

## Craniofacial analysis of the Tweed Foundation in Angle Class II, division 1 malocclusion

### *Análise craniofacial da Fundação Tweed na maloclusão Classe II, divisão 1 de Angle*

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**ABSTRACT:** This study has defined the cephalometric values of the Craniofacial Analysis of the Tweed Foundation for a sample of Brazilian subjects. The sample consisted of 211 cephalometric radiographs from subjects aged 12-15, which were divided into two groups: Class II group, with 168 lateral telerradiographs (cephalograms) of white Brazilian subjects, with Angle Class II, division 1 malocclusion, of both genders (82 males and 86 females); and the Control Group, with 43 lateral telerradiographs (cephalograms) of subjects whose occlusion was clinically excellent, and also of both genders (21 males and 22 females). The telerradiographs were selected from the files of the Department of Orthodontics, School of Dentistry of Piracicaba, State University of Campinas, previously to the orthodontic treatment. The results demonstrated no sexual dimorphism for each group, as attested by the Student's *t*-test. The exploratory analysis ( $\pm 0.5$  standard deviation) enabled the tolerance limits to be determined and a Craniofacial Analysis Table to be constructed using the respective cephalometric intervals. In addition, the difference between the two groups was not statistically significant according to the maxilla position. The maxilla was in a good position in relation to the cranial base. On the other hand, the mandible was retruded in relation to the cranial base in the Class II cases. The skeletal pattern was not defined because only the Facial Height Index (FHI) showed a vertical pattern in Class II subjects, while the Y Axis, SN.PIO, SN.GoMe and FMA values did not show any statistically significant difference between the groups. The Class II division 1 subjects showed lower incisors more labially tipped and a convex facial profile.

**DESCRIPTORS:** Malocclusion, Angle Class II; Cephalometry; Diagnosis.

**RESUMO:** A pesquisa definiu os valores cefalométricos da Análise Craniofacial da Fundação Tweed em amostra de brasileiros. O estudo constava de 211 telerradiografias tomadas previamente ao tratamento ortodôntico de indivíduos na faixa etária de 12 a 15 anos, as quais foram divididas em dois grupos: o Grupo Classe II, com 168 telerradiografias registradas em norma lateral de indivíduos leucodermas, maloclusão Classe II, divisão 1 de Angle, de ambos os gêneros (82 do gênero masculino e 86 do feminino); e o Grupo Controle, com 43 telerradiografias registradas em norma lateral de indivíduos com oclusão clinicamente excelente, também de ambos os gêneros (21 do gênero masculino e 22 do feminino). As telerradiografias foram selecionadas no arquivo da Disciplina de Ortodontia da Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas. Os resultados demonstraram não existir dimorfismo sexual dentro de cada grupo, comprovado pelo Teste *t* de Student. A análise exploratória ( $\pm 0,5$  desvio padrão) tornou possível a determinação dos limites de tolerância e a elaboração de uma Tabela da Análise Craniofacial com os respectivos intervalos cefalométricos. Observou-se que não houve diferença significativa na posição de maxila entre os grupos estudados, ou seja, a maxila apresentou-se bem posicionada em relação à base do crânio. Por outro lado, a mandíbula apresentou-se retruída em relação à base do crânio nos casos de Classe II. O padrão esquelético não ficou definido, pois somente o IAF apresentou um padrão vertical na Classe II, enquanto os valores de Eixo Y, SN.PIO, SN.GoMe e FMA não apresentaram diferença significativa entre os grupos estudados. A Classe II divisão 1ª apresentou os incisivos inferiores mais inclinados para vestibular e o perfil facial convexo.

**DESCRIÇÕES:** Maloclusão de Angle Classe II; Cefalometria; Diagnóstico.

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## INTRODUCTION

The process of judgment of an existent problem is called diagnosis and depends on the largest possible quantity of collected data. The orthodontic diagnosis of malocclusion also depends on early correct detection and it is a fundamental point for the treatment planning.

Therefore, the establishment of any orthodontic treatment is marked by the identification of present abnormalities, and similar problems are frequently systematized for convenience purposes. This procedure, called classification, has always been one of the great challenges in the history of Orthodontics. Angle<sup>1</sup> (1907) classified the malocclusions based on occlusal relationships, considering the first permanent molar as the “key” of occlusion.

