Association between overbite and craniofacial growth pattern

Cristiane Aparecida de Assis Claro[a]
Jorge Abrão[b]
Silvia Augusta Braga Reis[b]

[a] Department of Orthodontics, School of Dentistry, University of Taubaté, Taubaté, SP, Brazil.

[b] Departamento de Ortodontia e Odontopediatria, Universidade de São Paulo (USP), São Paulo, SP, Brazil.

Abstract: The purpose of the present study was to assess the association between overbite and craniofacial growth pattern. The sample comprised eighty-six cephalograms obtained during the orthodontic pretreatment phase and analyzed using the Radiocef program to identify the craniofacial landmarks and perform orthodontic measurements. The variables utilized were overbite, the Jarabak percentage and the Vert index, as well as classifications resulting from the interpretation of these measurements. In all the statistical tests, a significance level of 5% was considered. Measurement reliability was checked by calculating method error. Weighted Kappa analysis showed that agreement between the facial types defined by the Vert index and the direction of growth trend established by the Jarabak percentage was not satisfactory. Owing to this lack of equivalency, a potential association between overbite and craniofacial growth pattern was evaluated using the chi-square test, considering the two methods separately. No relationship of dependence between overbite and craniofacial growth pattern was revealed by the results obtained. Therefore, it can be concluded that the classification of facial growth pattern will not be the same when considering the Jarabak and the Ricketts analyses, and that increased overbite cannot be associated with a braquifacial growth pattern, nor can openbite be associated with a dolichofacial growth pattern.

Descriptors: Orthodontics; Cephalometry; Growth and Development; Diagnostic Errors.

Corresponding author:
Cristiane Aparecida de Assis Claro
Av Tiradentes, 477, apto. 34, Centro
Taubaté - SP - Brazil
CEP: 12030-180
E-mail: *clarocris@ig.com.br*

Received for publication on Mar 31, 2010
Accepted for publication on Jun 04, 2010

Introduction

Changes in overbite (vertical incisor overlap) can be related to some functional alterations, such as phonoarticulatory problems.[1]

The terms "deep skeletal overbite" and "skeletal open bite" have been put forward to refer to vertical discrepancies.[2] Other authors have used the terms "long face syndrome"[3] and "short face syndrome"[4] to collectively describe characteristics occurring in patients with excessive vertical alterations.

An essential step in orthodontic diagnosis and planning is determining the craniofacial growth pattern. The cephalometric references used to identify the facial biotype can be different, as well as the terminology utilized by different authors.

In the present study the analyses of Ricketts *et al.*[5] and Siriwat & Jarabak[6] were utilized. The Ricketts analysis was used to identify growth patterns by means of the Vert index, which takes into account five cephalometric measurements (facial axis, facial depth, mandibular plane, anteroinferior facial height and mandibular arch) and classifies the face into six types (severe brachyfacial, brachyfacial, mesofacial, light dolichofacial, dolichofacial and severe dolichofacial) (Figure 1). The Siriwat & Jarabak analysis was performed by determining the Jarabak coefficient [(posterior facial height/anterior facial height) x 100], and classifies growth tendency into hyperdivergent (54 to 58%), neutral (59 to 63%) and hypodivergent (64 to 80%)[7] (Figure 2).

If vertical condylar growth exceeds dentoalveolar growth, anti-clockwise mandibular rotation occurs.[8] Among the three anti-clockwise rotational types, type I (rotational center on the condyle) and type III (rotational center on the premolars) produce compression of inferior incisors against superior incisors, giving rise to deepening of bite.[9]

Although certain craniofacial morphological characteristics present significant differences when groups with increased overbite and open bite are evaluated[10] – thus indicating that vertical skeletal alterations may justify the presence of abnormal overbite (open bite in dolichofacial patients and deep bite in brachyfacial patients) – it is possible that facial pattern differences may not be followed by corresponding dentoalveolar discrepancies.

The present study evaluated concordance between facial types defined by the Vert index and those indicated by the Jarabak percentage, and investigated whether an association was observed between overbite and the craniofacial growth pattern determined by these methods.

Material and Methods

This study was approved by the Institutional Ethics Committee. The sample comprised 86 patients (42 male and 44 female, with ages ranging from 11 to 37 years). Fifty-nine patients (31 female and 28 male) had ages up to 18 years, 15 patients (11 female and 4 male) had ages ranging from 18 to 26 years, and 12 patients (2 female and 10 male) had ages ranging from 26 to 37 years.

