

Lower Incisor Dentoalveolar Compensation and Related Mandibular Symphysis Morphology in Class II Division 1, Class I and Class III Malocclusions with Different Facial Vertical Skeletal Patterns

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Abstract

Objective: To evaluate lower incisor dentoalveolar compensation and related mandible symphysis morphology among patients with class II division 1, class I and class III malocclusions with different facial vertical skeletal patterns.

Subjects and Methods: Lower incisor extrusion and inclination, mandibular symphyseal height (LH), buccal (LA) and lingual (LP) symphyseal bony cortex depth were measured in 199 lateral cephalometric x-rays of adult patients without prior orthodontic treatment (Class II division 1 n = 66, Class I n = 71, Class III n = 62). A principal component analysis (PCA) considered both sagittal and vertical facial patterns.

Results: A response pattern for the lower incisor behavior inside its symphyseal environments were identified. The IMPA in Class II division 1 malocclusion exceeded 93° and negatively correlated with the mandibular plane in Class III. The increase of mandibular plane had a negative correlation with LA and LP for class I, II division 1 and III groups. Still, no significant differences were found in class II division 1 patient for LH. According to the PCA, close to 70% of the analyzed samples showed evidence that dentoalveolar compensation of II division 1 behaves differently than class I and III when vertical facial patterns were considered. In class II division 1, all the groups showed a similar pattern. LA and LP were reduced in long-face patterns, but LH didn't increase.

Conclusion: In class II division 1 malocclusion, the lower incisor was usually proclined, while the increase of the mandibular plane was related to a decrease in lower incisor inclination and extrusion. Symphyseal morphology and the lower incisor position did not respond in a consistent, precise mechanism of dental compensation, unlike in other malocclusions, suggesting a skeletal alteration in the morphology of the jawbone.

Keywords: Lower Incisor; Mandibular Symphysis; Dentoalveolar Compensation

Introduction

Natural dental compensations camouflage anterior-posterior, transversal and vertical skeletal craniofacial discrepancies to establish a functional occlusion [1,2]. Regarding the incisal relationship, dentoalveolar compensation modifies the sagittal and vertical position of the incisors to achieve incisal contact. Specifically, this compensation regulates the height and shape of the alveolar process of the mandibular symphysis. Occasionally, the regulation of the position of the lower incisor can be affected by the interposition of soft tissues such as the tongue and lips [3,4].

The position and inclination of the lower incisor is a cornerstone factor for orthodontic treatment planning. In this regard, the mandibular symphysis is a key anatomical factor that limits the incisal movement. The respect for anatomic limits avoids iatrogenic phenomena such as bone loss, alveolar dehiscence, gingival recession, and dental mobility [5-7].

A previous study [8] investigated the relationship between the lower incisor compensation degree and the mandibular symphyseal dimensions in class I and class III patients with different vertical facial patterns. The long-face pattern was a significant factor associated with mandibular symphysis alveolar morphology and lower incisor positioning for class I and class III patients. Short-faced Class III patients had a widened alveolar bone. However, natural compensation elongates the symphysis for long-faced and normal-faced class III and influences the lower incisor position.

In the case of Class II division 1 malocclusion, the etiology of the malocclusion has been found to originate from mandibular hypoplasia or a retroposition mandible usually [9,10]. Several investigations have observed that in those cases, the development of the mandible is deficient and unable to be further developed even when it is stimulated with functional appliances. This deficient mandibular development could affect the behavior of lower incisor and mandibular symphyseal compensations to attain incisor coupling. In previous investigations [5,9,19,23] the sample size was small and heterogeneous, their work has focused on how the morphology of the mandibular symphysis has been linked to mandibular growth rotations. Information about the compensation behavior of lower incisors and the shape of the mandibular symphysis in patients with class II division 1 malocclusion is limited.

Aim of the Study

This study aims to determine whether the dentoalveolar compensation mechanism of the lower incisor in Class II division 1 with different vertical patterns differs from compensation in class III and I malocclusions.

Subjects and Methods

Institutional ethical board approval was granted (ORT-ECL-2013-01). Consecutive orthodontic records of class I, II and III skeletal malocclusion patients were reviewed from three private orthodontic clinics. The final sample consisted of 199 lateral cephalometric X-rays (Table 1).

