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Dental and Skeletal Relationships in Subjects with Class III Malocclusions

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ABSTRACT

The objective of this study is to determine dental and skeletal relationships and growth patterns in a Croatian population with Class III malocclusions by cephalometric radiographic methods (focusing on differences between maxillary retrognathism and mandibular prognathism). The examined sample consisted of pretreatment lateral cephalometric records of 201 (111 females and 90 males) untreated Class III patients of Caucasian Croatian ancestry from the Department of Orthodontics at Zagreb University. The measurements were divided into seven categories for analysis: cranial base, maxillary, mandibular skeletal relationships variables, intermaxillary, dentoalveolar, vertical and soft tissue profile facial relationships. To determine the vertical growth pattern Bjork-Jarabak analysis and ratio between nasion-sella and menton-gonion (N-S/Me-Go) were used. Maxillary retrognathism was associated with shorter maxilla (Co-A), shorter length (Go-Gn), height (Ar-Go) and diagonal of the mandible (Co-Gn), larger mandible angle (Me-Go-Ar) and a more pronounced vertical growth pattern. A significant feature of mandibular prognathism is more pronounced proclination of the maxillary incisors. The results of the present study show that maxillary retrognathism is more often associated with a vertical growth pattern, which is not favorable for therapy with a protraction face mask.

Keywords: class III, mandibular prognathism, maxillary retrognathism, growth pattern.

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INTRODUCTION

Individuals with Class III malocclusion may have various combinations of skeletal and dentoalveolar components. There are complex interactions of genetic and environmental factors that can act synergistically, in isolation, or in opposition.[1] Consequently, its etiologic diversity is a complicating factor for diagnosis and treatment planning. Accurate diagnosis of skeletal and dental components of a given malocclusion is essential in determining the proper approach and treatment timing.[2]

There are six different types of class III problems depending on the anteroposterior position of the maxilla and mandible: mandibular prognathism with normal maxilla, maxillary retrognathism with normal mandible, normal maxilla and mandible, maxillary retrognathism with mandibular prognathism, bimaxillary prognathism and bimaxillary retrognathism.

The vertical growth pattern in class III patients is a very important factor to be considered. Reduced lower anterior facial height, deep overbite and passive lip seal associated with a Class III malocclusion have a better prognosis because treatment-induced backward rotation of the mandible will assist in camouflaging the antero-posterior (AP) discrepancy. When increased lower anterior facial height is associated with this malocclusion, orthognathic surgery is usually the treatment of choice because any orthodontically induced mandibular clockwise rotation will increase the vertical facial dimension and consequently cause lip incompetence.[3]

The prevalence of Class III malocclusion varies among different ethnic groups. In Asian societies, the frequency of Class III malocclusions is higher due to a large percentage of patients with maxillary deficiency.[4] Chinese and Malaysian populations showed a relatively high prevalence: 15.69% and 16.59%, respectively. Most of the African population showed a relatively low prevalence. Recent studies showed a range of 2% to 6% among European countries.[5]

The aim of this study was to determine dental and skeletal relationships and growth pattern in a Croatian population with Class III malocclusions by cephalometric radiographic methods (focusing on differences between maxillary retrognathism and mandibular prognathism) in order to give the best possible therapy.

MATERIALS AND METHODS

Sample

The present retrospective study consisted of 201 patients with a class III malocclusion (90 male and 111 female; aged 12-20 years; mean age 15±3 years). The sample was obtained from the archives of the Department of Orthodontics, Dental Clinic, Clinical Hospital Center Zagreb, Croatia. More than one thousand patient files were reviewed.

The inclusion criteria were as follows: (1) high quality of pretreatment lateral cephalograms, (2) age between 12 and 20 years, (3) Croatian ethnicity, (4) ANB angle less than 0.5°, (5) Wits appraisal of less than 0 mm for girls and less than: -1 mm for boys.

The norm of the ANB value was derived from a previous study on subjects of Croatian ethnicity with normal occlusion.[6]

Patients who exhibited an anterior mandibular shift, craniofacial syndromes, clefts, trauma, hypodontia and who had already received orthodontic therapy were excluded.