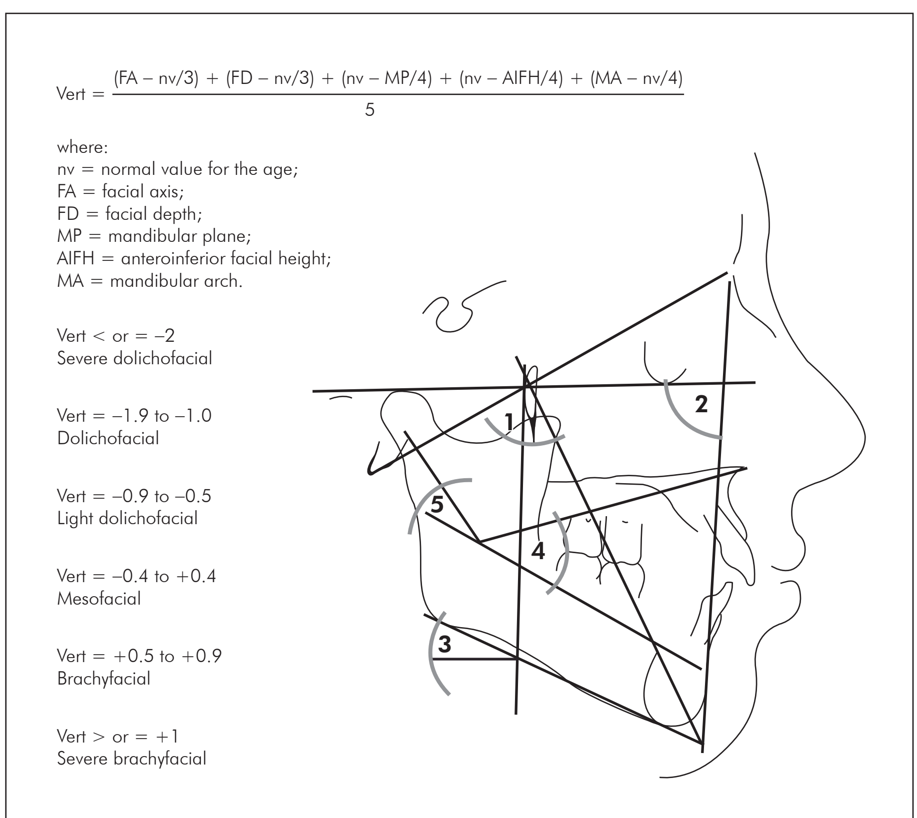


Figure 1 - Five cephalometric measurements used in the Vert index. **1:** facial axis; **2:** facial depth; **3:** mandibular plane; **4:** anteroinferior facial height; **5:** mandibular arch.

The eighty-six lateral X-rays of patients' heads were obtained at the same radiological institute and using the same apparatus. These patients, all in the pre-treatment orthodontic phase, presented permanent dentition with the second molars present.

The X-rays were scanned and the images were standardized using the Radiocef Studio version 4.0 computer program (Radio Memory Ltda, Belo Horizonte, MG, Brazil).

Following identification of the craniofacial landmarks, a database was composed of overbite variables, the Vert index (Figure 1) and the Jarabak percentage (Figure 2).

Overbite groups were divided fundamentally based on a criterion used by Beckmann *et al.*[11] (1998), and classified as deep bite (> +4 mm), normal overbite (> +1 mm and ≤ +4 mm), edge-to-edge overbite (> –1 mm and ≤ +1 mm) and open bite (≤ –1 mm). However, in the present study both edge-to-edge overbite and open bite were grouped together.

Method error

Twenty X-rays were re-evaluated after a period of time, and the first measurement was compared to the second by means of the *t* test for identification of systematic error. For evaluation of random error, the Dahlberg formula was employed. The weighted kappa statistic was used for categorical data.

Statistical method

Since the chi-square test required that the sample size be set at twenty or higher, our sample size was considered sufficient. However, if the sample size is less than forty, expected frequencies should be higher than five.[12] No expected frequency may be lower than one. A significance level of 5% was adopted for all statistical tests utilized.

The chi-square test was used to study associations between overbite and craniofacial growth patterns.

Results

Measurement reliability was confirmed by method error, which did not identify systematic error by means of the *t* test for paired samples. Random error assessed by the Dahlberg formula was considered acceptable since error variance did not exceed 10% of total variance. As such, the lowest coefficient of reliability was 90.29%, and the highest, 97.51% (table 1).

