# Laterotrusive Occlusal Schemes and Their Effect on Supra- and Infrahyoid Electromyographic Activity

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**Abstract:** The objective of this study was to determine the effects of canine guidance and group function on supra- and infrahyoid electromyographic (EMG) activity. The sample included 40 healthy subjects, 20 with bilateral canine guidance and 20 with bilateral group function. Surface electrodes were used to record the integrated EMG (IEMG) activity of the left supra- and infrahyoid muscles during (1) grinding from intercuspal position to lateral edge-to-edge contact position (with canine guidance or group function), (2) static clenching in edge-to-edge lateral contact position with canine guidance or group function, and (3) grinding from lateral edge-to-edge contact position (with canine guidance or group function) to intercuspal position. IEMG activity in the suprahyoid or infrahyoid muscles was not significantly different with canine guidance or group function. Supra- and infrahyoid IEMG activity in condition 2 was significantly higher than in condition 3, which was significantly higher than in condition 1. Supra- and infrahyoid IEMG activity was not significantly different with canine guidance and group function. Supra- and infrahyoid IEMG activity during the static recording (clenching) was significantly higher than during the dynamic recordings (grinding). Activity during grinding from the lateral edge-to-edge contact position to the intercuspal position was higher than vice versa.

**Key Words:** Canine guidance; Group function; Electromyography; Grinding; Clenching

## INTRODUCTION

Tooth contact during voluntary lateral movements varies. Such differences are reflected in therapeutic techniques through two well-known but opposing concepts:[1–11] canine protection (canine guidance), ie, contact only on the working-side maxillary and mandibular canines, and group function, ie, simultaneous contact of the canine and posterior teeth on the working side.

Several studies have been performed to compare the effects of canine guidance and group function on elevator electromyographic (EMG) activity. Some authors have found significantly lower EMG activity with canine guidance than with group function,[12–14] whereas other authors found no significant differences.[15,16] Recently, sternocleidomastoid EMG activity was recorded with both laterotrusive schemes, and lower EMG activity was found with canine guidance than with group function.[17]

Supra- and infrahyoid muscles are directly or indirectly involved in mastication, speech, swallowing, and breathing.[18–21] Supra- and infrahyoid muscular activity has been recorded at different functional conditions (ie, resting, swallowing, chewing, open-close-clench cycle).[18,21–24] It could be important to compare the effects of both laterotrusive occlusal schemes during grinding (dynamic recording), as well as clenching (static recording).[17]

There is no scientific evidence on the effect of canine-guided and group-function occlusions on supra- and infrahyoid EMG activity. Work of this nature could lead to an integral knowledge of suprahyoid and infrahyoid EMG activity in the context of the craniocervical-mandibular system.

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When a large amount of clinical oral rehabilitation is required, it is relevant to know which of the laterotrusive scheme is more effective to avoid physiological muscle tension during laterotrusive occlusal excursion. Therefore, this study was performed as a preliminary report aimed at answering the two following questions: (1) Does canine guidance or group function present different supra- and infrahyoid EMG activity? (2) Is supra- and infrahyoid EMG activity significantly different during static and dynamic recordings?

## MATERIALS AND METHODS

### Sample

This investigation was carried out on 40 healthy subjects, all with 28 natural permanent teeth (excluding the third molars) in Class I occlusion, no prior orthodontic treatment, no history of trauma or fractured teeth, and no large restorations that included an incisal edge or one or more cusps.

### Static occlusion

Molar occlusion was defined as the mesiobuccal cusp of the lower first molar occluding between the mesiobuccal cusp of the upper first molar and the buccal cusp of the second premolar.

### Dynamic occlusion

Subjects were asked to bite in their habitual intercuspal position and then slide the mandible into right or left lateral excursion cusp tip to cusp tip contact. The sample was classified according to the contacts between the teeth on the working side into the following two groups of 20 each:

1. Canine-guided occlusion: Canines in contact on the working side and no occlusal contact in the nonworking side for both right and left lateral excursions (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 the 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).

