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Research Article

Open Bite and Deep Bite Malocclusions: A Comparative Analysis of the Vertical Problems

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Abstract

Introduction: Open and Deep bite malocclusions should not be approached as disease entities; instead, they should be viewed as a clinical manifestation of underlying discrepancies. The aim of this study was to investigate the various skeletal and dental components contributing to vertical malocclusion, the significance of contribution of each, and if there are significant differences between their contributions in deep and open bite malocclusions.

Methods: Dental and skeletal measurements were made on lateral cephalometric radiographs and study models of 203 patients with deep or open bite. These measurements were statistically analysed.

Results: The discrepancy in the curve of Spee was the greatest shared dental component (76.4%), significantly higher than any other component (P = 0.00000). The gonial angle angle was the greatest shared skeletal component (45.8%), highly significant compared with the maxillary base angulation (P = 0.01988). When open and deep bite malocclusions were compared, the mandibular plane angle and the angulation of upper incisors (P = 0.00000) were highly sharing in open bite, while the eruption of the upper incisors and posterior teeth (P = 0.00000) were highly sharing in deep bite.

Conclusions: The discrepancy in the curve of Spee and the gonial angle were the greatest contributing components. This analysis of deep and open bite components could help clinicians design individualized mechanotherapy's based on offending cause, rather than being biased toward predetermined mechanics.

Keywords: Deep Bite Malocclusions; Orthodontic Treatment; Cephalometric.

Introduction

Vertical malocclusion problems comprise discrepancies in the development of overbite whether an increase or a reduction. An excessive overbite is referred to as deep overbite that is considered among the most common malocclusions in orthodontic practice. Severe deep bites (overbite ≥ 5 mm)are found in nearly 20% of children and 13% of adults [1] representing about 95.2% of vertical occlusal problems. Several dental and skeletal components were deemed to share in a developing deep bite, the most contributing components were proven to be the deep curve of spee and the decreased gonial angle [2].

On the other hand, open bite malocclusion is one of the highly challenging orthodontic problems. The prevalence of anterior open bite ranges from 1.5% to 11% and varies between ethnic groups and according to age and dentition [3]. Profit., *et al.* recorded a prevalence of approximately 3.5% in patients from 8 to 17 years of age [4]. An investigation on the components of open bite malocclusion had shown that the flattened curve of Spee, mandibular plane angle, and the proclination of upper incisors were the highest contributing components in its development [5].

From an expert orthodontist's point of view the challenging nature of any vertical discrepancy should not be restricted to the treatment mechanics. Instead, the clinician should be aware of the multifactorial nature of this type of malocclusion, including the components and factors that contribute to the decision-making process.

A limited number of studies had addressed indirectly the comparison between the components of open bite and deep bite malocclusions. Ceylan and Eroz [6] conducted their study on 4 groups of patients (20 patients in each group) with variable bite depths. They found that the gonial angle was the largest in the open- bite group and smallest in the deep bite group. Beane., *et al.* [7] compared, using cephalometric analysis, black subjects; 51 with open bite and 52 without open bite, to identify skeletal and dental differences between the two groups. They found that, the vertical skeletal growth pattern and the greater degree of dental proclination differentiated black patients with an anterior open bite from those without open bite.

The above-mentioned studies had either a small sample size or undefined inclusion criteria of the selected subjects and no study had undergone a direct comparison between open bite and deep bite malocclusions regarding the underlying components. Hence there is an actual void in orthodontic literature concerning this topic.

Accordingly, the current study aimed at elucidating the various skeletal and dental components responsible for the development of the vertical problems, either open or deep bite, and the significance of the contribution of each component to the malocclusion. Moreover, we aimed to draw certain measuring guidelines that could differentiate between the two malocclusions.

Materials and Methods

The sample comprised pre-treatment lateral cephalograms and study models of 203 patients (124 with deep bite and 79 with open bite malocclusions), selected from approximately 5500 patient re-

cords from the database of our department. The subjects were aged from 16 to 22 years, and their selection was based on the following:

Inclusion criteria for deep bite cases:

- Deep overbite of more than 5 mm.
- Complete eruption of the premolars.
- No history of previous orthodontic treatment.
- No severe craniofacial disorders.
- No missing teeth.

