

# Quantitative analysis of masseter and temporalis EMGs: a comparison of anterior guided versus balanced occlusal concepts in patients wearing complete dentures

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**SUMMARY** The lack of easily measurable, objective physiological activity parameters of the masseter and temporalis muscle during jaw movements in humans has led to the consideration to revise data of surface electromyographies (EMGs) by applying a computerized quantification method. The aim of this follow-up analysis was to get quantitative data out of EMG-records of an earlier study. These records were obtained with two different splints, splint 1 providing an anterior front-canine guidance and splint 2 providing bilateral balanced occlusion. Utilizing a computer aided integration method led to numeric results which statistically proves the prediction of the previous investigation. Applying the integration method, the EMG raw signal was

transformed into area-values which enabled a statistical work up of the data. Wilcoxon test statistics shows a significant ( $P < 0.05$ ) lower muscle activity in patients wearing dentures providing anterior front-canine guidance compared to those with balanced occlusion. It is concluded that the neuromuscular activity of the elevator muscles is highly reproducible and that the neuromuscular function is similar in edentulous subjects to that found in people with natural teeth. Furthermore, the study statistically proves earlier visual data that all those subjects, whose muscle activities were observed with anterior guidance (splint 1) compared to bilateral balanced occlusion (splint 2) showed significantly lower values with regard to subjects wearing splint 2.

## Introduction

Various authors (Jarabak, 1956; Ingervall & Hedegard, 1980; Kappler, 1980; Ramfjord & Ash, 1983; Shupe *et al.*, 1984; Belser & Hannan, 1985; Miralles *et al.*, 1989; Ott *et al.*, 1990; Grunert *et al.*, 1991, 1994) have described the relationship between occlusion and the neurofunctional behaviour of masticatory muscles. Grunert *et al.* (1994) emphasized the use of complete dentures with anterior front-canine guidance in order to show lower masticatory muscle activity compared to dentures with balanced occlusion. Her postulation was based on non-quantitative characterization of EMG data by visual estimation. In this study muscle activity was recorded utilizing surface electromyography during different jaw movements (postural position, maximal tooth contact in intercuspal position, protrusive-,

laterotrusive- and mediotrusive excursions of the mandible) in 17 patients wearing complete dentures with anterior front-canine guidance before and after the adaptation of two different splints to the upper dentures. The two different occlusal splints were manufactured on individually programmed articulators, the vertical dimension was raised to exactly the same height. Splint 1 providing anterior guidance leading to immediate disclusion of the posterior teeth during any jaw movement and splint 2 providing bilateral balanced occlusion.

Tschernitschek *et al.* (1997) presented a validation study on different EMG-quantification methods. In this evaluation of three different signal-to-value calculations ('classical' Willison analysis, FFT-based spectral analysis and integrated EMG) the integrated EMG

showed 69% correct values. In the present study a surface electromyography (EMG) quantification method was used to clarify functional characteristics of anterior guided versus balanced occlusal concepts.

## Material and methods

In this study the EMG raw signals of 16 patients could be utilized. All patients got well fitted complete dentures with anterior canine guidance which they wore for various lengths of time. All dentures were manufactured by the Department of Dentistry, University of Innsbruck.

In the precursor study an axiographic examination was carried out before the construction of the two different splints (Slavicek & Mack, 1982) and then the hinge axis was marked on the skin for correct mounting of the maxillary cast on a SAM-2-articulator\* with the left incisura infraorbitalis as the third reference point.

The mounting of the mandibular cast in centric relation was performed utilizing a central record by means of a central bearing point according to McGrane (1966). This registration set up gives an expedient basis for the reconstruction of a damaged or missing dentition namely in an anatomically and physiologically correct relationship to the temporo-mandibular joint (Gerber, 1975). After individual programming of the articulator concerning the steepness of the horizontal condylar inclination according to the axiographic data two different occlusal splints were manufactured (Grunert *et al.*, 1991). Splint 1 providing anterior guidance with guiding elements only in the region of incisors and canines leading to an immediate disclusion of the posterior teeth during any jaw movement. Splint 2 providing posterior guidance (bilateral balanced occlusion). Surface EMGs were then performed using a Neuroscript EE 216 EEG/EMG polygraph<sup>†</sup> with filter settings of 30 Hz for the low filter and 1 kHz for the high filter at a paper speed of 6 mm/s. The signal amplitude was displayed at 100  $\mu$ V/div. Beckmann surface electrodes<sup>‡</sup> were taped bilaterally on the muscle

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<sup>†</sup> Hellige-Neuroscript EE 216, Wiehemineustraße 91, 1160 Wien, Austria.