Dr Baeza and Dr Miralles carried out all the examinations of the static and dynamic occlusion. Agreement between both examiners was needed for the subject to meet the inclusion criteria. The consistency across the examiners was high, but when there was no agreement, the subject was excluded. The examiners selected the sample over a continuous 4-week period. None of the subjects were on a thera-

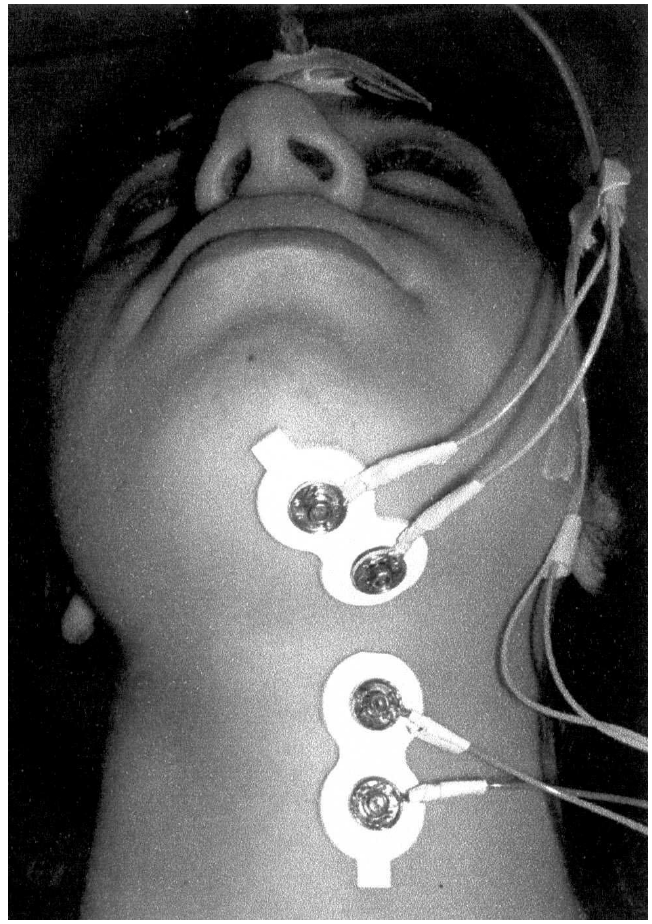

**FIGURE 1.** The electrodes are shown in position.

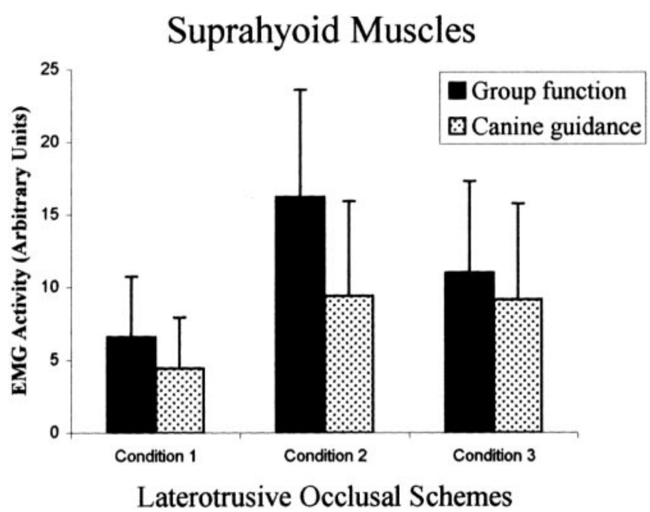


**FIGURE 2.** Bar graph showing the group mean value of suprahyoid electromyographic activity with canine guidance and group function in the condition 1 (grinding from intercuspal position to lateral edge-to-edge contact position), condition 2 (static clenching in edge-to-edge lateral contact position with canine guidance or group function), and condition 3 (grinding from lateral edge-to-edge contact position to intercuspal position).

peutic medication, which could have influenced muscle activity.

