Modulation of occlusal plane during puberty

Wilma Alexandre Simoes

The biological significance of the occlusal plane is of tremendous importance in the study of the etiology, diagnosis and treatment of malocclusion. The purpose of this investigation was to correlate the changes on the occlusal plane of patients in treatment with functional appliances and the subjects with no need of treatment during the prepubertal and pubertal period. Data on the space between the upper and lower occlusal lines-Interocclusal Distance (IOD) was obtained periodically. Some remarks about which changes are naturally provoked or not are very useful in the treatment of malocclusions and the evaluation of the occlusal plane in cases that do not need treatment.

INTRODUCTION

Time and adaptation are essential variables when considering biological phenomenon. It would be impossible to have proportionality of development and growth without adaptation.

The biological rhythms result from genetic and environmental influences being present in all plants, animals and man since the beginning of life.[1] The natural patterns[2] are under the adaptation possibilities at the proper moment. These patterns are closely related with phylogeny and ontogeny.[3] The peak velocity spurt of facial growth occurs slightly after[4,5] or coincides with the stature peak.[6,7] The mandible is the most affected bone of the craniofacial complex during the adolescent spurt.[8]

The duration of the pubertal growth spurt is around 5.2 years in boys and girls.[9] The timing varies among individuals, but there is a pattern that can be expressed by a curve, which always remains the same.[10]

There are some biological discontinuities of the occlusal plane that were evaluated through the measurement of the Interocclusal Distance (IOD) in the present investigation.

MATERIAL AND METHODS

Subjects

The random sample of 246 subjects, 138 boys and 108 girls, covers the age range from 11 to 20 yr. Only 109 were used in this cross-sectional study, because of many factors: 36 were considered with a very active period of teeth loss and teeth eruption (9.6 to 11 yr) therefore, reliable measurements were not available; 74 did not follow the experimental process and only 27, 15 boys and 12 girls, are still in the longitudinal study. Figure 1.

The individuals belong to the same socioeconomic status, middle and upper-class, descending mainly from European, Italian and Iberian ancestry; however, as a random sample, there can be found a few exceptions.

Criteria

Subjects were not separated into early, average and late maturers. They were separated in groups by sex, with no need of treatment called Harmonious group-HG and with need of treatment, the Jaw Functional Appliance group-JFA. Another two groups named JFAL also separated by sex will not be considered in this paper, they will be considered in a longitudinal study.

The JFA group used exclusively functional appliances. All the appliances did not have any technical resource on the occlusal surfaces interfering with the eruption movement of teeth. The malocclusion founded in this group was distocclusion with overbite, open bite, crossbite, crowding, lack of space or not. The measurements were made after at least four months of treatment effect.

Methods of Registration

Occlusograms or bite registrations were periodically taken with a thermoplastic impression material. Occlusogram is the result recorded on a material placed between teeth in forced occlusion. No frame, and only posterior occlusograms were used in this investigation. A caliper was used to measure the thick-

PROFESSOR "Honoris Causa"
Dental Faculty-C.C. Branco University

Address all correspondence to Dra. Wilma Alexandre Simoes, Av. Brig. Faria Lima, 613 - 5.° Andar - Conj. 51, CEP 01451-000, Sao Paulo, Brazil.

Fig. 1 Description of the exclusion of 36 (14.7%) subjects due to active period of teeth changes; 74 (30%) subjects who failed to follow the experimental process; 27 (11%) subjects who were used for the longitudinal study and the 109 (44.3%) remaining subjects used in the present cross-sectional study.

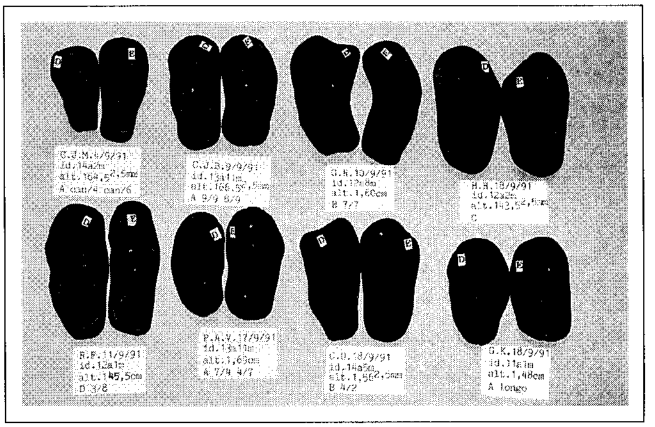
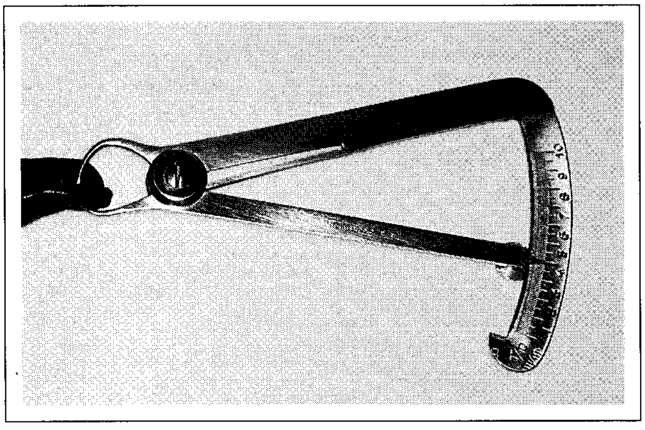
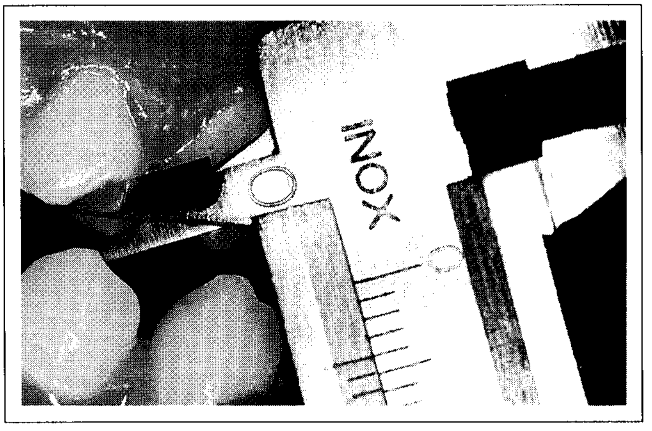


Fig. 2 Occlusograms of right and left sides with their respective identifications: initials, date, age, statuary height, gnathostatic and calcographic formula.