Inclusion criteria for open bite cases:

- Negative overbite
- Complete eruption of the premolars.
- No history of orthodontic treatment.
- No severe craniofacial disorders.
- No missing teeth.

The following measurements were utilized in the study:

a. Cephalometric dental measurements

Figure 1 and 2: Dental Cephalometric Measurements (1-Mx-AABH, 2-Md-AABH, 3-Mx-PABH 4-Md-PABH).

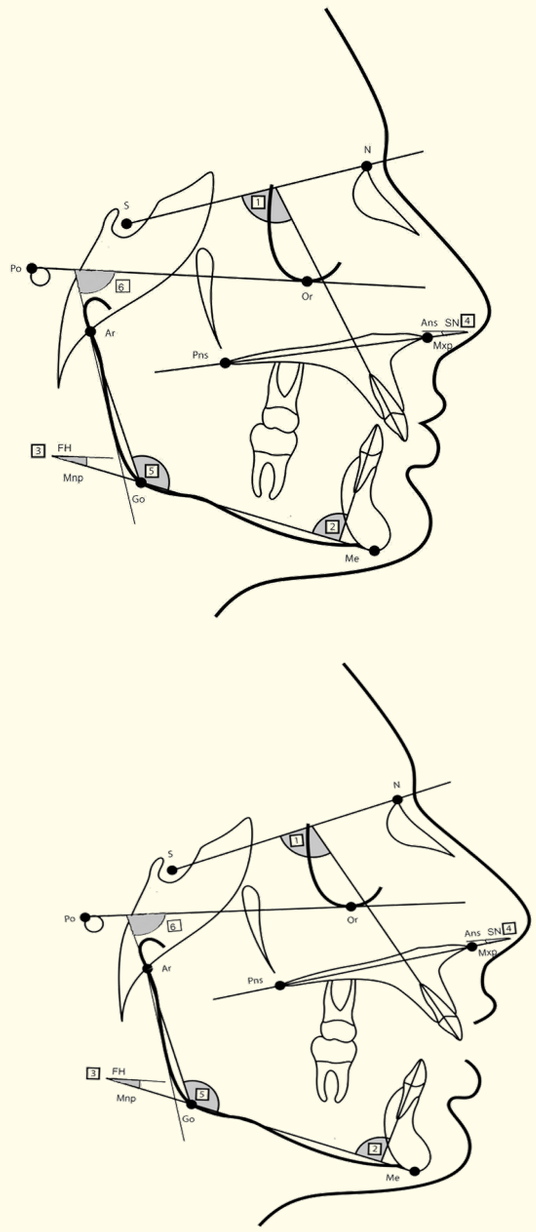

Figure 3 and 4: Dental Cephalometric Measurements (1- U1/SN, 2- L1/MP), and Skeletal Cephalometric Measurements (3-FH/Mnp, 4-Mxp-SN, 5-Gonial Angle (Ar-Go-Me), 6-Ramus/FH).

1.	Maxillary anterior alveolar and basal height (Mx-AABH,mm)(21 ± 3 mm).	The distance between the mid-point of the alveolar meatus of the maxillary central incisor and the intersection point between the palatal plane and the long axis of the maxillary central incisor.
2.	Maxillary posterior alveolar and basal height (Mx-PABH,mm) (26 ± 3 mm).	The perpendicular distance between the mid-pointof the alveolar meatus of themaxillary first molar and the palatal plane.
3.	The inclination of the upper incisors (U1/SN)(104 ± 6º).	The angle formed between the extension of the long axis of the upper incisor and theSN plane.
4.	Mandibular anterior alveolar and basal height (Md-AABH, mm) (35 ± 3 mm).	The distance between the mid-point of the alveolar meatus of the mandibular centralincisor and the intersection point between the mandibular plane and thelong axis ofthe mandibular central incisor.
5.	Mandibular posterior alveolar and basal height (Md-PABH, mm.) (35±3 mm).	The perpendicular distance between the mid-point of the alveolar meatus of the mandibular first molar and the mandibular plane
6.	The inclination of the lower incisors (L1/MP) (95 ± 5º)	The angle formed between the extension of the long axis of the lower incisor and the mandibular plane.

