Braz Oral Res
2005;19(3):176-82

Increase of condylar displacement between centric relation and maximal habitual intercuspation after occlusal splint therapy

Aumento do deslocamento condilar entre relação central e máxima intercuspidação habitual após terapia com placa oclusal

Solange Mongelli de Fantini*
João Batista de Paiva*
José Rino Neto*
Gladys Cristina Dominguez*
Jorge Abrão**
Júlio Wilson Vigoritto***

ABSTRACT: The present study assessed condylar displacement between initial maximal habitual intercuspation (MHI) and centric relation (CR), recorded after using a deprogramming occlusal splint for an average period of 7.8 ± 2.1 months prior to any orthodontic treatment. The sample consisted of 22 subjects, 11 male and 11 female, with an average age of 14.2 ± 1.4 years, with Class II malocclusion[2] and with no apparent signs or symptoms of temporomandibular dysfunction (TMD). Condylar displacement was measured using a Panadent axis position indicator in decimal fractions of a millimeter. The original mean vertical displacements and the corresponding standard deviations were 4.24 ± 2.53 mm and 3.86 ± 2.72 mm, respectively, for the right and left sides. Because a significant negative correlation was observed between original condylar displacements and age factors, the displacement values were statistically adjusted to 2.74 ± 2.00 mm and 2.44 ± 1.93 mm. On the horizontal plane, the mean displacements measured were –0.72 ± 1.53 mm on the right side and –0.51 ± 1.98 mm on the left. The mean displacement on the transversal plane was 0.03 ± 0.87 mm. A comparison between these values and those observed in non-deprogrammed groups, as well as those published in the related literature, indicates that use of occlusal splints results in greater mean condylar displacement values, especially vertically, between CR and MHI positions, which contributed to a more accurate orthodontic diagnosis.

DESCRIPTORS: Mandibular condyle; Temporomandibular joint; Centric relation.

RESUMO: O presente estudo avaliou os deslocamentos condilares entre a máxima intercuspidação habitual (MIH) inicial e a relação central (RC), registrada após o uso de placa oclusal desprogramadora por período médio de 7,8 ± 2,1 meses antes do tratamento ortodôntico. A amostra consistiu de 22 indivíduos, 11 do gênero masculino e 11 do feminino, com média de idade de 14,2 ± 1,4 anos, com maloclusão de Classe II[2], sem sinais e sintomas aparentes de disfunção temporomandibular (DTM). Os deslocamentos condilares foram medidos com aproximação de décimos de milímetro, por meio do indicador de posição axial Panadent. As médias originais dos deslocamentos verticais dos lados direito e esquerdo e correspondentes desvios padrões mediram 4,24 ± 2,53 e 3,86 ± 2,72 mm, respectivamente. Devido à correlação negativa significante observada entre esses deslocamentos e os fatores relativos à idade da amostra, os mesmos foram corrigidos estatisticamente para 2,74 ± 2,00 e 2,44 ± 1,93 mm. No plano horizontal, os deslocamentos médios foram de –0,72 ± 1,53 mm no lado direito e –0,51 ± 1,98 no esquerdo. A média no plano transversal foi de 0,03 ± 0,87 mm. A comparação destes valores com aqueles observados em grupos não desprogramados e publicados na literatura indica que o uso das referidas placas resulta em deslocamentos condilares médios maiores, especialmente no sentido vertical, entre as posições de RC e de MIH, o que contribuiu para um diagnóstico ortodôntico mais preciso.

DESCRITORES: Côndilo mandibular; Articulação temporomandibular; Relação central.

INTRODUCTION

Since the early 20th century, orthodontists have been subject to criticism for evaluating patients statically, in search for simple morphological malocclusions, while ignoring the possibility of occasional functional malocclusions. Lauritzen[15] (1974) suggests that morphological malocclusions do not necessarily represent any risk of damage to supporting tissues; on the other hand, functional

* PhD, Professors; **Postdoctorate Professor; ***Chair Professor – Department of Orthodontics and Dental Pediatrics, School of Dentistry, University of São Paulo.

malocclusions are considered triggers of parafunctions, and may cause the stomatognathic system self-destruction.

Although the role of occlusion in the etiology of temporomandibular dysfunction (TMD), evaluated in its dental aspects, is still a very controversial issue, Crawford[8] (1999) observed a high degree of correlation between signs and symptoms of these dysfunctions and condylar displacement between the positions of centric relation (CR) and maximal habitual intercuspation (MHI).

