



Case report

## EMG EVALUATION OF THE OCCLUSION WITH TEETHAN DEVICE: EFFECT OF THE MUSCLES

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### ABSTRACT

**Objectives:** The aim of the study is to assess the influence of the masticatory muscles on the indices of the occlusion, measured with electromyographic (EMG) device Teethan® (Teethan S.p.A., Milan, Italy). The device is designed to assess the effect of occlusion on muscle balance and thus indirectly guides the clinician to the necessary changes in occlusion. This paper aims to determine whether muscles influence the indices characterizing occlusion.

**Material and methods:** Material and methods: Thirty-three persons aged 13-43 (mean 21.33) years, 15 men and 18 women who fulfilled the criteria, were included in the study. All subjects had a good state of dental and periodontal health and complete permanent dentition. EMG recordings of the masseter and temporalis muscles were performed during maximum voluntary teeth clenching on cotton rolls and in centric occlusion. All values were standardized as a percentage of the maximum clenching on cotton rolls.

**Results:** Most of the results of the test on cotton rolls are below normal reference values provided by the manufacturer. Within the normal range are only the Global index and IMPACT. When compared to MVC in centric occlusion, some of the indices were higher than when biting on cotton rolls (POC MM, BAR, Global index), which pointed out the effect of the occlusal contact on these tests.

**Conclusions:** The calibration of the Teethan® device gives reliable and reproducible results. Test during MVC in centric occlusion will provide information on which of the indices are influenced by occlusal factors. Recording a test MVC on cotton rolls gives valuable information for the muscle balance, excluding the influence of the occlusion.

**Keywords:** Teethan, calibration, standardization of EMG signals, muscular balance, occlusion,

### INTRODUCTION

Surface EMG (sEMG) is a non-invasive objective method for the analysis of the myoelectric activity of the masticatory muscles generated during clenching. In clinical practice, EMG may be used to assess the influence of occlusal contacts on stomathognathic function [1]. sEMG of the temporalis and masseter muscles is considered a re-

liable tool to diagnose and discriminate temporo-mandibular disorders (TMD) of muscular origin [2] and is widely applied in dentistry for prosthetic rehabilitation, evaluation of the orthodontic treatment, temporomandibular dysfunction and orthognathic surgery [3, 4, 5, 6].

Skin impedance, muscle crosstalk, and the position of the electrodes can affect the signals generated by the muscles. Both recommendations for performing sEMG [7] and normalization of the data [8] were introduced to eliminate the biological and technical noise. Ferrario VF et al. (2000) developed a method for within-subject standardization (normalization) of the EMG potentials, and the muscle asymmetry is expressed by indices that take into account the whole morphology of the EMG wave as a function of time. This procedure allows useful comparisons between different subjects and different studies. In most studies, the results are presented as a percentage of maximal voluntary contraction (MVC). Good reproducibility was achieved and reported in EMG recordings during maximal voluntary clench by [9].

In a study by Jung JK, et al. (2022), thirty young healthy subjects performed three MVC tasks three times each in three sessions on the same day without replacing surface electrodes: clenching the teeth and biting down on two cotton rolls bilaterally with the posterior teeth or first molars. The surface EMG measurements, according to the three MVC methods, exhibited good to excellent reproducibility.

In recent years, the EMG recording device Teethan (Teethan S.p.A., Milan, Italy) has been introduced for the analysis of muscle activity of the masseter and anterior temporalis muscles. It is a medical device for the functional evaluation of dental occlusion that provides information on neuromuscular alterations induced by occlusal contacts. Teethan performs a surface electromyographic analysis of the main masticatory muscles to quantify the influence of the occlusion on the patient's neuromuscular balance. A new study confirmed the reproducibility of the results when a Teethan device is used for this purpose [1].

The aim of the study is to compare the results between the test with cotton rolls and the test without rolls during maximal voluntary clench to differentiate muscle from occlusal effects.

## MATERIALS AND METHODS

### Participants

Thirty-three persons aged 13-43 (mean 21.33) years, of which 15 men and 18 women were enrolled in the study. The participants in this study were not divided according to gender and age. In the applied methodology, we use the rule formulated by Ferrario et al. that standardized MVC on cotton rolls in young male and female adults show similar EMG patterns without differences in the average potentials [8]. Thus, all recordings are interpreted regardless of gender.

**Inclusion criteria:** All subjects should have a good state of dental and periodontal health status and complete permanent dentition with the exclusion of third molars.

**Exclusion criteria:** any pain or discomfort during maximal voluntary clenching, temporo-mandibular disorders; neurological disorders; fixed or removable prostheses; current orthodontic or dental treatment.

