4±2.5	0.8	6	0	1.6	0.042	*
U1-L1 (º)	135.6±10	135.4±10	135.8±10.8	0.4	136.4	-3.9	3	0.788	NS
Overjet (mm)	-.1.15±2.6	-.1.7±-2.4	- 0.6±2.6	- 1.1	-1.3	-1.9	-0.3	0.005	**
Overbite (mm)	0.3±2.5	0.2±3	0.4±1.8	0.2	0	-1	0.7	0.675	NS

n: number of cases, NS: non- significant, S.D: Standard deviation, Diff: Difference, S.L**:** Significant Level. * It is significant at the ($p \leq 0.05$) level of confidence, ** It is significant at the ($p \leq 0.01$) level of confidence, *** It is significant at the ($p \leq 0.001$) level of confidence.

DISCUSSION

The present study was based on the analysis of LCR data and demonstrated the existence of sexual dimorphism in craniofacial patterns of skeletal Class III malocclusion in adult Yemenis. Significant differences were found in 24 cephalometric variables, while other variables had little sexual effect. The results of this study show that there are significant biological differences between the sexes which are important for clinical diagnosis, treatment planning, orthodontic interventions and further research. All cranial base parameters in the current study were statistically different between the genders, with adult females having shorter anterior and posterior cranial bases than males. This confirms the data obtained by Baccetti *et al.*[19], who performed a cephalometric analysis to compare the maxillofacial dimensions of Class I and Class III individuals. They found a significant difference in the cephalometric values between the genders of Class III malocclusion. However, the value of the saddle angle (S-N-Ar) was larger in female than in male subjects in this study. These results are in line with the study by Namankani *et al.*[20], who examined the sex differences in Class III malocclusion among the Saudi people.

The present studyfound that Class III female cases showed more retrusive maxillary positions than male cases, both in the SNA angle and the distance from point A to the N-vertical plane. Moreover, Class III malocclusion in Yemeni adult females showed a significant reduction in the linear values of maxillary unit length (Co-A) and midface length (Co-ANS). This finding coincides with previous studies on Iranian, Caucasian, Saudi, and Bangladeshi populations for Class III malocclusions[19-21]. Ishii *et al.*[22], observed similarities when comparing Chinese males and females utilizing LCRs.

In female patients, the mandibular sagittal position relative to the cranial base was found to be more retruded. Adult females also had significantly smaller mandibles than the males. This result agrees with the findings reported in previous studies on Iranian and Saudi populations with Class III malocclusions[20].

Females of Class III had significantly smaller vertical dimensions of the mandible than males, as evaluated by ramus height (Ar-Go) and the articular angle (S-Ar-Go). This finding indicates that female patients position the skeletal anatomical landmarks Menton and Gonion more superiorly relative to the maxilla and Sella turcica. Male subjects showed greater vertical growth, leading to lower vertical positions for these points (the menton and gonion) compared to females. This result agrees with the findings reported in previous studies of Class III malocclusion in Caucasian, Bangladeshi, and Saudi populations[20,21].

Variations in the values of the cranial base length and the saddle angle can affect the articular angle that is created by the intersections of the S, Ar, and Go points. The relatively forward position of point A can lead to

increased joint angle and an acute saddle angle. A smaller cranial base angle, a longer anterior cranial base, and greater mandibular prognathism explain why males have larger mandibles than females[22]. Based on the findings in the Caucasian Mediterranean population, male subjects had larger measurement values than female subjects, indicating a mandibular rotation in a clockwise direction[23]. In the current study, Yemeni adult females with skeletal Class III exhibited smaller measurements in TAFH, UFH, LFH, and PFH compared to their male counterparts, which aligns with findings from previous studies in Yemeni and various populations, including Caucasian, Italian, and Egyptians[20,24].