Inclusion criteria: Caucasian adult subjects between 18 and 45 with complete permanent dentition up to second molars.

Exclusion criteria: Patients diagnosed with a Class II division 2 malocclusion. Patients who had received prior orthodontic treatment or maxillofacial surgery. Patients with any known craniofacial syndrome.

Cephalometric measurements: The X-rays were calibrated and traced with the Nemoceph® computer program (Software Nemotec, Madrid, Spain) by the same examiner.

Sagittal classification: ANB and Wits were used for determining the sagittal malocclusion. Both measurements had to agree for the sagittal malocclusion classification. Using ANB [11]: Class I ($ANB = 2^{\circ} \pm 2$), class II ($ANB > 4^{\circ}$) and class III ($ANB < 0^{\circ}$). For Wits appraisal [12]: Wits >0 for class II and Wits <-1 in class III.

Vertical facial type: The mandibular plane [11] (Go-Gn to SN line) was used to classify patients into long ($>35^{\circ}$), average ($30-35^{\circ}$) or short faces ($<29^{\circ}$) (Table 1).

Vertical Facial Type	Malocclusion
Long face (n = 18)	Class II (n = 66)
Normal face (n = 31)	
Short face (n = 17)	
Long face (n = 16)	Class I (n = 71)
Normal face (n = 33)	
Short face (n = 22)	
Long face (n = 19)	Class III (n = 62)
Normal face (n = 21)	
Short face (n = 22)	

Table 1: Final sample distribution according to sagittal and vertical variables.

Lower incisor position: IMPA [13] was obtained from the angle between the long axis of the lower incisor and the Downs mandibular plane. The amount of Extrusion from the edge of the incisor was calculated based on the functional occlusal plane [14] (Figure 1).

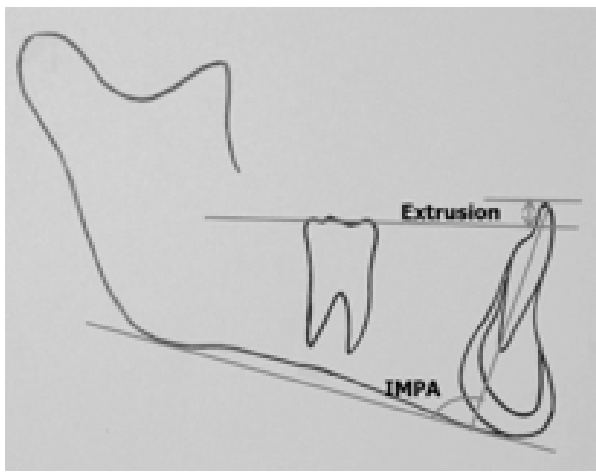


Figure 1: Position of the lower incisor: IMPA and extrusion.

Mandibular symphysis morphology: Quantified following Handelman’s criteria (6): LP: bone posterior to the apex of the incisor, LA: bone anterior to the apex of the incisor and LH: bone inferior to the apex of the incisor (Figure 2).

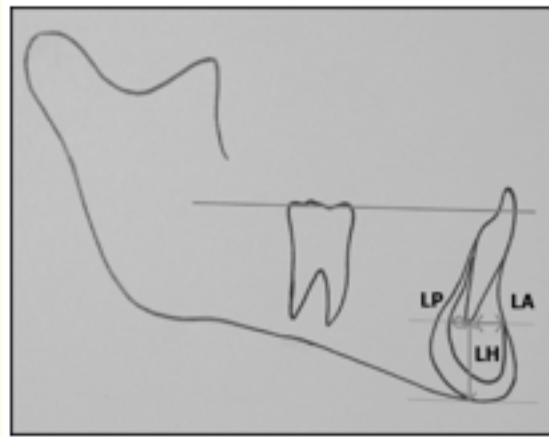


Figure 2: Dimensions of the symphysis: LP, LA and LH.

Statistical analysis

The data obtained were inserted into a Microsoft Excel spreadsheet and were analyzed using the Statgraphics Plus 5.1® statistics program.

To determine the intra-examiner variability, cephalometric tracings were repeated on fifteen randomly chosen x-rays.

Differences between the lower incisor position and symphysis dimensions were evaluated with analysis of variance (ANOVA), among the class I, II and III malocclusion samples.