## Electromyography

The examiners explained and demonstrated the lateral movements of the mandible to each subject, so they understood what to do. All subjects agreed to participate in the study and gave written informed consent. The local ethics committee approved the study.

Integrated EMG (IEMG) recordings were performed by placing bipolar surface electrodes (BIOTRODE No-Gel Electrodes, BioResearch Inc., Milwaukee, Wis) on the left suprahyoid and left infrahyoid muscles (Figure 1). The electrodes were placed on the suprahyoid muscles following the direction of the muscle fibers, according to the technique described in previous studies.[22,23] For infrahyoid EMG activity recordings, the electrodes were placed on the prominent anterior part of the thyroid cartilage, one cm lateral to the anterior median line.[25] A ground surface electrode was attached to the forehead. The EMG was amplified, integrated (time constant 1800 msec), and registered on a polygraph (Nihon Kohden, Kogyo Co. Ltd., Tokyo, Japan), which was calibrated before and after each recording. Before 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, Ore). The subjects were asked to remain standing, with their feet 10 cm apart, with their eyes open, looking straight ahead in natural head position.

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

1. Condition 1: grinding from intercuspal position to the left lateral edge-to-edge contact position (with canine guidance or group function)
2. Condition 2: static clenching in left edge-to-edge lateral contact position with canine guidance or group function.
3. Condition 3: 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 always, a vertical mark was made on the upper and lower left canines.

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

No trial was ever longer than 10 seconds. It has been reported that muscle fatigue occurs in the masseter after 30 seconds of isometric contraction (clenching), whereas 30 seconds of combined concentric and eccentric contractions (grinding) induced no fatigue.[26] To avoid muscular fatigue, the patient was allowed a rest period of 1 minute between each trial and a 3-minute rest period after the change of each condition.

In each trial, the total amplitude of IEMG activity (including tonic plus phasic activity) was measured in periods of one second each, and the mean value for each curve was obtained. Thereafter, the mean value of the three curves for each condition and muscle was obtained for each individual. 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.

A body mass index (BMI) was obtained for each subject, with the weight (in kilograms) divided by the square of the height (in meters). Age, sex, and BMI variables were used to check its possible influence on muscle activity recorded.[27]

## Statistical analysis

Regression analysis for repeated measures between IEMG activity and each one of the explanatory variables (age, sex, BMI, 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 unstructured covariance matrix. The data were analyzed using Stata, Release 7.0 (STATA Corp, College Station, Texas).

# RESULTS

Figure 2 shows the mean group suprahyoid IEMG activity during the laterotrusive occlusal schemes studied. A tendency of higher activity with group function than with canine guidance was present in the three conditions studied. The effect of the age, sex, and BMI on supra- and infrahyoid IEMG activity was not significant and not included in the mixed model with unstructured covariance matrix.

Table 1 shows that the change in vertical dimension between the intercuspal position and the left lateral edge-to-edge contact position (with canine guidance

**TABLE 1.** Comparison of Suprahyoid IEMG Activity Adjusted by Vertical Dimension and Laterotrusive Occlusal Schemes Studied (Mixed Model With Unstructured Covariance Matrix)[a,b]

| Suprahyoid EMG Activity | Coefficient | Standard Error | z | $P > \|z\|$ | [95% Confidence Interval] | |
|---|---|---|---|---|---|---|
| Vertical dimension | −1.07 | 0.79 | −1.35 | .177 NS | −2.62 | 0.48 |
| Group function | −0.64 | 1.66 | −0.39 | .699 NS | −3.89 | 2.60 |
| Condition 1 | −10.38 | 1.20 | −8.68 | .000*** | −12.73 | −8.04 |
| Condition 3 | −8.44 | 1.20 | −7.06 | .000*** | −10.79 | −6.10 |
| Constant | 16.83 | 2.56 | 6.57 | .000 | 11.81 | 21.84 |

[a] EMG indicates electromyographic; IEMG, integrated electromyographic; and NS, not significant.
[b] Occlusal scheme reference: canine guidance; reference = condition 2; condition 1 vs condition 3 = ***.
*** $P < .000$.