Table 1: Dental Cephalometric Measurements.

b. Cephalometric dental measurements

1.	Mandibular plane angle (MndP-FH) (27±5º)	The angle formed between the mandibular plane and the Frankfort horizontal plane.
2.	Gonial angle (A r-Go-Me) (123±7º)	The angle formed at the gonial area between the posterior border of the ramus and a corpus line
3.	Maxillary plane angle (SN-MaxP) (10±3º)	The angle formed between the maxillary plane and the SN plane.

Table 2: Skeletal Cephalometric Measurements.

c. Measurements on the dental cast

1.	The length of the clinical crown of the upper central incisors (U1 clinical crown length)	The line formed between the midpoint of the cervical margin of the tooth and the midpoint of the incisal edge.
2.	The length of the clinical crown of the lower central incisors (L1 clinical crown length)	The line formed between the midpoint of the cervical margin of the tooth and the midpoint of the incisal edge.
3.	The curve of Spee.	The line formed between the deepest point on the lower buccal segment and a horizontal line formed between the most over-erupted lower incisor and the most over-erupted molar tooth.

Table 3: Dental Cast Measurements.

Cephalometric and cast measurements of 20 cases were repeated by both the same observer and by a second observer to measure the intra- and inter- observer reliability.

Statistical Analysis

Descriptive Statistics: The mean and standard deviation of each of the dental and skeletal components of the vertical malocclusions, together with the percentage of contribution of each of the dental and skeletal components in the vertical malocclusions was calculated.

Inferential Statistics:

1) Hypothesis test (paired t-test) was used to compare the significance of the contribution of each component to the vertical malocclusions.

2) Hypothesis test (paired t-test) was used to compare the occurrence of the dental and skeletal components in open and deep bite malocclusions

The concordance correlation coefficient was used to calculate the intra-observer and inter-observer reliabilities.

Results

Statistical analysis of the measurements taken showed the following results:

i. The frequency and the percentage of contribution of the different dental and skeletal components in vertical malocclusions:

	Number of subjects	Frequecy of Occurance	Percent
Curve of spee (d1)	203	155	76.4%
Gonial angle (s1)	203	93	45.8%
U1 eruption (d2)	203	87	42.9%
U1 inclination (d3)	203	83	40.9%
Mandibular plane angle (s2)	203	81	39.9%
L1 eruption (d4)	203	71	35.0%
Maxillary plane (s3)	203	70	34.5%
L6 eruption (d5)	203	63	31.0%
U1 length (d6)	203	56	27.6%
U6 eruption (d7)	203	52	25.6%
L1 inclination (d8)	203	48	23.6%
L1 length (d9)	203	34	16.7%

Table 4: The Frequency and Percentage of Occurance of the Different Dental and Skeletal Components in Vertical Malocclusion.

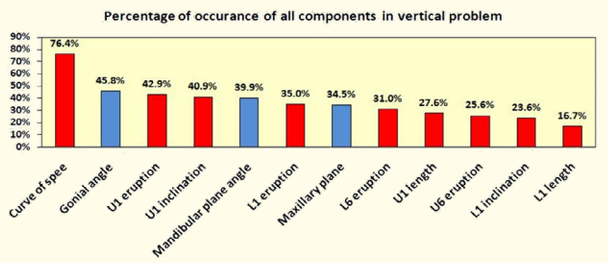

Figure 5: The Percentages of Occurrence of All Components in Vertical Malocclusion.

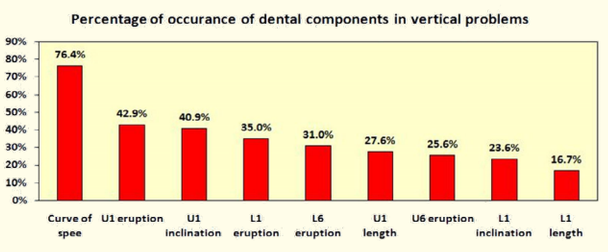

Figure 6: The Percentages of Occurrence of Dental Components in Vertical Malocclusion.