The ethics Committee of the School of Dental Medicine approved this study, as the patients were examined for routine diagnostic needs and future orthodontic treatment planning. All patients or their parents (if the patients were under 18) signed an informed consent form authorizing the use of their radiograms.

Cephalometric analysis

Lateral cephalograms were obtained under standardized conditions: in the maximal intercuspal position, with the head in the natural position and using ear rods for stabilization (median plane focal distance: 1.55 m; detector to midsagittal distance: 0.125 m). Two devices were used. Twenty cephalograms were taken with a Planmeca PM 2002 CC Proline (Planmeca, Helsinki, Finland). These analog cephalograms were digitized using a Scan Maker i900 (Microtek, Willich, Germany). Another 181 cephalograms were stored on a CD-ROM in digital format and were taken with an Orthopantomograph OP200D (Instrumentarium Oy, Tuusula, Finland) with an average exposure time of 10 seconds and at values of 85 kV – 13 mA.

Cephalometric analysis was performed with DOLPHIN IMAGE software (v.11.0). To prevent magnification error and to calibrate each cephalogram in the DOLPHIN software to obtain real linear values, pictures were taken with a metal calibration ruler incorporated in the cephalostat and two ruler points reproduced on the headfilm.

On each cephalogram, eighteen cephalometric landmarks, representing hard and soft tissues, were identified (**Figure 1**). From these landmarks, 43 angular and linear measurements were recorded and analyzed. The measurements were divided into seven categories for analysis: cranial base, maxillary, mandibular, intermaxillary, dentoalveolar, vertical and soft tissue profile facial relationships (**Figure 2**). To determine the vertical growth pattern Bjork-Jarabak analysis and N-S/Me-Go were used. If at least two parameters indicated the same growth pattern, the patient was classified in that category.

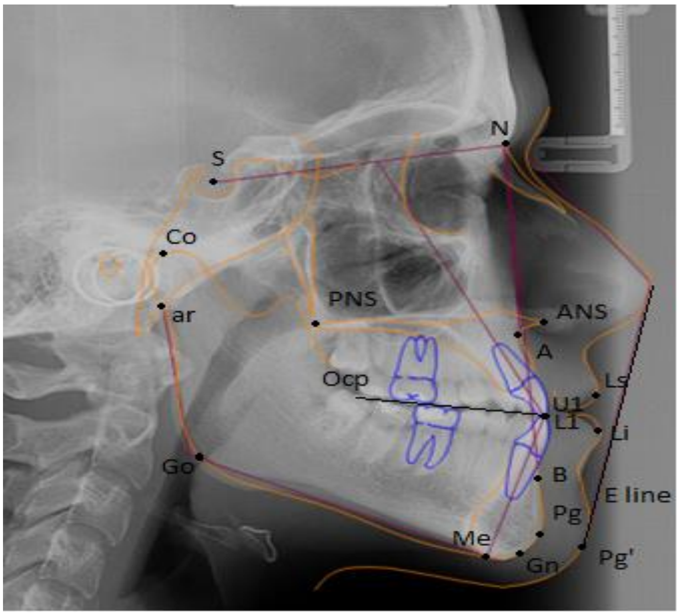

Figure 1. Landmarks used in the study: S indicates Sella; N, nasion; ar, articulare; Co, condilion; A, point A (subspinale); B, point B (supramentale), ANS, anterior nasal spine; PNS, posterior nasal spine; Gn, gnathion; Go, gonial intersection; Pg, pogonion; Me, menton; Ocp, occlusal plane; U1, tip of the upper central incisor; L1, tip of the lower central incisor; Ls, labrale superius; Li, labrale inferius; Pg', soft tissue pogonion; E line, the line connecting pronasale and soft tissue pogonion

Cranial base
Linear: S-N, S-ar
Angular: N-S-ar
Maxillary skeletal relationships variables
Linear: Co-A
Angular: SNA, S-N:ANS-PNS
Mandibular skeletal relationships variables
Linear: Co-Gn, ar-Go, Go-Gn
Angular: SNB, S-N-Pg, Me-Go-ar, Me-Go:S-N, A-ar-Go
Intermaxillary relationships variables
Linear: (Co-Gn)-(Co-A), Wits