Centric relation is currently understood as the maxillomandibular relation in which the condyles articulate with the thinner and avascular portion of their respective discs; this set occupies an anterosuperior position, against the posterior inclination of the articular eminentia. It is considered a position that does not depend on any dental contact and is clinically discernible when the mandible is positioned superoanteriorly and is restricted to a rotation movement around a transverse horizontal axis[1]. According to Roth[21] (1981a), the condyles must also be centralized transversally in the respective mandibular fossae.

On the other hand, MHI corresponds to the position of maximal dental contact established habitually by individuals and does not depend on the condyle-articular fossa relation.

Different studies have shown that, usually, condylar position is different between CR and MHI, giving rise to mandibular discrepancies or displacement between these two positions, which can be measured on a condylar level[11,20,24,25,27]. These discrepancies may significantly change the characteristics of the malocclusions observed, interfering substantially in orthodontic diagnosis and treatment plan[6,21,22,24].

According to Roth[21,22] (1981a, b), even if asymptomatic individuals were submitted to periods of deprogramming with occlusal splints, they would show greater condylar displacement between CR and MHI than originally observed without such deprogramming.

Mindful of the influence of the neuromuscular system on CR registration[3-5,7,10,13,14,16-19] and, consequently, on measurements of the displacement between CR and MHI positions, the present study proposed to evaluate the possible effects of neuromuscular deprogramming on these displacement measurements and on their frequency, in a group with similar characteristics to those of another group evaluated earlier[11], after a period of using deprogramming occlusal splints.

MATERIAL AND METHODS

Sample

The sample consisted of 22 subjects, eleven male and eleven female, with ages between 11.2 years and 16.8 years (mean of 14.2 ± 1.4 years) (Table 1).

Everyone in the sample was chosen through anamnesis and clinical examination, which were authorized by a parent or guardian, who signed an informed consent form after being duly informed of the procedures.

The following requisites were established as criteria for inclusion: presence of complete permanent dentition up to second molars, Angle Class II malocclusion[2], identified by analysis of the occlusal relations between molars and/or canines, and

TABLE 1 - Gender description, chronological ages, and skeletal maturity index according to the Fishman's method[12] and splint use time.

Patients	Gender	Ages at the beginning of splint therapy (in years)	Skeletal maturity at the beginning of splint therapy	Splint use time (in months)
1	male	14.4	6.5	6.4
2	male	14.1	8.0	5.5
3	female	12.9	9.0	7.1
4	male	15.0	5.0	5.8
5	male	12.0	4.0	9.9
6	male	14.5	5.0	6.2
7	female	12.1	5.0	5.9
8	male	15.9	7.5	11.6
9	female	13.7	10.5	11.9
10	female	12.6	7.0	7.6
11	male	14.7	7.5	10.6
12	male	15.4	8.0	6.7
13	female	15.4	10.5	6.4
14	female	16.8	11.0	6.9
15	female	15.2	11.0	8.5
16	female	15.1	11.0	6.9
17	male	12.6	–	7.1
18	female	11.2	8.0	6.9
19	male	14.3	8.0	6.2
20	male	13.3	5.0	11.0
21	female	14.4	10.0	10.2
22	female	14.8	10.5	4.8

lack of clinically perceptible signs or symptoms of temporomandibular dysfunction, such as spontaneous articular or muscular pain and/or pain during mandibular movements, pain prompted by palpation of the temporomandibular joints (TMJs) and related muscles, restricted mouth opening (maximum opening of less than 40 mm) and locking or dislocated mandible.

This study began after approval of the research project by the Research Ethics Committee, School of Dentistry, University of São Paulo.

Measuring condylar displacement

The displacement between CR – recorded after the neuromuscular deprogramming period with the occlusal splint – and the initial MHI was measured on the three planes of space in decimal fractions of a millimeter, based on pairs of casts from each patient, mounted in CR after splint use, in a semiadjustable articulator. Measurements were then taken with the Axis Position Indicator (API) using a millimeter-gauged magnifying glass, all made by the same manufacturer (Panadent Corporation, Grand Terrace, CA, USA).