Assessment of the method error for categorical data of facial type interpretation resulted in a

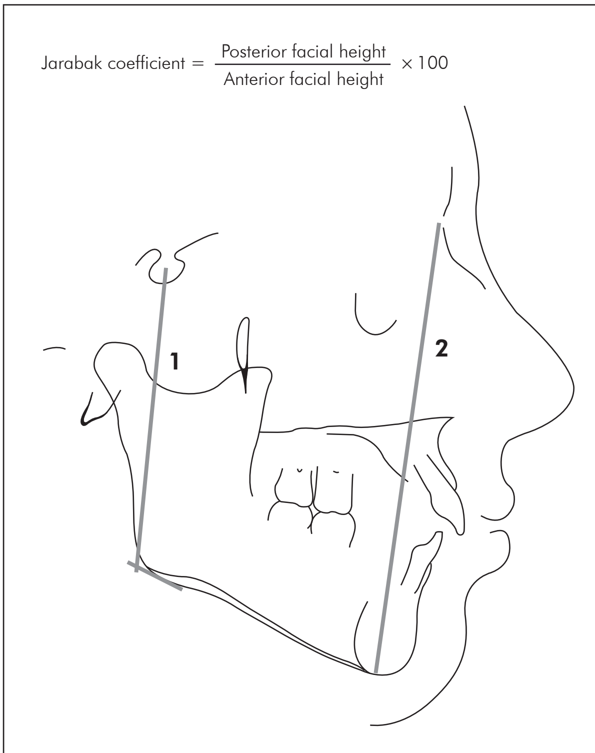


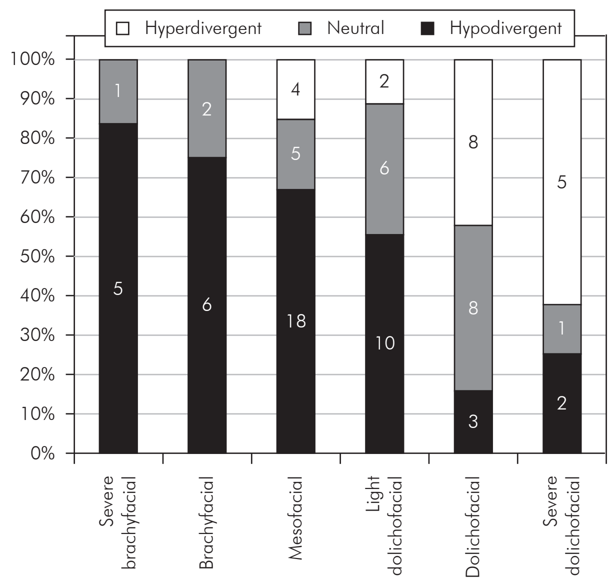
Figure 2 - Cephalometric measurements used in the Jarabak Coefficient. **1:** posterior facial height; **2:** anterior facial height.

Table 1 - Results of the Dahlberg method and t test.

Variables	Error variance (S_e^2)	Total variance (S_t^2)	Coefficient of reliability $[1 - (S_e^2/S_t^2)] \times 100$	t test paired samples		
				t	p-value	s/ns
Vert index	0.01	0.68	97.51	−1.28	0.216	ns
Jarabak %	1.45	14.95	90.29	1.24	0.230	ns
Overbite	0.20	6.08	96.63	1.53	0.141	ns

weighted kappa coefficient of 0.68 (substantial) for the interpretation of the Jarabak analysis; for the Ricketts analysis, the weighted kappa coefficient was 0.85 (almost perfect).

The data on the concordance between Vert index results and those defined by the Jarabak percentage are shown in Graph 1. To carry out the statistical analysis, the degrees (light, severe) of the Ricketts analysis were grouped together according to growth type. The weighted Kappa analysis showed that agreement between facial types defined by the Vert index and direction of the growth trend established by the Jarabak percentage was light (weighted Kappa = 0.20). The interpretation of kappa scores, according to Landis and Kock,[13] is shown in chart 1.



Graph 1 - Percentage of concordance between Vert index results and those defined by the Jarabak percentage.

Because the concordance between interpretations of growth types was not strong, we chose to conduct an association assessment considering separate analyses.