Angular: ANB, ANS-PNS:Me-Go, OcP:S-N, OcP:ANS-PNS, OcP:Me-Go, N-A-Pg
Vertical relationships
Linear: N-ANS, ANS-Me, N-Me, S-Go
Ratio: S-Go:N-Me (%)
Dental measurements
Linear: U1:N-A, L1:N-B, overjet
Angular: U1:S-N, L1:S-N, L1:Me-Go, U1:ANS-PNS, U1:L1
Soft tissue profile
Linear: Ls-E line (Prn'-Pg'), Li-E line, Ls-U1, Li-U1, Pg-Pg'
Angular: nasolabial angle, mentolabial angle, Holdaway angle (N-B:Pg'-Ls)

Figure 2. Seven categories for the analysis

Statistical analysis

Statistical analyses were performed with Statistical Package for Social Sciences software (version 10.0, SPSS, Chicago, SAD). The level of significance was set at P-values of < .05. Normality of distribution was verified using the Kolmogorov-Smirnov and Shapiro-Wilk tests.

For variables that were normally distributed, parametric statistics were used (arithmetic mean and standard deviation). For all others, non-parametric statistics (median and interquartile range) were used. Levene's test was used to assess the equality of variances.

For comparison of categorical variables (vertical growth pattern and sagittal skeletal categories), Fisher's exact test, Pearson's chi-squared test ($\chi 2$) and Cramér's V test were used. To compare vertical and sagittal skeletal parameters and dentoalveolar and soft tissue variables between skeletal sagittal categories with normally distributed and homogenous variances, analysis of variance (ANOVA) and Student-Newman-Keuls post-hoc tests were used; for non-normally distributed variables, the Kruskal-Wallis and Mann-Whitney tests were used, complemented by the Bonferroni correction.

Pearson correlation was used for normally distributed variables and Spearman correlation was used for non-normally distributed variables to estimate connections between soft tissues, vertical and dental parameters, and sagittal linear skeletal parameters. Discriminant analysis was used to evaluate which vertical, dentoalveolar and soft tissue variables best discriminated the group of subjects classified by the most frequent sagittal skeletal relationship of maxilla and mandible. Multiple linear regression was used to estimate whether the linear values of maxilla and mandible are predictors of vertical growth pattern in Class III malocclusion.

To test the magnitude of the measurement error for the cephalometric variables in this study, the lateral cephalograms of 30 randomly selected patients were redigitized 1 month later by the same examiner and were measured again through the use of intraclass correlation coefficients (ICCs) with their respective 95% confidence intervals, measurement errors (MEs), smallest detectable changes (SDCs), limits of agreement (LoAs) and the relationship between the differences of the two measurements that were within the limits of agreement.

ME was measured according to the procedure described by Bland and Altman as the square root of the mean square error from an analysis of variance.[8]

Examiner reproducibility was substantial to excellent (ICC=0.65-1.00). Measurement error was low (0.12-3.01) and was always lower than the biological variability of the associated variables.

RESULTS

Sagittal skeletal types

The distribution of sagittal skeletal types with class III malocclusion is shown in **Figure 3**. The most frequent sagittal skeletal type observed in this class III sample was mandibular prognathism (40.80%), followed by bimaxillary normognathism (21.89%), maxillary retrognathism (18.91%) and bimaxillary prognathism

(11.94%), and less commonly, bimaxillary retrognathism (3.98%). A combination of maxillary retrognathism and mandibular prognathism was observed only in 2.49% of the patients.