Dentoalveolar comparisonsin the present study indicated that male subjects had a more anterior position of lower incisors relative to the A-Pog line and exhibited greater upper incisor protrusion relative to the SN plane than female subjects. However, the other dentoalveolarlinear and angular measurements showed no substantial differences among genders. This aligns with findings suggested by previous investigations of Saudi people[20]. Severe prognathic mandible and hyper divergence patterns of skeletal Class III malocclusion make the treatment difficult and adversely affect prognosis, regardless of their growth potential[15]. This phenomenon is attributed to the endochondral growth of the mandible, which becomes more susceptible to genetic influences and less responsive to orthopedic treatments. In contrast, early therapy is more beneficial in Class III malocclusion with the maxillary retrusion phenotype because intramembranous ossification forms maxillary sutures that are more responsive to orthopedic forces[25].

Clinical Implication

The present study provides a more profound understanding of sexual dimorphism that is associated with craniomaxillofacial structures of skeletal Class III malocclusion. It stresses the importance of considering sexual dimorphism when planning treatment. It also enables the study of genetic factors and helps in determining suitable orthodontic and orthognathic interventions.

CONCLUSIONS AND RECOMMENDATIONS

This study reported a statistically significant sexual dimorphism in skeletal Class III malocclusion. Adult males generally have larger craniofacial vertical and sagittal dimensions than females. However, these differences may indicate real differences in craniofacial morphology between Yemeni adult males and females, or they may reflect the characteristics of the sample. Additional research is needed to address this problem. Although the current study met its objectives, it suffered from significant shortcomings. Researchers need to conduct further studies on the differences in facial and dental features related to sexual dimorphism among Yemeni Class III adults and other ethnicities using three-dimensional radiographs. Similar studies in the future could cover other types of skeletal malocclusion that influence facial aesthetics and oral health in the adult population.

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AUTHOR'S CONTRIBUTIONS

Al-Hababy MA: sample collection, conducting cephalometric tracing and measurements, interpreting the data, writing the manuscript. **Ishaq RAR:** supervision, editing. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

The related author can provide the empirical data supporting the study's conclusions upon request.

CONFLICT OF INTEREST

There are no conflicts of interest in regard to this project.

REFERENCES

1. Doraczynska-Kowalik A, Nelke KH, Pawlak W, *et al*. Genetic factors involved in mandibular prognathism. J Craniofacial Surge 2017; 28: e422-e431. *https://doi.org/10.1097/SCS.0000000000003627*
2. Dehesa SA, Iber DP, Iglesias LA. Genetic factors contributing to skeletal class III malocclusion: A systematic review and meta-analysis. Clin Oral Investig 2021; 25: 1587-1612. *https://doi.org/10.1007/s00784-020-03731-5*
3. Lew KKK, Foong WC. Horizontal skeletal typing in an ethnic Chinese population with true Class III malocclusions. Br J Orthod 1993; 20: 19-23. *https://doi.org/10.1179/bjo.20.1.19*
4. Ellis E, McNamara JA. Components of adult Class III malocclusion. J Oral Maxillofac Surg 1984; 42: 295-305. *https://doi.org/10.1016/0278-2391(84)90109-5*
5. Xue F, Wong RWK, Rabie ABM. Genes, genetics, and Class III malocclusion. Orthod Craniofac Res 2010; 13: 69-74. *https://doi.org/10.1111/j.1601-6343.2010.01485.x*
6. Awadh WMS. Gender Dimorphism of Skeletal Measurements and Dental Angle Classification in Orthodontic Patients. J Contemporary Dental Prac 2023; 24: 700-706. *https://doi.org/10.5005/jp-journals-10024-3524*
7. Ajwa N, Alkhars FA, AlMubarak FH, *et al*. Correlation between sex and facial soft tissue characteristics among young Saudi patients with various orthodontic skeletal malocclusions. Med Sci Monit 2020; 26:e919771. *https://doi.org/10.12659/MSM.919771*
8. Alzyoud JAM, Rababeh E, Rababah MK, *et al*. Gender differences in maxillary and mandibular morphology among the Jordanian population: Implications for orthodontic treatment and AI applications in dentistry. Edelweiss Applied Sci Tech 2025; 9: 1715-1724. *https://doi.org/10.55214/25768484.v9i4.6354*
9. Kavadia TS, Sidiropoulou CS, Georgia P. Cephalometric characteristics and sex dimorphism in class III malocclusion. Balkan J Stomatol 2004; 8: 149-153.
10. Ramezanzadeh B, Pousti M, Bagheri M. Cephalometric evaluation of dentofacial features of class III malocclusion in adults of Mashhad, Iran. J Dent Res Dent Clin Dent Prospects 2007; 1: 125-12530.
11. de Frutos VL, Martin C, Alarcon JA, *et al*. Subclustering in skeletal class III phenotypes of different ethnic origins: A systematic review. J Evidence Based Dental Pract 2019; 19: 34-52. *https://doi.org/10.1016/j.jebdp.2018.09.002*
12. Amini F, Mashayekhi Z, Rahimi H, *et al*. Craniofacial morphologic parameters in a Persian population: An anthropometric study. J Craniofacial Surg 2014; 25: 1874-1881. *https://doi.org/10.1097/SCS.0000000000000902*