Figs. 3 A, B A size-size correlation between the measurement with a caliper and a vernier, on a occlusogram and at the same teeth areas in the mouth.

ness on the occlusograms. At the time an occlusogram was taken a set of seven photographs were taken and the linear height was measured. Figures 2 and 3 A, B.

Methods of Analysis

The sample was analyzed according to cephalometric,[11-16] gnathostatic, calcographic (l x l) image,[17-19] pantomographic symmetry tracings and clinical examination.[19] The typological formula and the rotational group were obtained from the Bimler's and Petrovic and Lavergne's cephalometric analysis respectively.[11-16] Figures 4 A, B.

Chewing Side	+	Clinical MD	+	Gnathostatic and Calcographic tracings	+	Pantomogram of Symmetry

Fig. 4A - Deviation in form and position analysis. MD= midline deviation. Pantomogram as the cephalogram is the trace on the pantomography to get a symmetry analysis.[20]

Gnathostatic and Calcographic tracings	+	Typological Cephalometric Formula	+	Rotational Group

Figure 4B - Gnathostatic and Calcographic tracings included in Plana's symptomatological diagnosis,[17-20] typological Cephalometric Formula from Bimler's analysis[11,12] and Rotational group from Petrovic and Lavergne,[13,16] are elements of typological relation analysis.[20]

Statistical Analysis

The Chi-square test was used to compare frequency distributions of age and profile types among groups. The Kruskal-Wallis test was used to compare the 4 groups (HG-F, HG-M, JFA-F, JFA-M) for variables: 1st and 2nd Molars, 1st and 2nd Premolars. After finding a significant difference among the 4 groups, the Man-Whitney test was used to check, which one of the groups was different from the others (comparisons were made between male and female for each group and between JFA and HG within each group and sex).

Table 1: Distribution of gnathostatic profiles by groups. Tangential types were: A/B(7), C/B(4), A/F(1), B/C(1).

	Profiles									
Groups		Al		A		B		C		Tang
HG	8	47.06%	15	51.72%	15	62.50%	12	46.15%	8	61.54%
JFA	9	52.94%	14	48.28%	9	37.50%	14	53.85%	5	38.46%
Total	17	100.00%	29	100.00%	24	100.00%	26	100.00%	13	100.00%

$X^2 = 1.99$ $p = 0.7361$ ns

Table 2: Distribution of gnathostatic profile by sex.

	Profiles									
Groups		Al		A		B		C		Tang
Female	10	58.80%	12	41.38%	12	50.00%	17	65.38%	7	53.85%
Male	7	41.18%	17	58.62%	12	50.00%	9	34.62%	6	46.15%
Total	17	100.00%	29	100.00%	24	100.00%	26	100.00%	13	100.00

$X^2 = 3.49$ $p = 0.4787$ ns

Table 3: Frequency distribution by age by sex in the HG and JFA groups.

	HG						JFA					
	Females		Males		Total		Females		Males		Total	
Age	N	%	N	%	N	%	N	%	N	%	N	%
11y	2	6.5	1	3.7	3	5.2	3	11.1	1	4.2	4	7.8
12y	6	19.4	5	18.5	11	19.0	7	25.9	6	25.0	13	25.5
13y	4	12.9	4	14.8	8	13.8	3	11.1	5	20.8	8	15.7
14y	3	9.7	4	14.8	7	12.1	4	14.8	3	12.5	7	13.7
15y	4	12.9	3	11.1	7	12.1	3	11.1	1	4.2	4	7.8
16y	2	6.5	1	3.7	3	5.2	1	3.7	3	12.5	4	7.8
17y	4	12.9	2	7.4	6	10.3	3	11.1	3	12.5	6	11.8
18y	2	6.5	4	14.8	6	10.3	1	3.7	0	0.0	1	2.0
19y	3	9.7	2	7.4	5	8.6	2	7.4	1	4.2	3	5.9
20y	1	3.2	1	3.7	2	3.4	0	0.0	1	4.2	1	2.0
Total	31	100.0	27	100.0	58	100.0	27	100.0	24	100.0	51	100.0

$X^2 = 2.31$ $p = 0.7502$ ns $X^2 = 5.90$ $p = 0.9855$ ns

Table 4: Descriptive analysis for age by sex in the HG and JFA groups.

	Mean ± Std. Dev.	Minimum-maximum	N
HG - Female	15.400 ± 2.667	11.500 - 20.750	31
JFA - Female	14.568 ± 2.467	11.080 -19.670	27
HG - Male	15.391 ± 2.687	11.830 - 20.920	27
JFA - Male	14.778 ± 2.477	11.920 - 20.920	24

$F = 0.75$ $p = 0.5233$ ns

Table 5: Descriptive analysis for 2nd molars by sex in ghe HG and JFA groups.

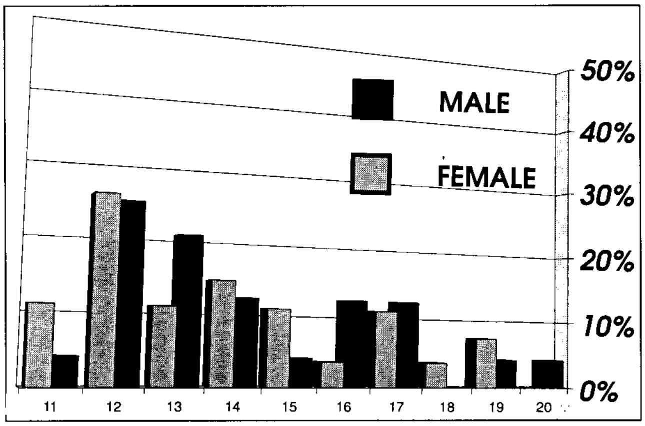
	Mean ± Std. Dev.	Median	Minimum-maximum	N
HG - Female	0.342 ± 0.464	0.167	0.000 - 2.000	30
JFA - Female	0.255 ± 0.330	0.155	0.000 - 1.183	22
HG - Male	0.186 ± 0.226	0.031	0.000 - 0.567	20
JFA- Male	0.321 ± 0.347	0.175	0.000 - 1.133	17

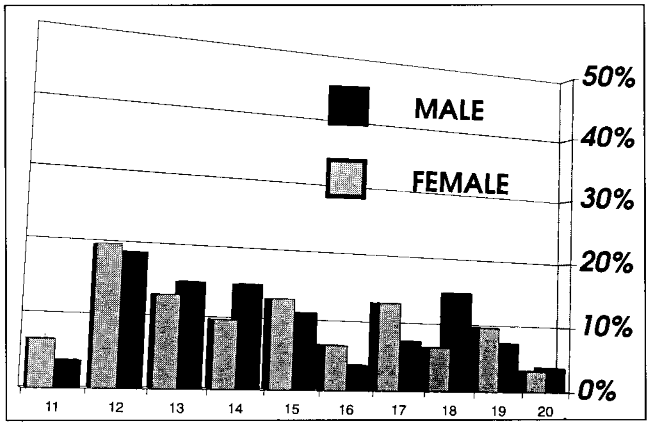
$H = 1.85$ $p = 0.6037$ ns

Table 6: Descriptive analysis for 1st molars by sex in the HG and JFA groups.