The data shown in tables 2 and 3 reveal a lack of

Chart 1 - Interpretation of kappa scores according to Landis and Kock (1977).[13]

kappa value	Interpretation
< 0	Poor
0 to 0.20	Light
0.21 to 0.40	Fair
0.41 to 0.60	Moderate
0.61 to 0.80	Substantial
0.81 to 1.00	Almost Perfect

Table 2 - Test results (chi-square) for the association between overbite and growth pattern defined by the Vert index.

Pattern	Open Frequency observed (frequency expected)	Normal Frequency observed (frequency expected)	Deep Frequency observed (frequency expected)	X^2	p	s/ns
Severe Dolichofacial	2 (1.58)	5 (3.63)	1 (2.79)	8.473	0.583	ns
Dolichofacial	7 (3.76)	6 (8.62)	6 (6.63)			
Light Dolichofacial	2 (3.56)	9 (8.16)	7 (6.28)			
Mesofacial	4 (5.34)	11 (12.24)	12 (9.42)			
Brachyfacial	1 (1.58)	5 (3.63)	2 (2.79)			
Severe Brachyfacial	1 (1.19)	3 (2.72)	2 (2.09)			

Table 3 - Test results (chi-square) for the association between overbite and growth pattern defined by the Vert index (grouped).

Pattern	Open Frequency observed (frequency expected)	Normal Frequency observed (frequency expected)	Deep Frequency observed (frequency expected)	X^2	p	s/ns
Dolichofacial	11 (8.90)	20 (20.41)	14 (15.70)	2.661	0.616	ns
Mesofacial	4 (5.34)	11 (12.24)	12 (9.42)			
Brachyfacial	2 (2.77)	8 (6.35)	4 (4.88)			

Table 4 - Test results (chi-square) for the association between overbite and growth pattern defined by the Vert index (grouped), excluding the normal overbite group.

Pattern	Open Frequency observed (frequency expected)	Deep Frequency observed (frequency expected)	X^2	p	s/ns
Dolichofacial	11 (9.04)	14 (15.96)	1.549	0.461	ns
Mesofacial	4 (5.79)	12 (10.21)			
Brachyfacial	2 (2.17)	4 (3.83)			

Table 5 - Test results (chi-square) for the association between overbite and growth pattern defined by the Vert index (grouped), excluding the normal overbite and mesofacial individual groups.

Pattern	Open Frequency observed (frequency expected)	Deep Frequency observed (frequency expected)	X^2	p	s/ns
Dolichofacial	11 (10.48)	14 (14.52)	0.22	0.634	ns
Brachyfacial	2 (2.52)	4 (3.48)			

association between the patterns established by the Vert index and overbite regardless of whether or not the degrees of facial type are considered.

With the objective of certifying that the values referring both to patients with normal overbite and to those who were mesofacial did not interfere with the results, chi-square was utilized excluding these groups. The results shown in tables 4 and 5 do not reveal any relationship of dependence between overbite and facial pattern.

The lack of association between overbite and facial growth pattern defined according to the Jarabak percentage was confirmed (table 6), even when maintaining only hyperdivergent and hypodivergent extremes (table 7). Although an association was observed when excluding the normal bite group (table 8), one of the expected frequencies was less than five and the sample size was reduced to less than forty, therefore the result of this association is not reliable.

Discussion

Our sample was representative of the patient population in the orthodontic pre-treatment phase, given that it was obtained randomly and had a size suitable for the statistical tests. The inclusion criteria were not excessively specific, in order to be coherent with the study purpose, which was to assess whether an association generically assumed between overbite types and facial pattern could be supported scientifically.

It is generally expected that malocclusion in patients with an elongated face includes open bite, while malocclusion in patients with a short face includes deep bite. However, although the combination of certain occlusion characteristics may be associated with specific facial types, this concept should not be generalized.[14]

Vertical malocclusion may be divided into those of predominantly skeletal origin, when related to mandibular and maxillary growth patterns, and those of predominantly dentoalveolar origin.[8,15] However, both factors may be jointly present or manifest separately.

Occurrence of normal or even deep overbite in patients with an elongated face may be justified by compensatory mechanisms in mandibular/maxillary and alveolar growth.[16,17,18]

The type II anti-clockwise mandibular rotation presents its center at the incisor contact area,[9] and is not normally related to overbite. However, if occlusion of the incisors is unstable, the fulcrum point will be located more posteriorly, and the bite will deepen with time.[8]

It is not uncommon to find incoherencies between the results obtained from applying the cephalometric analyses of different authors to the same individual. This situation may create diagnostic doubt, especially amongst recently graduated pro-

Table 6 - Test results (chi-square) for the association between overbite and growth pattern defined by the Jarabak percentage.

