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Research paper

Dentoalveolar compensation in Iranian adult skeletal open bite subjects

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ABSTRACT

Purpose: The aim of present study was to compare skeletal and dentoalveolar features of compensated and noncompensated adult open bite subjects with each other and also with those of control group.
Materials and methods: A total of 100 lateral cephalograms were included in the study and were divided according to skeletal vertical characteristics into two groups: control group (CG) and open bite group (OBG). The OBG further divided into two subgroups based on amount of overbite: dentally compensated open bite group (COBG) and non compensated open bite group (NCOBG). Twenty skeletal and dentoalveolar variables were evaluated and compared between OBG and CG and also between open bite subgroups by means of Student *t*-test. Association between different variables and overbite was assessed using Pearson's correlation coefficient.
Results: Increased molar and incisor height in both jaws were observed in OBG compared to CG. In NCOBG lower anterior facial height and lower posterior dentoalveolar height were significantly higher than COBG.
Conclusion: Dentoalveolar compensatory mechanisms in skeletal open bite patients consist of increased anterior and posterior dentoalveolar heights in upper and lower jaws compared to CG, while decreased mandibular molar height and shorter anterior face height are the most important determinants of adequate compensation in skeletal open bite subjects in our sample.

1. Introduction

Skeletal open bite malocclusion is difficult and challenging problem in orthodontics. Subjects with this malocclusion may have positive or negative open bite according to adequacy of dentoalveolar compensatory mechanisms [1]. Dentoalveolar compensation can help to attain and maintain normal overbite in various skeletal patterns [2]. In planning treatment for a patient with skeletal open bite a decision should be made whether to choose surgical approach or nonsurgical option for the patient. Dental decompensation is a prerequisite for surgical approach, while in non surgical treatment; we should mask the skeletal problem with dentoalveolar compensation.

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In the case of camouflage of malocclusion, uncompensated parameters can be successfully compensated, but pre-existing compensations should be determined and every effort should be made not to exaggerate these compensations since it lead to poor stability and esthetics [3]. A good understanding of the limits of dentoalveolar compensation is therefore a key to appropriate treatment [4].

Previous studies offer contradictory results regarding dentoalveolar features in high angle patients. While some investigators have shown increased maxillary anterior dentoalveolar dimensions in hyperdivergent patients [5–7], others reported no difference [8]. Regarding mandibular anterior dentoalveolar dimensions, once again there is little agreement; some authors reported reduction of aforementioned parameter in skeletal open bite, while others found no differences [5,7,9]. There is also disagreement about posterior dentoalveolar height in skeletal open bite patients; many investigators state that increased molar height is common finding in the high angle patients [10–15], however others do not support it [8,16–18].

Since craniofacial morphology differ according to ethnicity and racial differences [19], the aim of our study was to compare skeletal characteristics and dentoalveolar features in Iranian female skeletal open bite subjects with those of normal vertical subjects and further compare these features in compensated vs noncompensated skeletal open bite patients.

2. Materials and methods

The sample for this study consisted of 100 pretreatment lateral cephalograms of Iranian adult female. The cephalogerams of subjects who were in permanent dentition stage, aged over 15 years and have passed their adolescence growth spurt based on menarche were included in the study. Positive history of craniofacial anomalies or traumas and respiratory problems as well as previous orthodontic treatment history were exclusion criteria because of possible influence on vertical development of dentoalveolar processes. Information about menarche, anomalies and traumas and respiratory problems were accessible and retrieved from patient's medical histories. All records were selected from achieve of the Department of orthodontics at the Isfahan University of Medical Sciences.

The samples were divided into two groups named CG (control group) and OBG (open bite group) according to mandibular plane angle (ML/SN). OBG further divided into two sub groups (compensated open bite group (COBG) and noncompensated open bite group (NCOBG)) based on amount of overbite. Subjects in the control group (CG; $n = 50$, mean age; 18.6 years) were females with bilateral class I angle occlusion, normal overbite (between 1 and 4 mm) and mandibular plane angle within the range of $33 \pm 6°$. Subjects in dentally compensated open bite group (COBG; $n = 25$, mean age; 17.5 years) had ML/SN angle greater than 40° with positive overbite and non-compensated open bite group (NCOBG; $n = 25$; mean age; 17.8 years) consisted of subjects with negative overbite and ML/SN angle greater than 40°.