	Mean ± Std. Dev.	Median	Minimum-maximum	N
HG - Female	0.511 ± 0.531	0.250	0.000 - 2.000	31
JFA- Female	0.730 ± 0.487	0.720	0.100 - 2.189	27
HG - Male	0.471 ± 0.410	0.406	0.000 - 1.558	27
JFA - Male	0.710 ± 0.390	0.568	0.175 -1.589	24

H = 10.49 p = 0.0148 *





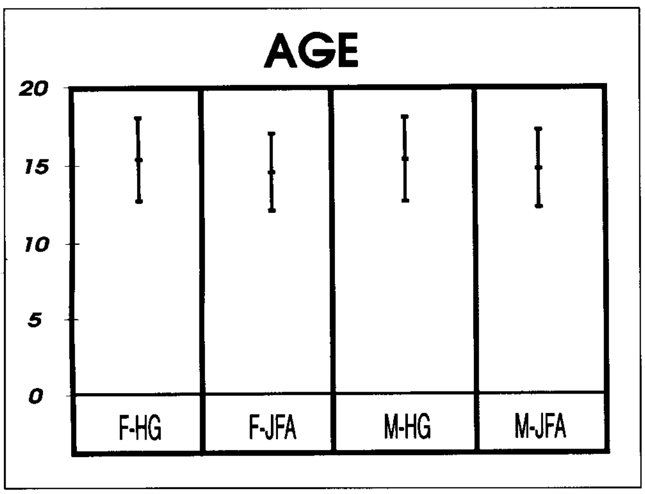


Fig. 5 Frequency distribution of age by sex for groups: a) JFA and b) HG; c) means and standard deviations of age per sex/group.

Correlation between age and each of the IOD of lst and 2nd Molars and Premolars was assessed by the Pearson correlation coefficient (r).

RESULTS

Evidence of differences were not found between distributions of profiles of the two groups (HG and JFA) and of the two sexes (female and male). The p-values of the chi-square test were 0.7361 and 0.4787 respectively. See Tables I and II.

The distribution of age by sex in the HG and JFA groups were not statistically significant using either of the tests; the chi-square test (HG: p = 0.7502 and JFA: p = 0.9855) and the F-test of the ANOVA (p = 0.5233). See Tables III and IV, and Figure 5.

The four groups were not statistically different regarding the measurements of the 2nd Molars (p = 0.6037). See Table V and Figure 6A.

Evidence of difference between the lst molars of the four groups was found (p = 0.0148). This difference occurred in both sexes (Female: p = 0.0403 and Male: p = 0.0202). See table VI and Figure 6B.

First and second premolars had the same behavior when comparing the four groups. The difference among the four groups was statistically significant (p < 0.0001 for 1st and 2nd premolars). Difference between groups HG and JFA were found for both sexes (2nd premolars: p = 0.0290 Female and p < 0.0001 Male; lst premolars: p = 0.0308 Female and p < 0.0001 Male). Also within group HG, Males were significantly different from Females (2nd premolars p = 0.0450 and 1st premolars p = 0.0470). See Tables VII and VIII and Figure 6 C, D.

Table 7: Descriptive analysis for 1st molars by sex in the HG and JFA groups.

	Mean ± Std. Dev.	Median	Minimum-maximum	N
HG - Female	0.675 ± 0.560	0.571	0.000 - 2.067	31
JFA - Female	1.145 ± 0.970	1.000	0.000 - 4.600	27
HG - Male	0.429 ± 0.505	0.314	0.000 - 1.900	27
JFA - Male	1.215 ± 0.942	0.921	0.000 - 3.275	24

H = 21.78 p < 0.0001 *

Table 8: Descriptive analysis for 1st premolars by sex in the HG and JFA groups.

	Mean ± Std. Dev.	Median	Minimum-maximum	N
HG - Female	0.959 ± 0.821	0.750	0.000 - 2.800	31
JFA - Female	1.439 ± 0.817	1.200	0.275 - 3.800	27
HG - Male	0.562 ± 0.671	0.471	0.000 - 2.767	27
JFA - Male	1.656 ±1.074	1.462	0.000 - 3.475	24