A simple regression analysis was used to determine the correlation coefficients between the mandibular plane and incisor position and symphysis dimensions in class I, II and III malocclusions.

A principal component analysis evaluated if the five variables related to incisor position and symphysis dimensions could be reduced to reduce data variability and strengthen the statistical analysis power. After completing the PCA, an ANOVA was performed to evaluate significant differences within the sagittal and vertical skeletal facial patterns.

An ANOVA-sum of squares was then performed. A representation was sought through an interactive graph to compare the principal components among the classes, faces and the different class-face combinations.

Results

No clinically significant measurement errors were identified. A kappa value of 0.84 was attained (CI 0.76, 0.89). The confidence interval (CI 95%) for each variable was: IMPA (20.6, 7.7), extrusion (20.97, 0.74), LP (20.55, 1.31), LA (20.19, 1.14), and LH (22.08, 2.78). Dahlberg formula: IMPA (0,069802), extrusion (0,024227), LP (0,027719), LA (0,03280443), LH (0,069095).

Table 2 and 3 depict the inclination and extrusion of the lower incisor and the mandibular symphyseal dimensions in class I, II and III malocclusions and among the three different vertical facial patterns.

	Class		
	I	II	III
IMPA	88,13 ± 6,05	93,79 ± 6,70	81,40 ± 7,76
Extrusion	1,36 ± 1,34	1,43 ± 1,92	1,99 ± 1,57
LA	3,99 ± 1,41	3,41 ± 1,28	4,20 ± 1,34
LH	19,39 ± 3,32	19,98 ± 3,63	19,46 ± 4,01
LP	1,68 ± 1,18	1,42 ± 1,43	1,62 ± 1,63

Table 2: Sample descriptive statistics in class I, II, III.

	Class I			Class II			Class III		
	SF	NF	LF	SF	NF	LF	SF	NF	LF
IMPA	88,68 ± 5,31	88,42 ± 6,01	86,76 ± 7,19	95,20 ± 7,48	94,49 ± 5,32	91,23 ± 7,70	84,15 ± 7,06	82,24 ± 8,38	77,29 ± 6,31
Extrusion	1,35 ± 1,29	1,36 ± 1,30	1,40 ± 1,55	2,03 ± 1,79	1,34 ± 1,84	1,02 ± 2,13	2,00 ± 1,22	1,78 ± 1,98	2,19 ± 1,46
LA	4,58 ± 1,25	3,90 ± 1,38	3,37 ± 1,46	3,63 ± 1,52	3,60 ± 0,96	2,87 ± 1,43	4,65 ± 1,12	4,40 ± 1,61	3,48 ± 0,96
LH	18,10 ± 4,06	19,56 ± 2,42	20,81 ± 3,35	19,68 ± 3,25	20,49 ± 3,84	19,39 ± 3,67	18,38 ± 2,80	19,33 ± 5,20	20,86 ± 3,41
LP	1,97 ± 1,13	1,66 ± 1,22	1,32 ± 1,12	2,07 ± 1,00	1,43 ± 1,48	0,77 ± 1,46	1,86 ± 1,70	2,06 ± 1,44	0,84 ± 1,56

Table 3: Sample descriptive statistics in class I, II, III vertical facial patterns: (SF) short, (NF) normal and (LF) long.

The lower incisor was more proclined in class II malocclusion patients (93,79°) than in class I (88,13°) and III (81,40°) ($p \leq 0.001$), while the extrusion only was augmented in class III malocclusions (Figure 3 and 4).

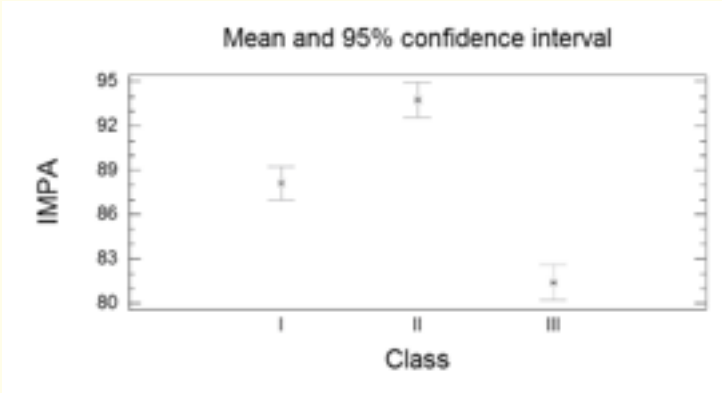


Figure 3: IMPA variation in class II vs class I and III.