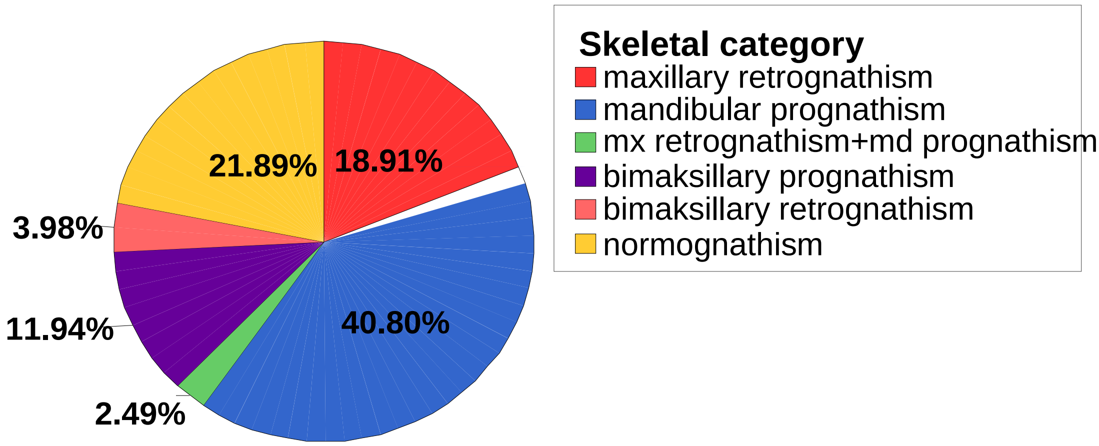

Figure 3. Distribution of sagittal skeletal types of class III malocclusion

Differences between maxillary retrognathism and mandibular prognathism

Differences in the distribution of sagittal cephalometric parameters between subjects with mandibular prognathism and maxillary retrognathism is shown in **Table 1.**

Table 1. Comparison of sagittal cephalometric parameters between skeletal sagittal categories

	skeletal category	N	arithmetic mean	standard deviation	p
n-s-ar	RETR MX	38	124.1	3.9	
	PROGN MD	82	120.3	4.8	<0.001
sna	RETR MX	38	75.4	1.7	
	PROGN MD	82	81.5	1.6	<0.001
snb	RETR MX	38	78.3	1.6	
	PROGN MD	82	83.9	1.7	<0.001
s-n-pg	RETR MX	38	79.3	1.8	
	PROGN MD	82	84.8	1.9	<0.001
s-ar-go	RETR MX	38	139.6	6.0	
	PROGN MD	82	141.3	7.1	0.191
anb	RETR MX	38	-2.9	2.4	
	PROGN MD	82	-2.4	1.9	0.294
wits	RETR MX	38	-7.3	2.7	
	PROGN MD	82	-7.2	3.1	0.853
n-a-pg	RETR MX	38	-7.9	5.2	
	PROGN MD	82	-6.8	4.5	0.231

Univariate analyses showed that maxillary retrognathism is associated with shorter maxilla (Co-A), shorter length (Go-Gn), height (Ar-Go) and diagonal (Co-Gn) of the mandible and with larger mandible angle. (**Table 2**).

Table 2. Comparison of linear cephalometric parameters between skeletal sagittal categories

	skeletal category	N	arithmetic mean	standard deviation	p
s-n	RETR MX	38	66.2	4.7	
	PROGN MD	82	66.8	4.4	0.453
s-ar	RETR MX	38	31.1	3.7	
	PROGN MD	82	31.9	3.8	0.270
n-ar	RETR MX	38	79.8	5.8	
	PROGN MD	82	79.0	5.7	0.478
co-a	RETR MX	38	75.7	5.5	
	PROGN MD	82	79.4	5.7	0.001
co-gn	RETR MX	38	113.6	9.0	
	PROGN MD	82	119.7	10.1	0.002
ar-go	RETR MX	38	42.2	4.8	
	PROGN MD	82	45.2	5.5	0.004
go-gn	RETR MX	38	73.4	5.8	
	PROGN MD	82	79.1	7.2	<0.001
cogn-coa	RETR MX	38	33.1	5.3	
	PROGN MD	82	34.9	6.3	0.121

Protrusion of the upper incisors is more pronounced in mandibular prognathism, and retrusion of the lower incisors is equal in both skeletal malocclusion types (**Table 3**).