H = 25.12 p < 0.0001 *

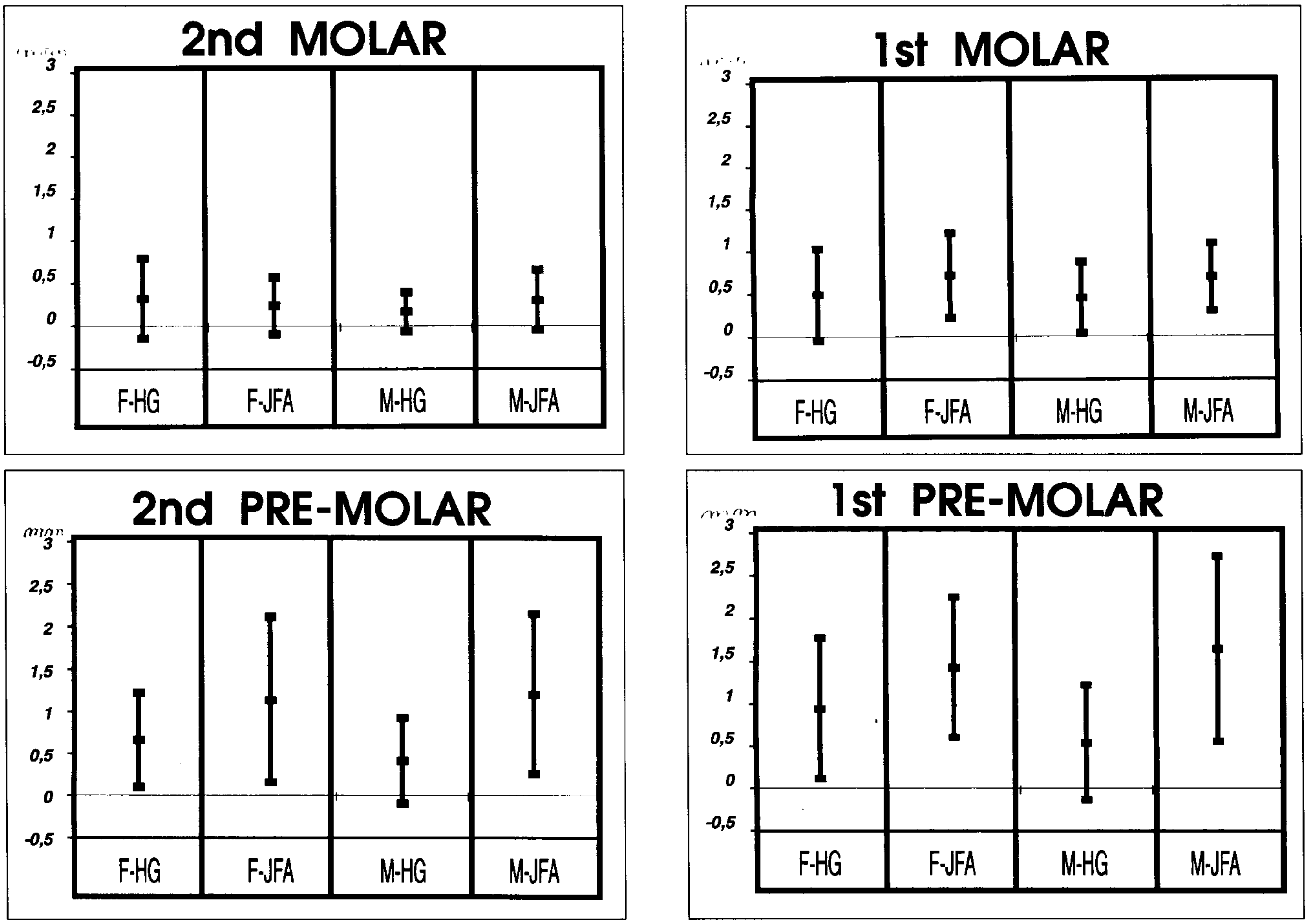


Fig. 6 Means and standard deviations by sex/group for a) 2nd Molar, b) 1st Molar, c) 2nd Premolar, d) 1st Premolar.

The Pearson correlation coefficient (r) between age and IOD for the four teeth within group HG varied from -0.47 to -0.61 for both sexes. The only exception was the 2nd molar of the females where the correlation coefficient was really low (0.01). Figures 7 and 8. In the group JFA, the correlation coefficients were not so high (between -0.21 and -0.35) and less significant than group HG. Figures 9 and 10.

DISCUSSION

A caliper to measure thickness on the occlusograms and a vernier at the same teeth areas in the mouth

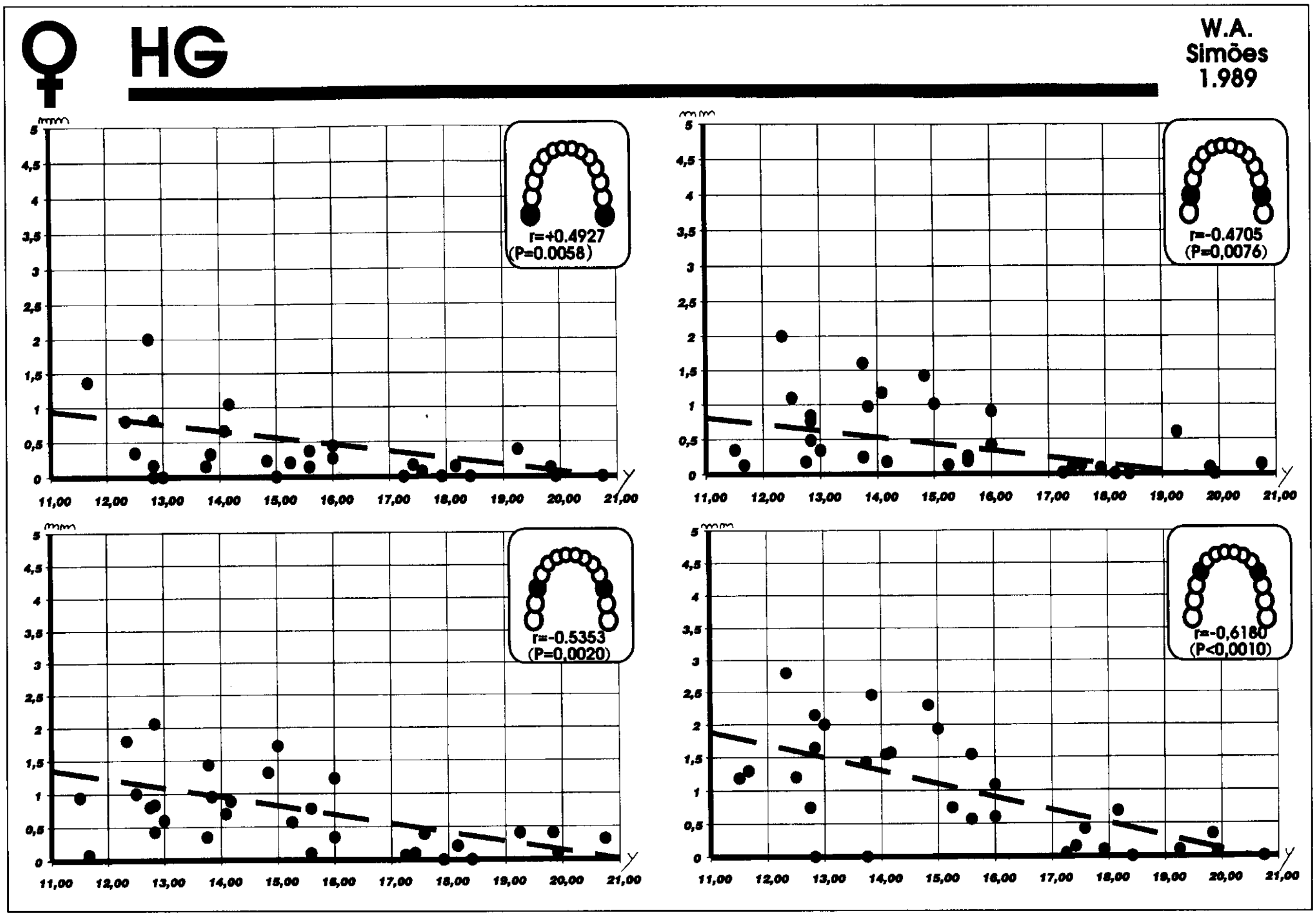


Fig. 7 Correlation between age and IOD for females with harmonious growth.

were used for a size-size correlation. This comparison was made, between distances of at least 3 millimeters to facilitate and assure a more reliable result. Trustworthy measurements were found. Figures 3 A, B. Posterior occlusograms were used to get the most proper mandibular position[19] for the major number of contact stops to be registered. No frame was used to improve the simplicity of the method reducing the risks of yet another factor of interference. The material used, modeling plastic, provides good stability.