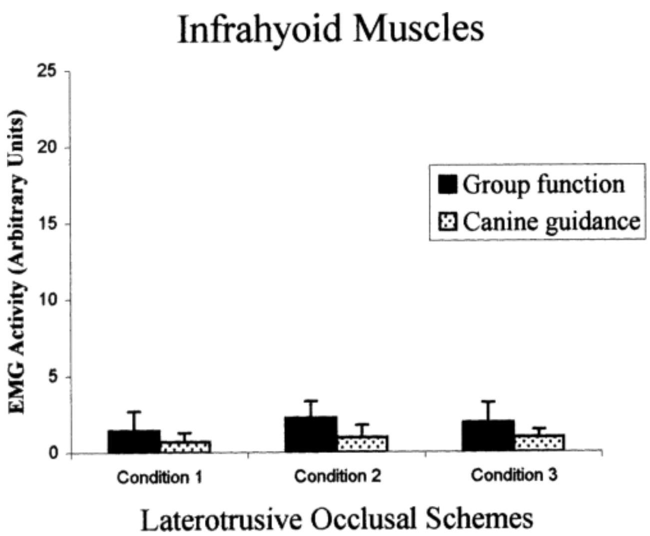


**FIGURE 3.** Bar graph showing the group mean value of infrahyoid electromyographic activity with canine guidance and group function in the condition 1 (grinding from intercuspal position to lateral edge-to-edge contact position), condition 2 (static clenching in edge-to-edge lateral contact position with canine guidance or group function), and condition 3 (grinding from lateral edge-to-edge contact position to intercuspal position).

or group function) did not present a significant effect on suprahyoid IEMG activity ($P > .05$). Suprahyoid IEMG activity was not significantly different with canine guidance and group function ($P > .05$). This table also presents the overall comparison of suprahyoid IEMG activity among the three conditions recorded. Activity recorded in condition 2 (static clenching in left edge-to-edge lateral contact position) was significantly higher than in condition 3 (grinding from intercuspal position to left lateral edge-to-edge contact position), which was significantly higher than in condition 1 (grinding from intercuspal position to left lateral edge-to-edge contact position).

Figure 3 presents the group means of infrahyoid IEMG activity during the laterotrusive occlusal schemes studied. A tendency for higher activity with group function than with canine guidance was present in the three conditions studied.

Table 2 shows that the change in vertical dimension between the intercuspal position and the lateral edge-to-edge contact position (with canine guidance or group function) did not present a significant effect on infrahyoid IEMG activity ($P > .05$). Infrahyoid IEMG activity was not significantly different with canine guidance and group function ($P > .05$). This table also presents the overall comparison of infrahyoid IEMG activity among the three conditions recorded. Activity in condition 2 (static clenching in left edge-to-edge lateral contact position) was significantly higher than in condition 3 (grinding from left lateral edge-to-edge contact position to intercuspal position), and both these were significantly higher than in condition 1 (grinding from intercuspal position to left lateral edge-to-edge contact position).

**TABLE 2.** Comparison of Infrahyoid IEMG Activity Adjusted by Vertical Dimension and Laterotrusive Occlusal Schemes Studied (Mixed Model With Unstructured Covariance Matrix)[a,b]

| Infrahyoid EMG Activity | Coefficient | Standard Error | z | $P > \|z\|$ | [95% Confidence Interval] | |
|---|---|---|---|---|---|---|
| Vertical dimension | −0.05 | 0.13 | −0.40 | .691 NS | −0.31 | 0.20 |
| Group function | 0.37 | 0.27 | 1.37 | .171 NS | −0.16 | 0.90 |
| Condition 1 | −0.75 | 0.12 | −6.30 | .000*** | −0.99 | −0.52 |
| Condition 3 | −0.58 | 0.12 | −4.84 | .000*** | −0.81 | −0.34 |
| Constant | 1.46 | 0.42 | 3.52 | .000 | 0.65 | 2.28 |

[a] EMG indicates electromyographic; IEMG, integrated electromyographic; and NS, not significant.
[b] Occlusal scheme reference: canine guidance; reference = condition 2; condition 1 vs condition 3 = ***.
*** $P < .000$.

