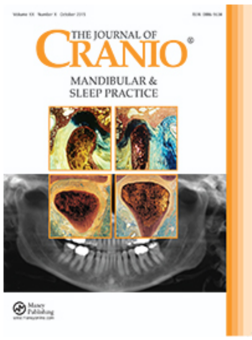

CRANIO®

The Journal of Craniomandibular & Sleep Practice

ISSN: 0886-9634 (Print) 2151-0903 (Online) Journal homepage: http://www.tandfonline.com/loi/ycra20

Laterotrusive Occlusal Schemes and Jaw Posture Tasks Effects On Supra- and Infrahyoid EMG Activity in the Lateral Decubitus Position

Rodolfo Miralles, Francisca Gallardo, Mauricio Baeza, Saúl Valenzuela, María José Ravera, Guillermo Ormeño & Gabriel Cavada

Laterotrusive Occlusal Schemes and Jaw Posture Tasks Effects On Supra- and Infrahyoid EMG Activity in the Lateral Decubitus Position

Rodolfo Miralles, D.D.S.; Francisca Gallardo, D.D.S.; Mauricio Baeza, D.D.S.; Saúl Valenzuela, D.D.S.; María José Ravera, D.D.S.; Guillermo Ormeño, B.S.C.; Gabriel Cavada, M.S.

0886-9634/2502-106$05.00/0, THE JOURNAL OF CRANIOMANDIBULAR PRACTICE,

Manuscript received May 31, 2006; revised manuscript received November 7, 2006; accepted November 8, 2006

Address for correspondence:
Dr. Rodolfo Miralles
Oral Physiology Laboratory
Biomedical Sciences Institute
Faculty of Medicine
University of Chile
Independencia 1027
Clasificador Nº 7,
Independencia, Santiago
Chile
E-mail:
rmiralle@med.uchile.cl

ABSTRACT: The purpose of this study was to determine the effect of canine guidance and group function on supra- and infrahyoid EMG activity in the lateral decubitus position at different jaw posture tasks. The sample included 40 healthy subjects with natural dentition and bilateral molar support, 20 with bilateral canine guidance and 20 with bilateral group function. An inclusion criterion was that subjects had to be free of signs and symptoms of any dysfunction of the masticatory system. Bipolar surface electrodes were located on the left supra- and infrahyoid muscles for EMG recordings. In the lateral decubitus position, EMG activity was recorded in subjects with canine guidance or group function, during the following jaw posture tasks: A. maximal clenching in the edge-to edge lateral contact position; B. grinding from intercuspal position to edge-to-edge lateral contact position, and C. grinding from edge-to-edge lateral contact position to intercuspal position. Supra- and infrahyoid EMG activity was not significantly different with canine guidance or group function (mixed model with unstructured covariance matrix). Overall comparison of suprahyoid or infrahyoid EMG activity among the three jaw posture tasks studied showed a significantly higher activity during jaw posture task A (clenching) than jaw posture tasks B and C (grinding). Suprahyoid EMG activity was significantly higher during jaw posture task C than B, whereas infrahyoid EMG activity did not present a significant difference between jaw posture tasks C and B. These EMG patterns observed could be of clinical importance in the presence of parafunctional habits, i.e., clenching and/or grinding. The neurophysiological mechanisms involved are discussed.

Dr. Rodolfo Miralles *received his D.D.S. degree in 1975 from the University of Chile. He is a full professor and chief of the Oral Physiology Laboratory, Biomedical Sciences Institute, Faculty of Medicine, University of Chile. Dr. Miralles is a member of the International Association for Dental Research and also an associate editor of the Chilean Odontology Journal.*

Tooth contact during voluntary lateral movements varies in regard to location and number. Such differences are reflected in therapeutic techniques through two well-known but opposing concepts: canine protection, i.e., contact only between working-side maxillary and mandibular canines, and group function, i.e., contacts between two or more pairs of opposing teeth on the working side.[1-4]

Canine guidance and group function both occur in natural dentition.[5-7] Currently, canine protected occlusion and group function without balancing-side contact are accepted as therapeutic occlusion for natural dentition.[8, 9]

Several studies[10-19] compare the effect of canine guidance and group function on anterior temporal, masseter and sternocleidomastoid electromyographic (EMG) activity. Some authors have found significantly lower EMG activity with canine guidance than group function, whereas other authors found no significant differences.