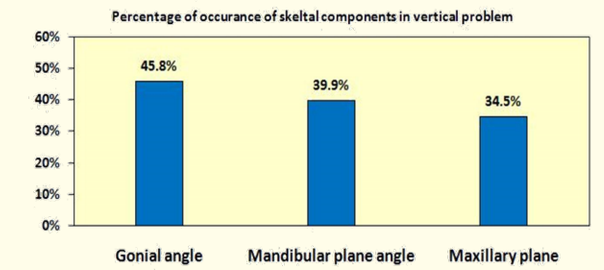

Figure 7: The Percentages of Occurrence of Skeletal Components in Vertical Malocclusion.

a- Dental Components (Figure 6): The discrepancy in the curve of Spee showed the highest contribution in the vertical malocclusions (76.4%) followed by the eruption of the upper incisors (42.9%), inclination of the upper incisors (40.9%), the eruption of the lower incisors (35%), and the eruption of the lower posterior segment (31%). This was followed by the upper incisors clinical crown length discrepancy (27.6%), the eruption of the upper posterior segment (25.6%). The least contributing factors in the vertical malocclusions were the inclination of the lower incisors (23.6%) and the discrepancy in the length of the lower incisors (16.7%).

b- Skeletal Components (Figure 7): The discrepancy in the gonial angle was found to be the most skeletal component contributing to the vertical malocclusions (45.8%) followed by the mandibular plane angle changes (39.9 %), and the least sharing skeletal component was the maxillary plane rotation (34.5%).

ii. The significance of the contribution of each of the measured components to vertical malocclusion:

Regarding the contribution of the dental components (Table 5) to the vertical problems; the discrepancy in the depth of the curve of Spee (P = 0.00000) was significantly the highest of all the other components. This was followed by the eruption (P = 0.01359) and the inclination (P = 0.03860) of the upper incisors which were significantly contributing to the malocclusion than the lower sharing components. The contributions of the eruption discrepancies of the lower incisors, the eruptive problems of the lower posterior segment and the discrepancies in the length of the upper incisors to vertical malocclusions were not significant from each other. While the contributions of the previous 3 components were significantly higher from the least sharing components which were the eruption of the upper posterior segment, the length and inclination of the lower incisors.

Considering the skeletal components (Table 6), the contribution of the gonial angle was significantly higher (P = 0.01988) than the sharing of the angulation of the maxillary plane to the vertical malocclusions. The angulation of the mandibular plane was not statistically different (P = 0.22880) from the highest sharing skeletal component, the gonial angle.

Variable	P1	P2	z	Probability
d1-d2 and smaller proportions	76.4%	42.9%	6.88	0.00000**
d2-d3,4	42.9%	40.9%	0.62	0.53226
d2-d5	42.9%	31.0%	2.47	0.01359*
d2-d6	42.9%	27.6%	3.22	0.00128**
d2-d7,8,9	42.9%	25.6%	3.66	0.00025**
d3-d4	40.9%	35.0%	1.23	0.21967
d3-d5	40.9%	31.0%	2.07	0.03860*
d3-d6,7	40.9%	27.6%	2.82	0.00474**
d3-d8,9	40.9%	23.6%	3.72	0.00020**
d4-d5,6	35.0%	31.0%	0.84	0.39848
d4-d7,8	35.0%	25.6%	2.05	0.04017*
d4-d9	35.0%	16.7%	4.19	0.00003**
d5-d6,7,8	31.0%	27.6%	0.76	0.44534
d5-d9	31.0%	16.7%	3.38	0.00074**
d6-d7,8	27.6%	25.6%	0.45	0.65324
d6-d9	27.6%	16.7%	2.63	0.00857**
d7-d8	25.6%	23.6%	0.46	0.64498
d7-d9	25.6%	16.7%	2.19	0.02879*
d8-d9	23.6%	16.7%	1.73	0.08351

Table 5: The Significance of Contribution of the Dental Components to Vertical Malocclusion, Utilizing Hypothesis T-Test.

* Statistically significant * (P ≤ 0.05), ** (P ≤ 0.01)

Variable	P1	P2	z	Probability
S1-S2	45.8%	39.9%	1.20	0.22880
S1-S3	45.8%	34.5%	2.33	0.01988*
S2-S3	39.9%	34.5%	1.13	0.25868

Table 6: The Significance of Contribution of the Skeletal Components to Vertical Malocclusion, Utilizing Hypothesis T-Test.

