Original Article

Anterior maxillary dentoalveolar and skeletal cephalometric factors involved in upper incisor crown exposure in subjects with Class II and III skeletal open bite

Luis Ernesto Arriola-Guillén[a]; Carlos Flores-Mir[b]

ABSTRACT

Objective: To compare the anterior dentoalveolar and skeletal maxillary cephalometric factors involved in excessive upper incisor crown exposure (UICE) in subjects with skeletal open bite Class II (SOBCIIG) and Class III (SOBCIIIG) against an untreated control group (CG).

Materials and Methods: Seventy pretreatment lateral cephalograms of orthodontic young adult patients (34 men, 36 women) were examined. The sample was divided into three groups according to both sagittal and vertical growth pattern and occlusion. The CG group (n = 25) included Class I, normodivergent cases with adequate overbite, and the SOBCIIG group (n = 25) and SOBCIIIG group (n = 20) included skeletal Class II or III malocclusions, respectively, with hyperdivergent pattern and negative overbite. Several cephalometric measurements were considered (skeletal and dental). Analysis of variance, multivariate analysis of covariance, and Tukey HSD post hoc tests were used. Principal component analysis (PCA) was used for reducing the number of cephalometric variables related to UICE. Finally, a multiple linear regression was calculated.

Results: Significant differences in UICE were found between the groups ($P < .05$). UICE was 3.9 mm in SOBCIIG, 2.5 mm in SOBCIIIG, and 0.4 mm in CG. PCA showed that a nondental component—including vertical maxillary height (VMH) and upper lip height (ULH)—was the only component significantly associated with UICE. The regression model had a moderate prediction capability.

Conclusions: Although the UICE was statistically different in SOBCIIG, the values were within the esthetic standards. The UICE was mainly influenced by VMH and ULH. (*Angle Orthod.* 2015;85:72–79.)

KEY WORDS: Upper incisor crown exposure; Skeletal open bite; Cephalometry

INTRODUCTION

Upper incisor crown exposure (UICE) is directly influenced by hard and soft tissue structures that surround and support these teeth.[1] Among the factors that affect UICE are vertical maxillary height, incisor extrusion, upper lip length, and maxillary incisor inclination.[2] The amount of UICE has a direct impact on dentofacial esthetics.[3]

A vertical maxillary excess likely leads to gummy smile exposure.[4–6] Depending on the maxillary vertical excess severity, an alternative treatment to maxillary impaction surgery is maxillary gingivectomy. Lately, (Temporary Anchorage Device) intrusion movements have been advocated, although their long-term stability has not been demonstrated.[7] Another possibility is orthodontic camouflage,[8–10] but their success is limited because true upper incisor (UI) intrusion mechanics are limited to 4 mm.[11]

The degree of UI inclination is also related to UICE, as teeth that are retroclined are usually more extruded. Maxillary incisor overeruption usually leads to a more coronal position of the gingival margins and excessive gingival display. Treatment of this condition may include orthodontic intrusion of the involved teeth with

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an associated movement of the gingival margin apically, surgical periodontal correction with or without adjunctive restorative therapy, or an interdisciplinary treatment plan.[2,4] Also, the upper lip length may play an important role in UICE,[2] as UIs that are well positioned may be overexposed when short upper lips are present. Short lips also decrease the possibility of a successful camouflage of the problem orthodontically when a surgical approach is not viable or declined.

There are only a couple of studies that had evaluated UICE in subjects with skeletal open bite conditions. Kucera et al.[12] concluded that incisor eruption was significantly greater in dentally compensated skeletal open bite and that UIs were significantly more retroclined in in these subjects. They did not distinguish whether their cases were Class II or III, which likely could have unique camouflage compensations. Arriola-Guillén and Flores-Mir[13] considered the sagittal malocclusion effect when analyzing skeletal open bite cases, but they analyzed the compensation mechanisms only at the molar level (posterior segment). The dental and skeletal compensations that could occur in the anterior segment of the occlusion were not considered.

The clinical challenge for the orthodontist is to resolve patients with open bite without increasing the exposure of the UIs with a consequent increase in gingival exposure. It is important to investigate whether UICE is altered in patients with open bite and take this into consideration during orthodontic treatment planning. It is also important to know which factors affect UICE and how they are presented in open bite cases with different growth patterns.