So far, knowledge concerning the effect of canine guidance and group function on supra- and infrahyoid EMG activity is limited to a study performed by Valenzuela, et al.[20] who found no significant different effect of canine guidance and group function on supra- and infrahyoid EMG activity in the standing position.

It would be clinically relevant to know if one of these laterotrusive occlusal schemes is more effective in order to avoid no physiological muscle tension during laterotrusive occlusal excursion, i.e., clenching or grinding in the lateral decubitus position, which is one of the habitual sleeping positions. Therefore, this study was aimed to compare the effect of canine guidance and group function on supra- and infrahyoid EMG activity in the lateral decubitus position at different jaw posture tasks.

Materials and Methods

Subjects

The sample studied included 40 healthy subjects with natural dentition, bilateral molar support, Angle Class I molar relationship, normal overbite and overjet, no prior orthodontic treatment, no history of orofacial pain or craniomandibular-cervical-spinal disorders, no history of trauma or fractured teeth, and no large restorations that included an incisal edge or one or more cusps. None of the subjects were on a therapeutic medication that could have influenced muscle activity. Participants were enrolled during July 2005 from students of the Dental School of the University of Chile. The study was approved by the Ethics Committee of the University of Chile and signed informed consent was obtained from all subjects.

During the clinical static occlusal exam, the Angle Class I occlusion was defined when the mesiobuccal cusp of the maxillary first molar occluded in the buccal groove of the mandibular first permanent molar. During the clinical dynamic occlusal exam, the subjects were asked to bite in their habitual intercuspal position and then slide the mandible to a right or left lateral excursion in tip to tip cusps contact. The sample was classified according to the contacts between the teeth on the working side into the following two groups of 20 each (**Figure 1**):

1. *Canine-guided occlusion*: Canines in contact on the working side and no occlusal contact on the nonworking side for both right and left lateral excursion (11 females and nine males, mean age 21.1 years; range from 18 to 28 years).
2. *Group-function occlusion*: Two or more teeth other than canines in contact on the working side and no contacts on the nonworking side for both left and right lateral excursions (14 females and six males, mean age 19.5 years; range from 18 to 25 years).

Two authors performed all of the examinations of the static and dynamic occlusion. Agreement between both examiners was needed for selecting the subject. The consistency in the clinical diagnosis across the examiners was high, but when there was no agreement, the subject was excluded. The period during which the examiners selected the sample was continuous and lasted four weeks.

Body Position

Subjects were placed in left lateral decubitus position (head, neck and body were horizontally aligned, checked by an operator standing approximately three meters from the bed)[21] (**Figure 2**). A Sleep Easy Pillow (Interwood Marketing Groups, Ontario, Canada) was used to support the head because a recent study showed that most of the

Figure 1
Clinical view of laterotrusive occlusal scheme studied: bilateral canine guidance (left top) and bilateral group function (left below).

subjects (62%) preferred the more rigid support of this pillow in comparison with other pillows.[22] A special bed and a Runnair Physio-Action mattress (Rosen S.A.C.I., Chile) were used. The light in the room was turned off, and the subjects were asked to keep their eyes closed.

Electromyography

EMG recordings were taken with the informed written consent of each participant. Bipolar surface electrodes (BIOTRODE No-Gel Electrodes, BioResearch, Inc., Milwaukee, WI) were used on the left suprahyoid and left infrahyoid muscles (**Figure 3**). The skin area was cleaned with alcohol. The electrodes were placed on the suprahyoid muscles following the direction of the muscle fibers, according to the technique described in previous studies.[23-25] For infrahyoid EMG activity recordings, the electrodes were placed on the anterior prominent part of the thyroid cartilage, one cm laterally to the anterior median line.[25,26] A surface ground electrode was attached to the forehead. The EMG was amplified, integrated (time constant 1800 msec), and then registered on a polygraph (Nihon Kohden, Kogyo Co., Ltd., Tokyo, Japan), which was calibrated both before and after each recording. Prior to integration, the high frequency control on the amplifier was turned off, and the time constant control set at 0.003 seconds. During recordings, the EMG was monitored continuously using a Tektronix type 502 Dual Beam Oscilloscope (Tektronix, Inc., Portland, Oregon).

Individuals underwent three IEMG recordings of the left supra- and infrahyoid muscles during the following jaw posture tasks:

Task A: Static clenching in left edge-to-edge lateral contact position with canine guidance or group function.