Table 3. Comparison of dentoalveolar cephalometric parameters between skeletal sagittal categories

	skeletal category	N	arithmetic mean	standard deviation	p
u1-sn	RETR MX	38	103.0	5.7	
	PROGN MD	82	110.0	5.1	<0.001
l1-sn	RETR MX	38	59.9	5.2	
	PROGN MD	82	64.6	5.3	<0.001
l1-mgo	RETR MX	38	82.1	6.2	
	PROGN MD	82	82.1	6.0	0.970
u1-sppm	RETR MX	38	111.5	6.0	
	PROGN MD	82	117.3	5.3	<0.001
u1-l1	RETR MX	38	136.9	7.2	
	PROGN MD	82	134.6	7.2	0.116
u1-na	RETR MX	38	6.1	2.3	
	PROGN MD	82	6.1	2.1	0.920
l1-nb	RETR MX	38	2.5	1.6	
	PROGN MD	82	3.0	1.7	0.137
oj	RETR MX	38	0.0	2.4	
	PROGN MD	82	0.1	2.2	0.819

Maxillary retrognathism is associated with a more pronounced vertical growth pattern (increased Bjork, increased S-N/Me-Go, decreased Jarabak) (**Table 4**).

Table 4. Comparison of vertical cephalometric parameters between skeletal sagittal categories

	skeletal category	N	arithmetic mean	standard deviation	p
sn-sppm	RETR MX	38	8.5	3.7	
	PROGN MD	82	7.3	3.2	0.063
m-go-ar	RETR MX	38	134.3	6.5	
	PROGN MD	82	131.6	7.1	0.048
mp-sn	RETR MX	38	38.1	4.4	
	PROGN MD	82	33.3	4.9	<0.001
sppm-gom	RETR MX	38	29.5	6.0	
	PROGN MD	82	26.0	5.2	0.001
or-sn	RETR MX	38	18.5	3.0	
	PROGN MD	82	13.2	4.1	<0.001

or-sppm	RETR MX	38	10.0	4.0	
	PROGN MD	82	6.0	4.1	<0.001
or-me-go	RETR MX	38	19.6	3.9	
	PROGN MD	82	20.0	3.9	0.542
Upper facial height	RETR MX	38	49.1	4.3	
	PROGN MD	82	49.5	4.0	0.676
Lower facial height	RETR MX	38	60.4	6.4	
	PROGN MD	82	62.0	8.0	0.275
Anterior facial height	RETR MX	38	110.7	9.3	
	PROGN MD	82	111.6	10.5	0.635
Posterior facial height	RETR MX	38	68.8	6.7	
	PROGN MD	82	72.8	7.4	0.005
jarabak	RETR MX	38	62.2	3.4	
	PROGN MD	82	65.3	3.6	<0.001
bjork	RETR MX	38	398.0	4.4	
	PROGN MD	82	393.3	4.9	<0.001

In the domain of soft tissue, mandibular prognathism is associated with a thinner upper lip (p=0.032) and a lower (more acute) NL (nasolabial) angle (p=0.014) (**Table 5**).

Table 5. Comparison of soft tissue cephalometric parameters between skeletal sagittal categories

	skeletal category	N	arithmetic mean	standard deviation	p
nl	RETR MX	38	118.6	10.9	
	PROGN MD	82	113.7	9.3	0.014
ml	RETR MX	38	141.3	13.0	
	PROGN MD	82	143.2	13.5	0.472
ls-e	RETR MX	38	-6.8	2.7	
	PROGN MD	82	-6.4	2.3	0.450
li-e	RETR MX	38	-3.7	2.2	
	PROGN MD	82	-2.7	2.4	0.040
thickness of upper lip	RETR MX	38	4.5	2.5	
	PROGN MD	82	3.5	2.3	0.032
thickness of lower lip	RETR MX	38	14.0	3.3	
	PROGN MD	82	14.4	2.6	0.544
thickness of chin	RETR MX	38	12.5	2.5	
	PROGN MD	82	11.9	2.3	0.252
holdaway	RETR MX	38	3.0	4.7	
	PROGN MD	82	4.6	4.2	0.059

Other soft tissue relationships are not significantly different between the two types of class III malocclusion.