Therefore, the purpose of this study was to compare anterior dentoalveolar and skeletal maxillary cephalometric factors involved in excessive UICE in subjects with skeletal open bite Class II (SOBCIIG) and Class III (SOBCIIIG) compared with an untreated control group (CG). A better understanding of the factors involved in unesthetic UICE when an underlying skeletal open bite malocclusion is present should improve our diagnostic capability and treatment planning. Almost all articles[14,15] regarding skeletal open bite are related to treatment protocols and their stability, but to our knowledge, none of these analyzed the individual contribution of different anterior dentoalveolar cephalometric factors on UICE.

MATERIALS AND METHODS

The study protocol was approved by the ethical committee of the School of Dentistry, Scientific University of the South, Lima, Perú. The sample included 70 pretreatment lateral cephalograms (34 men, 36 women) taken at maximum intercuspation. All of the cephalograms were taken with the lips at rest without forcing lip competency. Subjects with previous or under orthodontic treatment at the time acquisition were not considered. The age range of these patients varied from 16 to 40 years (all stage CV6[16]).

Sample size was calculated considering a mean difference of 3 mm in UICE as a clinically relevant difference between groups with a standard deviation of 3.74 mm (obtained from a preliminary pilot study in which the mean of the UICE between open bite Class II and control were compared). With a one-sided significance level of .05 and a power of 80%, a minimum of 19 patients per skeletal group was required.

Imaging was performed with digital cephalometric panoramic equipment (ProMax, Planmeca, Finland). Device settings were set at 16 mA, 72 kV, and 9.9 seconds.

Group Classification

The study sample was composed of three groups categorized according to their skeletal facial growth pattern and overbite (Tables 1 and 2).

- The CG ($n = 25$; mean age, 22.6 years) included subjects with ANB $2^\circ \pm 2^\circ$, Class I angle malocclusion, bilateral Class I molar relations, mandibular plane (MP) angle within the range of $33^\circ \pm 6^\circ$, palatal plane (PP) to MP within the range of $26^\circ \pm 3^\circ$, overjet between 2 and 3 mm, overbite between 1 and 4 mm, and with complete permanent dentition.
- The SOBCIIG group ($n = 25$; mean age, 23.4 years) included subjects with ANB $>5^\circ$, Class II-1 angle malocclusion, bilateral Class II molar relations, overjet greater than 5 mm, MP angle greater than 40°, hyperdivergent PP (PP-MP $>29^\circ$), and negative overbite greater than 0.5 mm.
- The SOBCIIIG group ($n = 20$; mean age, 20 years) included subjects with ANB $<0^\circ$, Class III angle malocclusion, bilateral Class III molar relations, overjet lower than -1 mm, MP angle greater than 40°, hyperdivergent PP (PP-MP $>29^\circ$), and negative overbite greater than 0.5 mm.

Vertical Measurements

Vertical measurements are provided in millimeters (Figure 1). Cephalometric measurements were performed digitally by a trained expert researcher and calibrated with the MicroDicom viewer 0.8.1 software (Simeon Antonov Stoykov), without magnification, at a scale of 1:1. The definitions of cephalometric points and angles used in this study are shown in Table 3.[12,17]

UICE was measured as the perpendicular distance from a line parallel to Frankfurt horizontal through the

Table 1. Characteristics of the Sample by Growth Pattern and Overbite

Group	Measurement	n	Mean	SD	Min	Max	*P*
1. Class I (control group)	Age	25	22.60	4.77	17.00	35.00	.084[a]
	ANB angle	25	2.91	0.94	0.57	4.50	<.001[a,b]
	NS-ML angle	25	32.21	2.43	27.00	37.00	<.001[a,b]
	PP-MP angle	25	24.80	2.48	23.00	29.00	<.001[a,b]
2. Skeletal open bite Class II group	Age	25	23.24	9.68	16.00	40.00	
	ANB angle	25	6.74	1.45	5.00	10.11	
	NS-ML angle	25	44.09	3.80	40.01	52.00	
	PP-MP angle	25	33.65	3.32	30.00	37.60	
3. Skeletal open bite Class III group	Age	20	20.00	3.96	16.00	27.00	
	ANB angle	20	−0.88	0.82	−0.10	−2.60	
	NS-ML angle	20	42.51	2.33	40.00	47.29	
	PP-MP angle	20	32.65	2.15	30.00	35.76	

[a] Analysis of variance test.