In 1966, Merrifield<sup>8</sup> developed a specific guide to analyze the patient’s facial profile, introducing a profile line, tangent to the soft chin and the most protuberant point on the lip, which he denominated the “Z line”. That line was extended to the horizontal Frankfort plane so as to compose the Z angle. The author observed that the Z angle presented a medium value of 80° for adults and 78° for subjects from 11 to 15 years of age, with harmonic faces and normal values of FMA, FMIA and IMPA.

Soon after that, Merrifield, Gebeck<sup>9</sup> (1989) analyzed the dimensions of the lower face in comparison with the “anterior facial height” (AFH) and “posterior facial height” (PFH). They demonstrated that the success in the correction of Class II malocclusion depended on the control of the anterior and posterior facial heights; in other words, it depended on the control of the vertical dimension<sup>16</sup>.

Horn<sup>4</sup> (1992) proposed the facial height index (FHI) during the orthodontic treatment, in order to establish a relationship between AFH and PFH. A balanced FHI ratio should present values between 0.65 and 0.75.

In an attempt to improve the diagnostic and prognostic tools, Gramling<sup>3</sup> (1995) used five cephalometric measurements – FMA, ANB, occlusal plane inclination, FMIA and SNB – to determine the “probability index”, which suggested mean values for the treatment success. Hence, FMA should have 20° to 30°; ANB, 6° or less; the occlusal plane, 7° or less; FMIA, 60° or more; and SNB, 80° or more.

Angle Class II, division 1 malocclusion represents the second most prevalent malocclusion in the Brazilian population, according to Nouer<sup>13</sup> (1966) and Silva Filho *et al.*<sup>15</sup> (1989). However, the

simple definition of Class II, division 1 malocclusion is too broad, since it comprises an enormous variety of dental and skeletal disturbances, with only one common feature: the Class II molar and canine relationships<sup>6,7,11,14,17,18</sup>. For this reason, it is quite difficult for beginners in orthodontics to identify the dentoskeletal components implicated in this type of malocclusion<sup>2,12</sup>.

Searching for a larger number of significant data for the success of diagnosis and treatment planning has been a constant challenge. In this process, a differential diagnosis analysis system was developed by researchers of the “Charles Tweed International Foundation”<sup>10</sup>. This diagnosis protocol consists of facial, skeletal pattern, and dental analyses, allowing the orthodontist to determine the area showing greater disharmony and also supplying professionals with a strategic treatment guide.

The Differential Diagnosis System for Craniofacial Analysis of the Tweed Foundation comprises six cephalometric measurements with quite significant individual values. To each cephalometric measurement was given a numerical value, named “difficulty factor”. Thus it is possible to determine for each patient the degree of cephalometric difficulty for his/her orthodontic treatment.

The objective of this study was to compare a group of subjects with Angle Class II, division 1 malocclusion with a control group with excellent occlusion, applying the differential diagnosis system for Craniofacial Analysis of the Tweed Foundation in lateral cephalometric radiographs. The study also attempted to determine the tolerance intervals of the cephalometric variables of Craniofacial Analysis for Brazilian subjects, allowing a more reliable calculation of the index of difficulty, and to analyze the different behavior of the structures involved among the groups, and the presence of sexual dimorphism.

## MATERIAL AND METHODS

The sample of this study was composed of 211 lateral radiographs taken before the orthodontic treatment of white Brazilian subjects, ages ranging from 12 to 15 years, selected from the patient files of the Discipline of Orthodontics, School of Dentistry of Piracicaba, State University of Campinas. Selection of the Angle Class II malocclusion sample was based on skeletal aspects – ANB angle – and a full Class II molar and canine relationship observed in dental cast examinations.

The sample was divided into two different groups: the Class II Group, with 168 radiographs

of both genders (82 males and 86 females), and the Control Group, with 43 radiographs (21 males and 22 females) of subjects with clinically normal occlusion. This study was approved by the Research Ethics Committee, School of Dentistry of Piracicaba, 9912000 protocol number, according to the CNS 196/96 Resolution, National Council of Health, dated 10/10/1996.

The anatomical structures of the skull and face were delimited, and a single examiner in a dark room drew the lines and plans to obtain the cephalometric landmarks (Figure 1).

The analysis of errors in orthodontic measurements used in the present study was calculated according to Houston<sup>5</sup> (1983). The measurements of 30 records from the main series were replicated and drawn at random and were measured under the same conditions by the same examiner after a 30-day period. Systematic and random errors were evaluated separately by means of repeatability and reproducibility analysis (Gage R&R), which studies the amount of variation in the measurement system. The results were given as a percentage (Table 1).