To establish CR after deprogramming, the mandible was manipulated as described by Dawson[9] (1974), and the recording was made in blue wax (Delar Bite Registration Wax, Delar Corp., Lake Oswego, OR, USA) in two stages according to the "Power Centric" technique proposed by Roth (1994 *apud* Wood *et al.*[26], 1994). On the other hand, the MHI was recorded at the beginning of the study before deprogramming, in Moyco extra-hard pink wax (Moyco Beauty Pink Wax, Moyco Industries, Philadelphia, PA, USA).

The different steps involved in this research were carried out by one single experienced operator, except splint adjustments, which were carried out by graduate students (master degree), under the orientation and rigorous control of the said operator at each adjustment appointment. Only patients with excellent compliance were included in this study.

Neuromuscular deprogramming

This was achieved using a deprogramming occlusal splint built according to criteria proposed by Roth, Rolfs[23] (1981). The patients were instructed to wear the splints 24 hours a day, removing them only to enable oral hygiene, until the desired neuromuscular deprogramming was achieved, as confirmed by the following criteria: easy mandibular manipulation, mandibular stability, and recurrence of three consecutive CR records obtained at one-week intervals.

The total splint use time ranged from a minimum of 4.8 months to a maximum of 11.9 months. The average time of use was 7.8 ± 2.1 months (Table 1).

Stages of growth, bone maturity and statistical method

In the selected group, it was possible to identify patients in distinct stages of growth and bone maturity, a process that could explain the different growth rates while the splint was being used (Table 1).

These different growth rates could, in turn, interfere in measurements of condylar displacement under study. After evaluating the stage of skeletal maturity of all the subjects through carpal radiography of the left hand, according to the method of Fishman[12] (1982), it was possible to establish comparisons (Mann-Whitney U Test) between two sub-groups: with or without accelerated growth (Table 2).

TABLE 2 - Comparisons between groups in accelerated growth period or not, and the studied condylar displacements (mm).

Measurement	With accelerated growth (n = 15)		Without accelerated growth (n = 7)		Comparison	
	Mean ± S.D.	Median	Mean ± S.D.	Median		
API vert R	3.07 ± 1.66	2.80	6.73 ± 2.31	6.70	U = 09.5	P = 0.001*
API vert L	2.66 ± 2.08	2.30	6.41 ± 2.15	7.00	U = 08.0	P = 0.001*
API hor R	–0.77 ± 1.47	–1.00	–0.60 ± 1.78	–0.20	U = 47.0	P = 0.731
API hor L	–0.48 ± 1.67	–0.30	–0.59 ± 2.69	–1.30	U = 46.0	P = 0.680
API transv	0.01 ± 0.81	–0.20	–0.06 ± 1.06	–0.10	U = 48.0	P = 0.783

*Significant at 0.1%. API vert: vertical condylar displacement. API hor: horizontal condylar displacement. API transv: transversal condylar displacement. R: right. L: left.

An inverse correlation between measurements of age-related factors (bone maturity and chronological age) and vertical condylar displacement on the right and left sides of all participants was observed according to Spearman's rank correlation coefficient (r_s) (Table 3).

These comparisons led to the statistical adjustment of vertical condylar displacements based on a multiple linear regression model according to the following formula:

API vert r = 16.458 – (0.410 × Age) – (0.723 × Maturity)
R^2 = 0.509

API vert l = 14.047 – (0.223 × Age) – (0.805 × Maturity)
R^2 = 0.439

Where: API vert: vertical condylar displacement; r: right; l: left.

In this model, the discrepancy measurement was used as a dependent variable, and chronological age and skeletal maturity, as independent variables.

The level of significance adopted was 0.05 (α = 5%). Descriptive levels (P) lower than this value were considered significant and represented by "*".

RESULTS

The original values, corresponding to the variables studied, are presented in Table 4. The resulting mean values, standard deviations and medians are shown in Table 5.

The original measurements of vertical displacement on the right and left sides were statistically adjusted by the variables of age (chronological age and skeletal maturity) and are shown in Table 6. The adjusted mean values, standard deviations and medians are found in Table 7.

DISCUSSION

Study of frequency, degree and nature of condylar displacement between CR and MHI, in different populations, depends on the precision with which these positions are recorded. Special attention has been given to how CR is located and recorded as it is greatly influenced by the neuromuscular system[3-5,7,14]. Several neuromuscular deprogramming methods[16,17,19] have been adopted in an attempt to lessen this influence. Comparisons between these methods have shown that occlusal splints allow CR to be recorded in a more consistent and reproducible manner[3,5,10,18,19].