<sup>‡</sup> Sensor Medics Corporation, 1717 South State College Blvd, Anaheim, CA 92806, U.S.A.

bellies of the masseter and temporalis muscles with an interelectrode distance of approximately 25 mm. EMG raw signals were recorded within one session leaving the electrode positions unchanged for providing a standard for intra-individual comparison (Ott *et al.*, 1990). Recordings were performed during maximal tooth contact and a sequence of different jaw movements (protrusion and laterotrusion) first with complete dentures only, then after adapting either splint upon the upper denture.

The quantification of EMG raw signals was performed stepwise. Integrational EMG (calculation of the area within the EMG-envelope-trace) was found to be the most feasible way to get reproducible values as basis for statistical analysis of muscle activities. The EMG raw-signal traces were marked in comparable and artifact-free segments of 10 cm length. These cuts underwent photoscanning at a defined resolution of 155 dpi (dots per inch). An image processing software package (Adobe Photo Shop 3.0)<sup>§</sup> was used to edit the trace images for artifact elimination and setting of duration limits (Fig. 1). For the calculation of the curve envelope, rectification and area (integration) an individual software was developed. This software is able to calculate numerical values for the integrated EMG within a certain time limit. After this all area values were taken as a data matrix for the statistical work-up. Various standard statistical routines served as validation methods: descriptive statistics, including mean, standard deviation and cross table analysis as well as the Wilcoxon pair comparison.

## Results

Standardized percentile values of muscle activity during maximal bite and different jaw movements are shown in Fig. 2.

*Postural activity and integrated muscle activity during maximal intercuspidal contact.* There is no significant difference in muscle activity with dentures only versus either splint in postural activity. Most individuals showed negligible neuromuscular activity. Nevertheless markedly increased values representing neuromuscular activity were found during maximal tooth contact in intercuspidal position with also no significant differ-

<sup>§</sup> Adobe Photoshop, Adobe Systems Direct Ltd, Dept. AA 12, Postfach 1000, 1150 Wien, Austria.

ence between dentures only versus either splint (Fig. 3).

*Protrusive movement.* The activities of the masseter and temporalis muscles showed, in most cases, mild or moderate potentials. Twenty four out of 32 samples (75%) showed significantly higher area values calculated for splint 2 compared with splint 1 in the masseter muscle ( $P = 0.01$ ) more than in the temporalis muscle ( $81.25\% = 26$  out of 32 samples,  $P = 0.05$ ) (Fig. 4).

*Laterotrusive excursions of the mandible.* The area values

for the muscle activities of the masseter and temporalis muscle range from small (negligible muscle activity) to high (marked muscle activity). The same amount of muscle activity with dentures only versus with splint 1 was found in 53% during either laterotrusive movement. After applying splint 2 neuromuscular activity was increased in the elevator muscles in 68.75% of 64 samples on the working side ( $P = 0.01$ ). On the mediotrusive non-working side 78.13% showed increased values for muscle activities in 64 EMG-samples ( $P = 0.001$ ).

Splint 2 EMG shows a highly significant increase of muscle activity especially on the working side (Fig. 5).

