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RESEARCH ARTICLE

DEEP BITE MALOCCLUSION: EXPLORATION OF THE SKELETAL AND DENTAL FACTORS

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Abstract

Background and objective: A deep bite malocclusion may be due to skeletal and dental factors. The analysis of the etiological factors may have an influence on the treatment plan. The aim of this study was to exploration the most common dental and skeletal factors that contribute to deep bite malocclusion in Yemeni individuals, as well as the correlations between them.

Material and methods: a cross-sectional prospective study was conducted to evaluate 136 individuals with deep bites using study casts and lateral cephalometrics (62 males and 74 females), with ages ranging from 18 to 28 years, with the Onyx program used for analysis. The recorded data was collected, tabulated, and statistically analyzed by SPSS.

Results: The Gonial angle and Jarabak index form the highest contribution to skeletal deep bite (59.3%), and the least contributing factors were the decreased saddle angle (3%), followed by decreases in the inclination angle (Pn line- PP) (11.1%). On the other hand, the most contributing dental factor to the deep bite was an exaggerated curve of spee (63.5%), followed by a decreased clinical crown length of the Lower first molar (52.6%), and the least contributing dental factor was an increased clinical crown length of the maxillary incisors. There was more correlation between skeletal factors than dental factors.

Conclusion: Deep bite malocclusion was characterized mostly by counterclockwise rotation of the mandible and increased spee curve. Understanding the most common dental and skeletal contributors will help clinicians treat patients with deep malocclusions more successfully.

Keywords: deep bite, dental factors, skeletal factors, Yemen.

INTRODUCTION

Malocclusion is a widespread problem of the oral cavity around the world, children and adults suffer from it, and it is no less important than other oral problems. Although malocclusion is not a life-threatening condition, the poor condition of the gums and masticatory impairment associated with DBM raises the need to explore the prevalence of malocclusion in different age groups[1-3]. Deep malocclusion (DBM) is understood as a type of malocclusion that can have a complex etiology, necessitating elaborate and careful differential diagnosis, and which can be exacerbated when the overbite of the upper incisors over the lower incisors exceeds one-third of the crown of the lower incisors in central occlusion and is seen regularly cases of this type of malocclusion frequently[4]. According to Proffit[5], an overbite greater than 5 mm is present in approximately 20% of children and 13% of adults" and contributes to approximately 95.2% of vertical occlusal disorders. DBM may result from either intrinsic or acquired factors such as condyle growth pattern and skeletal pattern and malocclusion. Acquired characteristics such as muscular habit, tooth position changes, loss of posterior abutment teeth, and lateral tongue thrust. DBM is multifactorial in nature and is classified depending on the causes as genetic and environmental factors[1,6]; others classified it as dental or skeletal in origin[7]. Dental deep bite (DDB) is associated with an increase in the spee curve. DBM has been associated with higher oral root torque of the upper incisors. In addition, it had favorable associations with DBM which are the anterior maxillary and maxillary basal elevations, the anterior maxillary and maxillary mandibles, and the posterior maxillary and mandibular maxillary elevations. Extraction of the lower incisors causes the arch to collapse, deepening the bite[7]. A skeletal deep bite (SDB) might be the consequence of an inconsistency in the cant, mandible, or maxilla's vertical orientation. According to a few studies, the vertical component of mandibular growth has a more significant impact than the rotational component. Mandibular skeletal changes were also twice as important as mandibular dental changes and roughly 2.5 times as important as maxillary changes in causing overbite changes[1,2].

Patients with small DBM often do not require treatment unless the patient requests it for aesthetic reasons. On the other hand, severe DBM causes problems with periodontal disease and tooth wear, as well as traumatizing the incisive papilla and interfering with mastication function. It must be treated clinically with orthodontic or surgical intervention after knowing the causes. Various procedures for DBM correction have been developed in orthodontics[8,9]. DBM is one of the occlusal defects that are difficult to treat and maintain after orthodontic treatment. However, any treatment must be carefully designed for each patient based on the aetiology of the malocclusion and investigation of the active ingredients. Treatment failure is prevalent when the etiologic variables are not accurately identified[10]. Studies on dental health problems in Yemen are still modest and limited, although there are studies that dealt with the problems of tooth decay, gum infections, the causes of permanent tooth extraction, and the prevalence and pattern of impaction of the third molar in adults and children, in oral microbiology and pathology, and drug resistance[11-31]; but no research has investigated the most common dental and skeletal factors that contribute to DBM etiology in Yemeni adults prior to this study. The goal of this study was to identify the most common dental and skeletal factors that contribute to DBM in Yemeni individuals, as well as the correlations between them using lateral cephalograms and study casts.