	Open Frequency observed (frequency expected)	Normal Frequency observed (frequency expected)	Deep Frequency observed (frequency expected)	X^2	p	s/ns
Hypodivergent	7 (8.70)	18 (19.95)	19 (15.35)	5.037	0.284	ns
Neutral	4 (4.55)	11 (10.43)	8 (8.02)			
Hyperdivergent	6 (3.76)	10 (8.62)	3 (6.63)			

Table 7 - Test results (chi-square) for the association between overbite and growth pattern defined by the Jarabak percentage, considering only hypodivergent and hyperdivergent patterns.

	Open Frequency observed (frequency expected)	Normal Frequency observed (frequency expected)	Deep Frequency observed (frequency expected)	X^2	p	s/ns
Hypodivergent	7 (9.08)	18 (19.56)	19 (15.37)	4.841	0.089	ns
Hyperdivergent	6 (3.92)	10 (8.44)	3 (6.63)			

Table 8 - Test results (chi-square) for the association between overbite and growth pattern defined by the Jarabak percentage, considering only hypodivergent and hyperdivergent patterns, open bite and deep bite.

	Open Frequency observed (frequency expected)	Deep Frequency observed (frequency expected)	X^2	p	s/ns
Hypodivergent	7 (9.66)	19 (16.34)	4.523	0.033	s
Hyperdivergent	6 (3.34)	3 (5.66)			

fessionals.

Utilization of the Vert index minimizes possible distortions stemming from regional morphological variations. These distortions may occur when defining facial pattern based on individual cephalometric measurements. However, the Vert index presents some shortcomings related to the adjustment between average values, which would permit a true correspondence between factors.[19]

The lack of satisfactory concordance between the interpretation derived from the Jarabak percentage and that defined by the Vert index is coherent with the results obtained in other studies.[20-22]

Since concordance between the facial types established by the different analyses was unsatisfactory, we chose to conduct an assessment of the association between overbite and the different facial types, initially as defined by the Vert index, and afterwards as defined by the Jarabak percentage.

Because differences between observed and expected frequencies were smaller in both mesofacial and normal overbite groups, and these factors may have interfered in the chi-square results, the association between overbite and facial growth patterns was tested. Nevertheless, this association was not identified when the facial type was defined by the Vert index. An association was identified when the facial type was defined according to the Jarabak percentage. This result, however, may not be completely relied upon, since the sample number was below forty and, in this case, the expected frequency could not be lower than five, as occurred in the hyperdivergent open bite group.

The lack of a relationship of dependence between facial type and overbite is coherent with the results of other studies where facial type did not influence the extent of the observed incisor intrusion.[23]

The main determining factor of overbite in patients with an elongated face is inferior facial height, whereas, in short-faced patients, the major influence on overbite is inferior dentoalveolar morphology. Normal overbite in individuals with an elongated face may be maintained by limited inferior dentoalveolar compensation.[17]

Some factors may influence the occurrence of compensatory mechanisms. Compensation requires that the eruptive system be normal and that the forces exercised by soft tissue be in balance. The position of adjacent teeth during eruption, much like the plane inclination effect of opposing teeth during occlusion and mastication, also influences the mechanisms of compensation.[18]

In the present study the lack of association between overbite and facial pattern suggests that compensatory mechanisms should be fairly frequent. However, in clinical practice the probable perception of the effects of these compensatory mechanisms occurs with higher frequency only in extreme cases.

Conclusions

In agreement with the analyses of the present study, and considering the characteristics of the study sample, the following may be concluded:

1. The degree of concordance between the interpretation of facial type defined by the Vert index and that defined by the Jarabak percentage was not satisfactory.
2. There was no association between overbite and craniofacial growth pattern.

Acknowledgments

The authors wish to thank Radio Memory Ltda. for having generously provided the Radiocef Studio version 4.0 computer program for this study.