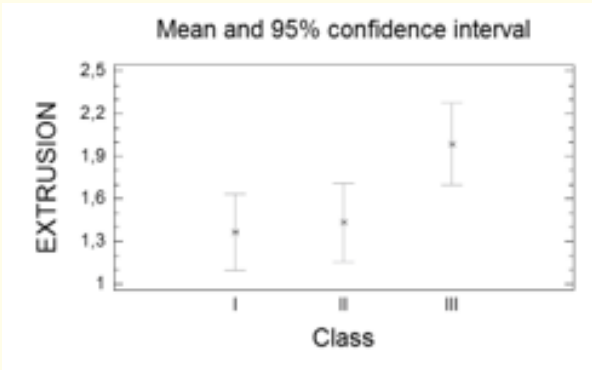


Figure 4: Extrusion variation in class II vs class I and III.

The evaluation of the mandibular symphyseal dimensions, LA ($p = 0.003$), showed significant differences, as the class II (3,41 mm) malocclusion was the group with the smallest LA (Figure 5).

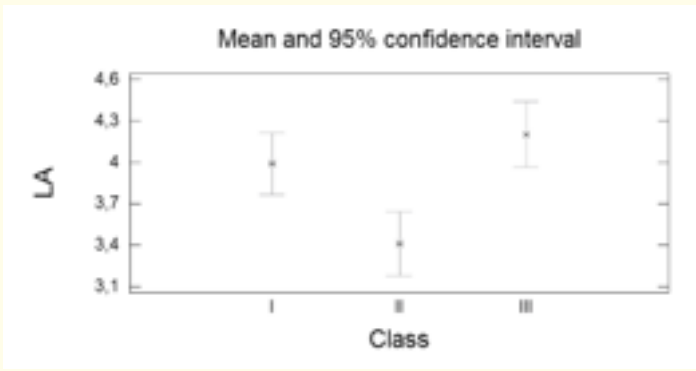


Figure 5: LA variation in class I, II and III.

In the class II malocclusion group, both IMPA ($p = 0.023$) and extrusion ($p = 0.006$) magnitudes had a negative correlation with the mandibular plane (Table 4). No negative correlation was observed in the Class I group, and only IMPA had a negative correlation ($p = 0.002$) with the mandibular plane in the Class III group. However, the variability coefficients were relatively small.

	Mandibular Plane-Class I		Mandibular Plane-Class II		Mandibular Plane-Class III	
Lower Incisor	IMPA	Extrusion	IMPA	Extrusion	IMPA	Extrusion
Correlation	-0,1403	0,0684	-0,2795	-0,3350	-0,3815	-0,0178
Coefficients R ²	1,97	0,47	7,81	11,23	14,55	0,03
Sample size (n)	(71)	(71)	(66)	(66)	(62)	(62)
P-value	0,2430	0,5708	0,0230	0,0060	0,0022	0,8905

Table 4: Correlations between the mandibular plane and the lower incisor in class I, II and III.

The increase of mandibular plane had a negative correlation with LA and LP for both class I, II and III malocclusion groups and a positive correlation with LH for class I and III malocclusion groups (Table 5). However, no significant differences were found in class II patients with LH. Again, variability coefficients were small.

	Mandibular Plane-Class I			Mandibular Plane-Class II			Mandibular Plane-Class III		
Mandibular Symphysis	LP	LA	LH	LP	LA	LH	LP	LA	LH
Correlation	-0,2487	-0,410	0,3416	-0,2954	-0,2743	0,0182	-0,2880	-0,3272	0,2884
Coefficients R ²	6,18	16,56	11,67	8,72	7,52	11,67	8,30	10,70	8,32
Sample size (n)	(71)	(71)	(71)	(66)	(66)	(66)	(62)	(62)	(62)
P-value	0,0365	0,0004	0,0036	0,0161	0,0258	0,8849	0,0232	0,0094	0,0230

Table 5: Correlations between the mandibular plane and the mandibular symphysis in class I, II and III.

