The Online ANGLE ORTHODONTIST
An International Journal of Orthodontics and Dentofacial Orthopedics
77th Anniversary 1930-2007

[Print Version]
[PubMed Citation] [Related Articles in PubMed]

TABLE OF CONTENTS

---

doi: 10.2319/0003-3219(2007)077[0260:EAOMNA]2.0.CO;2
The Angle Orthodontist: Vol. 77, No. 2, pp. 260–265.

Electromyographic Activity of Masticatory, Neck and Trunk Muscles of Subjects with Different Mandibular Divergence

A Cross-Sectional Evaluation

Simona Tecco;[a] Sergio Caputi;[b] Stefano Tete;[c] Giovanna Orsini;[d] Felice Festa[b]

ABSTRACT

Objective: To record and compare the surface electromyographic (sEMG) activity of masticatory, neck, and trunk muscles at different functional requirements of the stomatognathic system in an adult sample classified according to the mandibular divergence angle (SN-GoGn angle).

Materials and Methods: 60 Caucasian adult subjects were classified on the basis of SN-GoGn angle: 20 subjects with normal mandibular divergence, 20 subjects with lower angles, and 20 subjects with higher angles. Their sEMG activity was recorded at mandibular rest position and during maximal voluntary clenching.

Results: sEMG activity of subjects with a lower angle was significantly higher than that of subjects in the other two groups at mandibular rest position for the masseter, the anterior temporal, the upper trapezius, and the posterior cervical muscles. During maximal voluntary clenching, no significant difference was observed in the sEMG activity of the masticatory muscles among the three groups. However, the sEMG activity of the posterior cervicals and that of the upper trapezius were significantly higher in subjects with a lower angle than in the other two groups.

Conclusion: Skeletal class does seem to affect the sEMG pattern activity of the masticatory, neck, and trunk muscles.

KEY WORDS: Skeletal facial type, Mandibular divergence, Cephalometry, Electromyography, Neck and trunk muscles.

Accepted: April 2006. Submitted: December 2005

INTRODUCTION Return to TOC

The importance of investigating the surface electromyographic (sEMG) activity patterns of neck and trunk muscles involves several different aspects. From a functional point of view, it seems that a dynamic relationship exists between dental occlusion and head posture.[1] In fact, masticatory, neck, and trunk muscles have a reciprocal innervation between the trigeminal and the cervical system that produces a mutual inhibition and activation.

The anatomical bases of these correlations have been studied in some mammals, and this has shown the presence of neuronal connections between the trigeminal afferents and the cervical spinal cord.[2] Trigeminal sensory afferents have been found to project in several nontrigeminal areas of the central nervous system, even to the lower cervical neuromers. Neurons of the three divisions of cranial nerve V and of cranial nerves VII, IX, and X seem to share in the same neuron pool with neurons from the upper cervical spine segments.[3]

Thus, trigeminal inputs from periodontal receptors, temporomandibular joint receptors, and muscular receptors may play some role in the modulation of the motor neurons pool of the cervical muscles. In addition, in nonhuman primates, a nucleus of the medullary reticular formation was found to possess a specific role for concomitant jaw, facial, head, and upper limb movements, suggesting that feeding and eating behaviors are probably related to all these anatomical connections.[4]

Based on these concepts, several investigations have been performed. For example, it has been shown that voluntary teeth-clenching normally provokes a coactivation of the sternocleidomastoid (SCM) muscle.[5] Further, it is known that the SCM, trapezius, and masticatory muscles have reciprocal innervation between the trigeminal and the cervical system, and in this way it is possible that the SCM and trapezius muscles exhibit a referred pain that spreads over the masticatory muscle areas.[6] According to these observations, it is possible that afferents from cervical nerves triggered by variation in the occlusal contacts might also modulate the motor neuron pools innervating the SCM and cervical muscles.

In 1995, Zuniga et al[2] determined the influence of variations in occlusal contacts on sEMG activity of cervical muscles in 20 patients with myogenic cranio-cervical-mandibular dysfunction. They found that higher sEMG activity of cervical muscles was recorded with maximum clenching during the retrusive occlusal contact position.