Table 1: Definition of skeletal measurements.

1	Mandibular plane angle (FH-MP)	Angle between the Frankfort plane and the mandibular plane.
2	Basal angle (PP-MP)	Angle between the palatal plane and the mandibular plane.
3	Angle between (Sn- MP)	Angle between the mandible plane and the sella-nasion plane.
4	Saddle angle (Sn-SAr)	Angle between the anterior cranial base and the posterior cranial base.
5	Articular angle (SAr-ArGo)	Angle between the posterior cranial base and the ramus plane.
6	Gonial angle (Ar -Go-Me)	Angle between the posterior border of the ramus and the corpus line.
7	Sum of Bjork	Sum of Gonial, articular and saddle angles.
8	Posterior facial height=PFH(S-Go)	A linear measurement from the midpoint of the sella and the most inferior posterior portion of the angle of the mandible.
9	Jarabak ratio	The ratio of the posterior facial height to the anterior facial height.
10	Total anterior facial height =TAFH (N-Me)	A linear measurement from the junction of the nasal and frontal bone to the menton.
11	Upper anterior facial height=UAFH (N-A)	A linear measurement from the junction of the nasal and frontal bone to the most concave portion of the premaxilla.
12	Lower Facial height=LAFH (A-Me)	A linear measurement from the most concave portion of the premaxilla to the menton.
13	Lower Facial height/Total Facial height×100 (LAFH/TAFH)	The ratio of the lower facial height to the total anterior facial height.
14	Lower Facial height/upper Facial height ×100 (LAFH/UAFH)	The ratio of the lower facial height to the upper facial height.
15	Ramus length (Ar-Go)	A linear measurement from the intersection of the posterior of the ramus and the outer margin of the cranial base to the most inferior posterior portion of the angle of the mandible.
16	Inclination Angle (Pn line-PP)	Angle between the perpendicular plane and the palatal plane.

MATERIALS AND METHODS

This was a cross-sectional study conducted to explain the skeletal and dental factors of DBM in a sample of Yemeni individuals using skeletal and dentoalveolar measurements (Table 1, Table 2 and Figure 1, Figure 2, and Figure 3). The sample was taken from Sana'a University students, where the study included 136 participants, 74 (54.4%) of whom were females, while 62 participants (45.6%) were males between the ages of 18 and 28 years. Selection was made according to the inclusion criteria as follows: Yemeni nationality, no previous orthodontic or prosthodontic treatment, complete permanent teeth with a vertical bite greater than 5 mm when the teeth are in central occlusion.; no systemic disease or craniofacial abnormalities, premolars were fully erupted, there were no extra teeth or missing teeth, the study cast was unaffected and of acceptable quality. The study's objective was explained to each participant, and each one signed an information and consent form.

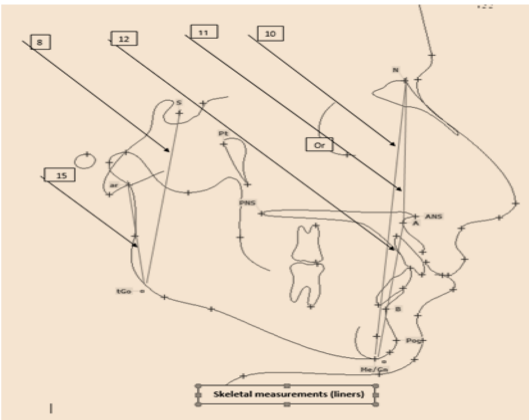

Figure 1: Skeletal measurements (angles).

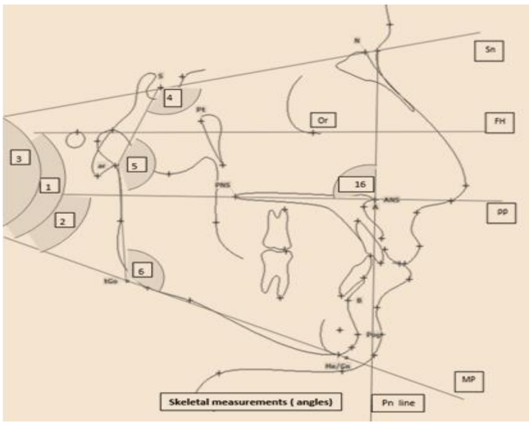

Figure 2: Skeletal measurements (liners) cv.