Lateral cephalograms of all subjects were hand traced by one investigator on acetate paper over view box. The reference points and planes used in this study are shown in Fig. 1. Some

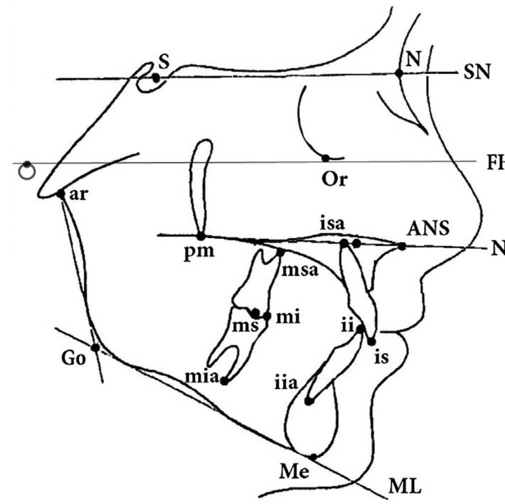

Fig. 1 – Cephalometric reference points and reference lines used in this study.

skeletal variables are illustrated in Fig. 2. In Fig. 3 dentoalveolar variables are depicted. The following skeletal and dentoalveolar variables were measured and compared between groups.

Skeletal variables:

ML/SN (degrees): inclination of mandibular jaw base (ML) to cranial base (SN) or mandibular plane angle.

ML/FH (degrees): inclination of mandibular jaw base (ML) to Frankfort horizontal plane (FH).

NL/SN (degrees): inclination of maxillary jaw base (NL) to cranial base (SN) or maxillary plane angle.

ML/NL: (degrees): inclination of mandibular jaw base (ML) to maxillary jaw base (NL) or inter jaw base angle.

S–Go (mm): total posterior facial height.

N–Me (mm): total anterior facial height.

N–ANS (mm): upper anterior facial height.

ANS–Me (mm): lower anterior facial height.

N–ANS/ANS–Me: upper anterior facial height to Lower anterior facial height or UAFH/LAFH.

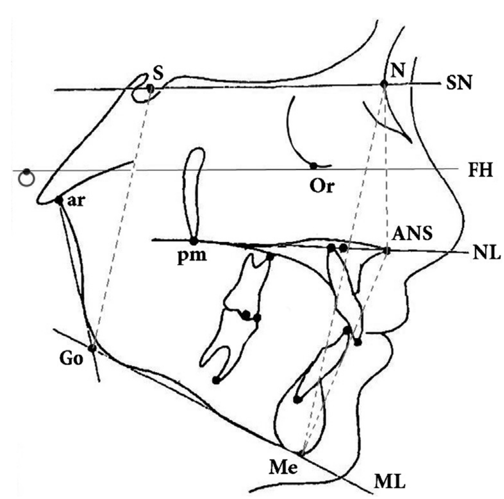

Fig. 2 – Skeletal variables.

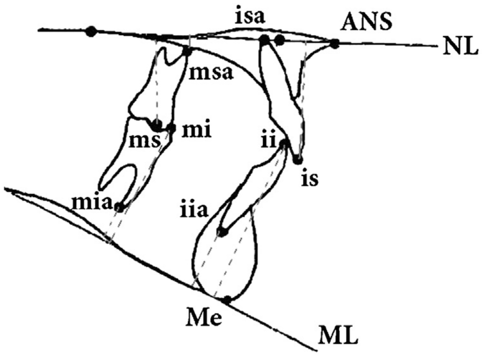

Fig. 3 – Dentoalveolar variables.

Go angle (degrees): gonial angle; Angle formed between Ar–Go and Go–Me.

Ar–Go (mm): distance between articulare and gonion (ramal height).

Go–Me (mm): distance between gonion and menton.

Dentoalveolar variables:

is–NL (mm): distance between the most extruded upper incisor tip (is) to maxillary jaw base (NL).

isa–NL (mm): distance between the apical point of the most extruded upper incisor (isa) to maxillary jaw base (NL).

ii–ML (mm): distance between the most extruded lower incisor tip (ii) to mandibular jaw base (ML).

iia–ML (mm): distance between the apical point of the most extruded lower incisor (iia) to mandibular jaw base (ML).

ms–NL (mm): distance between the mesial cusp tip of the upper first molar (ms) to maxillary jaw base (NL).

msa–NL (mm): distance between the apical point of upper first molar mesial root (msa) to maxillary jaw base (NL).

mi–ML (mm): distance between the mesial cusp tip of the lower first molar (mi) to mandibular jaw base (ML).

mia–ML (mm): distance between the apical point of lower first molar mesial root (mia) to mandibular jaw base (ML).