Task B: Grinding from intercuspal position to the left lateral edge-to-edge contact position (with canine guidance or group function).

Task C: Grinding from left lateral edge-to-edge contact position (with canine guidance or group function) to intercuspal position.

To reproduce the same edge-to-edge contact position consistently, a vertical mark was made on the upper and lower left canines.

The jaw tasks were shown to each subject and explained using dental casts. Then, all individuals repeated the jaw tasks at least five times prior to the recordings, while looking in a mirror. During maximal voluntary clenching, individuals were instructed to bite as hard as they could. During grinding, they were asked to grind heavily while they performed the movement. The initial and final jaw position was checked during the IEMG recordings. Before performing the IEMG recordings, the sequence of conditions was randomized to assure similar basal IEMG activity.

No trial lasted longer than ten seconds. It has been reported[27] that muscle fatigue occurs in the masseter after 30 seconds of isometric contraction (clenching), whereas 30 seconds of combined concentric and eccentric contractions (grinding) induce no fatigue. To avoid muscular fatigue, a rest period of one minute between each trial was allowed. In addition, a three-minute rest period after each change of jaw task was included.

On each trial, the total amplitude of EMG activity (including tonic plus phasic activity) was measured in periods of one second each and the mean value for each curve was obtained. Mean value of the three curves obtained for each subject at each jaw task was used. To quantify the increase of vertical dimension from intercuspal position to lateral edge-to-edge contact position, horizontal marks were made in the upper and lower left canines (**Table 1**). A body mass index (BMI) was obtained

Figure 2
Subject in left lateral decubitus position with head supported.

Figure 3
View of electrodes in position.

for each subject, dividing the weight (in kilograms) by the square of the height (in meters). Age, gender and BMI variables were used to check its possible influence on muscle activity recorded.[28]

Statistical Analysis

Regression analysis for repeated measures between EMG activity and each one of the explanatory variables (age, gender, body mass index, and the increase in the vertical dimension) was performed for suprahyoid as well as for infrahyoid muscles. Only those explanatory variables that showed a significant effect on supra- and infrahyoid activity were included in the mixed model with an unstructured covariance matrix. The data were analyzed using SAS, Release 8.1 (SAS Institute, Inc., Cary, NC).

Results

Figure 4 presents the group mean value of suprahyoid IEMG activity during the laterotrusive occlusal schemes studied. A tendency of higher activity with group function than canine guidance was observed in the three jaw posture tasks studied. The effect of age, gender, and body mass index (BMI) on supra- and infrahyoid IEMG activity was not significant and not included in the mixed model with unstructured covariance matrix.

Table 2 shows that suprahyoid EMG activity was not significantly different with canine guidance and group function ($p>.05$). The change in vertical dimension between the intercuspal position and left lateral edge-to-edge contact position (with canine guidance or group function) did not have a significant effect on suprahyoid IEMG activity ($p>.05$). This table also shows the overall comparison of suprahyoid EMG among the three jaw posture tasks studied. EMG activity recorded during jaw posture task A (static clenching in left edge-to-edge lateral contact position) was significantly higher than during jaw posture task B (grinding from intercuspal position to left lateral edge-to-edge contact position) which was significantly higher than during jaw posture task C (grinding from left lateral edge-to-edge contact position to intercuspal position).

Figure 5 presents the group mean value of infrahyoid EMG activity during the laterotrusive occlusal schemes studied. A tendency of higher activity with group function than with canine guidance was observed in jaw posture tasks A and C, whereas an opposite tendency was observed in jaw posture task B.

Table 3 shows that infrahyoid EMG activity was not significantly different with canine guidance and group function ($p>.05$). The change in vertical dimension between the intercuspal position and left lateral edge-to-edge contact position (with canine guidance or group function) did not have a significant effect on infrahyoid IEMG activity ($p>.05$). This table also shows the overall comparison of infrahyoid EMG among the three jaw posture tasks studied. EMG activity recorded during jaw posture task A (static recording) was significantly higher than during jaw posture tasks B and C (dynamic recordings), whereas activity recorded during dynamic recordings did not present a significant difference.