Lateral cephalogram: Alginate and impression material was used to create diagnostic casts of the maxillary and mandibular arches. The dentist stone poured the alginate impression, and a model was made. Linear parameters were measured using digital Vernier calipers (0-150 mm) with a manufacturer-specified reliability of 0.01 mm and accuracy of 0.02 mm to reduce the probability of error**.** 11 radiographs and 11 casts of all individuals was analysis twice at a two-week interval and an error analysis was performed.

Data analysis: For data analysis, SPSS version 19.00 was utilized, the frequencies, averages, and standard deviations of numerous skeletal and dental deep bite etiological components were calculated using descriptive statistics. Using the Pearson correlation coefficient, all of these values were associated. Statistical significance was defined as a *p*-value of 0.05 or lower.

RESULTS

Frequency of the Skeletal factors in a deep bite: Among the skeletal factors in Table 3, the Gonial angle (Ar-GO-Me) and Jarabak index (ratio of PFH to AFH) form the highest contribution to skeletal deep bite malocclusion was 59.3%, followed by decreases in lower anterior facial height in relation to upper anterior facial height (LAFH/UAFH) in 53.3%, decreased posterior facial height was 52.6%, and decreased lower anterior facial height in relation to total anterior facial height was 50.4%), increases upper anterior facial height was in 44.4%, decreases the basal angle, which is between maxilla and mandible occurred in 40.7%, decreases the Sum of Bjork, increases the Ramus length (Ar-Go) occurred in 31.9%, and decreases angle between FH-MP was 28.1%. On the other hand, the least contributing factor to skeletal deep bite malocclusion was the decreased saddle angle (3 %) followed by clockwise rotation of the maxilla (decreases inclination angle) (11.1%), increases total anterior facial height (15.6%), decreases articular angle (17.5%), decreases lower anterior facial height (ANS-Me) (18.5%), and decreases angle between anterior cranial base and mandible (20.7%).

Frequency of the dental factors in a deep bite: Among the dental factors (Table 4), an exaggerated curve of Spee showed the highest contribution to dental deep bite malocclusion was 63.5%, followed by decreased clinical crown length of the mandibular buccal segment with 52.6%, and then by decreased distance from the mesial cusp tip of the lower first molar to the mandibular plane (under eruption of the mandibular buccal segment), which formed 48.9%. Then there was over eruption of the upper incisors in 40%, retroclination of the maxillary incisors and a decrease in length of the maxillary posterior segment in 31.1%, under eruption of the maxillary posterior segment was 30.4%, over eruption of the mandibular incisors was 28.9%, increased clinical crown length of the mandibular incisors was in 25.2%, retroclination of the mandibular incisors (17%), and the least contributing factor was the increased clinical crown length of the maxillary incisors with 8.1%.

Correlations between skeletal factors: Several skeletal deep bite factors were correlated by using Pearson correlation coefficient as show in Table (5), this correlation divided into:

1. Perfect positive correlation: Correlations between FH-MP and PP-MP (r=0.809 p=0.01), Sn-MP (r=0.864 p=0.01), and Sum of Bjork (r=0.801 p=0.01), as well as PP-MP and Sn-MP (r=0.807 p=0.01) and Sn-MP and Sum of Bjork (r=0.943 p=0.01).

2. Strong positive correlation: Correlation between Ar-GO-Me and FH-MP (r=0.666, p=0.01), PP-MP (r=0.648, p=0.01), Sn-MP (r=0.647, p=0.01), sum of Bjork (r=0.689, p=0.01), between PP-MP and sum of Bjork (r=749, p=0.01), between Jarabak index and PFH (r=0.715, p=0.01), Ar-Go (r=0.703, p=0.01), between TAFH and UAFH (r=0.649, p=0.01), LAFH (r=0.798, p=0.01), PFH (r=0.501, p=0.01), between LAFH and LAFH/TAFH (r=0.551, p=0.01), LAFH/UAFH (r=0.705, p=0.01), between