There is a consistent relationship between the occlusal plane and the facial type.[21] The sample was considered homogeneous through the methods of analysis. See Figures 4 A, B and Figure 5.

All the bones and muscles of the body during pubertal growth spurt increase the growth rate.[10,22] The result of many hormonal secretions occurring at the same time can be called hormonal discharges.[20,23] The onset of puberty is controlled by the CNS and hormonal discharges as GnRH, FSH, LSH4. Eruption, growth and development, posture and movement of mandible and tongue receive neuroendocrinological influences. These are the main natural forces actuating over the modulation of the occlusal plane. The action of hormones during prepuberty and puberty is related to changes on the occlusal plane.[10,15,23] It is likely that the adrenarche in boys at 6-7yr and in girls 7-8yr[22] is a factor corroborating with many changes on the occlusal plane during this period.

As from 11 yr for females and 13 yr for males there is a burst of condylar growth that disturb the occlusal equilibrium, separating the jaws,[10,24] this mechanism allows the release of the eruptive forces at the second phase of active eruption between 14y-18yr.[24] This is a period of rapid and great changes. The cybernetic view of discontinuities in occlusal relationship and the regulation of facial growth[15] fits into the above mentioned considerations. During the second phase of active eruption the teeth move two or three millimeters measured between their apices and inferior dental canal.[24]

The variation in the level of hormones affects the turnover rate of alveolar bone, the condylar cartilage growth rate, the retrodiscal pad, the muscle activity[13-16,25-27] and the eruption rate.[24,29] The mandibular ramus and corpus grow alternatively[30] and not at an uniform rate.[13-16,30]

However, there is a pattern of growth of parts, which results in the organized overall growth of the entire living being.[3] These patterns are evident in the occurrence of menarche and voice change always at,

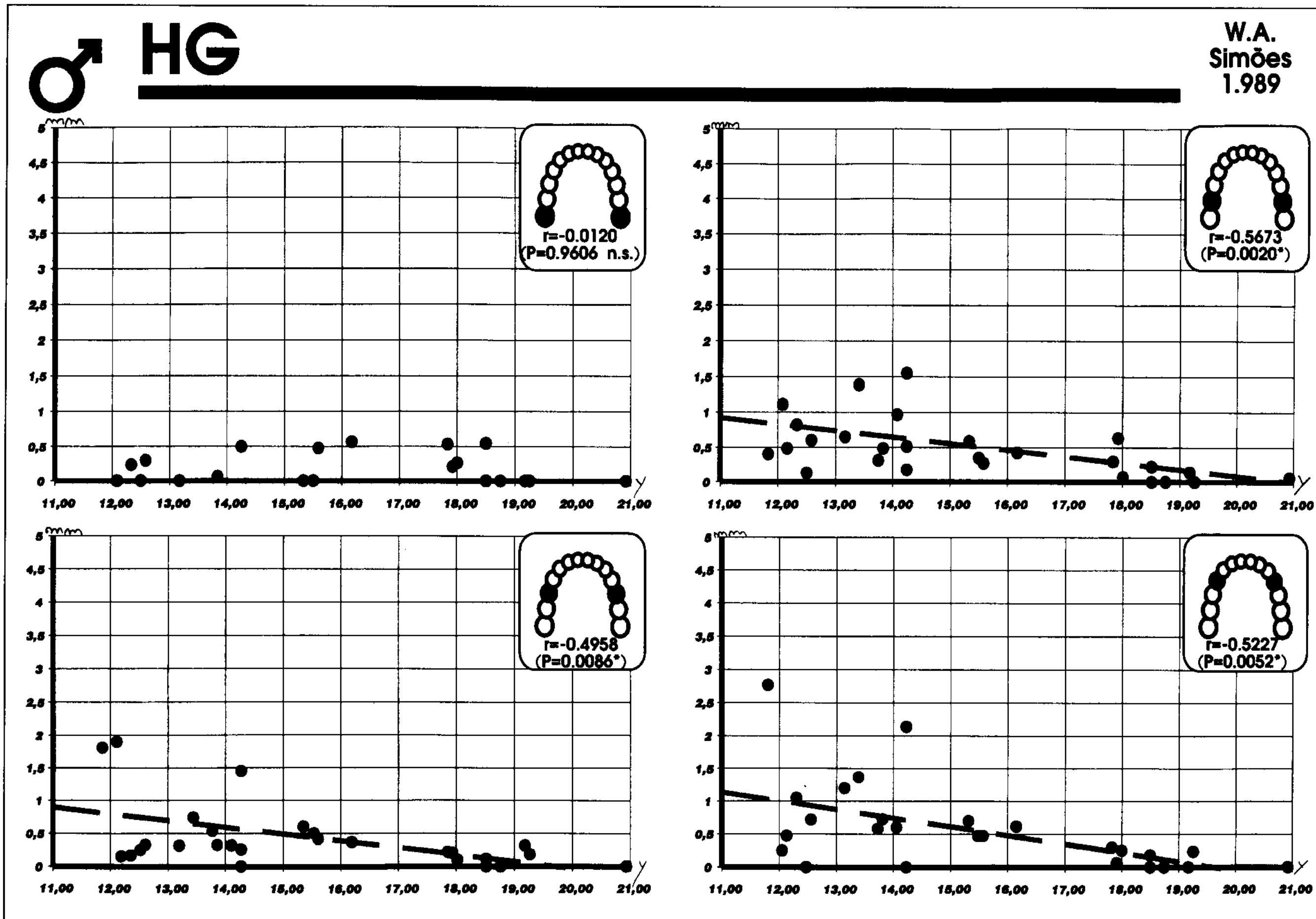


Fig. 8 Correlation between age and IOD for males with harmonious growth.