For each of the cephalometric parameters mean and standard deviation were calculated. Student's *t*-test for unpaired samples was used to make comparison between groups. The correlation coefficient *r* (Pearson) was used to describe association between skeletal and dentoalveolar variables with overbite in open bite subjects:

$|r| > 0.8$ strong correlation

$|r| = 0.4–0.8$ moderate correlation

$|r| < 0.4$ weak correlation

The levels of statistical significance were determined as follows:

$^{*}P < 0.05$, $^{**}P < 0.001$, $^{***}P < 0.0001$, NS (not significant) = $P \geq 0.05$.

To calculate method error 30 lateral cephalograms were randomly selected and traced again by the same examiner who did the tracing for the first time. The repeated tracing was done one month after the first session. Dahlberg's formula [20] for assessment of method error was used. The method errors for linear and angular measurement were 0.22 mm and 0.38° respectively.

Table 1 – Descriptive statistics of cephalometric variables.

Variables	CG		COBG		NCOBG	
	Mean	SD	Mean	SD	Mean	SD
Subject selection						
ML/SN	32.49	4.44	41.20	4.10	43.28	3.72
Overbite	2.06	1.15	2.12	1.76	−2.72	2.00
Skeletal						
ML/FH	23.8	4.03	31.84	1.55	33.02	1.80
NL/SN	8.89	2.76	8.62	3.51	8.16	3.54
ML/NL	23.84	4.15	32.98	3.93	35.12	4.09
S–Go	85.25	8.79	79.98	4.77	81.64	7.72
N–Me	127.48	7.45	131.78	5.58	136.12	8.63
N–ANS	57.30	3.99	55.76	3.17	55.96	4.10
ANS–Me	72.38	4.78	78.86	3.91	83.42	6.42
N–ANS/ANS–Me	0.79	0.08	0.70	0.09	0.67	0.13
Go angle	121.2	4.8	127.8	4.6	130.3	5.7
Ar–Go	51.94	5.90	48.32	3.88	49.22	5.18
Go–Me	70.00	4.01	70.9	3.95	71	5.42
Dentoalveolar						
is–NL	30.30	2.60	34.00	2.56	33.88	3.46
isa–NL	5.24	2.46	9.02	2.75	8.18	3.03
ms–NL	24.88	2.44	27.80	2.38	28.42	3.62
msa–NL	3.05	2.36	7.24	2.48	8.30	4.83
ii–ML	43.98	3.13	46.70	3.04	46.44	4.38
iia–ML	19.62	2.60	22.44	3.66	21.32	2.66
mi–ML	35.58	3.26	35.22	3.10	38.18	3.78
mia–ML	13.18	3.79	13.32	3.60	16.36	3.39

3. Results

Descriptive statistics for the variables are shown in Table 1. Table 2 presents intergroup differences (student *t*-test). Association of skeletal and dentoalveolar variables with overbite are shown in Table 3.

Results showed (Table 2) that upper posterior (ms–NL) and upper and lower anterior dentoalveolar heights (is–NL and ii–ML respectively) were significantly greater in COBG and NCOBG compared to CG ($P < 0.05$). The mean value of lower posterior dentoalveolar height (mi–ML) in COBG was not significantly different from CG ($P > 0.05$) while in NCOBG it showed significant difference from that of CG. No significant difference was observed in dentoalveolar heights between COBG and NCOBG except for lower posterior dentoalveolar height which was greater in NCOBG. Among skeletal variables most of them in COBG and NCOBG showed significant difference from those of CG ($P < 0.05$) except NL/SN, N–ANS (upper anterior face height) and Go–Me. Inclination of mandibular jaw base to cranial base (ML/SN) and to Frankfort horizontal plane (ML/FH), gonial angle and lower anterior facial height (ANS–Me) were main significant skeletal differences between COBG and NCOBG. As can be seen from Table 3, two parameters that had strongest association with overbite were posterior dentoalveolar height (mi–ML) and lower anterior facial height (ANS–Me) respectively.