Discussion

In the lateral decubitus position, supra- and infrahyoid EMG activity was not significantly different with canine guidance or group function, suggesting that both laterotrusive occlusal schemes have a similar effect on supra- and infrahyoid muscles to avoid physiological muscle tension. This result agrees with a previous study[20] performed in the standing position that found a similar

Table 1
Characteristics of Studied Individuals

Group Function							Canine Guidance						
Subject	Age (yrs)	Gender	Weight (kgs)	Height (meters)	BMI	VD*	Subject	Age (yrs)	Gender	Weight (kgs)	Height (meters)	BMI	VD*
1	20	F	48	1.58	19.23	0.67	1	20	M	69	1.72	23.32	3.00
2	18	M	60	1.65	22.03	1.00	2	19	F	66	1.70	22.83	3.50
3	18	F	57	1.65	20.93	1.33	3	18	M	71	1.82	21.43	1.80
4	19	F	67	1.63	25.21	1.00	4	19	M	63	1.76	20.33	3.00
5	19	F	59	1.60	23.04	1.00	5	19	M	70	1.75	22.85	2.00
6	19	F	52	1.62	19.81	1.50	6	23	F	59	1.63	22.20	3.00
7	19	M	70	1.72	23.66	0.50	7	19	F	65	1.60	25.39	4.00
8	19	F	51	1.64	18.93	2.00	8	28	M	81	1.83	24.18	3.00
9	18	F	52.5	1.65	19.28	1.66	9	19	F	55	1.60	21.48	3.00
10	19	F	52	1.64	19.33	1.83	10	23	F	77	1.61	29.70	3.50
11	18	M	61	1.75	19.91	2.00	11	24	F	59	1.65	21.67	3.50
12	22	F	66	1.67	23.66	1.00	12	19	M	102	1.78	32.19	3.00
13	20	M	75	1.78	23.67	1.00	13	19	F	55	1.65	20.20	2.00
14	18	M	54	1.67	19.36	2.50	14	25	F	58	1.63	21.82	2.00
15	19	F	60	1.73	20.04	1.00	15	18	F	44	1.52	19.04	4.50
16	20	F	59	1.62	22.48	2.00	16	24	F	70	1.60	27.34	2.50
17	25	F	85	1.67	30.47	2.00	17	20	M	80	1.80	24.69	3.00
18	19	F	59	1.68	20.90	1.00	18	28	M	71	1.73	23.72	3.00
19	21	M	63	1.70	21.79	1.00	19	19	F	62	1.71	21.20	3.00
20	21	F	55	1.63	20.70	2.00	20	20	M	68	1.83	20.30	4.50

F: female; M: male
BMI: body mass index
VD*: change in vertical dimension between the intercuspal position and the left lateral edge-to-edge contact position (with canine guidance or group function)

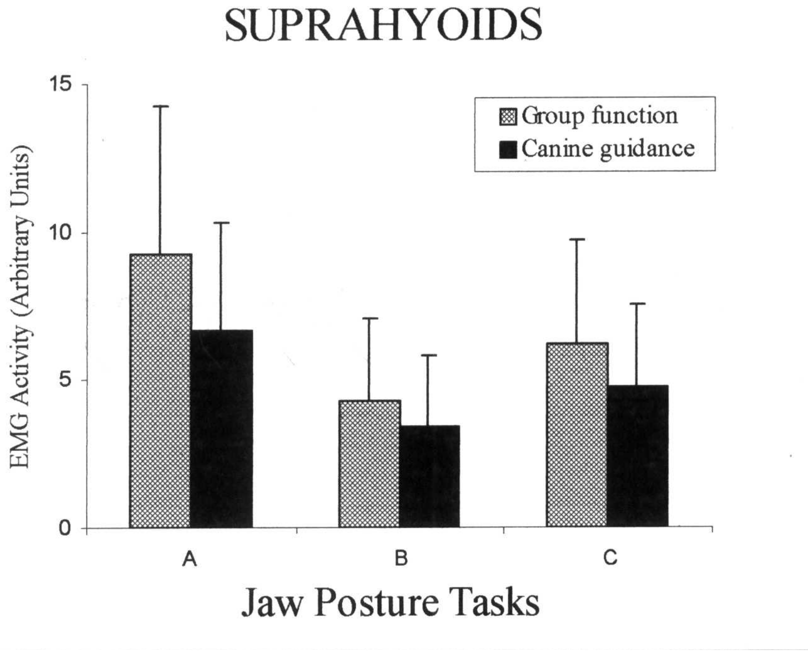

Figure 4
Bar graph showing the group mean value of suprahyoid EMG activity with canine guidance and group function during the following jaw posture tasks: **A**: clenching in the lateral edge-to-edge contact position; **B**: grinding from maximum intercuspation to lateral edge-to-edge contact position; **C**: grinding from lateral edge-to-edge contact position to maximum intercuspation.