[b] Tukey test: ANB angle: $P < 0.001$, I and II; $P < .001$, I and III; $P < .001$, II and III. NS-ML: $P < .001$, I and II; $P < .001$, I and III; $P = .341$, II and III. PP-MP: $P < .001$, I and II; $P = .001$, I and III; $P = .800$, II and III.

upper stomion (lowermost point on the vermilion of the upper lip) to the incisal border of the UI.

Upper incisor height (UIH) was measured as the distance of a vertical perpendicular line from the PP projected to the incisal border of the UI.

Vertical maxillary height (VMH) was measured as the distance of a vertical perpendicular line from the PP projected to the prosthion of the UI.

Prosthion to incisal border of the UI (UIPr) was considered as a measurement of the clinical crown.

Upper lip height (ULH) was measured as the perpendicular distance from a line parallel to Frankfurt horizontal through the subnasal point to the superior stomion point.

Inclination measurements (in degrees) are presented in Figure 1.

Upper incisor inclination (UIPP) was evaluated considering the angle formed between the PP and the long axis of the upper central incisor.

Statistical Analysis

All statistical analyses were performed using SPSS versioin 20 for Windows (IBM SPSS, Chicago, Ill). The normality and homogeneity of variance assumptions were satisfied with Shapiro-Wilk tests. A multivariate analysis of covariance (MANCOVA) test was initially considered, with UICE as the dependent variable and considering age, sex, group, and their interactions as the independent variables. Neither sex nor age nor the interactions were significant.

One-way analysis of variance test with Tukey HSD post hoc tests were performed to determine whether there were differences between the three groups regarding UICE, UIH, VMH, UIPr, ULH, and UIPP measurements. In addition, principal component analysis (PCA) was used to reduce interrelated factors to increase the statistical power of the subsequent analysis. Based on the PCA results, a MANCOVA test

Table 2. Distribution of the Sample by Skeletal Pattern and Sex

Group	Sex: Female	Sex: Male	Total
Class I (control group)	12	13	25
Skeletal open bite Class II group	14	11	25
Skeletal open bite Class III group	10	10	20
Total	36	34	70

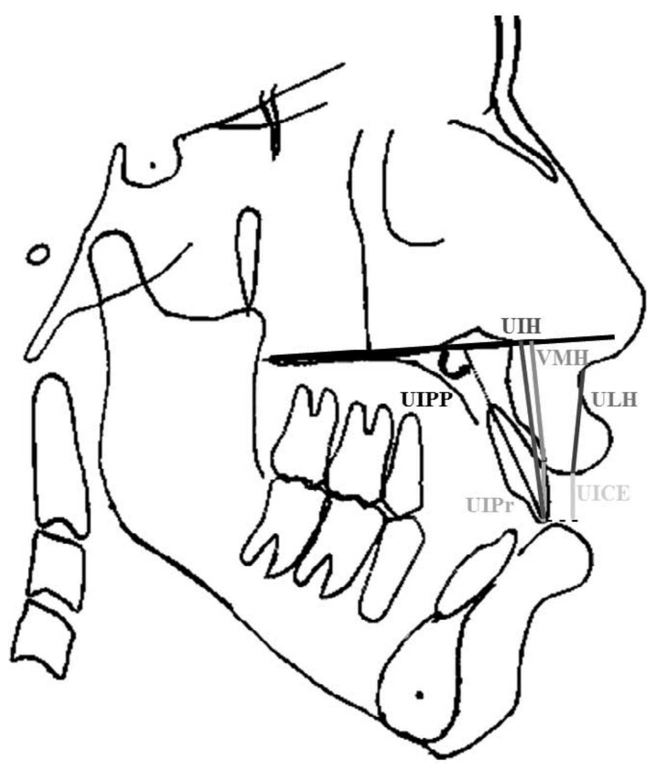

Figure 1. Angular and linear measurements. UICE indicates upper incisor crown exposure; UIPP, upper incisor to palatal plane; UIH, upper incisor height; VMH, vertical maxillary height; UIPr, prosthion to incisal border of the UI; ULH, upper lip height.