The principal component analysis has provided three linear combinations (principal components) for the initial five variables with an eigenvalue exceeding 1.0. As a whole, these three components explained 69.69% of the data variability (Table 6 and 7).

Principal Component	Eigenvalue	Variance Percentage	Cumulative Variance %
1	1,26223	25,245	25,245
2	1,21873	24,375	49,619
3	1,00364	20,073	69,692
4	0,809006	16,180	85,872
5	0,706385	14,128	100,000

Table 6: Principal component analysis.

Component 1 (PC1): Increase in incisor inclination (IMPA) and decrease in incisor extrusion (Extrusion).

Component 2 (PC2): Decrease in bone thickness in the buccal cortex (LA) and increase in bone thickness (LH) between the apex and the cortex of the symphysis.

Component 3 (PC3): Increase the distance between the apex and the lingual cortex of the symphysis (LP).

	Component 1	Component 2	Component 3
IMPA	0,540479	-0,265856	0,539013
Extrusion	-0,606598	0,28882	0,0816498
LP	-0,350632	0,195018	0,787386
LA	-0,214766	-0,686417	0,212945
LH	0,413345	0,580261	0,193589

Table 7: Weight of principal components.

Using the PCA components, the ANOVA analysis showed statistically significant differences in PC1 ($p \leq 0.001$), PC2 ($p = 0.0016$) and PC3 ($p = 0.005$) (Figure 6, 7, 9-11).

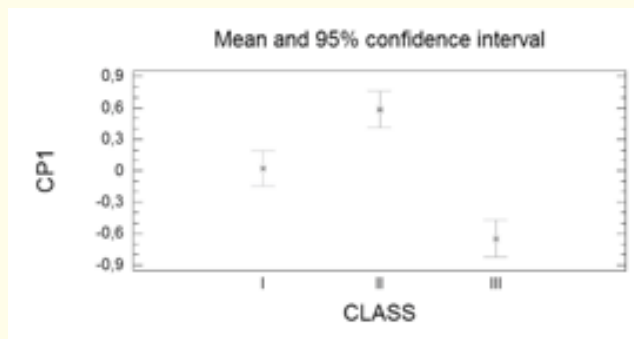


Figure 6: Average value for principal component 1 (PC1) in class I, II and III.

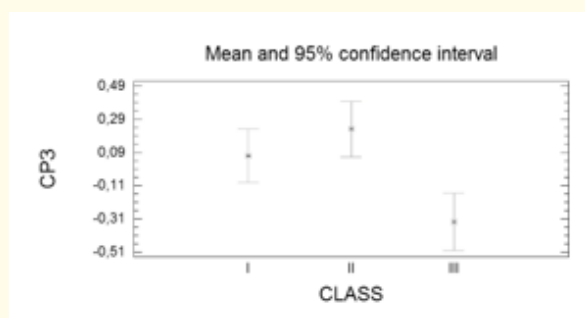


Figure 7: Average value for principal component 3 (PC3) in class I, II and III.

In figure 8, the observed dispersion of class II subjects was different than in class I and III subjects, placing them towards positive PC1 values. According to PC3, class I and II malocclusion subjects showed dispersion towards more positive values. Observed dispersion among class III subjects placed them towards negative PC1 and PC3 values.

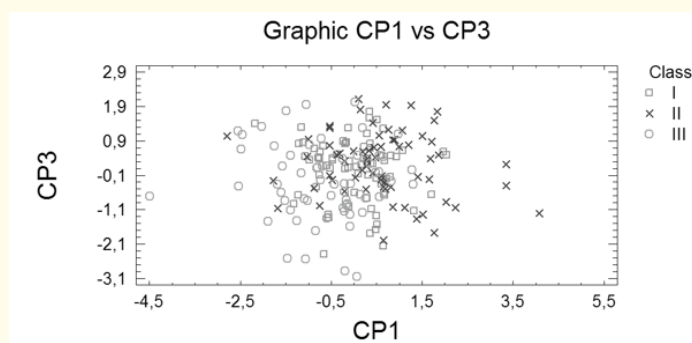


Figure 8: Principal component 1 (PC1) and 3 (PC3) in class I, II and III.