In 1991, Miralles et al[7] investigated the sEMG pattern activity of masticatory muscles in skeletal Classes I, II, and III, classified on the basis of the ANB angle and corrected for maxillary position and rotation of the jaw. They found that subjects in skeletal Class III showed a significantly higher sEMG activity of anterior temporal and masseter muscles than did subjects in skeletal Classes I and

II, which showed no significant difference. On the contrary, during maximal voluntary clenching (MVC), no significant difference was observed in the sEMG activity of the two muscles among the three study groups.

As seen, the relationship between the stomatognathic system and the neck and trunk areas seems to be well accepted in the literature. Thus, the hypothesis that is the basis of the present investigation is that the morphological aspect of the face, that is, the mandibular divergence, may be correlated to different patterns of sEMG activity, regarding not only the masticatory muscles but also the neck and trunk muscles.

The aim of this investigation was to record and compare the sEMG activity of masticatory, neck, and trunk muscles at different functional requirements of the stomatognathic system in an adult sample classified according to the mandibular divergence angle (the SN-GoGn angle).

MATERIALS AND METHODS Return to TOC

The subjects included in the present investigation were selected from the patients of the Department of Oral Science, Orthodontic Unit, University G. D'Annunzio. The sample included 60 Caucasian adult female subjects (32.5 ± 3.8 years). These included 20 patients (mean age: 29.3 ± 4.2 years) with a normal mandibular divergence angle, 20 patients (mean age: 34.5 ± 4.5 years) with a low mandibular divergence angle, and 20 patients (mean age: 33.5 ± 4.2 years) with a high mandibular divergence angle. All the subjects were randomly selected according to three ranges of divergence angles from a population of patients in the Department of Oral Science, University G. D'Annunzio.

All the cephalometric tracings used to classify the groups were done by the same author, and all of the patients had no complaints of temporomandibular joint dysfunction and no history of bruxism. Informed consents were obtained from all the subjects prior to the experiments. Institutional approval was obtained by the Ethics Committee of the University G. D'Annunzio.

Cephalometric Tracings

The angular measurements used to classify the three study groups were carried out on the lateral skull radiographs by the same author (Figure 1). The groups were individuated according to the SN-GoGn angle.[8] Values of the SN-GoGn angle between 27° and 37° were included in the normal angle group, values higher than 37° were classified as the high angle group, and values lower than 27° were classified as the low angle group.

In order to evaluate the method error, 10 radiographs were randomly selected and the measurements were repeated after 1 week by the same author and compared with the originals. The data obtained from the first and the second measurements (at a time distance of 1 week) were compared and statistically analyzed using Dahlberg's formula[9] to evaluate the method error.

sEMG Recordings

The study was performed using a Key-Win 2.0 sEMG unit (Biotronic srl, S. Benedetto Tronto, Ascoli Piceno, Italy) with disposable electrodes (DUO F3010 bipolar—10 mm, Ag-AgCl, lithium chloride gel, unit distance 22 mm, LTT FIAB Vicchio, Firenze, Italy). The Key-Win 2.0 is a 60-channel electromyographic unit with a 15- to 430-Hz band-pass filter, containing a special 60-Hz notch filter to eliminate any of the electrical noise from the recording environment that exceeds the capabilities of the common mode rejection scheme.

All monitoring was performed with the patients in a standing position. The subjects were asked to make themselves comfortable, to relax their arms by their sides, and to look straight ahead and make no head or body movements during the test. The electrodes, which determine to a large extent the quality of the recordings, were placed according to the electrode atlas of Cram and Kasman.[10] Before the electrodes were applied, the skin was thoroughly cleaned with alcohol. The input impedance was controlled through the use of an electrolytic gel under the electrodes.

The sEMG activity of seven muscles was studied bilaterally with the mandible at the rest position, and during MVC. For the MVC recording, the subjects were instructed to close their jaws in centric occlusion as forcefully as possible. The recordings were begun only when the teeth were in contact without any jaw movement. The MVC contraction was 15 seconds long. The movements were conducted for at least three repetitions to ascertain stability according to the protocol developed by Donaldson and Donaldson.[11] The first movement patterns were eliminated as the learning sequence, because they were frequently dissimilar to the other two. In a single subject, all sEMG data reported were the arithmetic means of the last two surface sEMG recordings.

The muscular areas tested were the masseter, anterior temporal, posterior temporal, SCM, posterior cervicals, upper trapezius, and lower trapezius on both sides.

The sEMG recording time for each analysis was at least 15 seconds, and the values (the root mean square–integrated signals) were expressed in microvolts per second.[12] The data were recorded using a personal computer with dedicated software (Key-Win, Biotronic).