4. Discussion

The purpose of this study, as mentioned before, was to assess dentoalveolar and skeletal variables in skeletal open bite

Table 2 – Significance of intergroup differences.[a]

Variables	COBG and CG	Mean differences (COBG–CG)	NCOBG and CG	Mean differences (NCOBG–CG)	COBG and NCOBG	Mean differences (NCOBG–COBG)
Subject selection						
ML/SN	***	8.71	***	10.79	*	2.08
Overbite	NS	0.06	***	−4.78	***	−4.84
Skeletal						
ML/FH	***	8.04	***	9.22	*	1.18
NL/SN	NS	−0.27	NS	−0.73	NS	−0.46
ML/NL	***	9.14	***	11.28	NS	2.14
S–Go	**	−5.27	**	−3.61	NS	1.66
N–Me	**	4.3	***	8.64	**	4.34
N–ANS	NS	−1.54	NS	−1.34	NS	0.20
ANS–Me	**	6.48	***	11.04	**	4.56
N–ANS/ANS–Me	***	−0.09	***	−0.12	*	−0.03
Go angle	***	6.6	***	9.1	*	2.5
Ar–Go	**	−3.62	**	−2.72	NS	0.9
Go–Me	NS	0.9	NS	1	NS	0.1
Dentoalveolar						
is–NL	***	3.7	***	3.58	NS	−0.12
isa–NL	***	3.78	***	2.94	NS	−0.84
ms–NL	***	2.92	***	3.54	NS	0.62
msa–NL	***	4.19	***	5.25	NS	1.06
ii–ML	***	2.72	***	2.46	NS	−0.26
iia–ML	***	2.82	***	1.7	NS	−1.12
mi–ML	NS	−0.36	**	2.6	**	2.96
mia–ML	NS	0.14	***	3.18	**	3.04

[a] Tests were performed at a level of statistical significance of $P < 0.05$.
* $P < 0.05$.
** $P < 0.001$.
*** $P < 0.0001$, NS, not significant.

Table 3 – Linear correlation between the overbite and skeletal and dentoalveolar variables in OBG (COBG and NCOBG).

Variables	r-Value	Sig.
Skeletal		
ML/SN	−0.205	*
ML/FH	−0.299	*
NL/SN	−0.006	NS
ML/NL	−0.174	NS
S–Go	−0.182	NS
N–Me	−0.309	*
N–ANS	−0.040	NS
ANS–Me	−0.348	**
N–ANS/ANS–Me	−0.278	*
Go angle	−0.214	*
Ar–Go	−0.185	NS
Go–Me	−0.142	NS
Dentoalveolar		
is–NL	−0.246	NS
isa–NL	−0.021	NS
ms–NL	−0.251	*
msa–NL	−0.254	*
ii–ML	−0.138	NS
iia–ML	−0.029	NS
mi–ML	−0.323	**
mia–ML	−0.403	**

NS, not significant.
* $P < 0.05$.
** $P < 0.001$.

groups and a control group. All lateral cephalograms belonged to Iranian adult female subjects. The reason for that was to avoid potential biases resulted from intersexual differences [21], different growth stages [21] and racial differences [19].

Both upper and lower posterior dentoalveolar heights were significantly greater in NCOBG compare to CG which corroborate previous findings [10–15], but higher level of significance was related to upper rather than lower posterior dentoalveolar heights. This finding is confirmed with Schudy's findings who showed that maxillary molars are considered to be the primary ''bite openers'' [22]. The clinical application of these findings is usefulness of molar intrusion, especially maxillary molars, in treatment of skeletal open bite patients. Skeletal anchorage devices are of great importance for achieving this goal [23–25]. Although the difference in lower posterior dentoalveolar height between COBG and CG was not significant, this parameter was significantly higher in NCOBG compared to COBG. Upper posterior dentoalveolar height in COBG was significantly higher than that of CG which again confirms the bite opening effect of upper posterior teeth in open bite subjects. These findings suggest that decreased lower posterior dentoalveolar height contributes to compensating the open bite in high angle subjects, so it can be concluded that decrease in lower posterior dentoalveolar height is part of natural compensatory mechanisms that can be completed with intrusion of maxillary molars as a treatment objective to camouflage the problem.

In anterior dentoalveolar region, increased heights of upper and lower jaws were observed in OBG (open bite groups including both COBG and NCOBG) compared to CG. This result is consistent with findings of some studies [13,26,27] but differ from those of others [8,16,17]. These features are signs of compensatory dentoalveolar mechanisms in skeletal open bite patients to minimize the severity of skeletal problems. Therefore, every effort should be made to avoid excessive extrusion of incisors during orthodontic treatment because of its poor esthetic results and lack of stability [9].