or shortly after, the growth spurt stature peak.[31,32] The increase of stature is a consequence of longitudinal skeletal growth. The vertebrae are one of the main structures which growth and position reflects on the stature. Vertebral age reaches its peak at around 14 yr.[33]

The relationship between the hyoid bone and the third and the fourth cervical vertebrae follows a pattern. "At 3 yr the hyoid bone is at the level between the third and fourth vertebrae and then progressively descends reaching the level of the fourth vertebra by full adulthood."[34] This vertebrae by the age of 12 yr is at a lower position than menton. During adolescence, the cervical vertebrae descend at a faster rate than the chin. The relations between the hyoid bone and the border of mandible is not as stable as that between the hyoid bone and the fourth vertebra. Gradually, there is a wider distance between them.[34]

The pharyngeal growth is related with the different morphologic types probably because the vertebrae growth may be under genotype control,[35] however there is sexual dimorphism in the amount of neck growth; males have three times more than girls between 12yr-18yr.[34]

The tongue remains at the same rest position between 3yr to 12yr. From 12yr to 19yr the tongue drops more than two millimeters reaching 7 mm in full adulthood.[34]

The pubertal growth spurt for height occurs after the peak of the overall length of mandible growth measured by Ar-Po4. There is a rotational phenomenon of growth in the whole craniofacial complex to harmonize the difference of rate in the parts.

The mandibular expression of rotation concerns not only the growth rotation changes, but also its position rotation.[13-16] The relationships between maxilla and mandible must be framed by the proportionality of harmonious growth. The growth compensation in the different parts of the whole craniofacial complex gathers the best proportions for the evolution of functional efficiency even during transient periods. Basically, the neuromuscular activity manages to determine the proper ways for the coordination of these growth process.

Even saliva has its composition altered by sex and age. Progesterone, for example, presents a spiking phenomenon in pre-menarcheal girls. Generally, the menarche occurs around 12yr and the spiking phenomenon should be over by 14yr.[36]

The occlusal plane adjustments need time to mature

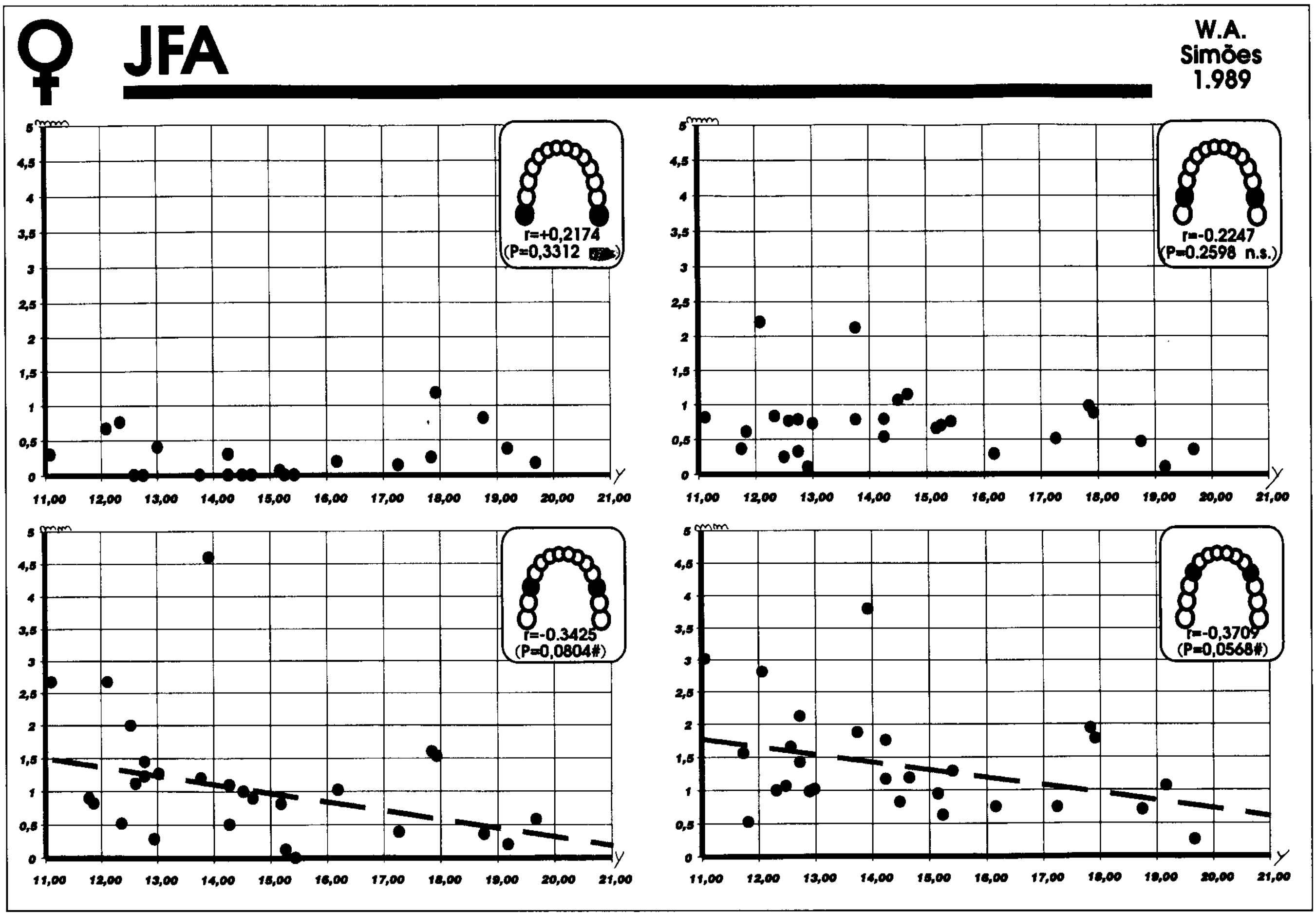


Fig. 9 Correlation between age and IOD for females with jaw functional appliances.

in conjunction with all the mechanisms of eruption, rotation, displacement and relocation of the various parts of the craniofacial complex. The upper and lower occlusal lines gradually adjust to the fast changes.

The longitudinal and cross-sectional data seems to be compatible, even though there maybe individual variation.

The statistical analyses reveal that each tooth shows a different behavior pattern. Figure 6. It seems quite likely that this occurs because their final position on the mature occlusal plane is also different. There could be another reason as the location of each tooth in the dental arches and the different timing of active eruption. It seems that the occlusal plane "finds the way" to its dynamic mature equilibrium when there is physiological conditions to release the natural forces.