Table 3. Definitions of Cephalometric Points and Angles Used in This Study

Angular measurements	Definition
ANB	The angle between points A and B in degrees[20]
NS-ML	The angle between the nasion-sella line and mandibular line in degrees[13]
PP-MP	The angle between the palatal plane and mandibular plane in degrees[13]
UIPP	The angle between the upper incisor inclination and palatal plane in degrees[21]
Linear measurements	**Definition**
Upper incisor crown exposure	Distance in millimeters of the perpendicular distance from a line parallel to Frankfurt horizontal through the upper stomion to the incisal border of the upper incisor (UI)
Upper incisor height	Distance in millimeters of a vertical perpendicular line from the PP projected to incisal border of the UI[21]
Vertical maxillary height	Distance in millimeters of a vertical perpendicular line from the PP projected to prosthion of the UI[21]
Prosthion to incisal border of the UI	Distance in millimeters of the prosthion to incisal border of the UI
Upper lip height	Distance in millimeters of the perpendicular distance from a line parallel to Frankfurt horizontal through the subnasal point to superior stomion point[21]

was developed considering only the nondental component (VMH and ULH). Finally, a multiple linear regression was calculated. Statistical significance was set at $P < .05$ for all tests.

RESULTS

Reliability

The intraexaminer reliability (Table 4) was assessed with the intraclass correlation coefficient (ICC), which gave a result greater than .90 in all measurements. In addition, the Dahlberg error was less than 1 mm for linear measurements and 0.8° for angular measurements. All of the cephalometric tracings were drawn with a 2-month interval between them.

Vertical Measurements

Descriptive statistics are shown in Table 5. When comparing all study variables grouped by sex and group, significant differences were observed for ULH (all $P < .05$).

In Table 6, significant differences in the UICE among the vertical measurements (UIH, VMH, UIPr, UIPP) were found between the groups ($P < .05$). UICE was higher in SOBCIIG (4 mm) than in SOBCIIIG (2.5 mm) and CG (0.4 mm; $P < .01$). UIH was larger by approximately 2.8 mm in SOBCIIG and 1.5 mm in SOBCIIIG in comparison with CG, but was significant only for SOBCIIG when compared with CG ($P = .002$). The VMH for SOBCIIG was approximately 2 mm larger in comparison with CG ($P = .007$). SOBCIIIG was 1 mm greater than CG, but without significance. No difference was demonstrated between SOBGs. UIPr was significantly larger only for SOBCIIG compared with CG by approximately 1 mm ($P = .011$). For ULH, no difference was demonstrated between SOBGs and CG ($P = .080$). The UIPP was larger for SOBCIIIG by 6° and 4°, respectively, than for SOBCIIG ($P = .041$) and CG ($P = .001$).

Principal Component Analysis

Two significantly factors were obtained after the reduction of the number of independent variables considered (Table 7). These factors were named the "nondental component" and the "dental component."

Final Statistical Analysis

A MANCOVA considered the only nondental component (VMH and ULH) because it was the only factor significantly involved in the UICE (Table 8). VMH, ULH, and groups were significant ($P = .008$, $P = .034$, and $P < .001$, respectively).

Finally, a multiple linear regression model (Table 9) was conducted with the variables that were significant in the last MANCOVA. The regression model had a

Table 4. Intraobserver Concordance and Error Analysis[a]

Measurement	Intraobserver Concordance: ICC	CI Inferior Limit	CI Superior Limit	Dahlberg error $s_x = \sqrt{\frac{\sum D^2}{2N}}$
Upper incisor crown exposure	.997	.992	.999	0.1 mm
Upper incisor height	.995	.930	.999	0.5 mm
Vertical maxillary height	.915	.900	.925	0.5 mm
Prosthion to incisal border of the UI	.978	.940	.999	0.3 mm
Upper lip height	.990	.980	.999	0.5 mm
Incisor inclination maxillary	.997	.995	.999	0.8°

[a] ICC indicates intraclass correlation coefficient; CI, confidence interval; UI, upper incisor.