The correlations indicate that compared to maxillary retrognathism, mandibular prognathism is associated with longer maxilla (Co-A) and an effectively longer mandible (Co-Gn), a higher ramus (Ar-Go), longer corpus of mandible (Go-Gn) and a shorter facial height (Mp-Sn). (**Tables 6** and **7**).

Table 6. Point-biserial correlation between skeletal category and predictor variables: age, gender, linear values of the jaw and facial growth pattern

		skel cat (1=mx retro, 2=md pro)
age	r	0.127
	p	0.168
gender	r	-0.021
	p	0.821
co-a	r	0.296
	p	0.001
co-gn	r	0.281

	p	0.002
ar-go	r	0.260
	p	0.004
go-gn	r	0.368
	p	0.000
mp-sn	r	-0.427
	p	0.000
n-a-pg	r	0.110
	p	0.231

Table 7. Point-biserial correlation between skeletal category and predictor variables of incisor position and soft tissue

		skel cat (1=mx retro, 2=md pro)
l1-mgo	r	0.003
	p	0.970
u1-sppm	r	0.441
	p	0.000
nl	r	-0.225
	p	0.014
ml	r	0.066
	p	0.472
ls-e	r	0.070
	p	0.450
li-e	r	0.188
	p	0.040
holdaway	r	0.173
	p	0.059

For logistic regression variables that significantly correlated in point biserial correlations with a dichotomous outcome variable, skeletal category 1- maxillary retrognathism and 2-mandibular prognathism were selected. Two models of logistic regression were made, the first with all variables and the second with stepwise regression (**Table 8**). In the first model, only the rotational growth made a significant difference between the maxillary retrognathism and mandibular prognathism groups (p=0.005). In the second model, when only the variables with the strongest correlation were involved, it became evident that mandibular prognathism is associated with shorter facial height (p=0.003), greater protrusion of the upper incisors (p=0.005) and greater mandible length (p=0.002) (**Table 8**). The model correctly classified 81.7% of patients, where affiliation to their original groups retained 68.4% of the patients with maxillary retrognathism and 87.8% with mandibular prognathism.

Table 8. Logistic regression for prediction of maxillary retrognathism and mandibular prognathism

		B	standard error	p	Odds ratio	95% confidence interval	
Model 1*	mp-sn	-0.281	0.099	0.005	0.755	0.621	0.917
	u1-sppm	0.112	0.06	0.062	1.118	0.994	1.258
	nl	0.006	0.028	0.843	1.006	0.952	1.062
	li-e	0.246	0.136	0.071	1.279	0.98	1.669
	co-a	-0.157	0.103	0.129	0.855	0.698	1.047
	co-gn	0.147	0.13	0.258	1.158	0.898	1.493
	ar-go	-0.009	0.121	0.942	0.991	0.783	1.255
	go-gn	0.072	0.104	0.492	1.074	0.876	1.318
	constant	-11.803	10.375	0.255	0		
Model 2**	mp-sn	-0.177	0.059	0.003	0.838	0.746	0.941
	u1-sppm	0.145	0.052	0.005	1.156	1.045	1.28
	go-gn	0.144	0.046	0.002	1.155	1.057	1.263
	constant	-20.496	7.546	0.007	0		

*Negelkerke pseudo R2=0.532; p<0.001. 83.3% correctly classified members of the group (71.1% maxillary retrognathism i 89.0% mandibular prognathism).
**Negelkerke pseudo R2=0.480; p<0.001. 81.7% correctly classified members of the group (68.4% maxillary retrognathism and 87.8% mandibular prognathism)

Table 9. Distribution of growth pattern between maxillary retrognathism and mandibular prognathism

		Growth pattern		Total	p*
Skeletal category		Neutral or horizontal	vertical		
Maxillary retrognathism	N	16	22	38	
	%	42.1%	57.9%	100.0%	
Mandibular prognathism	N	64	18	82	
	%	78.0%	22.0%	100.0%	
Total	N	80	40	120	
	%	66.7%	33.3%	100.0%	<0.001

Fischer's exact test (Cramer's V=0.355)