The chi-squared test showed a descriptive level of 0.9987, which means that both groups were equivalent (Table 2).

The differential diagnosis system for Craniofacial Analysis of the Tweed Foundation comprises six cephalometric variables, and it was based on

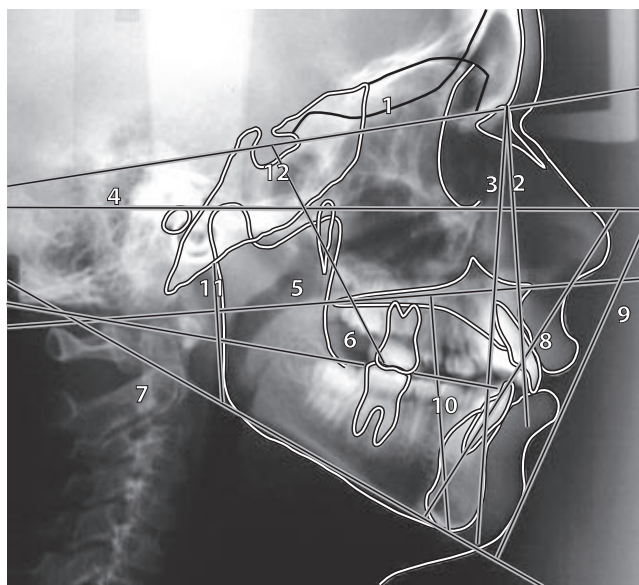
the studies of Gramling<sup>3</sup> (1995), Merrifield, Gebeck<sup>9</sup> (1989) and Horn<sup>4</sup> (1992). This analysis defines the "index of difficulty" of the patient's treatment in function of these cephalometric variables. Therefore, when those values are out of the interval that is suggested in the table, the difference is multiplied by the existent numerical value, defining the Craniofacial Difficulty. As a result, it is possible to perform a unique calculation for each patient and to visualize the treatment prognosis (Table 3).

The mean and the standard deviation of each cephalometric variable in the samples of Angle Class II, division 1 patients (Class II Group), and normal occlusion (Control Group) subjects were calculated.

To verify the existence of sexual dimorphism between the means of the variables observed in both genders, the Student's *t*-test was applied separately to each group, with a level of significance of 5% and 1% (Tables 4 and 5).

Again, the Student's *t*-test was applied to the variables of the groups to verify the existence of significant difference between the individuals with Class II, division 1 malocclusion and the subjects with normal occlusion (Table 6). The gender was not considered because it was already known that there was no significant difference between genders.

An exploratory analysis based on the mean  $\pm$  0.5 standard deviation was also per-



**FIGURE 1** - Cephalometric landmarks. 1. SN line, 2. NA line, 3. NB line, 4. Frankfort plane, 5. Palatine plane, 6. Occlusal plane, 7. Mandibular plane, 8. Lower incisor line, 9. Profile line, 10. Anterior facial height, 11. Posterior facial height, 12. Y Axis.

**TABLE 1** - Systematic and random errors.

Variables	Repeatability and reproducibility analysis	P/T%
FMIA	0.28868	4.25
IMPA	0.2582	3.43
Z Angle	0.2582	3.29
Y AXIS	0.2582	8.26
SNA	0.2582	8.65
SNB	0.2236	7.94
ANB	0.2887	13.17
Occlusal Plane	0.2887	8.80
AFH	0.1826	5.31
PFH	0.0000	0.00
FHI	0.0013	1.97
SN.GoMe	0.3416	6.91
FMA	0.2500	16.24

P/T: variation of the analysis.

**TABLE 2 -** Distribution of groups (%).

Gender	Age (years)	Control	Class II
Male	12-13	21.4	22.0
	13-14	16.7	15.5
	14-15	11.9	11.3
Female	12-13	19.0	22.0
	13-14	16.7	16.1
	14-15	14.3	13.1
Total		100.0	100.0

**TABLE 3 -** Differential Diagnosis System for Craniofacial Analysis of the Tweed Foundation.

Normal pattern	Cephalometric Value	Difficulty Factor	Difficulty Index
FMA (22°-28°)		5	
ANB (1°-5°)		15	
Z Angle (70°-80°)		2	
Occlusal Plane (8°-12°)		3	
SNB (78°-82°)		5	
FHI (0.65-0.75)		3	

formed for all the considered variables, in both the Class II Group and the Control Group. Based on the means  $\pm$  0.5 standard deviation, the lower limit of tolerance (LLT) and the upper limit of tolerance (ULT) were obtained, and constituted the tolerance intervals (Table 7). By means of these tolerance intervals, a customized table of Craniofacial Analysis of the Tweed Foundation was built (Table 8).