Table 5. Factors Involved in the Exposure of Upper Incisors by Malocclusion and Sex

Group	Variable	Sex	n	Mean	SD	P^a
Skeletal open bite Class II group	Upper incisor crown exposure, mm	Male	11	3.11	1.90	.058
		Female	14	4.62	1.86	
	Upper incisor height, mm	Male	11	31.01	3.80	.682
		Female	14	30.50	2.37	
	Vertical maxillary height, mm	Male	11	18.34	3.06	.824
		Female	14	18.10	2.29	
	Prosthion to incisal border of the UI, mm	Male	11	13.34	1.47	.124
		Female	14	12.62	0.72	
	Upper lip height, mm	Male	11	23.67	1.37	.026
		Female	14	21.82	2.26	
	Upper incisor palatal plane, °	Male	11	112.92	5.84	.305
		Female	14	115.23	5.14	
Skeletal open bite Class III group	Upper incisor crown exposure, mm	Male	10	2.21	2.17	.526
		Female	10	2.84	2.15	
	Upper incisor height, mm	Male	10	29.93	2.87	.309
		Female	10	28.83	1.37	
	Vertical maxillary height, mm	Male	10	17.59	2.66	.304
		Female	10	16.47	1.84	
	Prosthion to incisal border of the UI, mm	Male	10	12.80	0.74	.813
		Female	10	12.73	0.45	
	Upper lip height, mm	Male	10	22.96	1.76	.012
		Female	10	20.82	1.60	
	Upper incisor palatal plane, °	Male	10	120.28	6.22	.092
		Female	10	115.92	4.28	
Class I (control group)	Upper incisor crown exposure, mm	Male	12	0.54	0.98	.409
		Female	13	0.26	0.59	
	Upper incisor height, mm	Male	12	29.46	2.66	.024
		Female	13	26.92	1.89	
	Vertical maxillary height, mm	Male	12	17.02	2.33	.044
		Female	13	15.21	1.90	
	Prosthion to incisal border of the UI, mm	Male	12	12.37	0.77	.218
		Female	13	11.82	1.32	
	Upper lip height, mm	Male	12	22.70	1.65	<.001
		Female	13	20.04	1.38	
	Upper incisor palatal plane, °	Male	12	111.16	5.91	.469
		Female	12	112.77	5.01	

[a] Student *t* test. UI indicates upper incisor.

moderate prediction capability of about 54% ($P < .001$, $R^2 = .536$).

DISCUSSION

The purpose of this study was to consider anterior maxillary dentoalveolar and skeletal cephalometric factors associated with an excessive UICE in subjects with a Class II and III skeletal open bite malocclusion as contrasted with a CG with adequate occlusion and no major skeletal imbalances. The group's age and sex were initially balanced to diminish classification bias. SOBCIIG and SOBCIIIG groups met skeletal open bite requirements including a negative overbite, MP hyperdivergency, and upward inclination of the PP observed on the lateral cephalograms. Differences between the groups, some clearly clinically and statistically significant, were identified.

An increased UICE evaluated at rest and with smile has been previously associated with maxillary vertical excess, short upper lip, increased clinical crown, and/or more retroclined UIs.[2] The authors of that study suggested that these features were related primarily to a genetic etiology; however, they may be favored if there is no anterior contact between the upper and lower incisors. This lack of contact is characteristic of a skeletal open bite and stimulates incisor extrusion and dentoalveolar process vertical development. In this study, the cephalograms were taken with the lips at rest without forcing lip competency. The amount and direction of upper lip movement during different smile movements (dynamic condition of UICE) is a difficult variable to control in this type of research.

In our study, the SOBCIIG had the highest values of UICE (4 mm), but this value does not exceed the ideal esthetic values proposed by Burstone et al.[17] of 2 ± 2 mm in maximum exposure at rest. Because of the relatively small standard deviation (±2 mm), the treatment of most of these cases should focus primarily on maintaining or slightly decreasing the

Table 6. Factors Involved in the Exposure of Upper Incisors in Subjects With Skeletal Open Bite Class II, Class III, and Control Group