Table 2
Comparison of Suprahyoid EMG Activity Adjusted by Vertical Dimension and Laterotrusive Occlusal Schemes Studied (Mixed Model with Unstructured Covariance Matrix)

EMG activity	Coef.	SD	z	p>|z|	[95% conf. interval]	
Vertical dimension	-0.61	0.68	-0.89	0.374 NS	-1.94	0.73
Group function	0.66	1.42	0.46	0.644 NS	-2.13	3.45
Jaw posture task B	-4.07	0.51	-7.91	0.000**	-5.08	-3.06
Jaw posture task C	-2.45	0.51	-4.76	0.000**	-3.46	-1.44
Constant	8.96	2.18	4.10	0.000	4.68	13.24

Occlusal scheme reference: canine guidance
Jaw posture reference: task A
Task B vs. Task C = **
**p<0.01; NS: not significant

effect of both laterotrusive occlusal schemes on supra- and infrahyoid muscles.

The present study performed in the lateral decubitus position and our previous work performed in the standing position[20] did not support the idea that canine guidance is better than group function with respect to the effect on supra- and infrahyoid EMG activity when large oral rehabilitation is required.

This study supports the idea that jaw stability during maximal voluntary clenching or grinding is more important than the type of occlusal scheme during laterotrusive jaw excursion. This suggests the existence of complex and not well-understood interactions within the cranio-cervical-mandibular system.

The similar pattern of supra- and infrahyoid EMG activity observed with both laterotrusive occlusal schemes could be explained by a counterbalance of several peripheral and central neuromechanisms.[29] In addition to the trigeminal peripheral influences, i.e., from articular, muscular, and periodontal receptors,[30] the effect of other influences must be considered, i.e., vestibular receptors, and neck tonic reflex.[29,31]

The comparison of the overall EMG activity recorded at different jaw posture tasks showed a significantly higher activity in task A (static recording) than tasks B and C (dynamic recordings) in the suprahyoid as well as in the infrahyoid muscles. This could be due to the isometric contraction of suprahyoid and infrahyoid muscles

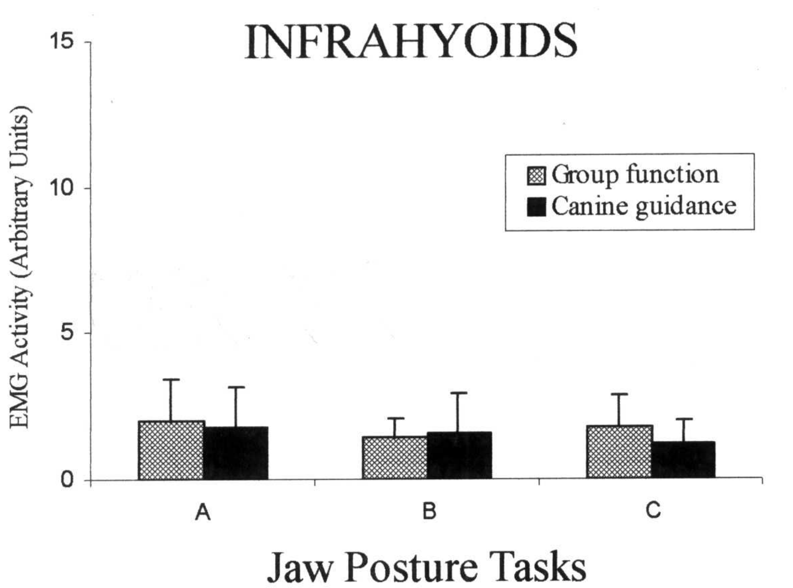

Figure 5
Bar graph showing the group mean value of infrahyoid EMG activity with canine guidance and group function during the following jaw posture tasks: **A**: clenching in the lateral edge-to-edge contact position; **B**: grinding from maximum intercuspation to lateral edge-to-edge contact position; **C**: grinding from lateral edge-to-edge contact position to maximum intercuspation.