LAFH/TAFH and LAFH/UAFH (*r*=0.760, *p*=0.01). **3. Moderate positive correlation:** Correlation between FH-MP and TAFH (*r*=0.317, *p*=0.01), LAFH (*r*=0.320, *p*=0.01), between PP- MP and LAFH/UAFH (*r*=0.433, *p*=0.01), Inclination angle (*r*=0.328 *p*=0.01), ANS-Me (*r*=0.359, *p*=0.01), between Sn-MP and TAFH (*r*=0.303, *p*=0.01), between TAFH and Ar-Go (*r*=0.345, *p*=0.01), between LAFH and PFH (*r*=0.461, *p*=0.01), Ar-Go (*r*=0.348, *p*=0.01), between LAFH/TAFH and Inclination angle (r=0.420, *p*=0.01), between UAFH and PFH (r=0.429, *p*=0.01).

Table 2: Definition of dentoalveolar measurements.

1	UI - PP	Distance from incisal edge of the upper central incisors to palatal plane
2	L1- MP	Distance from incisal edge of the lower central incisors to mandible plane
3	U6 – PP	Distance from mesial cusp of the upper first molar to palatal plane
4	L1- MP	Distance from mesial cusp of the upper first molar to mandible plane
5	Inclination of Lower incisors (L1-MP)	Measured at the intersection of the long axis of the lower central incisor with the mandibular plane.
6	Inclination of upper incisors (U1-PP)	Measured at the intersection of the long axis of the upper central incisor with the palatal plane.
7	U1 Clinical Crown Length (U.1.L)	Distance between the midpoint of the cervical margin of the tooth and the midpoint of the incisal edge.
8	L1 Clinical Crown Length (L.1.L)	Distance between the midpoint of the cervical margin of the tooth and the midpoint of the incisal edge.
9	U6 Clinical Crown Length (U.6.L)	Distance between the cervical margin of the tooth and the tip of the buccal cusp.
10	L6 Clinical Crown Length (L.6. L)	Distance between the cervical margin of the tooth and the tip of the buccal cusp.
11	Curve of Spee	Perpendicular distance between the deepest cusp tip and a flat plane that was laid on top of the mandibular dental cast, touching the incisal edges of the central incisors and most distal cusp in the arch.

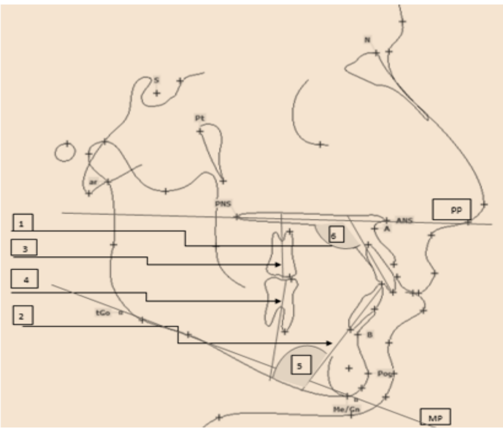

Figure 3: Dentoalveolar measurements.

4. Weak positive correlation: Correlation between FH-MP and Sar- Ar GO (r=0.187 p=0.05), LAFH/UAFH (r=0.228, *p*=0.01), between PP- MP and TAFH (r=0.196, *p*=0.05), LAFH/TAFH (r=0.278, *p*=0.01), between Sn-MP and ANS-Me (r=0.202, *p*=0.05), between Sn-Sar with N-ANS (r=0.228, *p*=0.01), Ar-Go (r=0.173, *p*=0.01), between the Ar-GO-Me and LAFH/UAFH (r=0.216, *p*=0,05),and between TAFH and LAFH/UAFH (r=0.201, *p*=0.05), between UAFH and Ar-Go (r=0.295, *p*=0.01), between LAFH and Inclination angle (r=0.224, *p*=0.01), between Sum of Bjork and TAFH (r=0.225, *p*=0.01), ANS-Me (r=0.195, *p*=0.05).

5. Perfect negative correlation: Correlation between Jarabak index and FH-MP (r=-0.8, *p*=0.01), Sn-MP (r=-0.910, *p*=0.01), Sum of Bjork (r=-0.913, *p*=0.01), TAFH (r=-0.195, *p*=0.05), between Sn-MP and PFH (r=-0.551, *p*=0.01).

Table 3: The frequency of the skeletal factors in a deep bite.