As per PC1 (Figure 9), significant differences can be observed: Class II malocclusion patients showed a progressive increase in PC1 values from short faces to long faces. Class I patients showed a similar pattern but with lower values. On the contrary, in class III malocclusion subjects, the three facial patterns behaved very similarly as all subjects showed negative PC1 values: smaller IMPA and more significant extrusion.

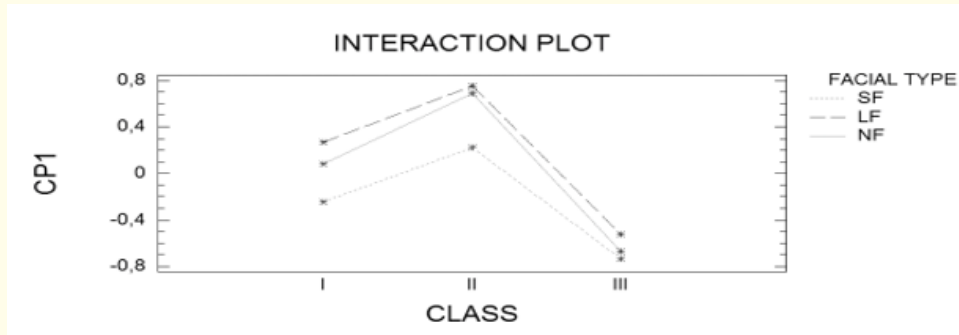


Figure 9: Interactions among class I, II and III and vertical facial types: (SF) short, (LF) long and (NF) normal according to principal component 1 (PC1).

As per PC2 (Figure 10), in class II malocclusion subjects, the three facial patterns behave similarly. On the contrary, in class I and III malocclusions, significant differences were observed among short and long faces. In short faces there was a tendency towards negative values (decreased LH and increased LA), mainly in class I malocclusion subjects. In long faces it was found the opposite, a tendency towards positive values (increased LH and decreased LA), mainly in class III malocclusion subjects. In normal faces, similar behavior was found for class I, II and III malocclusion subjects.

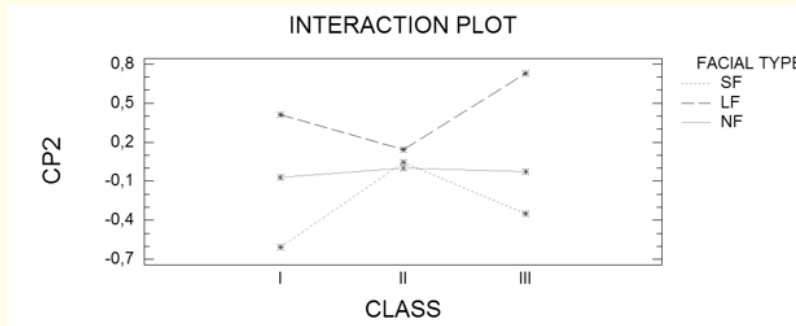


Figure 10: Interactions among class I, II and III and vertical facial types: (SF) short, (LF) long and (NF) normal according to principal component 2 (PC2).

As per PC3 (Figure 11), significant differences can be observed among malocclusions and faces: In class II malocclusion subjects, there is a marked tendency to decrease PC3 values when lower facial height increases. Class I showed a similar trend, with more negligible differences among the three facial patterns. In class III malocclusion subjects, normal and short faces had negative values and were very similar for PC3, while the longer face moved towards the most negative values in the graph.

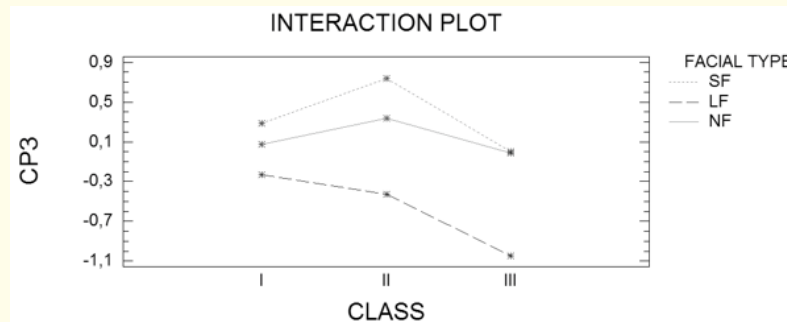


Figure 11: Interactions among class I, II and III and vertical facial types: (SF) short, (LF) long and (NF) normal according to principal component 3 (PC3).