Measurement	Group	n	Mean	SD	Min	Max	S^2	P
Upper incisor crown exposure (UICE), mm	1. Class I (control group)	25	0.40	0.80	0.00	3.00	0.64	
	2. Skeletal open bite Class II group	25	3.95	1.99	0.00	7.04	3.97	$<$.001
	3. Skeletal open bite Class III group	20	2.49	2.13	0.00	6.57	4.54	
Upper incisor height (UIH), mm	1. Class I (control group)	25	27.99	2.51	22.71	34.00	6.34	.002[a,b]
	2. Skeletal open bite Class II group	25	30.72	3.02	24.95	37.34	9.17	
	3. Skeletal open bite Class III group	20	29.44	2.33	25.44	35.79	5.44	
Vertical maxillary height (VMH), mm	1. Class I (control group)	25	16.08	2.27	10.68	21.00	5.17	.010[a,b]
	2. Skeletal open bite Class II group	25	18.21	2.60	13.20	23.22	6.76	
	3. Skeletal open bite Class III group	20	17.09	2.34	13.73	22.63	5.49	
Prosthion to incisal border of the UI (UIPr), mm	1. Class I (control group)	25	12.08	1.10	10.01	14.28	1.23	.010[a,b]
	2. Skeletal open bite Class II group	25	12.94	1.15	10.47	15.00	1.32	
	3. Skeletal open bite Class III group	20	12.77	0.61	12.00	14.33	0.38	
Upper lip height (ULH), mm	1. Class I (control group)	25	21.32	2.01	18.00	25.41	4.05	.080[a,b]
	2. Skeletal open bite Class II group	25	22.64	2.10	17.78	25.87	4.45	
	3. Skeletal open bite Class III group	20	21.99	1.98	18.00	25.79	3.92	
Upper incisor palatal plane (UIPP), °	1. Class I (control group)	25	112.00	5.41	104.00	121.64	29.29	.001[a,b]
	2. Skeletal open bite Class II group	25	114.21	5.47	102.00	124.96	29.94	
	3. Skeletal open bite Class III group	20	118.32	5.75	106.00	135.01	33.07	

[a] Analysis of variance test.

[b] Tukey test: UICE: $P < .001$, I and II; $P < .001$, I and III; $P = .016$, II and III. UIH: $P = .002$, I and II; $P = .173$, I and III; $P = .249$, II and III. VMH: $P = .007$, I and II; $P = .350$, I and III; $P = .274$, II and III. UIPr: $P = .011$, I and II; $P = .068$, I and III; $P = .851$, II and III. UIPP: $P = .338$, I and II; $P = .001$, I and III; $P = .041$, II and III.

exposure, not necessarily implying major surgical procedures. Intrusion of the posterior teeth as the treatment of choice has been indicated by some studies,[12,13] although the long-term stability of molar intrusion is still controversial. According to Baek et al.,[18] relapse occurred on an average of 23% of the amount of molar intrusion facilitated by microscrews within 3 years of the postretention period.

The SOBCIIIG difference (2 mm) may be of questionable clinical importance. Furthermore, it seems that the most important factors involved with an increased UICE are related to a decrease of the length of the upper lip and an increase of the vertical maxillary height. Burstone et al.[17] found that the distance of the upper incisor edge to the PP in males was 30.5 $\pm$ 2.1 mm and in females 27.5 $\pm$ 1.7 mm, where larger values were considered as overeruption and smaller values as infraeruption. Also, Kucera et al.[12] found that in the skeletal open bite group, the incisor height was significantly elongated compared with CG by approximately 3 mm. Our results were consistent with those of previous studies,[12–19] but they contradict those reported by Nahoum,[20] who found smaller values for incisor height in patients with open bite with respect to CG. None of these studies took into account the sagittal skeletal pattern.

In orthodontic treatment of a skeletal open bite, careful consideration must be given to esthetic factors. In those cases, therapy could be directed primarily to the intrusion of molars instead of extruding the incisors, as it is very frequently the case that the incisors are already extruded. More extrusion could worsen the case esthetically, and the incisors may be more likely to relapse. In summary, excessive extrusion of incisors in open bite treatment may bring results that are neither stable nor esthetic.

The regression model had a moderate prediction capability of about 54%, which indicates that there are other uncontrolled variables in this study that significantly influence exposure incisors. Our study did focus

Table 7. Principal Component Analysis of the Factors Involved in the Crown Exposure of Upper Incisors

Variable	Component 1	Component 2
Upper incisor height	[a]0.967*	0.012
Vertical maxillary height	[a]0.924*	−0.149
Prosthion to incisal border of the upper incisors	0.492	[b]0.573*
Upper lip height	[a]0.611*	0.357
Upper incisor to palatal plane	−0.153	[b]0.854*
Total variance explained (% of variance)	48.525	24.150

* Significant component: [a]nondental component, [b]dental component.