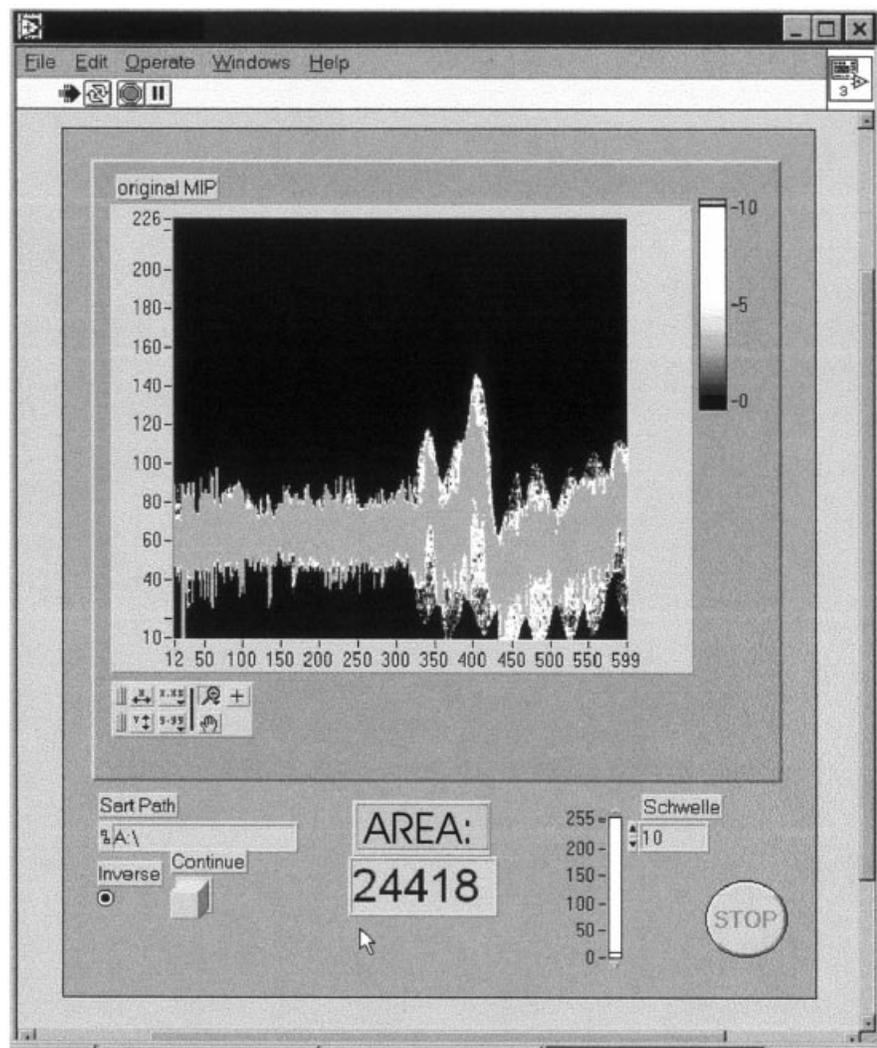
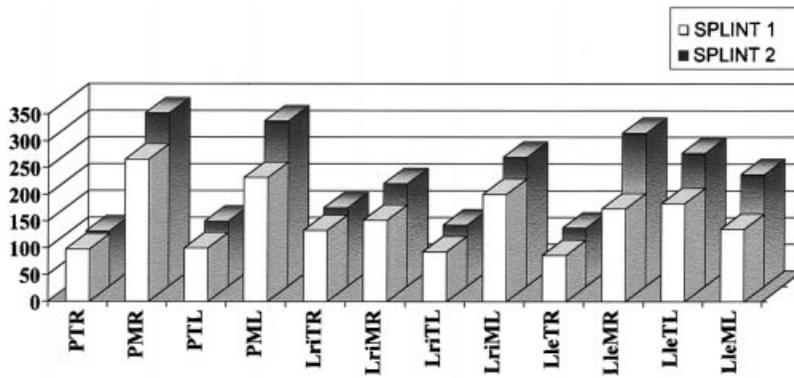


Fig. 1. Computer software for area calculation.



**Fig. 2.** Standardized percentile values of muscle activity during maximal bite and different jaw movements. P, protrusion; Lri, laterotrusion to the right; Lie, laterotrusion to the left; M, m. masseter; T, m. temporalis; R, right muscle; L, left muscle.

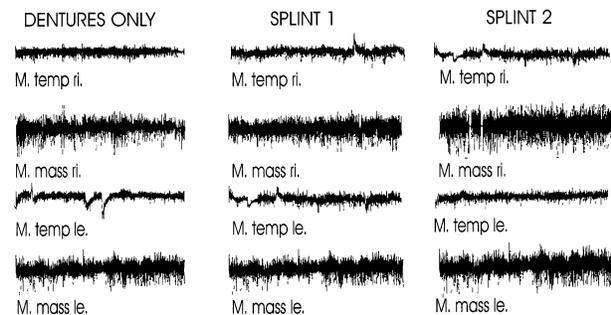
## Discussion

The area values which numerically represent the muscle activities during maximal intercuspitation recorded with anterior front-canine guided dentures were not significantly different from those derived from elevator muscle EMGs obtained with an adapted splint providing either anterior guiding elements on the upper denture or balanced occlusion in spite of a different vertical dimension. However, significantly higher values were observed during protrusion, and even more during laterotrusion on the working side as well as on the non-working side with a splint providing bilaterally balanced occlusion. The masseter EMG generally shows higher potentials, and is therefore more significantly proving this fact compared to the values of the temporalis muscle.