TABLE 3 - Spearman's correlation coefficient between "chronological age" and "skeletal maturity" variables and condylar displacement measurement.

Measurement	Initial chronological age	Initial skeletal maturity
API vert R	r_s = –0.62	r_s = –0.68
	p = 0.002*	p < 0.001*
API vert L	r_s = –0.54	r_s = –0.71
	p = 0.009*	p < 0.001*
API hor R	r_s = 0.10	r_s = 0.12
	p = 0.667	p = 0.533
API hor L	r_s = 0.08	r_s = 0.13
	p = 0.732	p = 0.567
API transv	r_s = 0.33	r_s = 0.11
	p = 0.137	p = 0.641

*Significant at < 1.0%. API vert: vertical condylar displacement. API hor: horizontal condylar displacement. API transv: transversal condylar displacement. R: right. L: left.

With this in mind, this study proposed to analyze the degree of condylar displacement between original MHI positions and CR positions recorded after neuromuscular deprogramming using occlusal splints for an average period of 7.8 ± 2.1 months.

Similarly to other evaluations[20,24,27], the records showed great dispersion, accounting for the variability of condylar displacements among individuals. This finding contraindicates the application of average values observed in studies of this nature to the overall population. Therefore, what is needed to obtain possible displacements between CR and MHI is an examination of each patient individually.

After analyzing the "chronological age" and "skeletal maturity" variables of this group, two subgroups were identified, classified as patients in accelerated growth period or not. Analysis of these two subgroups revealed significant inverse correlations between the variables of age and vertical condylar displacement on the right and left sides. It was observed that the older or the more skeletally mature the patient, the less the vertical condylar displacement. These variables, inversely related to the accelerated growth stage, revealed possible influence on the original data, thus justifying the statistical adjustment of these data, based on a multiple linear regression model.

The mean vertical displacements on the right and left sides, both original (4.24 ± 2.53 mm; 3.86 ± 2.72 mm, respectively) and adjusted

TABLE 4 - Original values, in mm, for vertical condylar displacement on the right side (API vert R) and left side (API vert L); for horizontal condylar displacement on the right side (API hor R) and left side (API hor L); and for transversal condylar displacement (API transv).

Patients	API vert R	API vert L	API hor R	API hor L	API transv
1	2.9	3.8	–0.1	–0.2	–0.1
2	3.9	2.2	–1.6	0.1	–0.4
3	7.0	5.7	–1.7	–1.7	–0.3
4	9.1	8.6	–1.5	–2.0	0.3
5	5.1	3.7	1.3	4.0	–1.0
6	6.7	7.0	–3.7	–3.7	0.5
7	9.3	7.8	–1.4	–1.3	–0.7
8	1.4	0.7	0.6	0.2	0.6
9	2.8	2.2	1.5	–0.3	1.0
10	8.1	8.7	1.4	1.8	–0.7
11	5.9	8.5	–3.4	–3.8	–0.2
12	2.5	2.3	0.5	0.4	1.1
13	2.8	1.5	–1.3	1.4	–0.3
14	1.3	0.9	–0.7	–0.4	0.0
15	1.2	0.2	0.9	1.6	–0.4
16	1.7	1.4	–1.0	–0.8	0.0
17	2.7	2.3	–0.7	2.0	–0.5
18	3.6	3.3	–1.5	–3.5	1.0
19	2.8	3.0	–3.0	–1.7	–1.7
20	5.9	5.3	–0.2	–2.7	2.1
21	4.3	3.2	–1.4	–0.7	–0.8
22	2.2	2.5	1.2	0.0	1.1

(2.74 ± 2.00 mm; 2.44 ± 1.93 mm, respectively), proved greater than those found previously by Fantini, Abrão[11] (2001), in a non-deprogrammed group, with mean values of 1.31 mm on the right side and 1.86 mm on the left side; by Wood, Korne[27] (1992), with mean values of 1.24 mm on the right side and 1.13 mm on the left side; by Wood, Elliott[25] (1994), with a mean of 1.2 mm on both sides; and by Utt *et al.*[24] (1995), with a mean of 0.91 mm on the right side and 0.73 mm on the left side. In the above-mentioned studies, a similar method was adopted to measure condylar displacement; however, in none of the four mentioned studies was any neuromuscular deprogramming method before recording CR used.