Discussion

This study revealed some differences in the behavior of the position and inclination of the lower incisors and the shape and size of the mandibular symphysis when class II malocclusion patients were compared with matched class I and class III malocclusions patients. Understanding these patterns helps the clinicians be aware of the natural compensation mechanisms. The clinical relevant question becomes: if those compensations were removed, how would the increased OJ and OB be solved.

The inclination of the lower incisor appears to be strongly associated with the sagittal malocclusion pattern, as suggested before [2,15]. The IMPA in class II division 1 malocclusion exceeded 93°, while in class III malocclusions, the average value was 81°. But when related to the facial pattern, in class II division 1 malocclusion, the increase of the mandibular plane entailed a decrease in inclination and extrusion of the lower incisor. Esenlik [9] in a study of class II division 1 lateral cephalogram, reported that this malocclusion entailed vertical dysplasia in its etiology [16]. A lower incisor extrusion limitation could be related to the lingual and labial interposition on the incisal edge, which prevents the eruption capacity from being further expressed when the face is lengthened [10].

Different studies [17,18] argued that, during craniofacial growth, the inclination of the lower incisors could affect the morphology of the symphysis. There is an associated remodeling on the external surface that follows the apex of the lower incisor. Our results agree. Class II division 1 malocclusion was the group with the lowest LA. When the lower incisor was more proclined, the adjacent alveolar bone curved following the apex. On the contrary, the class III malocclusion group, with retroclined incisors, was the group with the lowest LP.

Our results also indicate that, in both class II division 1, class I, and class III malocclusions, the increase of the mandibular plane leads to a decrease in LA and LP so that mandibular symphysis becomes narrower. This data is consistent with Handelman [5] and Yu [23] where the narrowest symphysis is observed in protrusions and class III long face malocclusions.

From the vertical point of view, the data obtained are consistent with previous publications [19-21] stating that the morphology of the mandibular symphysis varies according to vertical skeletal malocclusion trends. There are defined patterns: hypodivergent facial types with broad and shortened symphysis or hyperdivergent facial types with thin and elongated symphysis. Although this vertical pattern is maintained in class II malocclusions, there are hardly any differences between them as both the long face and the short face show very similar values. Recent studies have differentiated the expression mechanism of height, thickness and size in the mandibular symphysis. Although dentoalveolar compensation, mandibular rotations and age-related changes are already known, their observations highlight the role of mastication and transmission of forces through the mandibular symphysis as part of the functional selection [22]. In this sense,

we observed that the length of the symphysis (LH) had a different behavior for class II division 1 malocclusion compared to class I and III malocclusions. An increase in the mandibular plane leads to an increase in LH for class I and III malocclusions, while in class II division 1 malocclusion, LH does not vary. This fact can be explained because the basal bone of the symphysis region shows adaptive alterations to achieve skeletal-neuro-balance in the craniofacial complex due to the presence of incisal contact [3,4] but this compensatory elongation is limited in class II division 1. In class II division 1 malocclusion, loss of incisal contact due to retroposition jaw may inhibit the mastication load. Therefore, loss of long-term function may cause stagnation in the vertical dimension development of the alveolar bone region.

In prior related publications [6,16-20] their statistical analyses sought differences between different malocclusion types but did not concurrently evaluate to what extent the symphysis dimensions were related to variations in the position of the incisor and the skeletal pattern. In our work, we have applied the PCA technique that has allowed us to understand the mechanism of dentoalveolar compensation.

Conclusion

1. In class II division 1 malocclusion, the lower incisor was proinclined. Increased mandibular plane angulation decreased inclination and extrusion values for the lower incisors. There is an associated remodeling on the external surface that follows the apex of the lower incisor and class II division 1 malocclusion was the group with the lowest LA.
2. Regarding PC2 (LA and LH), in class II division 1 malocclusion, all facial patterns showed a similar pattern.
3. Regarding PC3 (LP), in class II division 1 malocclusion were identified, symphysis of small morphology (reduced LP) in long faces or large morphology (increased LP) in normal and short faces.
4. Dentoalveolar compensation of class II division 1, behave differently than class I and III malocclusions regarding vertical facial patterns. In long-face there was no vertical elongation of the symphysis.

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