Skeletal measurements	%
Gonial angle (Ar-GO-Me)	59.3
Jarabak index (ratio of PFH to AFH)	59.3
LAFH/UAFH*100	53.3
Posterior facial height PFH= S-GO	52.6
LAFH/TAFH*100	50.4
Upper anterior facial height =N-ANS	44.4
Basal angle (PP- MP)	40.7
Sum of Bjork	40.0
Ramus length (Ar-Go)	31.9
Mandibular plane angle (FH-MP)	28.1
angle between (Sn-MP)	20.7
Lower anterior facial height=ANS-Me	18.5
Articular angle (Sar-ArGO)	17.0
Total anterior facial height TAFH =N-Me	15.6
Inclination angle	11.1
Saddle angle (Sn-Sar)	3.0

6. Strong negative correlation: Correlation between FH-MP and Ar-Go (r=-0.524 p=0.01), between the with Jarabak index (r=-0.777, *p*=0.01), Sar-ArGO (r=-0.542, *p*=0.01), between Ar-GO-Me and Jarabak index (r=-0.620, *p*=0.01), PFH (r=-0.536, *p*=0.01), between Sum of Bjork and PFH (r=-0.610, *p*=0.01), Ar-Go (r=-0.562, *p*=0.01), between UNFH with LAFH/UAFH (r=-0.554, *p*=0.01), between Sn-MP and PFH (r=-0.589, *p*=0.01), Ar-Go (r=-0.562, *p*=0.01).

7. Moderate negative correlation: Correlation between FH-MP and PFH (r=-0.481 p=0.01), between Sar-ArGO and Ar-GO-Me (r=-0.356, *p*=0.01), between Ar-GO-Me and Ar-Go (r=-0.433, *p*=0.01), between UAFH and LAFH/TAFH (r=-0.436, *p*=0.01).

8. Weak negative correlation: Correlation between FH-MP and Sn-Sar (r=-0.248, *p*=0.01), between PP-MP and Sn-Sar (r=- 0.209, *p*=0.05), N-ANS (r=-0.217, *p*=0.05), between Sn-MP and Inclination angle (r=-0.175, *p*=0.05), between Sn-Sar and Ar-GO-Me (r=-0.171, *p*=0.05), LAFH/TAFH (r=-0.204, *p*=0.05), LAFH/UAFH (r=-0.270, *p*=0.01), Ar-Go (r=-0.173, *p*=0.05), between Ar-GO-Me and LAFH/UAFH (r=-0.216, *p*=0.05), between Sum of Bjork with Inclination angle (r=-0.181, *p*=0.05).

Table 4: The Frequency of the dental factors in a deep bite.

Dental measurements	%
Curve of spee	63.5
L6 clinical crown length	52.6
Distance of mesial cusp of L6 to MP	48.9
Distance of incisal edge of U1 to PP	40
Inclination of upper incisor(U1-PP)	31.1
U6 clinical crown length	31.1
Distance of mesial cusp of U6 to PP	30.4
Distance of incisal edge of L1 to MP	28.9
L1 clinical crown length	25.2
Inclination of lower incisor (L1-MP)	17
U1 clinical crown length	8.1

Correlations between dental factors:

From Table 6, it was noticed that there were few correlations between the dental factors, this correlation divided in to:

1. Strong positive correlation: Correlations between the distance of L1 to MP and U6 to PP (r=0.589, *p*=0.01), between U1 clinical crown length and L1 clinical crown length (r=0.538, *p*=0.01).

2. Moderate positive correlation: Correlations between the distance of L1 to MP and L6 to MP (r=0.419, *p*=0.01), between U6 clinical crown length and L6 clinical crown length (r=0.403, *p*=0.01).

3. Weak positive correlation: Correlations between Distance U6 to PP and distance L6 to PP (r=0.193, *p*=0.05), between The angle of U1-PP and the angle of L1-MP (r=0.299, *p*=0.05), between U1 clinical crown length and L6 clinical crown length (r=0.260, *p*=0.01), curve 0f spee (r=0.263, *p*=0.01), between L1 clinical crown length and U6 clinical crown length (r=0.226, *p*=0.01), L6 clinical crown length (r=0.268, *p*=0.01), curve of spee (r=0.212 *p*=0.05).