The horizontal displacements observed between CR and MHI, namely, a mean of –0.72 (± 1.53) mm on the right side and –0.51 (± 1.98) mm on the left side, also proved greater than corresponding data found by Fantini, Abrão[11] (2001), with mean values of –0.13 mm on the right side and –0.11 mm on the left side; by Wood, Korne[27] (1992), with mean values of –0.32 mm and +0.31 mm on the right and left sides, respectively; and by Wood, Elliott[25] (1994), with a mean value of –0.26 mm. Comparing the data obtained here with those of Utt *et al.*[24] (1995), the horizontal displacement on the right side observed in this study proved greater than that found by the cited author (0.63 mm); however, horizontal displacement on the left side proved less than the value of 0.64 mm found by the same author.

The mean transversal displacement of 0.03 ± 0.87 mm observed was less than that found by Utt *et al.*[24] (1995), measuring 0.27 mm, and is equal to that found by Fantini, Abrão[11] (2001), measuring –0.03 ± 0.30 mm, but in the opposite sense.

Consistently with other authors[7,10,13], and based on the data of this study, it was found that deprogramming occlusal splints influence con-

TABLE 5 - Mean values, standard deviations and median, in mm, of vertical condylar displacement on the right and the left sides (API vert R and API vert L, respectively), horizontal condylar displacement on the right and the left sides (API hor R and API hor L, respectively), and transversal condylar displacement (API transv).

Measurement	Mean ± S.D.	Median
API vert R	4.24 ± 2.53	3.25
API vert L	3.86 ± 2.72	3.10
API hor R	–0.72 ± 1.53	–0.85
API hor L	–0.51 ± 1.98	–0.35
API transv	0.03 ± 0.87	–0.15

dylar relations, even in asymptomatic patients, since a greater degree of vertical condylar displacement was evidenced between CR and MHI. This mentioned displacement brought consequences over the dental, skeletal and soft tissue aspects of malocclusion after such appliance was used. This resulted in a more precise orthodontic diagnosis, with obvious advantages to the patients studied, considering that all of them initiated orthodontic treatment immediately after splint therapy.

Unfortunately, for practical and economic reasons, the recommended use of occlusal splints before orthodontic treatment is traditionally restricted to patients presenting signs and/or symptoms of temporomandibular dysfunction. However, it is noteworthy that even in asymptomatic individuals the period of time during which these deprogramming splints are used may influence CR records substantially, and consequentially affect diagnosis and planning of orthodontic corrections. Because impracticality makes it impossible to deprogram all orthodontic patients, it is therefore recommended that CR recording be done carefully, to make sure that such record be as precise as possible. On the other hand, the deprogramming procedure cannot be dismissed, by all means, in symptomatic individuals. This circumstance does not diminish the interest or importance of performing diagnoses in centric relation, a procedure that requires the routine mounting of diagnostic casts in articulators for all orthodontic patients.

CONCLUSIONS

The data obtained in the present study leads to the conclusion that:

- The neuromuscular deprogramming performed in this study, before recording CR, resulted in greater mean condylar displacement between the positions evaluated than that found in similar studies conducted in non-deprogrammed groups.
- The displacement between CR and MHI showed frequent incidence, inasmuch as it occurred in 100% of the sample, on at least two planes of space.
- The splint therapy resulted in more accurate orthodontic diagnosis, with obvious benefits to the studied patients.

TABLE 6 - Values, in mm, for vertical condylar displacement (API vert) on the right (R) and left (L) sides, adjusted by the variables chronological age and stage of skeletal maturity.

Patients	API vert R adjusted	API vert L adjusted
1	4.9	4.7
2	4.4	3.8
3	4.1	3.4
4	6.2	6.2
5	7.6	7.2
6	6.3	6.3
7	7.0	6.4
8	3.1	3.0
9	2.5	1.9
10	5.3	4.7
11	4.0	3.7
12	3.8	3.7
13	2.0	1.6
14	1.4	1.3
15	2.0	1.7
16	2.1	1.7
17	5.3	4.7
18	5.2	4.2
19	4.3	3.9
20	6.6	6.4
21	2.6	2.2
22	2.7	2.2

TABLE 7 - Mean values, standard deviations and medians, in mm, for vertical condylar displacement (API vert) on right (R) and left (L) sides, adjusted by chronological age and skeletal maturity factors.