Table 8. Multivariate Analysis of Covariance Considering Only the Dental Principal Component Analysis Factors Group, Sex, and the Interaction

Dependent Variable	Co-variables and Fixed Factors	f	P
Upper incisor crown exposure	Corrected model	11.360	$<$.001
	Intercept	2.180	.145
	Vertical maxillary height	7.413	.008
	Upper lip height	4.688	.034
	Group	22.805	$<$.001

Table 9. Multiple Linear Regression of the Influence of the Nondental Principal Component Analysis Factor Components and Groups Over UICE[a]

Model	Coefficient B	t	P	95% Confidence Interval Inferior Limit	95% Confidence Interval Superior Limit	Correlations Partial
Constant	.255	1.183	.241	−1.757	6.867	
VMH	.251	2.915	.005	0.079	0.423	0.340
ULH	−.290	−0.266	.006	−0.494	−0.087	−0.333
SOBCIIG	.489	0.723	<.001	2.430	4.381	0.654
SOBCIIIG	.487	0.408	<.001	1.064	3.011	0.460

[a] $R = .732$, $R^2 = .536$, $P < .001$. UICE indicates upper incisor crown exposure; VMH, vertical maxillary height; ULH, upper lip height; SOBCIIG, skeletal open bite Class II group; SOBCIIIG, skeletal open bite Class III group.

only on the measurement of variables related only to the anterior part of the face. However, anterior open bite can also occur due to posterior dentoalveolar adaptations such as increased molar extrusion. Kucera et al.[12] concluded that the increased molar height is a common finding in adults with skeletal open bite. In a study using the same sample, Arriola-Guillén and Flores-Mir[13] concluded that the skeletal open bite groups had greater molar heights than did CG.

In addition, in open bite patients undergoing orthognathic surgery, it has been suggested that extrusion of the incisors is to be avoided in presurgical orthodontics to decrease the risk of dental relapse after surgery.[21,22] The reasoning is that if upper teeth were to be extracted for decompensation purposes before surgery, the amount of incisor exposure at rest must be taken into account because it could easily worsen the case.

The UIPP determines the degree of upper incisor inclination with respect to its bony base. The measurement of the extrusion is strongly influenced by the angulation of incisors. In this research, the control of the UIPP as selection criteria was not made because all cases would be similar, and they will unlikely reflect the reality of compensation responses in the different malocclusions. Burstone et al.[17] found that average value of inclination were $111^\circ \pm 4.7^\circ$ in men and $112.5^\circ \pm 5.3^\circ$ in women, where larger values indicate vestibular inclination. Our results showed that the upper incisor inclination on SOBCIIIG was 6° and 4° more proclined in SOBCIIIG than in SOBCIIG and CG groups, respectively. This inclination is typical for Class III patients, in whom tongue pressure and lack of upper lip resistance over the upper incisors allow for a greater vestibular inclination.[13] No statistically significant differences were found on incisive inclination between SOBCIIG and CG. This is in agreement with other research, which found that the open bite group did not differ significantly from a CG in this regard.[12,23,24] The ULH was not statistically significantly different between SOBGs and CG. This makes sense as the length of the upper lip is not influenced by the sagittal skeletal malocclusion.

In summary, our study evaluated which of the evaluated cephalometric factors was most significantly associated with UICE. PCA was used to reduce the number of evaluated variables during the statistical analysis, so that an increase in the statistical power was obtained. It was expected that among the evaluated cephalometric variables, several will be closely associated (some shared common cephalometric structures). Therefore, PCA allowed grouping them based on the strength of their interrelations. This automatically diminished the chances of false-positive results. After grouping the variables into two factors in relation to UICE, only the nondental component showed statistical significance regarding UICE. This component included the variables VMH and ULH. Therefore, we may assume that these are the variables that most influence UICE.

CONCLUSIONS

- Although the UICE was statistically different in SOBCIIG, the values were within the esthetic standards.
- UICE was mainly influenced by VMH and ULH.

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