## DISCUSSION

This is the first study that compared the effects of canine guidance and group function on supra- and infrahyoid EMG activity during static and dynamic laterotrusion schemes. In this study supra- and infrahyoid IEMG activity was not significantly different with canine guidance and group function, suggesting that both laterotrusive occlusal schemes have a similar effect on supra- and infrahyoid muscles to avoid physiological muscle tension. This differs with the significantly lower EMG activity reported with canine guidance as compared with group function in the anterior temporal, masseter, and sternocleidomastoid muscles in previous works.[12–14,17]

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 craniocervical-mandibular system.

The similar pattern of supra- and infrahyoid IEMG activity observed with both occlusal schemes could be explained by a counterbalance of several peripheral and central neuromechanisms.[28] In addition to the trigeminal peripheral influences, ie, from articular, muscular, and periodontal receptors,[29] the effect of other influences must be considered, ie, vestibular receptors and neck tonic reflex.[28,30]

The comparison of the overall IEMG activity recorded during static and dynamic conditions showed a higher activity in condition 2 (static recording) than in conditions 1 and 3 (dynamics recordings) in the suprahyoid as well as in the infrahyoid muscles. This could be because of the isometric contraction of suprahyoid and infrahyoid muscles to fix the position of the hyoid bone, whereas isometric contraction of elevator muscles fixes the position of the jaw. This finding could be of great clinical relevance to parafunctional clenching habits, depending on their intensity, frequency, and duration. Static contractile activity of the mandibular elevator muscles produces high levels of isometric tension and leads to masseter muscle fatigue in about 30 seconds.[26] Contingent on the level of the generated force and the duration of the isometric contractions, static activities give rise to fatigue and pain.[31]

IEMG activity recorded during condition 3 was significantly higher than that during condition 1, in the suprahyoid as well as in the infrahyoid muscles. The higher IEMG activity could be because of a nonisometric concentric contraction during condition 3, whereas the lower IEMG activity could be because of a nonisometric eccentric contraction during condition 1. From a clinical point of view, the higher IEMG activity recorded in the supra- and infrahyoid muscles during condition 3 than that during condition 1 is new knowledge, which could be of great clinical relevance to the presence of a grinding parafunctional habit, depending on their intensity, frequency, and duration.

Dynamic muscle activities are divided into concentric contractions with shortening of muscle fibers and the production of positive work (condition 3) and eccentric contractions with lengthening of muscle fibers and the production of negative work (condition 1). In positive work, muscle tension overcomes muscle external forces. In negative work, external forces overcome muscle tension. The latter phenomenon, with relatively few active motor units, explains the injuries induced by eccentric contractions. Both the contractile and the noncontractile elements are involved in muscle injuries and, clinically, they are referred to as myofibrositis.[32]

### General consideration

The great suprahyoid IEMG activity observed in Figure 2 could be explained by (1) suprahyoid muscles are more directly involved in stabilizing the mandible during the tasks studied, and (2) surface electrodes in the suprahyoid region frequently recorded a considerable amount of activity during clenching, whereas no such activity has been recorded from intramuscular electrodes located in the digastric bellies. Widmalm et al[24] and Basmajian[33] suggested that the use of surface electrodes also pick up activity from neighboring muscles over a rather broad area.

## CONCLUSIONS

- Supra- and infrahyoid IEMG activity was not significantly different with canine guidance and group function, suggesting that to avoid no physiological muscle tension during eccentric jaw positions, both laterotrusive occlusal schemes have a similar effect on supra- and infrahyoid muscles.
- Supra- and infrahyoid IEMG activity during the static recording (clenching) was significantly higher than that during the dynamics recordings (grinding). Moreover, activity during grinding from the lateral edge-to-edge contact position to the intercuspal position was higher than vice versa.

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