Table 3
Comparison of Infrahyoid EMG Activity Adjusted by Vertical Dimension and Laterotrusive Occlusal Schemes Studied (Mixed Model with Unstructured Covariance Matrix)

EMG activity	Coef.	SD	z	p>|z|	[95% conf. interval]	
Vertical dimension	-0.21	0.20	-1.01	0.310 NS	-0.60	0.19
Group function	-0.14	0.42	-0.32	0.747 NS	-0.97	0.70
Jaw posture task B	-0.40	0.20	-2.02	0.044*	-0.78	-0.01
Jaw posture task C	-0.39	0.20	-1.99	0.047*	-0.77	-0.01
Constant	2.44	0.65	3.73	0.000	1.16	3.73

Occlusal scheme reference: canine guidance
Jaw posture reference: task A
Task B vs. Task C = NS
*p<0.05; NS: not significant

to fix the position of the hyoid bone, whereas isometric contraction of elevator muscles fixes the position of the jaw.[20] This EMG pattern observed could be of clinical importance in the presence of clenching parafunctional habits, depending on their intensity, frequency and duration. It is has been shown that static contractile activity of the mandibular elevator muscles produces high levels of isometric tension and could lead to masseter muscle fatigue in about 30 seconds.[27] Contingent on the level of the generated force and the duration of the isometric contractions, static activities give rise to fatigue and pain.[32]

A different EMG activity behavior was observed in both muscular groups during dynamic recordings in the lateral decubitus position. Suprahyoid EMG activity recorded during jaw posture task C was significantly higher than jaw posture task B, whereas infrahyoid EMG activity was similar in both jaw posture tasks. This EMG pattern suggests a differential modulation on motor neuron pools of the supra- and infrahyoid muscles of peripheral and/or central origin.[20,25,33] Probably, during a dynamic laterotrusive movement in the lateral decubitus position, in addition to the trigeminal peripheral influences, it must be considered the effect of other influences, i.e., vestibular receptors, neck tonic reflex, and skin receptors of the body. These inputs should have a more predominant influence on the motoneuron pools of the infrahyoid than the suprahyoid muscles, because suprahyoid EMG patterns in the lateral decubitus position were similar to those observed in a previous work performed in the standing position.[20] Supra- and infrahyoid EMG patterns observed during dynamic jaw posture tasks could be important in the presence of grinding parafunctional habits, depending on their intensity, frequency and duration.

Final Considerations

In the present study, the effect of canine guidance and group function on supra- and infrahyoid EMG activity in the lateral decubitus position at different jaw posture tasks was evaluated in each subject without altering his/her oral environment.[19,34] Experimentally gained data about co-activation of the supra- and infrahyoid muscles during jaw posture tasks studied promote a better understanding of the control strategies of the motor system.[35]

From an overall point of view, knowledge concerning supra- and infrahyoid EMG patterns during laterotrusive occlusal schemes at different jaw posture tasks is important because of the significant role of these muscles in the mandibular dynamics. They are directly or indirectly involved in mastication, speech, swallowing, and breathing.[33,36-40]

The results of the present study illustrate that there is a close association between the jaw posture tasks and the action of the supra- and infrahyoid muscles.

The major clinical finding of this study is the higher activity observed during task A (static recording) than in tasks B and C (dynamic recordings). Therefore, in the presence of clenching habits in the edge-to edge lateral contact position, depending on the intensity, frequency, and duration of the parafunctional habit, it could mean clinical muscular symptoms in the supra- and infrahyoid muscles, once the physiological adaptation mechanisms are overridden.

Acknowledgements

We would like to express our appreciation to Bio-Research (Milwaukee, WI) for the donation of the BioFlex: Flexible No-Gel EMG Electrodes.