Data Analysis

All statistical analyses were performed using the Statistical Package for Social Sciences program (SPSS Inc, Chicago, Ill).

For each muscle, sEMG activity was expressed as mean and standard deviation. For each condition (mandibular rest position and MVC) and each muscle, a one-way analysis of variance and post hoc evaluation was employed to test the significance levels of difference in the sEMG activity among the three study groups. The .05 level was used to denote statistical significance throughout the testing.

RESULTS Return to TOC

When the errors in cephalometric landmark localization were evaluated, Dahlberg's formula revealed that the error from both sources was less than 5% of the biological variance of the whole sample for each of the variables investigated. Thus, all the cephalometric measurements were accepted as corrected.

Figures 2 and 3 show the mean sEMG activity of the masticatory muscles at mandibular rest position and during MVC, respectively. Figures 4 and 5 show the mean sEMG activity of the neck and trunk muscles at mandibular rest position and during MVC, respectively.

At mandibular rest position, subjects with lower angles showed a significantly higher sEMG activity pattern of the masseter and the anterior temporal than did the other two groups (Figure 2). However, in the MVC condition, no differences were observed among the three groups (Figure 3).

Significant differences among the three study groups were observed in the neck and trunk muscles, both at mandibular rest position (Figure 4) and during MVC (Figure 5).

The sEMG activity of the posterior cervicals and the upper trapezius was significantly higher in the low angle group than in the other two groups in all the considered conditions (Figures 4 and 5).

DISCUSSION Return to TOC

Masticatory Muscles

The existence of different sEMG activity patterns among subjects with different facial types was observed by Miralles et al,[7] who found some differences in subjects with different skeletal classes. Our findings about the sEMG activity of the masticatory muscles seem to be in accord with those from Miralles et al[7] because they found no significant difference in the sEMG activity of masticatory muscles during MVC among the three study groups, whereas significant differences were observed at mandibular rest position.

For the masticatory muscles, Miralles et al[13] gave an explanatory hypothesis to clarify the significantly different sEMG pattern activity observed among the three groups. They underlined that the differences in the position and in the rotation of the two jaws could determine a change in the muscular force axis, with a change in the vertical component and consequently a different stimulation of the neuromuscular spindles of the jaw elevator muscles.

Neck and Trunk Muscles

In both conditions, the subjects with low angles showed a significantly higher sEMG activity of the posterior cervicals and the upper trapezius muscles compared with subjects of the other two groups. This finding seems to suggest the existence of neuronal connections between the neck and trunk muscles and the stomatognathic system. However, no certain conclusions about the mechanism in these types of associations could be given because of the cross-sectional construction of this investigation.

It is known that in an adult sample of Caucasian females, the mandibular divergence angle correlated to the cervical lordosis angle, because the higher the divergence angle, the higher the resulting cervical lordosis angle.[14] In addition, it has also been reported that the mandibular divergence angles and the different size and position of the mandible are associated with the degree of vertical and sagittal dimension of the pharyngeal airway space, the respiratory function and, consequently, the extension of the head upon the spinal column with a change of the cervical lordosis angle.[15,16] Finally, it has also been reported that the function of the lower tract of the cervical column seems to be strongly associated with the function of the trunk segment of the vertebral column.[17]

According to this literature, it seems to reasonable to hypothesize that the functional activities of the cervical and trunk areas (which correspond to the posterior cervicals and the upper trapezius muscles) could both be affected by the same factors, for example, by the mandibular divergence angle. Regarding the microstructural mechanism associated with these observed differences in the sEMG activity of masticatory, head, neck, and trunk muscles, a muscular-neural network could play an important role.

In the literature, it has been reported[18,19] that a muscular-neural connection between the stomatognatic area and the neck area is responsible for some of the common symptoms of disorders of the masticatory system and/or of the cervical spine. In addition, in a clinical study, Miralles et al[13] showed, in a group of 15 healthy subjects, a significant increase in basal tonic sEMG activity of the neck muscles when varying the vertical dimension every few millimeters from the vertical dimension of occlusion to 45 mm of jaw opening. Their work confirmed that reflex connections exist between the morphological structure of the face and the fusimotor muscle spindle system of the dorsal neck muscles.