DISCUSSION

Class III malocclusion is one of the most severe dentofacial anomalies. Its origin can be functional, skeletal or dentoalveolar. The skeletal manifestation can be due to mandibular anterior positioning (prognathism) or growth excess (macrognathia), maxillary posterior positioning (retrognathism) or growth deficiency (micrognathia), or a combination of mandibular and maxillary discrepancies.[9]

When treating Class III patients orthodontically, whether they are growing children or mature adults, the anteroposterior and vertical positions of facial components as well as the dental relationships must be considered so that the excess or deficiency may be treated where it actually exists.[10] The reliability of ANB relative to the jaw relationships in the sagittal plane depends on the inclination of the mandible with reference to the anterior cranial base. If the inclination of the mandible is out of the normal range, ANB is not a reliable measure of the jaw relationships in the sagittal plane.[11] This is why the Wits appraisal was also considered. It is not an analysis per se, but merely a linear measurement that assists in the interpretation of ANB and thus in the assessment of the relative jaw relationships in the sagittal plane.[12] The assessment of the anteroposterior relationships with the Wits appraisal depends mainly on the accurate definition of the occlusal plane and its inclination.[13] Stellzig-Eisenhower et al. reported that the Wits appraisal was the most discriminative in determining whether a developing Class III malocclusion should be treated by camouflage treatment or surgery.[14]

The available literature on Class III anomalies shows that the number of studies on clinical management and therapeutic outcomes clearly outweighs those focusing on the morphological and developmental aspects of these malocclusions.[15] If we focus on the morphological aspects might help us in determining the correct treatment.

Distribution of sagittal skeletal types of class III malocclusion

Mandibular protrusion was found in the majority of individuals (41%), in accord with the results of Sanborn (45.2%) and Jacobson (49%). In this study, bimaxillary normognathism was second (22%), followed by maxillary retrognathism with normal mandible (19%). The dominance of mandibular prognathism in this sample reinforces the results of previous cephalometric studies on Class I and Class III subjects in Croatian populations.[16] Although there are reports that a hypoplastic midface and poor maxillary growth, associated with a shortened anterior skull base, are the main factors involved in the development of Class III malocclusion in Asian children, a comparative analysis between Japanese subjects and American subjects with European ancestors revealed that mandibular prognathism was identified as an important component of Class III malocclusion in individuals of European descent.[17]

In our research we focused on the two main groups of Class III: mandibular prognathism and maxillary retrognathism.

Comparison of sagittal cephalometric parameters between maxillary retrognathism and mandibular prognathism

Regarding sagittal cephalometric parameters, statistically significant differences between maxillary retrognathism and mandibular prognathism were found in the following parameters: N-S-Ar, SNA, SNB and S-N-Pg ($p<0.001$). Other sagittal cephalometric parameters (S-Ar-Go, ANB, Wits, N-A-Pg) were not significantly different between the two types of class III malocclusion. (**Table 1**). These results indicated that SNA, SNB and S-N-Pg were smaller in maxillary retrognathism and N-S-Ar was larger in maxillary retrognathism. A large cranial base angle (N-S-Ar) is thought to signify a posterior condylar and glenoid fossa position and a mandible that is positioned posteriorly with respect to the cranial base and the maxilla, unless it is compensated by a larger gonial angle and increased mandibular length. Additionally, a large cranial base angle may be associated with vertical growth pattern and a posteriorly situated Ar point, which is shown in this study to dominate in maxillary retrognathism. A previous study reported that although the maxilla is connected with the cranial base's anterior part and the mandible's rotation is influenced by the maxilla, a relationship can be found between the cranial base morphology and sagittal malpositioning of the jaws.[18] Bjork et al. reported that the anterior position of the glenoid fossa relative to the cranial base could be considered an important etiologic factor of mandibular prognathism.[19-21]

Comparison of linear cephalometric parameters between maxillary retrognathism and mandibular prognathism

Maxillary retrognathism is associated with a shorter maxilla (CoA), shorter length (Go-Gn), height (Ar-Go) and diagonal (Co-Gn) of the mandible and a larger mandible angle (Me-Go-Ar) (**Table 2**). However, other linear cephalometric parameters, including the length of the anterior cranial base (S-N), the length of the posterior cranial base (S-Ar), the length between the nasion and the articulare (N-Ar) and the proportion between the maxillary and mandibular lengths (CoGn-CoA), did not show any significant difference between maxillary retrognathism and mandibular prognathism.