References

1. Ingervall B: Tooth contact in the functional and nonfunctional side in children and young adults. *Arch Oral Biol* 1972; 17:191-200.
2. Woda A, Vigneron P, Kay D: Nonfunctional and functional occlusal contacts: a review of the literature. *J Prosthet Dent* 1979; 42:335-341.
3. Clark JR, Evans RD: Functional occlusion: I. a review. *J Orthodont* 2001; 28:76-81.
4. Jemt T, Lundquist S, Hedegard B: Group function or canine protection. *J Prosthet Dent* 2004; 91:403-408.
5. Beyron HL: Characteristics of functionally optimal occlusion and principles of occlusal rehabilitation. *JADA* 1954; 48:648-656.
6. D'Amico A: Functional occlusion of the natural teeth of man. *J Prosthet Dent* 1961; 11:899-915.
7. Beyron HL: Optimal occlusion. *Dent Clin North Am* 1969; 13:537-554.
8. Ramfjord S, Ash MM: Occlusal adjustment of natural teeth. In: Ramfjord S, Ash MM, eds. *Occlusion*. Philadelphia: Saunders, 1983:384-424.
9. Wiskott HWA, Belser UC: A rationale for a simplified occlusal design in restorative dentistry: historical review and clinical guidelines. *J Prosthet Dent* 1995; 73:169-183.
10. Williamson EH, Lundquist DO: Anterior guidance: its effects on electromyographic activity of the temporal and masseter muscles. *J Prosthet Dent* 1983; 49:816-823.
11. Shupe RJ, Mohamed SE, Christensen LV, Finger MI, Weinberg R: Effects of occlusal guidance on jaw muscle activity. *J Prosthet Dent* 1984; 51:811-818.
12. MacDonald JWC, Hannam AG: Relationship between occlusal contacts and jaw-closing muscle activity during tooth clenching. Part I. *J Prosthet Dent* 1984; 52:718-728.
13. MacDonald JWC, Hannam AG: Relationship between occlusal contacts and jaw-closing muscle activity during tooth clenching. Part II. *J Prosthet Dent* 1984; 52:862-867.
14. Belser UC, Hannam AG: The influence of altered working-side occlusal guidance on masticatory muscles and related jaw movement. *J Prosthet Dent* 1985; 53:406-413.
15. Manns A, Chan C, Miralles R: Influence of group function and canine guidance on electromyographic activity of elevator muscles. *J Prosthet Dent* 1987; 57:494-501.
16. Graham GS, Rugh JD: Maxillary splint occlusal guidance patterns and EMG activity of the jaw-closing muscles. *J Prosthet Dent* 1988; 59:72-77.
17. Akoren A, Karaagaclioglu L: Comparison of electromyographic activity of individuals with canine guidance and group function occlusion. *J Oral Rehabil* 1995; 22:73-77.
18. Borromeo GL, Suvinen TI, Reade PC: A comparison of the effects of group function and canine guidance interocclusal device on masseter muscle electromyographic activity in normal subjects. *J Prosthet Dent* 1995; 74:174-180.
19. Leiva M, Miralles R, Palazzi C, Marulanda H, Ormeño G, Valenzuela S, Santander H: Effects of laterotrusive occlusal scheme and body position on bilateral sternocleidomastoid EMG activity. *J Craniomandib Pract* 2003; 21:99-109.
20. Valenzuela S, Baeza M, Miralles R, Cavada G, Zúñiga C, Santander H: Laterotrusive occlusal schemes and their effect on supra- and infrahyoid electromyographic activity. *Angle Orthod* 2006; 76:585-590.
21. Santander H, Miralles R, Pérez J, Valenzuela S, Ravera MJ, Ormeño G, Villegas R: Effects of head and neck inclination on bilateral sternocleidomastoid EMG activity in healthy subjects and in patients with myogenic cranio-cervical-mandibular dysfunction. *J Craniomandib Pract* 2000; 18:181-191.
22. Ambrogio N, Cuttiford J, Lineker S, Li L: A comparison of three types of neck support in fibromyalgia patients. *Arth Care Res* 1998; 11:405-410.
23. Pancherz H, Winnberg A, Westesson PL: Masticatory muscle activity and hyoid bone behavior during cyclic movements in man. *Am J Orthod* 1986; 89:122-131.
24. Winnberg A, Pancherz H, Westesson PL: Head posture and hyo-mandibular function in man. *Am J Orthod Dentofac Orthop* 1988; 94:393-404.
25. Ding R, Logemann JA, Larson CR, Rademaker AW: The effects of taste and consistency on swallow physiology in younger and older healthy individuals: a surface electromyographic study. *J Speech Lang Hear Res* 2003; 46:977-989.
26. Miralles R, Gutierrez C, Zucchino G, Cavada G, Carvajal R, Valenzuela S, Palazzi C: Body position and jaw posture effects on supra- and infrahyoid electromyographic activity in humans. *J Craniomandib Pract* 2006; 24:98-103.
27. Christensen LV, Mohamed SE: Contractile activity of the masseter muscle in experimental clenching and grinding of the teeth in man. *J Oral Rehabil* 1984; 11:191-199.
28. Jordan AS, Catcheside PG, O'Donoghue FJ, Saunders NA, McEvoy RD: Genioglossus muscle activity at rest and in response to brief hypoxia in healthy men and women. *J Appl Physiol* 2002; 92:410-417.
29. Kraus S: Cervical spine influence on the craniomandibular region. In: *TMJ disorders: managements of the craniomandibular complex*. London: Churchill-Livingstone, 1998:389-390.
30. De Laat A: Reflexes elicitable in jaw muscles and their role during jaw function and dysfunction: a review of the literature. Part I: Receptors associated with the masticatory system. *J Craniomandib Pract* 1987; 5:139-151.
31. Willis WD Jr, Grossman RG: *Medical neurobiology*. 2nd ed. St. Louis: CV Mosby, 1977.
32. Christensen LV: Physiology and pathophysiology of skeletal muscle contractions. Part II. Static activity. *J Oral Rehabil* 1986; 13:463-477.
33. De Mayo T, Miralles R, Barrero R, et al.: Breathing type and body position effects on sternocleidomastoid and suprahyoid EMG activity. *J Oral Rehabil* 2005; 32:495-503.
34. Yamaguchi S, Rikimaru H, Yamaguchi K, Itoh M, Watanabe M: Overall activity of all masticatory muscles during lateral excursion. *J Dent Res* 2006; 85:69-73.
35. Schindler HJ, Rues S, Turp JC, Schweizerhof K, Lenz J: Activity patterns of the masticatory muscles during feedback-controlled simulated clenching activities. *Eur J Oral Sci* 2005; 113:469-478.
36. Rocabado M: Biomechanical relationship of the cranial, cervical, and hyoid regions. *J Craniomandib Pract* 1983; 1:61-66.
37. Berzin F: Electromyographic analysis of the sternohyoid muscle and anterior belly of the digastric muscle in jaw movements. *J Oral Rehabil* 1995; 22:463-467.
38. Takahashi S, Ono T, Ishiwata Y, Kuroda T: Breathing modes, body positions, and suprahyoid muscle activity. *J Orthod* 2002; 29:307-313.
39. Doual A, Leger JL, Doual JM, Hadjiat F: The hyoid bone and vertical dimension. *J Orthod Fr* 2003; 74:333-363.
40. Maeda K, Ono T, Otsuka R, Ishiwata Y, Kuroda T, Ohyama K: Modulation of voluntary swallowing by visual inputs in humans. *Dysphagia* 2004; 19(1):1-6.