Visscher et al[20] also supported those findings from a clinical point of view by showing that the prevalence of cervical spine pain, assessed using oral history and dynamic/static testing with a visual analog scale, was higher in a group of craniomandibular pain patients than in a group of subjects without craniomandibular pain. Perhaps this was because of the neurophysiological principles of convergence and sensation.

Limits of the Study

In this study, no attempt was made to separate females and males, although a certain difference in the sEMG pattern activity could probably exist. This was done to avoid a decrease in statistical power, but this classification will be the aim of a future investigation that will evaluate both males and females. In this study, only adult females were considered, in order to avoid errors caused by sexual dimorphism.

CONCLUSIONS Return to TOC

- The morphological aspect of the face could influence the sEMG pattern of masticatory activity as well as that of neck and trunk muscles.
- In a Caucasian adult female sample, subjects with a low angle showed a significant higher sEMG pattern activity at the mandibular rest position of the anterior temporal, masseter, posterior cervicals, and upper trapezius muscles as compared with subjects with normal or high angles.
- In addition, during MVC, subjects with a low angle showed a significantly higher sEMG pattern activity of the posterior cervicals and upper trapezius muscles.

REFERENCES Return to TOC

1. Daly P, Preston CB, Evans WG. Postural response of the head to bite opening in adult males. *Am J Orthod.* 1982; 82:157–160.

2. Zuniga C, Miralles R, Mena B, Montt R, Moran D, Santander H, Moya H. Influence of variation in jaw posture on sternocleidomastoid and trapezius electromyographic activity. *J Craniomandibular Pract.* 1995; 13:157–162.

3. Green JD, De Groot J, Sutin J. Trigemino-bulbar reflex pathways. *Am J Physiol.* 1957; 189:384–388.

4. Eriksson PO, Zafar H, Nordh E. Concomitant mandibular and head-neck movements during jaw opening-closing in man. *J Oral Rehabil.* 1998; 25:859–870.

5. Ehrlich R, Garlick D, Ninio M. The effect of jaw clenching on the electromyographic activities of 2 neck and 2 trunk muscles. *J Orofac Pain.* 1999; 13:115–120.

6. Weeks VD, Travell J. Postural vertigo due to trigger areas in the sternocleidomastoid muscle. *J Pediatr.* 1955; 47:315–327.

7. Miralles R, Hevia R, Contreras L, Carvajal R, Bull R, Manns A. Patterns of electromyographic activity in subjects with different

skeletal facial types. *Angle Orthod.* 1991; 61:277–282.

8. Steiner C. Cephalometric in clinical practice. *Angle Orthod.* 1959; 29:8–29.

9. Dahlberg G. *Statistical Methods for Medical and Biological Students*. London: George Allen and Unwin Ltd; 1940:40–49.

10. Cram JR, Kasman GS. *Introduction to Surface Electromyography*. Gaithersburg, Md: Aspen Publishers; 1997:102–115.

11. Donaldson S, Donaldson M. 1990; Multi-channel EMG assessment and treatment techniques. In: Cram JR, ed. *Clinical EMG for Surface Recordings.* 2nd ed. Nevada City, Calif: Clinical Resources; 1990:143–174.

12. van der Bilt A, Weijnen FG, Bosman F, van der Glas HW, Kuks JB. Controlled study of EMG activity of the jaw closers and openers mastication in patients with myasthenia gravis. *Eur J Oral Sci.* 2001; 109:160–164.

13. Miralles R, Dodds C, Manns A, Palazzi C, Jaramillo C, Quezada V, Cavada G. Vertical dimension. Part 2: the changes in electrical activity of the cervical muscles upon varying the vertical dimension. *J Craniomandibular Pract.* 2002; 20:39–47.

14. Festa F, Tecco S, Dolci M, Ciuffolo F, Di Meo S, Filippi MR, Ferritto AL, D'Attilio M. Relationship between cervical lordosis and facial morphology in Caucasian women with a skeletal Class II malocclusion: a cross-sectional study. *J Craniomandibular Pract.* 2003; 21:121–129.

15. Solow B, Tallgren A. Natural head position in standing subjects. *Acta Odontol Scand.* 1971; 29:591–607.

16. Hellsing E, McWilliam J, Reigo T, Spangfort E. The relationship between craniofacial morphology, head posture, and spinal curvature in 8, 11, and 15-year-old children. *Eur J Orthod.* 1987; 9:254–264.