* Statistically significant * (P ≤ 0.05), ** (P ≤ 0.01).

iii. Comparative statistical analysis between the components contribution in deep bite and open bite malocclusions

	Open - bite n = 79		Deep - bite n = 124		z	Probability
	Frequency	Percent	Frequency	Percent		
U1 eruption	5	6.3%	82	66.1%	8.39	0.00000
L1 eruption	25	31.6%	46	37.1%	0.79	0.42717
U6 eruption	1	1.3%	51	41.1%	6.34	0.00000
L6 eruption	1	1.3%	62	50.0%	7.32	0.00000
U1 inclination	53	67.1%	30	24.2%	6.06	0.00000
L1 inclination	21	26.6%	27	21.8%	0.79	0.43183
Curve of spee	58	73.4%	97	78.2%	0.79	0.43183
U1 length	16	20.3%	40	32.3%	1.87	0.06206
L1 length	19	24.1%	15	12.1%	2.22	0.02616
Mandibular plane angle	57	72.2%	24	19.4%	7.49	0.00000
Gonial angle	47	59.5%	46	37.1%	3.12	0.00179
Maxillary plane	30	38.0%	40	32.3%	0.84	0.40345

Table 7: Comparison of the Occurance of Different Components in Open- Bite and Deep Bite Malocclusions, Utilizing Hypothesis T-Test.

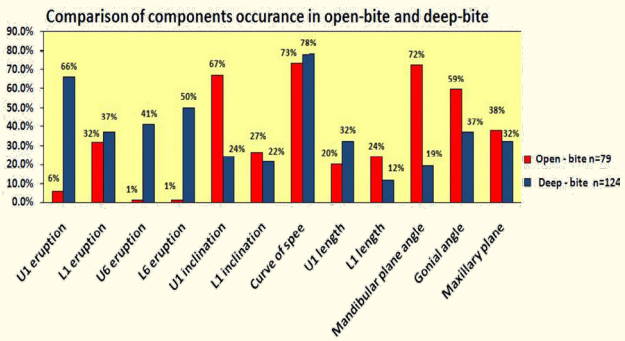

Figure 8: Comparison of the Occurrence of Different Components in Open-Bite and Deep Bite Malocclusions.

Regarding open bite malocclusion the components which were highly sharing in its development were the skeletal mandibular variables; the mandibular plane angle (P = 0.00000) and the gonial angle (P = 0.00179) which were highly sharing in open bite as compared to deep bite malocclusion. The dental components that highly shared in open bite than deep bite was the angulation of the upper incisors (P = 0.00000), and the clinical crown length of the lower incisors (P = 0.02616). While the discrepancy in the eruption of the upper incisors (P = 0.00000), the upper posterior segment (P = 0.00000), and the lower posterior segment (P = 0.00000) were highly significantly sharing in the development of deep bite malocclusion and lower in open bite.

The contribution of some components had no significant difference between open and deep bite malocclusions which were the eruption and inclination of the lower incisors, the curve of Spee, the clinical crown length of the upper incisors and the angulation of the maxillary plane.

iv. Inter-observer and intra-observer reliability:

High intra-observer (0.9998) and inter-observer (0.9978) reliability were found indicating reliable measurements.

Discussion

Vertical discrepancies comprise those problems that affect the anterior overbite. Multiple skeletal and dental components were deemed to contribute in the development of both deep bite and open bite malocclusions. Only few studies had addressed this issue where one study [6] conducted a comparison between 4 groups of patients (20 patients in each group) with variable bite depths. Among their significant findings was that the gonial angle was the largest in the open-bite group and smallest in the deep bite group. Direct comparisons between the contribution of the dental and skeletal components in open and deep bite malocclusions, or evaluating their actual contribution in the development of the vertical malocclusions as a whole, has never been tested.

The discrepancy in the depth of the curve of Spee was the highest sharing dental component. This elucidated the importance of levelling and normalizing the curve of Spee in the various treatment modalities. Also, the inclination and eruptive discrepancies of the upper incisors were shown to have a significant contribution in both open and deep overbite malocclusions. Thus, habits and eruptive problems affecting the eruption and orientation of the upper incisors early in life should be considered as main etiologic factors in the development of the vertical aberrations.

Regarding the skeletal components, the mandibular parameters were shown to have a higher role in the etiology of the vertical malocclusions. As the gonial angle was the highest sharing skeletal component reflecting the importance of the growth and orientation of the mandibular ramus, together with the angulation of the body of the mandible, in the development of vertical malocclusions.