Ott (1989) found that even performing small excursions of the mandible led to a drastic decrease of elevator muscle activity in patients with natural dentition providing anterior front-canine guidance. In the presence of balanced occlusion the muscle activity increased. Miralles *et al.* (1989) compared muscle activities of patients with natural dentition and patients with dentures. They found similar activity in both populations during swallowing and in the intercuspital position. Tscharré-Zachhuber & Riedl (1988) revealed that patients wearing dentures with anterior front-canine guidance showed similar mastication patterns as people after restoration of a complete natural dentition. Patients with dentures providing balanced occlusion show, on the contrary to this, irregular patterns which normalize after adapting dentures providing the occlusal concept with anterior front-canine guiding elements.

Mechanisms of the difference of topognostic ability between anterior tooth and posterior tooth have been discussed by Kawamura, Nyshiyama & Funakoshi (1967). Williamson & Lundquist (1983) suggested the use of so-called 'anteriorly controlled occlusal concepts' not only for restorations in patients with natural teeth but also in edentulous patients. Fried *et al.* (1991) proved the existence of reinnervation (of trigeminal afferent inputs to the CNS) in the ridge mucosa after loss of pulpal tissue due to tooth loss. Bachmann (1994) investigated the pressure sensibility of different ridge segments in edentulous people and found a higher sensibility in the anterior regions of the upper and lower jaw. Referring to this it must be assumed that the central neurophysiological control of mastication stays fairly unchanged despite the fact that patients lose their teeth including pulpal proprioception.

Together with other authors, this study points out that in edentulous patients the same gnathological principles have to be applied as in persons with natural dentition. The use of anteriorly guided dentures may help to avoid the development of craniomandibular



**Fig. 3.** Vectorized EMG raw signals during maximal intercuspital contact.

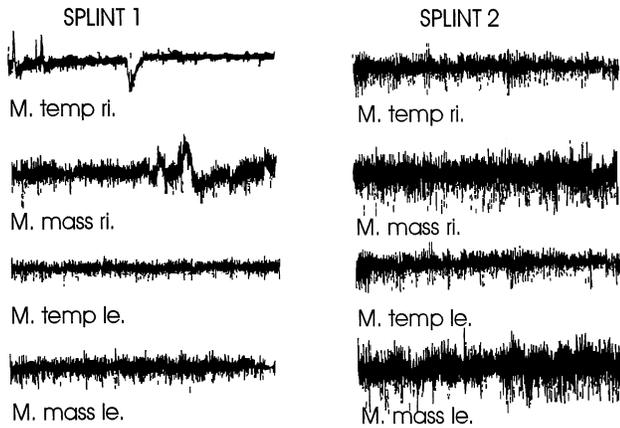


Fig. 4. Vectorized EMG raw signals during protrusive movement.

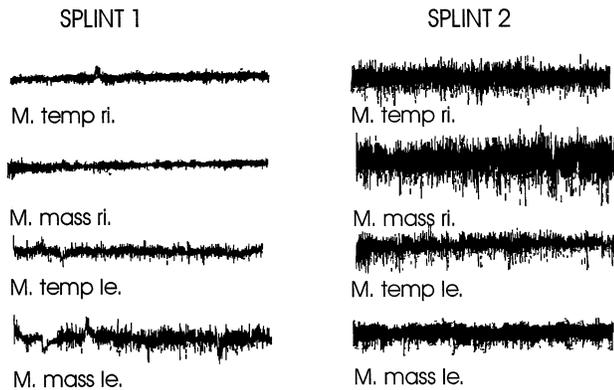


Fig. 5. Vectorized EMG raw signals during laterotrusion to the right side.

dysfunction, pathologically increased muscle activity with muscle pain and potential temporomandibular joint disorders or destruction and also to minimize sore spots and ridge resorption.

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