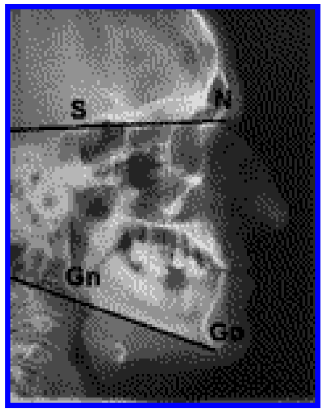
17. Solow B. The pattern of craniofacial associations. A morphological and methodological correlation and factor analysis study on young male adults. *Acta Odontol Scand.* 1966; 24:1–14(suppl 46).

18. Graber TM. Implementation of the roentgenographic cephalometric technique. *Am J Orthod.* 1958;Dec:906–932.

19. Hellstrom F, Thunberg J, Bergenheim M, Sjo-lander P, Djupsjo-backa M, Johansson J. Increased intra-articular concentration of bradykinin in the temporomandibular joint changes the sensitivity of muscle spindles in dorsal neck muscles in the cat. *Neurosci Res.* 2002; 42:91–99.

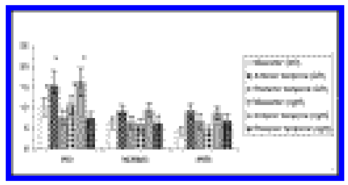
20. Visscher CM, de Boer W, Naeije M. The relationship between posture and curvature of the cervical spine. *J Manipulative Physiol Ther.* 1998; 21:388–391.

FIGURES [Return to TOC]



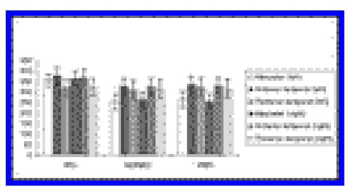
Click on thumbnail for full-sized image.

Figure 1. Lateral skull radiographs



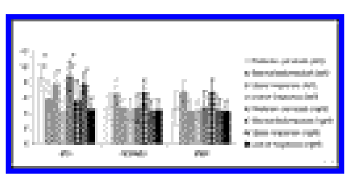
Click on thumbnail for full-sized image.

Figure 2. sEMG activity of masticatory muscles at mandibular rest position. IPO indicates the group of subjects with GoGn-SN angle < 27°; IPER, the group of subjects with GoGn-SN angle > 37°; and NORMO, the group of subjects with GoGn-SN angle between 27° and 37°



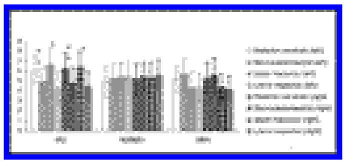
Click on thumbnail for full-sized image.

Figure 3. sEMG activity of masticatory muscles during maximal voluntary clenching. IPO indicates the group of subjects with GoGn-SN angle < 27°; IPER, the group of subjects with GoGn-SN angle > 37°; and NORMO, the group of subjects with GoGn-SN angle between 27° and 37°



Click on thumbnail for full-sized image.

Figure 4. sEMG activity of neck and trunk muscles at mandibular rest position. IPO indicates the group of subjects with GoGn-SN angle < 27°; IPER, the group of subjects with GoGn-SN angle > 37°; and NORMO, the group of subjects with GoGn-SN angle between 27° and 37°



Click on thumbnail for full-sized image.

Figure 5. sEMG activity of neck and trunk muscles during maximal voluntary clenching. IPO indicates the group of subjects with GoGn-SN angle < 27°; IPER, the group of subjects with GoGn-SN angle > 37°; and NORMO, the group of subjects with GoGn-SN angle between 27° and 37°

[a]Research Scientist, Department of Oral Science, University G. D'Annunzio, Chieti Chieti, Pescara, Italy

[b]Professor, Department of Oral Science, University G. D'Annunzio, Chieti Chieti, Pescara, Italy

[c]Associate Professor, Department of Oral Science, University G. D'Annunzio, Chieti Chieti, Pescara, Italy

[d]Research Fellow, Department of Oral Science, University G.d'Annunzio, Pescara, Italy

Corresponding author: Dr Simona Tecco, University G. D'Annunzio, Chieti, Department of Oral Sciences, Via Le Mainarde 26, Pescara, Pescara 65121 Italy (E-mail: simtecc@tin.it)