Among skeletal variables inter jaw base angle (ML/NL) and total anterior facial height (N–Me) as well as lower anterior facial height (ANS–Me) were significantly higher in OBG, while total posterior facial height (S–Go) were greater in CG. The ratio of upper to lower anterior facial height was significantly lower in OBG, Nahoum [17] emphasized the importance of this crucial ratio in treatment planning of open bite patients and believed that patients with ratio less than 0.65 have poor prognosis for conventional orthodontic treatment. There were no significant difference in inclination of maxillary jaw base (NL/SN) and upper anterior facial height (N–ANS) between OBG and CG. Our findings is in line with Hapak and Schudy who have shown that upper anterior facial height in patients with vertical problems do not differ significantly from normal subjects and the difference is in lower anterior facial height [28]. These findings are further corroborated by others, this can be the result of the fact that cephalometric characteristics of skeletal open bite patients is mostly located below the palatal plane and in lower anterior facial region [1,9,29,30]. Gonial angle showed a significant higher value in OBG compared to CG while mandibular ramus height (Ar–Go) was significantly lower in OBG. These findings can be explained by the fact that the pattern of mandibular rotation in subjects with normal occlusion is often forward rotation with the rotation center in the incisor area. This results in increased ramus height and increased posterior facial height compared to high angle subjects in whom mandibular rotation takes place around temporomandibular joint or molars [31]. The value of Go–Me was comparable between OBG and CG. These findings are supported by findings of Subtelny [32] and Epker [33] who observed decreased ramus height in high angle subjects. Significant differences in the amount of ML/SN, overbite and ML/FH between OBG and CG are expected and the basis of subjects' grouping.In comparison between COBG and NCOBG the results of our study showed that total anterior facial height (N–Me), lower anterior facial height (ANS–Me) and ratio of upper to lower anterior facial height (N–ANS/ANS–Me) as well as lower posterior dentoalveolar height (mi–ML and mia–ML) are significantly different while posterior facial height (S–Go), interjaw base angle (ML/NL), maxillary plane angle (NL/SN), ramus height (Ar–Go) and Go–Me, upper anterior facial height (N–ANS) as well as upper and lower anterior dentoalveolar height (is–NL, isa–NL, ii–ML, iia–ML) are comparable in COBG and NCOBG. So according to our findings the most important determinants of having positive or negative overbite in skeletal open bite subjects were lower anterior facial height and lower posterior dentoalveolar height. These parameters were further confirmed with correlation test results shown in Table 3 to have strongest correlation with overbite among our variables. Our observations are confirmed with those of Kuitert et al. [4] who concluded that lower facial height can be considered a cutoff point for estimating the individual predisposition for an open bite and have found that in subjects with lower facial height exceeding 80 mm there will be a negative overbite which is in accordance with our findings. Decreased lower posterior dentoalveolar height in COBG could be suggesting of a role for mandibular molar intrusion in natural compensatory mechanisms in skeletal open bite subjects which help, at least in part, to gain positive overbite in dentally compensated patients. Significant greater amounts of ML/SN, ML/FH and gonial angle in NCOBG compared to COBG seem reasonable since more severe skeletal discrepancies are more difficult to become dentally compensated.

As mentioned previously the strongest correlation with overbite was belonged to lower anterior face height and lower posterior dentoalveolar height which both of these variables negatively correlate to the amount of overbite. Significant negative correlation was also observed between total anterior face height (N–Me) and N–ANS/ANS–Me ratio since these variables are affected by the ANS–Me variable. Upper posterior dentoalveolar height was also negatively correlated to overbite variable which confirms the role of maxillary molars as "bite openers" which was discussed before. Higher values of ML/SN, ML/FH and gonial angle which correspond to more severe skeletal vertical problem were also showed to negatively affect the amount of overbite.

5. Conclusion

Increased molar and incisor height in both jaws are present in open bite subjects compared to control group. From a clinical point of view these data suggest that the primary goal in the treatment of skeletal open bite patients can be molar intrusion with vertical control on incisor region to avoid further extrusion.

Decreased mandibular posterior dentoalveolar height along with shorter lower anterior facial height is suggestive of compensated open bite and these values are well correlated with gaining positive overbite in skeletal open bite subjects.

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