When the contributions of the components to open and deep bite malocclusions were compared, the skeletal components had a more evident influence in the etiology of open bite. On the other hand, the dental discrepancies were more sharing in the development of deep bite. The mandibular skeletal parameters were shown to play a more important role in the development of open bite malocclusion compared to deep overbite. Accordingly, the orthopaedic control of the mandibular growth and rotation can have a more profound impact in the treatment of open bite malocclusion.

The dental component that had a role in the development of open bite malocclusion compared to deep bite was the inclination of the upper incisors; as the proclination of the upper incisors had a potent contribution in opening the anterior overbite. Thus, a thorough analysis of the inclination of incisors should be done prior to embarking on treating an open bite case. Normalizing the

inclination of excessively flared upper incisors could close the bite without undue intrusion of posterior segments or extrusion of anterior segments.

The eruption discrepancies of the upper incisors shared in establishing deep bite malocclusion compared to its contribution in open bite. Their over-eruption contribution in deep bite justifies the intrusive mechanics of the upper incisors. However, certain factors control the amount of intrusion to prevent adverse effects to the facial aesthetics. The display of the maxillary incisors at rest and the amount of their show on smile influence the treatment decision; excessive incisor display favours intrusion of the maxillary anterior teeth8. The smile arc influences the treatment of choice for deep bite patients. In case of a flat or nearly flat smile arc, intrusion of the maxillary incisors is contraindicated [8,9]. Also, it was proven in a systematic review that the maximum amounts of intrusion for non-growing subjects were merely 1.5 mm for the maxillary incisors and 1.9 mm for the mandibular incisors [10]. While the poor contribution of the under-eruption of the incisors in open bite emphasizes on the concept that extruding the incisors increases the tendency for relapse.

Whilst, the over-eruption of the posterior segments was accused in its sharing in open bite malocclusion [11], the findings of the current study have shown surprisingly that this concept was based on inaccurate assumptions. The very low contribution of the over eruption of the upper and lower first molars proves the diminished need for the massive intrusion of posterior teeth in open bite treatment protocols [12,13]. This also makes the claim that open bite treatment with molar intrusion is more stable unjustified [14]. Since both the under-eruption of the lower incisors together with the over-eruption of the lower molars are nearly not contributing to open bite malocclusion, while the reverse curve of Spee [15] is highly contributing. Therefore, the over-eruption of the premolars should be over emphasized as one of the main dento-alveolar etiologic factors in the development of open bite malocclusion. This would highlight the importance of extracting or intruding the premolars rather than the first molars in open bite extraction mechanics.

Thereby, based on the current findings, we can draw some guidelines elucidating the sharing components in vertical malocclusion as a whole and also clarifying some components that could differentiate between open and deep bite malocclusions (Figure 9). Our decision-making process in planning the treatments for deep and open bite malocclusions should be directed to address the underlying cause; as every individual case should receive customized mechanics to resolve the offending component rather than restricting our treatments to limited predetermined techniques.

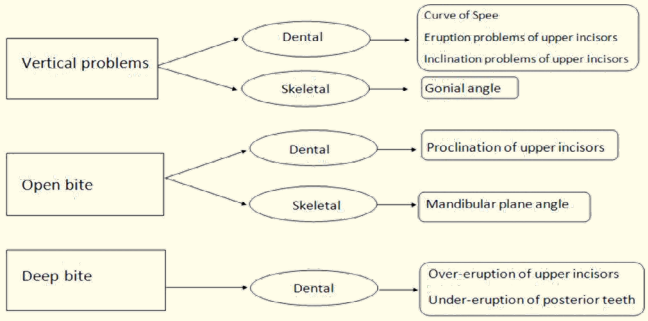

Figure 9: Diagram Showing Some Guidelines in Differentiating the Vertical Malocclusions.

Conclusions

1) The discrepancy in the depth of the curve of Spee was the highest sharing dental component in the development of vertical malocclusions.
2) The mandibular parameters were shown to have a higher role than the maxillary ones in the etiology of the vertical malocclusions.
3) The skeletal components had a more marked influence in the etiology of open, while the dental discrepancies were more sharing in the development of deep bite.
4) The proclination of the upper incisors had a potent contribution in open bite while the over-eruption of the upper incisors was highly sharing in the development of deep bite.

5) The under-eruptions of the posterior segments were the least sharing components in open bite malocclusion.

6) The treatments of open and deep bites should be customized to address the underlying component in every individual case.

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