When the treatment starts later, the phasic growth influences on the occlusal plane are longer lasting. Then, probably, the distance between the upper and lower occlusal lines is the sum of the distance that would naturally occur under harmonious growth plus the result of transformations provoked by the jaw functional appliances. This distance can achieve around 5 millimeters in certain cases of malocclusions where there are greater changes within short periods of time. This occurs when the distance coincides with the equilibrium stage of eruption,[24,28] posterior positional rotation of mandible, alterations in the rate of ramus and/or corpus. This IOD is also evident, for example, in severe distocclusions with overbite, when the incisors contact (D.A.)[37] is reached by the action of the change of posture in jaw functional orthopedic therapy.[23] It seems that the overbite, in such cases, preclude the releasing of natural forces of the first phase of active eruption on the posterior segments of dental arches that will be additionally liberated at the second phase of active eruption.

The reduction of the IOD was natural without any technical resource, after a period of "static" apart situation. Figure 3B. Sometimes, it was a long period that could last for more than one year. It is possible that the result of the hormonal activity suddenly activated and the IOD was reduced within a few months.

The IOD were very discrete, two to three millimeters, in cases that did not require treatment (HG-group), measured between fossa/cusp; in some cases, imperceptible. The worse the situation of the malocclusion (dental arches available space and/or the distocclusion, etc.), the bigger the IOD and the modulation of the occlusal plane.

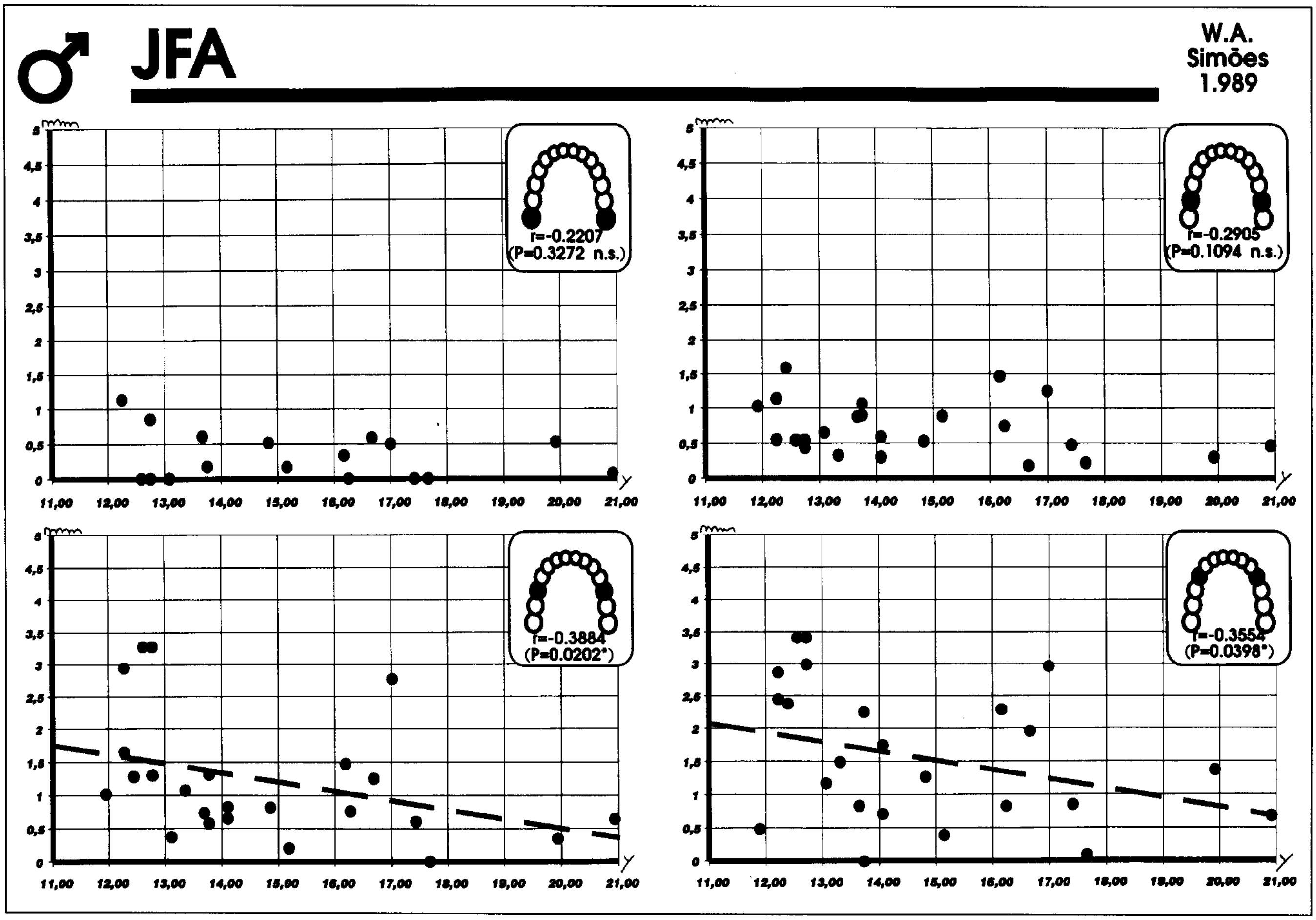


Fig. 10 Correlation between age and IOD for males with jaw functional appliances.

MANDIBLE ERUPTION MAXILLA
ERUPTION MANDIBLE MANDIBLE
MAXILLA ERUPTION

(((ONSET))) (((PHV))) (((END)))

Eruption, rotation and growth activating with different predomination according to the age corroborate to synchronize the harmonious growth adjustment. Figures 7 and 8. During treatment, the jaw functional appliances, influences the maladjustment of that particular age, but the compensation only comes in the next development stage. This explains why, for some time the IOD is bigger than in harmonious growth and why it cannot be compensated before the natural growth mechanisms and eruption are active in the favorable direction of the upper and lower occlusal plane. Figures 9 and 10. The rotation of the maxilla and/or mandible is a compensatory adaptation growth that also contributes for the adjustment of occlusal plane. It is of major clinical importance that all these adaptations be understood to avoid the interference of appliances. Only the natural forces can drive the reduction of IOD properly; compensatory mechanisms, in addition to eruption, posture and movement of mandible and tongue are called upon to secure the integrity and the maturation of the occlusal plane.