## RESULTS

Except for the mean value of PFH in the Class II Group, the comparison among the mean values, which was obtained for both genders and all ages, did not show significant difference in the Class II Group or in the Control Group (Tables 4 and 5).

The difference between the groups was not significant when the variables Y-Axis, SNA, occlusal plane angle, AFH, SN.GoMe and FMA were compared (Table 6).

In Table 7, the values obtained for the two groups for the tolerance interval are presented.

**TABLE 4 -** Comparison between genders for data of the Class II Group.

Variables	Males	Females	t-test	p-value
FMIA (°)	58.80	59.05	-0.22	0.82 (NS)
IMPA (°)	94.68	94.10	0.54	0.59 (NS)
Z Angle (°)	68.11	68.76	-0.54	0.59 (NS)
Y AXIS (°)	58.66	59.03	-0.67	0.50 (NS)
SNA (°)	83.67	83.63	0.06	0.95 (NS)
SNB (°)	78.40	78.34	0.11	0.91 (NS)
ANB (°)	5.27	5.56	-0.80	0.42 (NS)
Occlusal Plane (°)	6.02	5.61	0.50	0.62 (NS)
AFH (mm)	66.84	64.02	-0.54	0.59 (NS)
PFH (mm)	43.76	41.59	2.67	0.01 (**)
FHI	0.65	0.64	0.38	0.70 (NS)
SN.GoMe (°)	35.41	36.22	-1.03	0.31 (NS)
FMA (°)	26.54	26.77	-0.30	0.77 (NS)

(\*\*) - significant at 1%; (NS) - no significant difference.

Based on the tolerance limits, the intervals for cephalometric variables used in the Craniofacial Analysis for a Brazilian sample were determined (Table 8).

## DISCUSSION

The present study analyzed the behavior of the angular and linear measurements of the Differential Diagnosis System for Craniofacial Analysis of the Tweed Foundation, determining more adequate values for the Brazilian population. For such reason, we will discuss the cephalometric variables obtained in this study for the development of a Craniofacial Analysis Table for a Brazilian sample<sup>4,8,10</sup>, and also discuss the behavior of the comprised structures, when the Angle Class II, division 1 group is compared with the normal occlusion group.

FMA is considered the most important angle of Tweed triangle, because it represents the skeletal pattern of the face. The ideal mean value of FMA, according to Tweed<sup>16</sup> (1962), should be of 25°, varying from 22° to 28°. The mean value found in the Class II Group was 26.66° (interval from 24.12° to 29.21°), while in the Control Group it was 25.12° (interval from 23.75° to 26.49°). Both groups showed mean values close to normal, and they did not present significant statistical difference. The same was observed with the values of the angle of the “Y Axis” and of the SN.GoMe angle (Table 6). Therefore, it was observed that the skeletal pattern of the Class II Group presented the

**TABLE 5** - Comparison between genders for data of the Control Group.

Variables	Females	Males	t-test	p-value
FMIA (°)	62.91	62.95	-0.05	0.96 (NS)
IMPA (°)	92.41	91.48	1.08	0.29 (NS)
Z Angle (°)	77.36	77.48	-0.11	0.92 (NS)
Y AXIS (°)	57.68	58.29	-0.85	0.40 (NS)
SNA (°)	82.55	82.38	0.53	0.60 (NS)
SNB (°)	80.32	80.29	0.10	0.92 (NS)
ANB (°)	2.41	2.24	0.62	0.54 (NS)
Occlusal Plane (°)	7.55	7.29	0.43	0.67 (NS)
AFH (mm)	65.73	66.43	-0.77	0.45 (NS)
PFH (mm)	46.50	47.19	-0.64	0.52 (NS)
FHI	0.70	0.70	0.10	0.92 (NS)
SN.GoMe (°)	35.82	32.33	1.62	0.11 (NS)
FMA (°)	24.68	25.57	-1.07	0.29 (NS)

(NS) - no significant difference.