Comparison of dentoalveolar cephalometric parameters between maxillary retrognathism and mandibular prognathism

One of the most interesting outcomes of the present study is that retrusion of the lower incisors is equal in both skeletal malocclusion types (mandibular prognathism and maxillary retrognathism), but protrusion of the upper incisors is more pronounced in mandibular prognathism.

Dental compensation acts to camouflage anterior-posterior and vertical basal bone discrepancies in an attempt to establish a normal incisor relationship.[22,23]

Comparison of vertical cephalometric parameters between maxillary retrognathism and mandibular prognathism

Owing to a reduction of posterior facial height, maxillary retrognathism is associated with a more pronounced vertical growth pattern (increased Bjork, increased S-N/Me-Go, decreased Jarabak). In maxillary retrognathism, the occlusal plane is rotated posteriorly in relation to the cranial base and the maxilla, but it is not rotated in relation to the base of the mandible. This could be associated with the possible compensation mechanism for a reduced overjet by the downward and backward rotation of both the mandible and the occlusal plane. **Table 9** shows the distribution of growth patterns between maxillary retrognathism and mandibular prognathism. When the horizontal growth pattern was added to neutral, Fisher’s exact test indicated that the vertical growth pattern was more often associated with maxillary retrognathism than with mandibular prognathism (57.9 vs. 22%; $p<0.001$).

Comparison of soft tissue cephalometric parameters between maxillary retrognathism and mandibular prognathism

In the soft tissues, mandibular prognathism is associated with a thinner upper lip ($p=0.032$) and a lower (more acute) NL angle ($p=0.014$) (**Table 5**). However, considering other soft tissue relationships (ML angle, distance of upper and lower lip to E line, Holdaway angle), they are not significantly different between the two types of class III malocclusion.

It is likely that the distinctions between skeletal types decrease the large individual variations in treatment response in samples of Class III patients. Furthermore, this approach might facilitate the identification of predictive parameters for treatment success.[24]

Clinical investigations describe forward and downward maxillary movement, a clockwise rotation of the mandible and an increase of lower facial height as consequences of protraction face mask therapy, making class III malocclusions associated with long anterior facial height clinically the most difficult to treat orthodontically or orthopedically. Unfortunately, this study showed that patients who needed protraction face mask therapy (those with maxillary retrognathism) in majority have a vertical growth pattern, so it is doubtful that starting early with face mask therapy would be beneficial.

CONCLUSION

From the results of the present study, it was concluded that maxillary retrognathism was associated with the following:

- a shorter maxilla (Co-A);
- shorter length of the mandible (Go-Gn);
- shorter height of the mandible (Ar-Go);
- shorter diagonal of the mandible (Co-Gn);
- a larger mandible angle (Me-Go-Ar);
- a more pronounced vertical growth pattern;
- and that mandibular prognathism was associated with:
- greater length of the mandible;
- shorter facial height;
- greater protrusion of the upper incisors (U1:S-N, U1:Sp-Pm).

There are evident compensatory mechanisms as a result of skeletal discrepancies. They manifest as dentoalveolar compensation mechanisms and as a downward and backward rotation of the mandible. In contrast to maxillary retrognathism, mandibular prognathism was associated with a horizontal growth pattern as well as a more pronounced dentoalveolar compensatory mechanism, which was expressed by remarkably more protrusive maxillary incisors.

It is important to point that, to be successfully performed, diagnosis must be detailed, to evaluate, specifically, dental and facial features, as well as the limitations imposed by the magnitude of the discrepancy. Since the method of treatment between the surgical and non surgical patients is completely different, maybe these findings can help to better discern which patients are candidates for camouflage orthodontic treatment (horizontal growth pattern, protrusion of the upper incisors) and in which we will immediately decide for orthognathic surgery.

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