4. Weak negative correlation: Correlation between the distance of L1 to MP and U1-PP (r=-296, *p*=0.01).

DISCUSSION

This study defining the relationship between dental, skeletal and recurring factors causing DBM. While other studies by Fatahi *et al*.[32], Azeem,[10], and Joshi *et al*.,[33], only investigated the frequency of the causative factors of DBM. However, it was found that the retrospective studies conducted by El-Dawlatly *et al*.[8], Bhateja[34], and Barman[35], agree with the current study on investigation the frequency of factors causing DBM and determine the correlation between dental and skeletal factors. The present study include N=136 participants (male=62; female=74); based on a sample size formula. Their ages range from 18 to 28 years. Fattahi *et al*.,[32] studied 170 patients divided into normal and DBM groups, with mean age for cases equal to 19.6 ±5.9 years and for control was 20.6 ±5.7 years. Bhateja[34] examined the skeletal and dental aspects of DBM in 113 participants (35 men and 78 women). Azeem[10] include 100 DBM subjects (female=60, male=40) in order to assess the frequency of dental and skeletal factors. Joshi *et al*.,[33] evaluated and compared the skeletal and dental factors of DBM with a normal occlusion. Joshi *et al*.,[33] examined samples from the first and second groups, each with 50 participants. The study by Barman[35] include113 participants (35 men and 78 women) for the examination and evaluation of dental and skeletal factors in DBM. The present study, like earlier ones, used software programs for analysis. However, in their work, Fatahi *et al*.,[32] used manual cephalometric analysis. Software programs are considered to be more precise during analysis and to produce more reliable results than manual tracing.

Despite the fact that some studies El-Dawlatly *et al*.,[8], Bhateja[34], Azeem[10], Joshi *et al*.,[33], and Barman[35] included the curve of spee in addition to the clinical crown length of the upper and lower central incisors on the dental casts and ten variables on the cephalometric, with the exception of Azeem[10], which only included five variables on the cephalometric, and As a result, the present study has advantages over these studies because it included five measurements on the dental cast and twenty-two on the cephalometric, which was similar to a study by Fatahi *et al*.,[32] that included five measurements on the dental cast and twenty-three on the cephalometric. However, one measurement from that study—the Ramus/FH angle—was excluded from the present study because it could not be found in the Onyx program that was used to analyze the sample.

Correlation between different factors in a deep bite:

Pearson correlation coefficients determine the strength of the relationship between two factors.

Correlation between factors reveals that as one factor changes in value, the other tends to change in a particular direction. Understanding this relationship is useful because we can use the value of one factor to predict the value of the other. Use El-Dawlatly *et al*.[8], Bhateja[34], and Barman[35] correlates between different DBM components and showed that U1 clinical crown length has a statistically significant positive relationship with L1 clinical crown length, which is consistent with the results of the current study, which mentioned that there is a positive correlation between the overeruption of the maxillary and mandibular incisors highlights the necessity for careful consideration of mandibular incisor intrusion in the majority of individuals before maxillary incisor intrusion, and vice versa. The physician would benefit from the ability to equally divide the necessary intrusion between the maxillary and mandibular incisors, avoiding higher ranges of intrusive mechanics that could increase the risk of root resorption and compromise stability.

This correlation provides the orthodontist with some recommendations that could aid in the more effective treatment of certain malocclusions.

In addition, the findings of present study agree with those of Bhateja[34,] and Barman[35], who found that there is a statistically significant positive connection between the mandibular plane angle and the gonial angle.

Frequency of skeletal factors in a deep bite: According to the findings of present study, decreases in gonial angle were the most common skeletal factors contributing to DBM, while decreases in saddle angle (Sn-Sar) were the least common skeletal factor of DBM. This was in agreement with the findings of El-Dawlatly *et al.*,[8], Bhateja[34], Azeem[10], and Barman[35] regarding the most common skeletal factors and not in agreement regarding the least common skeletal factors contributing to DBM. These studies found an increase in the SN-MP. This discrepancy can be explored by the fact that these previous studies did not include saddle angle (Sn-Sar) in their variables. In addition, the current study did not include SN-MP, the reason being that this angle was not found in the Onyx software that was used for the analysis. This is one of the shortcomings of the current study, as well as some other studies in this field did not include this angle, such as Fatahi *et al.*,[32] and Joshi *et al.*,[33].