**TABLE 6** - Result of the Student's t-test between Class II and Control Groups.

Variables	Class II	Control	t-test	p-value
FMIA (°)	58.93	62.93	-3.68	0.00 (**)
IMPA (°)	94.38	91.95	2.26	0.02 (*)
Z Angle (°)	68.44	77.42	-7.32	0.00 (**)
Y AXIS (°)	58.85	57.98	1.51	0.13 (NS)
SNA (°)	83.65	82.47	1.79	0.07 (NS)
SNB (°)	78.37	80.30	-3.62	0.00 (**)
ANB (°)	5.42	2.33	8.36	0.00 (**)
Occlusal Plane (°)	5.81	7.42	-1.92	0.06 (NS)
AFH (mm)	65.43	66.07	-0.68	0.49 (NS)
PFH (mm)	42.64	46.84	-4.86	0.00 (**)
FHI	0.64	0.70	-5.17	0.00 (**)
SN.GoMe (°)	35.83	34.12	1.80	0.07 (NS)
FMA (°)	26.66	25.12	1.91	0.06 (NS)

\*\* - significant at 1% (p < 0.01); \* - significant at 5% (p < 0.05); (NS) - no significant difference.

**TABLE 7** - Upper and lower limits of tolerance (ULT and LLT), calculated from the mean values (M) ± 0.5 standard deviation (SD), for the Class II Group and the Control Group, with all the studied variables.

Variables	Class II Group				Control Group				LLT	ULT
	Mean	SD	M - 0.5SD	M + 0.5SD	Mean	SD	M - 0.5SD	M + 0.5SD		
FMIA (°)	58.93	6.98	55.44	62.42	62.93	2.78	61.54	64.32	55.44	64.32
IMPA (°)	94.38	6.90	90.93	97.83	91.95	2.84	90.53	93.37	90.53	97.83
Z Angle (°)	68.44	7.84	64.52	72.36	77.42	3.43	75.71	79.14	64.52	79.14
Y AXIS (°)	58.85	3.62	57.04	60.66	57.98	2.32	56.82	59.14	56.82	60.66
SNA (°)	83.65	4.30	81.50	85.80	82.47	1.01	81.97	82.98	81.50	85.80
SNB (°)	78.37	3.44	76.65	80.09	80.30	1.08	79.76	80.84	76.65	80.84
ANB (°)	5.42	2.38	4.23	6.61	2.33	0.89	1.89	2.78	1.89	6.61
Occlusal Plane (°)	5.81	5.41	3.11	8.52	7.42	1.94	6.45	8.39	3.11	8.52
AFH (mm)	65.43	5.97	62.45	68.42	66.07	2.97	64.59	67.56	62.45	68.42
PFH (mm)	42.64	5.38	39.95	45.33	46.84	3.49	45.10	48.59	39.95	48.59
FHI	0.64	0.07	0.61	0.68	0.70	0.04	0.68	0.72	0.61	0.72
SN.GoMe (°)	35.83	5.09	33.29	38.38	34.12	7.19	30.53	37.72	30.53	38.38
FMA (°)	26.66	5.09	24.12	29.21	25.12	2.74	23.75	26.49	23.75	29.21

same cephalometric characteristics as that of the Control Group; in other words, The Class II Group presented a balanced skeletal pattern<sup>14</sup>.

On the other hand, the Facial Height Index (FHI)<sup>4,9</sup>, which also determines the skeletal pattern, presented a mean value of 0.64 (interval from 0.61 to 0.68) for the Class II Group and of 0.70

(interval from 0.68 to 0.72) for the Control Group, with a significant difference between both values. This corroborates the concept that the Class II Group presented a more vertical skeletal pattern. The Facial Height index is established according to the relationship between the posterior facial height (PFH) and the anterior facial height (AFH).

**TABLE 8** - Table of the Craniofacial Analysis with values and intervals developed for the Brazilian sample.

Normal pattern	Cephalometric Value	Difficulty Factor	Difficulty Index
FMA (23.75°-29.21°)		5	
ANB (1.89°-6.61°)		15	
Z Angle (64.52°-79.14°)		2	
Occlusal Plane (3.11°-8.52°)		3	
SNB (76.65°-80.84°)		5	
FHI (0.61 - 0.72)		3	

Therefore, the mean value for PFH of 42.64 mm (interval from 39.95 mm to 45.33 mm) could have caused the decrease of the value for FHI in this group, and, as a consequence, it would determine a more vertical pattern for the individuals with Class II, division 1 malocclusion<sup>6,7,11,17</sup>.