13. Zacharopoulos GV, Manios A, Kau CH, *et al*. Anthropometric analysis of the face. J Craniofacial Surg 2016; 27: e71-e75. *https://doi.org/10.1097/SCS.0000000000002231*
14. Celebi AA, Kau CH, Femiano F, *et al*. A three-dimensional anthropometric evaluation of facial morphology. J Craniofacial Surg 2018; 29: 304-308. *https://doi.org/10.1097/SCS.0000000000004110*
15. Al Hababy M, Ishaq RAR. Phenotypic Characterization of skeletal class III malocclusion using principal component analysis and cluster analysis: Article text. Orthod J Nepal. 2024;14(1):40–56.
16. de Frutos-Valle L, Martin C, Alarcón J, Palma-Fernández J, Ortega R, Iglesias-Linares A. Sub-clustering in skeletal class III malocclusion phenotypes via principal component analysis in a southern European population. Sci Rep 2020; 10(1):17882.
17. Uribe LMM, Vela KC, Kummet C, Dawson DV, Southard TE. Phenotypic diversity in white adults with moderate to severe Class III malocclusion. Am J Orthod Dentofacial Orthop 2013; 144(1):32–42.
18. Paik FJLLB, Fleiss JL, Levin BR. Statistical methods for rates and proportions. Hoboken. NJ: J Wiley-Interscience 2003; 203: 151.
19. Baccetti T, Reyes BC, McNamara JA. Gender differences in Class III malocclusion. Angle Orthodontist 2005; 75: 510-520.
20. Mohammed B, Eman N. Gender differences in Saudi class in malocclusion.
21. Alam MK, Nowrin SA, Shahid F, *et al*. Determining cephalometric characteristics of Bangladeshi adults with class III malocclusion. Int Med J 2016; 23: 572-575.
22. Ishii N, Deguchi T, Hunt NP. Craniofacial differences between Japanese and British Caucasian females with a skeletal Class III malocclusion. The European J Orthodontics 2002; 24: 493-499. *https://doi.org/10.1093/ejo/24.5.493*
23. Larrazabal MC, Sanchis GJA. Gonial angle growth patterns according to age and gender. Annals of Anatomy-Anatomischer Anzeiger 2018; 215: 93-96. *https://doi.org/10.1016/j.aanat.2017.09.004*
24. Bukareza F, Al-Harazi G, Al-Rai S. Phenotypic characterization of Class III malocclusion using three-dimensional analysis on a sample of Yemeni population: A retrospective cross-sectional study. Dental Press J Orthod; 30. Epub ahead of print 2025. *https://doi.org/10.1590/2177-6709.30.3.e2524129.oar*
25. Hassan AG, Elshial M, Hassan B, *et al*. Bone-anchored maxillary protraction versus conventional orthopedic treatment for Class III malocclusion in children under 12 years: A systematic review. J Orthodontic Sci 2025; 14. *https://doi.org/10.4103/jos.jos_67_25*