Table 5: Correlations between skeletal factors in deep bite group.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A	1															
B	.809**	1														
C	.864**	.807**	1													
D	-.248-**	-.209-*	-.006-	1												
E	.178*	.138	.114	-.542-**	1											
F	.666**	.648**	.647**	-.171-*	-.356-**	1										
G	.801**	.749**	.943**	.001	-.019-	.689**	1									
H	-.800-**	-.777-**	-.910-**	.037	-.075-	-.620-**	-.913-**	1								
I	.317**	.197*	.303**	.067	.086	.032	.285**	-.195-*	1							
J	.051	-.217-*	.116	.228**	.022	-.142-	.124	-.063-	.649**	1						
K	.320**	.359**	.220*	-.155-	.101	.131	.195*	-.115-	.798**	.161	1					
L	.085	.278**	-.005-	-.204-*	.008	.137	-.027-	.071	.081	-.436-**	.551**	1				
M	.228**	.433**	.107	-.270-**	.054	.216*	.081	-.049-	.201*	-.554-**	.705**	.760**	1			
N	-.481-**	-.551-**	-.589-**	.077	.013	-.536-**	-.610-**	.715**	.501**	.429**	.461**	.142	.080	1		
O	-.524-**	-.557-**	-.562-**	.173*	-.103-	-.433-**	-.562-**	.703**	.345**	.295**	.348**	.153	.095	.875**	1	
P	.047	.328**	-.175-*	-.332-	.010	.074	-.181-*	.074	-.134-	-.487-**	.224**	.420**	.489**	-.026-	-.119-	1

A	Mandibular plane angle(FH-MP)	G	Sum of Bjork	M	LAFH/UAFH*100
B	Basal angle (PP- MP)	H	Jarabak index (ratio of PFH to AFH)	N	Posterior facial height PFH= S-GO
C	Angle between (Sn-MP)	I	Total anterior facial height TAFH =N-Me	O	Ramus length (Ar-Go)
D	Saddle angle (Sn-Sar)	J	Upper anterior facial height =N-ANS	P	Inclination angle
E	Articular angle (Sar-ArGO)	K	Lower anterior facial height=ANS-Me		
F	Gonial angle (Ar-GO-Me)	L	LAFH/TAFH*100		

Pearson's correlation coefficient ranges between -1.0 and 1.0. Here -1.0 represents perfect negative correlation, less than -0.8 represents strong negative correlation, less than -0.5 represent moderate negative correlation, 0 represent zero or no correlation and 1.0 represents perfect positive correlation, less than 0.8 represents strong positive correlation, less than 0.5 represent moderate positive correlation. A positive correlation coefficient means that an increases in one variable causes an increases in the other. While A negative correlation coefficient means that an increases in one variable causes an decreases in the other.

N=**136** , Pearson Correlation,**Correlation is significant at the 0.01 level (2-tailed),* correlation is significant at the 0.05 level (2-taile)

Table 6: Correlations between dental factors in the deep bite group.

	Q	R	S	T	U	V	W	X	Y	Z	AA
Q	1										
R	.501**	1									
S	.589**	.532**	1								
T	.419**	.696**	.193*	1							
U	-.296**	.125	.045	-.111-	1						
V	-.044	-.027-	-.012-	.089	.299*	1					
W	-.009-	.051	-.054-	-.025-	-.044-	-.030-	1				
X	.155	.128	.123	-.003-	-.002-	.013	.538**	1			
Y	.092	-.126-	.071	-.021-	-.122-	-.025-	.136	.226**	1		
Z	.032	-.049-	.103	-.037-	.016	.216	.260**	.268**	.403**	1	
AA	-.048-	-.068-	.083	-.120-	.052	-.108-	.263**	.212*	-.042-	.058	1

Q	Distance U1 to PP	W	U1 clinical crown length
R	Distance L1 to MP	X	L1 clinical crown length
S	Distance U6 to PP	Y	U6 clinical crown length
T	Distance L6 to MP	Z	L6 clinical crown length
U	Angle of (U1-PP)	AA	Curve of spee
V	Angle of(L1-MP)		

N=136, Pearson Correlation,**Correlation is significant at the 0.01 level (2-tailed),* correlation is significant at the 0.05 level (2-tailed)

There are other differences with the present study, such as decreases in mandible plane angle (FH-MP) were considered common skeletal factors of DBM after gonial angle[8,10,34,35], but this is not in agreement with the findings of present study, which regarded basal angle (PP-MP), sum of Bjork, and Ramus length (Ar-Go) as common skeletal factors of DBM after gonial angle, respectively. This difference is significant because the present investigation is more thorough than these early studies, which left out certain important variables. It should be noted that growth modification is the preferred treatment for growing patients who have SDB. The cervical vertebral maturation index (CVM) can be used to gauge a child's growth stage[36]. It has been demonstrated that deep-bite growing subjects reach their maximal pubertal growth alterations two years after open-bite subjects[37]. As a result, growth manipulation should be tried in the latter stages of the pubertal growth spurt.