The occlusal plane angle was defined as a function of the Frankfort horizontal plan, and in this study it presented a mean value of 7.42° (interval from 6.45° to 8.39° counterclockwise) for the Control Group and a mean value of 5.81° (interval from 3.11° to 8.52° counterclockwise) for the Class II Group. We observed that the values of this measurement for both groups were not significantly different (Table 6), although these values were smaller than the mean value of 10° with an interval from 8° to 12° recommended by the Tweed Foundation<sup>3</sup>.

The FMIA angle is also part of the Tweed triangle, representing a more balanced face when a value of 68° is observed<sup>16</sup>. The present study showed a mean value of 58.93° (from 55.44° to 62.42°) for the Class II Group, and of 62.93° (from 61.54° to 64.32°) for the Control Group. The values of FMIA for both groups presented significant difference, indirectly demonstrating that the lower incisors presented a more buccal inclination in the Class II Group when compared with the Control Group<sup>6,7,12,18</sup>.

The mean value observed for SNA was 82.47° (interval from 81.97° to 82.98°) for the Control Group, and 83.65° (interval from 81.50° to 85.80°) for the Class II Group. Thus, the maxilla did not present a significant difference between both groups, and consequently it was shown that the maxilla is well positioned in relation to the base

of the skull, for both the Class II Group and the Control Group<sup>6,7,11</sup>.

The mean value for SNB was 80.30° (interval from 79.76° to 80.84°) for the Control Group, while the Class II Group presented a value of 78.37° (interval from 76.65° to 80.09°). The values showed significant difference between the two groups, and it was evident that the mandible was retrusive with regard to the base of the skull in the Class II Group<sup>2</sup>.

The relationship between the maxilla and the mandible was determined by the ANB angle, which presented a mean value of 2.33° in this study (interval from 1.89° to 2.78°) for the Control Group, and of 5.42° (interval from 4.23° to 6.61°) for the Class II Group. Thus, the existence of significant difference was observed in the relationship between the apical bases of the two groups. Consequently, the maxilla and the mandible were observed to present a good relationship in the Control Group, while in the Class II Group they presented a striking anteroposterior discrepancy.

In this study, the balance of facial profile was defined by the Z angle<sup>10</sup>. The mean value of this variable was 77.42° (interval from 75.71° to 79.14°) in the Control Group, and 68.44° (interval from 64.52° to 72.36°) in the Class II Group. The values for the Z angle showed significant differences between the two groups, justifying the balanced or straight profile for the individuals of the Control Group, and the convex profile for the Class II Group<sup>9,18</sup>.

The intervals obtained according to the tolerance limits, observed in Table 7, guided the construction of a Craniofacial Analysis Table for the Brazilian sample. This table will be offered as a suggestion for the Differential Diagnostic System of the Tweed Foundation for calculating the treatment difficulty in white Brazilian individuals with Angle Class II, division 1 malocclusion.

This way, the intervals for Craniofacial Analysis cephalometric variables in a Brazilian sample were defined: FMA ranging from 23.75° to 29.21°; Z Angle ranging from 64.52° to 79.14°; ANB ranging from 1.89° to 6.61°; Occlusal Plane ranging from 3.11° to 8.52°; SNB ranging from 76.65° to 80.84° and FHI ranging from 0.61 to 0.72.

## CONCLUSIONS

Based on the results obtained from the studied sample, the intervals for Craniofacial Analysis cephalometric variables for the Brazilian sample were defined: FMA ranging from 23.75° to 29.21°; Z Angle ranging from 64.52° to 79.14°; ANB rang-

ing from 1.89° to 6.61°; Occlusal Plane ranging from 3.11° to 8.52°; SNB ranging from 76.65° to 80.84° and FHI ranging from 0.61 to 0.72. There were no significant differences between genders for the cephalometric variables studied.

The mandible was retrusive in relation to the base of the skull in the cases of Angle Class II, division 1 malocclusion. There were no significant differences in the maxillary position between the Class II Group and the Control Group; in other

words, the maxilla was well related to the base of the skull.

It was not possible to define a skeletal pattern in the sample, because the facial height index presented a vertical pattern in the Class II Group, while the Y Axis, Occlusal Plane, SN.GoMe and FMA values did not present significant difference between the studied groups. The cases of Class II malocclusion presented a convex profile.

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Received for publication on Dec 15, 2003

Sent for alterations on Jul 30, 2004

Accepted for publication on Mar 30, 2005