References

1. Sahad MG, Nahás ACR, Scavone-Junior H, Jabur LB, Guedes-Pinto E. Vertical interincisal trespass assessment in children with speech disorders. Braz Oral Res. 2008 Jul-Sep;22(3):247-51.
2. Sassouni V. A classification of skeletal facial types. Am J Orthod. 1969 Feb;55(2):109-23.
3. Schendel SA, Eisenfeld J, Bell WH, Epker BN, Mishelevich DJ. The long face syndrome: vertical maxillary excess. Am J Orthod. 1976 Oct;70(4):398-408.
4. Opdebeeck H, Bell WH. The short face syndrome. Am J Orthod. 1978 May;73(5):499-511.
5. Ricketts RM, Roth RH, Chaconas SJ, Schulhof RJ, Engel GA. Orthodontic diagnosis and planning: their roles in preventive and rehabilitative dentistry. Pacific Palisades: Rock Mountain Data Systems; 1982. 269 p.
6. Siriwat PP, Jarabak JR. Malocclusion and facial morphology. Is there a relationship? An epidemiologic study. Angle Orthod. 1985 Apr;55(2):127-38.
7. Jarabak JR, Fizzel JA. Technique and treatment with light wire edgewise appliances. 2nd ed. Saint Louis: Mosby; 1972. 612 p.
8. Nielsen IL. Vertical malocclusions: etiology, development, diagnosis and some aspects of treatment. Angle Orthod. 1991 Dec;61(4):247-60.
9. Bjork A. Prediction of mandibular growth rotation. Am J Orthod. 1969 Jun;55(6):585-99.
10. Trouten J, Enlow D, Rabini M, Phelps A, Swedlow D. Morphologic factors in open bite and deep bite. Angle Orthod. 1983 Jul;53(3):192-211.
11. Beckmann SH, Kuitert RB, Prahl-Andersen B, Segner D, The RPS, Tuinzing DB. Alveolar and skeletal dimensions associated with overbite. Am J Orthod Dentofacial Orthop. 1998 Apr;113(4):443-52.
12. Cochran WG. Some methods for strengthening the common X^2 tests. Biometrics. 1954 Dec;10(4):417-51.
13. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977 Mar;33(1):159-74.
14. Keeling SD, Riolo ML, Martin RE, Ten Have TR. A multivariate approach to analyzing the relation between occlusion and craniofacial morphology. Am J Orthod Dentofacial Orthop. 1989 Apr;95(4):297-305.
15. Van der Linden FPGM. The vertical dimension. In: McNamara Jr JA, Brudon WL. Orthodontics and dentofacial orthopedics. Needham: Ann Arbor; 2001. p. 111-48.
16. Beckmann SH, Kuitert RB, Prahl-Andersen B, Segner D, The RPS, Tuinzing DB. Alveolar and skeletal dimensions associated with lower face height. Am J Orthod Dentofacial Orthop. 1998 May;113(5):498-506.
17. Kuitert R, Beckmann S, Loenen M, Tuinzing B, Zentner A. Dentoalveolar compensation in subjects with vertical skeletal dysplasia. Am J Orthod Dentofacial Orthop. 2006 May;129(5):649-57.
18. Solow B. The dentoalveolar compensatory mechanism: background and clinical implications. Br J Orthod. 1980 Jul;7(3):145-61.
19. Rino Neto J, Paiva JB, Queiroz GV. Variabilidade entre os fatores componentes do índice Vert na determinação do padrão facial. Ortodontia. 2004 Sep-Dec;37(3):32-6.
20. Moresca R, Reis SAB, Vigorito JW, Scanavini MA. Estudo comparativo cefalométrico-radiográfico do padrão facial na má-oclusão de Classe II, 1 de Angle, empregando as análises

cefalométricas de Ricketts e Siriwat & Jarabak. J Bras Ortodon Ortop Facial. 2002 Nov-Dec;7(42):520-5.
21. Scanavini C, Vigorito JW. Estudo cefalométrico-radiográfico das possíveis correlações existentes entre as análises de Vigorito, Ricketts e Siriwat & Jarabak na definição dos tipos faciais, em indivíduos leucodermas. Ortodontia. 2001 Sep-Dec;34(3):27-41.
22. Poubel D. Estudo comparativo da determinação do tipo facial por meio de análise facial e cefalométrica em indivíduos com oclusão normal [dissertação]. São Bernardo do Campo: Faculdade de Odontologia da Universidade Metodista de São Paulo; 2003.180 p.
23. Otto RL, Anholm JM, Engel GA. A comparative analysis of intrusion of incisor teeth achieved in adults and children according to facial type. Am J Orthod. 1980 Apr;77(4):437-46.