Frequency of dental factors in a deep bite : This study demonstrated that the exaggerated curve of Spee had the highest contributing factor among all dental factors of DBM, which agrees with the investigation of studies by El-Dawlatly *et al.*,[8] Fatahi *et al.*,[32], Bhateja[34], Azeem[10], Joshi *et al*.,[33], Barman,[35], and Jhalani *et al.*,[38]. The present study emphasizes how important the mandibular dentoalveolar factors in DBM. It has been established that every 1mm of posterior extrusion increases the bite anteriorly by 1.5 mm, this discovery demonstrates that a small amount of molar extrusion can result in a considerable anterior bite opening[39]. The second-highest contributing dental factor to DBM in the present study was a decrease in the clinical crown length of the lower posterior teeth. This does not agree with studies by Fattahi *et al.*,[32] Bhateja[34], Azeem[10], and Barman[35], that preferred to increase the clinical crown length of the upper incisors. Also, it does not agree with studies by El-Dawlatly *et al*.,[8] and Joshi *et al*.,[33] in which the upper incisor over-eruption is the second-highest contributing dental factor to DBM. Increases in the clinical crown length of the upper incisors are the least common dental causes of DBM in the current study, followed by a decrease in the inclination of the lower incisors and an increase in the clinical crown length of the lower incisors. This did not agree with the studies by El-Dawlatly *et al.*,[8] Bhateja[34], Azeem[10], and Barman[35], who found the increase in the clinical crown length of the lower incisors as the least contributing dental factors in the DBM, but agreed with a decrease in the lower incisor tilt (L1/MP) as the second lowest contributing dental factor to DBM. Although the degree of parasitism depends on a number of factors to minimize complications on facial appearance. Upper incisor intervention was recommended by Burston as the best treatment option for DBM in his study[40]. Zacharisson[41] said that the amount of upper incisors that appear when smiling and when at rest determines the appropriate treatment; the maxillary incisor width is best treated by intrusion the upper anterior teeth. Intrusions of the lower anterior teeth or posterior teeth are better treatment options for patients with moderate or low maxillary incisor width. For patients with DBM, the smile arch is used as a design guide for developing customized treatment programmes. Intrusion of the upper front teeth is not recommended for those with a flat smile arch.

Limitation of the study

It is clear that the current study has limitations as this study is not representative of the entire Yemeni population. Hence, further research is required to measure the causative factors of deep bite on a larger sample on a community basis, reliability in all measurements with the exception of the articular angle (Sar-ArGO), where the *p*-value was 0.025. The cause may have been due to superimposition in the condylar area with poor sharpness in lateral cephalometric. The Ramus/FH angle—was excluded from the recent study because it could not be found in the onyx program that was used to analyze the sample.

CONCLUSIONS

The gonial angle and jaraback ratio were the two skeletal characteristics that contributed the most to a deep bite, showing the significance of ramus growth and angulation in a growing deep bite. The skeletal elements that were least frequently shared in deep bite malocclusions included decreases in saddle and inclination angles. The most important dental component was a deep Spee curve, supporting the significance of mandibular incisor intrusion in deep bite mechanotherapy. A decreased clinical crown length of the lower first molars was the second highly contributing dental component in DBM. Among the least shared dental elements in deep bite malocclusions were lengthening of the upper and lower incisors' clinical crowns and lingual inclinations of the mandibular incisors. There were many correlations between the skeletal components, more than those in the dental ones.

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AUTHOR’S CONTRIBUTIONS

This research is part of a master's degree in the Orthodontics, Pedodontics and Prevention Department, Faculty of Dentistry, Sana’a University, Yemen. **Alaklany BAGA**: field work, and who did clinical work. **Almotareb FL:** methodology, investigation. **Albaham SHA:** data analysis and interpretations. **Al-Shamahy HA:** formal analysis, supervision. **Al-hamzi AHY:** methodology, data curation. All the authors approved the finished version of the manuscript.

DATA AVAILABILITY

The data supporting the findings of this study are not currently available in a public repository but can be made available upon request to the corresponding author.

CONFLICT OF INTEREST

None to declare.

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