CONCLUSIONS

1. During puberty there are variations in the relation between the upper and lower occlusal plane.
2. The IOD is different according to the tooth considered.
3. The modulation of the occlusal plane is different according to age in both sexes.
4. During the harmonious growth the IOD are discrete, sometimes imperceptible.
5. The IOD is not discrete in subjects in treatment with functional jaw appliances. In certain cases, expressive values can be achieved twice those with no need of treatment. Therefore, the IOD is more visible in patients in treatment with functional appliances.[23]
6. The IOD is reduced spontaneously and there is no need of treatment.

REFERENCES

1. Cipolla-Neto, J., Muques, N., Menna-Baneto, L.S. Cronobiologia, S. Paulo, Ed. Icone. p 15, 1988.
2. Simoes,W.A., Bradao, M.RC. A lingua e o complexo hioideo como recurso no diagnostico e tratamento das ma-oclusoes. Ortodontia, 26: 89-98, 1993.
3. Simoes, W.A. New concept of serial extraction. J Pedod 6:91-113, 1982.
4. Kelch, R.P. Endocrinology of adolescence. In: Craniofacial growth during adolescence. D. Carlson, KA.Ribbens. Michigan, Craniofacial growth series. 23-30, 1987.
5. Nanda, S.K. The development basis of occlusion and malocclusion. Chicago, Quintessence pp. 52-79, 1983.
6. Nanda, R.S. The rates of growth of several facial components measured from serial cephalometric roentgenograms. Am J Orth 41: 658-673, 1955.
7. Bambha, J.K. Longitudinal cephalometric roentgenographic study of face and cranium in relation to body height. J A D A 63: 776-799, 1961.
8. Fukuhara, T., Matsumoto, M. A longitudinal study of facial growth in relation to general body height during adolescence. Bull Tokyo Med Dent Univ 15: 161-170, 1968.
9. Bjork, A. Timing of interceptive orthodontic measures based on stages of maturation. Trans Eur Orthod Soc 48: 61-74, 1972.
10. Tanner, J.M. Growth at adolescence. 2nd ed Oxford, Blackwell Scientific Pub. p 13, 1962.
11. Muller, L. Cephalometrie et orthodontie. Paris, Soc Pub Medicales et Dentaires. pp 82-93, 1962.
12. Bimler, H.P. The Bimler cephalometric analysis. Wiesbaden, p 65, 1976.
13. Lavergne, J., Gasson, N. Operational definitions of mandibular morphogenetic and positional rotations. Scand J Dent Res 85: 185-192, 1977.
14. Lavergne, J., Gasson, N. The influence of jaw rotation in the morphogenesis of malocclusions. Am J Orth 73: 658-666, 1978.
15. Lavergne, J., Petrovic, A. Discontinuities in occlusal relationship and the regulation of facial growth. A cybernetic view. European J Orthod 5: 269-278, 1983.
16. Petrovic, A. Lavergne, J., Stutzzmann, J. Diagnostic et traitement en orthopedie dentofaciale: principes et diagramme de decision. L'Orth Fr 58: 517-542, 1987.
17. Planas, P. - Gnatostato Planas. Actas XIV Congresso de Odontologia Madrid, Ed Sucesores Riva. pp 757-765, 1945.
18. Planas, P. Diagnostico sintomatologico gnatostatico. L'Orth Fr 31, 1960.
19. Planas, P. Rehabilitacion neuro-oclusal. Barcelona. Ed Salvat. pp lO3-1288, 254, 256, 1987.
20. Simoes, W.A. Orthopedia funcional de los maxilares vista a traves de la rehabilitacion neuro-oclusal. Tomo IL Venezuela Ed Isaro. pp 311-375, 1989.
21. Hartono, R. The occlusal plane in relation to facial tgpes. J Prosth Dent 17: 549-557, 1967.
22. Griffin, J. F., Ojeda, S.R. Textbook of endocrine physiology. Oxford, Univ Press pp 148-154, 176-177, 1988.
23. Simoes, W.A. Ooclusal plane: an up-to date approach. J J Orth Soc 51: 320, 1992.
24. Darling, A I., Levers, B.G.H. The pattern of eruption In: The eruption and occlusion of teeth. D.F.G. Poole and M.V. Stack. London Butterworths pp 80-97, 1976.
25. Stutzmann, J., Petrovic, A. Le muscle pterygoidien externe, un relais de l'action de la langue sur la croissance du condyle mandlbulaire. L'Orth Fr 45: 385-399, 1974.
26. Stutzmann, J., Petrovic, A. Effects de la resection du muscle ptaygoidien externe sur la croissance du cartilage condylien. Bull Ass Anat 165:524-534, 1975.
27. Stutzmann, J., Petrovic, A. Role of the lateral pterygoid muscle and menisco-temporomandibular frenum in spontaneous growth of the mandible and in growth stimulated by the postural hyperpropulsor. Am J Orth Dentof Orthop 97:381-392, 1990.
28. Profflt, W. The control of tooth eruption. J J Orth Soc 51: 26-36, 1992.
29. Berkowitz, B.K.B. Mechanism of tooth eruption. In: Applied Physiology of the mouth. C.L.B. Lavelle Bristol, Ed. John Wright and Sons Ltda. pp 99-123, 1975.
30. Dibbets, J.M.H. et al. Shape change in the mandible during adolescence. Michigan. Craniofacial growth series. Monograph 20. pp 23-30, 1987.
31. Hagg, U., Tarsnger, J. Menarche and voice change as indicators of the pubertal growth spurt Acta Odontol Scand 38:179-186, 1980.
32. Hagg, U., Taranger, J. Maturation indicators and the pubertal growth spurt. Am J Orth 82:299-309, 1982.
33. Nanda, S.K. Prediction of facial growth using different biologic criteria in females. In: Carlson, D. and Ribbens, K.A. - Craniofacial growth during adolescence. Michigan. C.F.G. series. Monograph 20. pp 135-205, 1987.
34. Bench, R.W. Growth of the cervical vertebrae as related to tongue, face and denture behavior. Am J Orthod 49:183-214, 1963.
35. Tournel, P.M. Growth of the pharynx and its physiologic implications. Am J Orthod 99:129-139, 1991.
36. Riad-Fahmy, D. Salivary progesterone for investigating ovarian activity. In: Y. Kawamura and D.B. Ferguson, Frontiers of Oral Physiology vol 5. ppl 10-123, Karger Basel, 1984.
37. Simoes, W.A. - Functional jaw orthopedics - better oral neurophysiological information gives better clinical results. J Pedodontics 8:108-115, 1983.