Measurement	Mean ± S.D.	Median
API vert R	2.74 ± 2.00	2.20
API vert L	2.44 ± 1.93	1.72

REFERENCES

1. Academy of Denture Prosthetics. Glossary of prosthodontic terms. 5th ed. St. Louis: Mosby; 1987.
2. Angle EH. Classification of malocclusion. Dent Cosmos 1899;41(2):248-64.
3. Capp NJ, Clayton JA. A technique for evaluation of centric relation tooth contacts. Part I: during normal temporomandibular joint function. J Prosthet Dent 1985a;54(4):569-74.
4. Capp NJ, Clayton JA. A technique for evaluation of centric relation tooth contacts. Part II: following use of an occlusal splint for treatment of temporomandibular joint dysfunction. J Prosthet Dent 1985b;54(5):697-705.
5. Carlson N, Moline D, Huber L, Jacobson J. Comparison of muscle activity between conventional and neuromuscular splints. J Prosthet Dent 1993;70(1):39-43.
6. Chang FHF, Chen KC, Shiau YY. The importance of determination of jaw position in orthodontic diagnosis and treatment planning for adult patients. Dent Clin North Am 1997;41(1):49-66.
7. Contin I. Estudo comparativo do reposicionamento mandibular (MIC-RC), frente ao uso do Jig e da placa miorrelaxante em pacientes dentados assintomáticos e com dor miofascial na região da cabeça e pescoço [Tese de Doutorado]. São Paulo: Faculdade de Odontologia da USP; 1997.
8. Crawford SD. Condylar axis position, as determined by occlusion and measured by the CPI instrument, and signs and symptoms of temporomandibular dysfunction. Angle Orthod 1999,69(2):103-14.
9. Dawson PE. Evaluation, diagnosis and treatment of occlusal problems. St. Louis: Mosby; 1974.
10. Dyer EH. Importance of a stable maxillomandibular relation. J Prosthet Dent 1973;30(3):241-51.
11. Fantini SM, Abrão J. Deslocamentos condilares entre RC e MIH, em jovens assintomáticos, com maloclusão de Cl II. Ortodontia 2001;34(1):28-34.
12. Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. Angle Orthod 1982;52(2):88-112.
13. Kovaleski WC, De Boever J. Influence of occlusal splints on jaw position and musculature in patients with temporomandibular joint dysfunction. J Prosthet Dent 1975;33(3):321-7.
14. Koyano K, Ogawa T, Sumiyoshi K, Tsukiyama Y, Ichiki R, Suetsugu T. Effect of occlusal splint on masticatory movement in healthy individuals. Cranio 1997;15(2):127-31.
15. Lauritzen A. Atlas of occlusal analysis. Chicago: HAH; 1974.
16. Long JH. Location of the terminal hinge axis by intraoral means. J Prosthet Dent 1970;23(1):11-24.
17. Lucia VO. A technique of recording centric relation. J Prosthet Dent 1964;14(3):492-505.
18. Neff P. Trauma from occlusion. Restorative concerns. Dent Clin North Am 1995;39(2):335-54.
19. Nelson SJ. Principles of stabilization bite splint therapy. Dent Clin North Am 1995;39(2):403-21.
20. Rosner D, Goldberg GF. Condylar retruded contact position and intercuspal position correlation in dentulous patients. Part I: three-dimensional analysis of condilar registrations. J Prosthet Dent 1986;56(2):230-9.
21. Roth RH. Functional occlusion for the orthodontist. J Clin Orthod 1981a;15(1):32-51.
22. Roth RH. Functional occlusion for the orthodontist. Part III. J Clin Orthod 1981b;15(3):174-98.
23. Roth RH, Rolfs DA. Functional occlusion for the orthodontist. Part II. J Clin Orthod 1981;15(2):100-23.
24. Utt TW, Meyers CE Jr, Wierzba TF, Hondrum SO. A three-dimensional comparison of condylar position changes between centric relation and centric occlusion using the mandibular position indicator. Am J Orthod Dentofacial Orthop 1995;107(3):298-308.
25. Wood DP, Elliott RW. Reproducibility of the centric relation bite registration technique. Angle Orthod 1994;64(3):211-20.
26. Wood DP, Floreani KJ, Galil KA, Teteruck WR. The effect of incisal bite force on condylar seating. Angle Orthod 1994;64(1):53-61.
27. Wood DP, Korne PH. Estimated and true hinge axis: a comparison of condylar displacements. Angle Orthod 1992;62(3):167-75.

Received for publication on Dec 14, 2004
Sent for alterations on Mar 17, 2005
Accepted for publication on Jul 18, 2005