Dr. Francisca Gallardo *received her D.D.S. degree in 2006 from the University of Chile. During her work on this study, she was a research fellow of the Oral Physiology Laboratory, Biomedical Sciences Institute, Faculty of Medicine, University of Chile.*

Dr. Mauricio Baeza *received his D.D.S. degree in 2005 from the University of Chile. During his work on this study, he was an academic of the Faculty of Odontology, University of Chile.*

Dr. Saúl Valenzuela *received his D.D.S. degree in 1990 from the University of Chile. He is an academic of the Prosthodontics Department, Faculty of Odontology, University of Chile. Dr. Valenzuela is currently a staff member of the Oral Physiology Laboratory, Biomedical Sciences Institute, Faculty of Medicine, University of Chile. He devotes his professional time to work in oral rehabilitation in several private health institutions and in private practice.*

Dr. Maria José Ravera *received her D.D.S. degree in 1990 and obtained a post graduate degree in orthodontics in 1996 from the University of Chile. She is currently a staff member of the Oral Physiology Laboratory, Biomedical Sciences Institute, Faculty of Medicine, University of Chile. Dr. Ravera is dedicated to orthodontic treatment in several private health institutions and in private practice.*

Dr. Guillermo Ormeño *received his B.S. degree in 1967 from the Catholic University of Chile. He is an assistant professor and a staff member of the Oral Physiology Laboratory, Biomedical Sciences Institute, Faculty of Medicine, University of Chile. Dr. Ormeño is a member of the Chilean Biology Society, the Chilean Society of Physiological Sciences and the Chilean Society of Pediatrics.*

Mr. Gabriel Cavada *received his statistical technician degree in 1996 from the University of Chile and a Master of Biostatistics in 1998 from the same university. He is an assistant professor of the Public Health School, Faculty of Medicine, University of Chile. Mr. Cavada is a member of the Chilean Chapter of Biometrics Society and the Chilean Statistics Society.*