**Technical devices:** the electromyographic device Teethan (Fig. 1) records EMG signal through wireless probes with active electrodes. Probes are attached directly to the pre-gelled electrodes; their peripheral part adheres to the skin without further fixation. The electrodes are positioned over masseter (MM) and anterior temporalis (TA) muscles, according to SENIAM (Surface EMG for Non-Invasive Assessment of Muscles) recommendations [7]. Each probe consists of two electrodes, which in turn are equipped with clips. The two parts, connected by a flexible cable, can be positioned at a variable distance if necessary. Each probe is dedicated to the acquisition of a specific muscle (left or right temporalis anterior and left and right masseter muscle). The muscle is palpated during a maximal clench to identify the anterior bundle of the temporalis. The major axis of the zygomatic process of the frontal bone is identified, and the probe is applied along with the muscle anterior margin - close to the coronal suture and keeping 2 centimeters from the zygomatic process. To identify the masseter muscle, the clenched muscle is

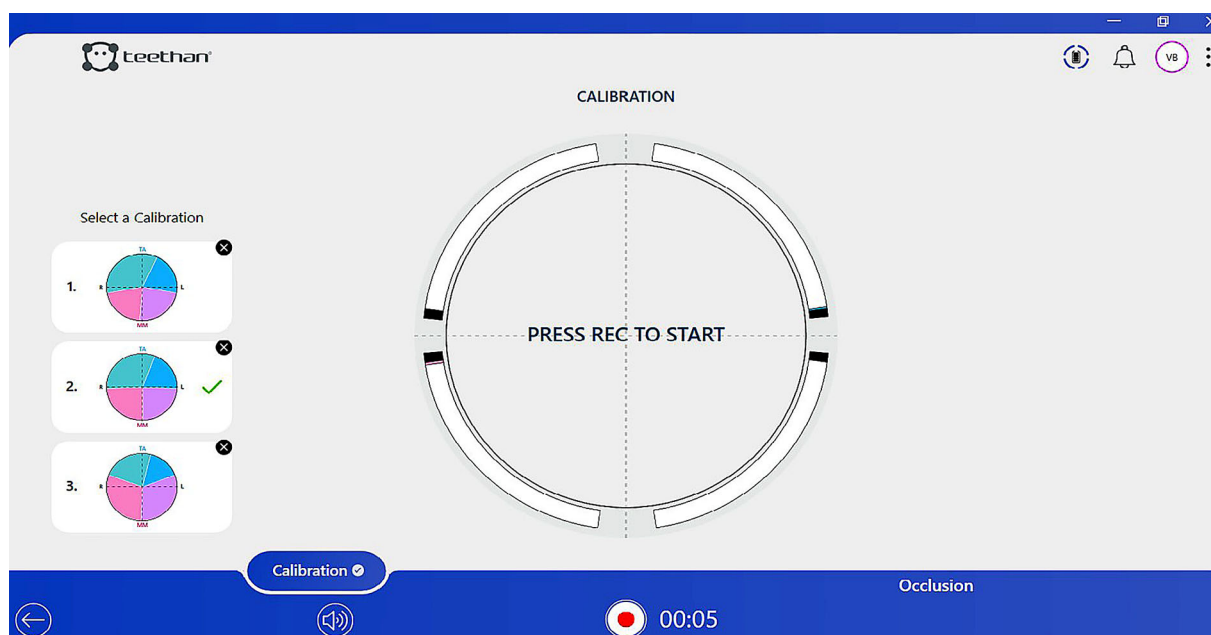
palpated to identify its belly. The probe is positioned in a direction parallel to the course of the muscle fibers and in the central portion of the muscle - along the line joining the outside edge of the eye with the angle of the jaw.

For calibration of the appliance, the patient must clench his teeth as hard as possible on cotton rolls. The cotton rolls are inserted between the arches on the fifth and sixth tooth - second premolars and molars. When a patient bites on a cotton roll, the teeth are not in contact, so muscle balance is not influenced by any occlusal interferences. The recording stops automatically after five seconds and goes directly to the occlusion acquisition step. Previews of the calibration tests, if more than one, in the form of pie charts for each of the acquisitions, are visible on the screen (Fig. 2). It is possible to compare several calibration tests to select the one considered best (Fig. 3). After the calibration test is chosen, the cotton rolls are removed, and the software is ready to perform the actual Occlusal Test. The patient is asked to clench as hard as possible in maximal intercuspation.

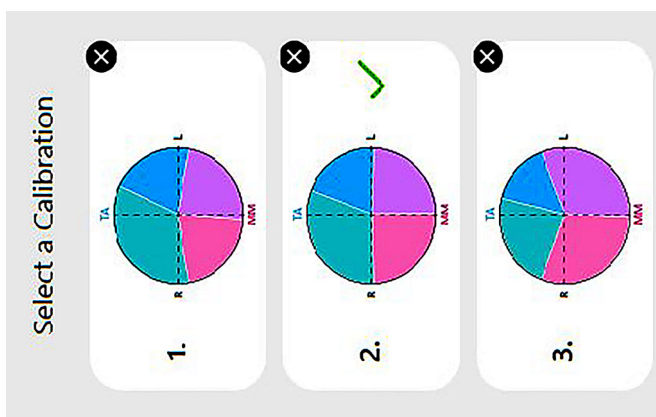
Fig. 1. Teethan device



Fig. 2. Calibration test screen



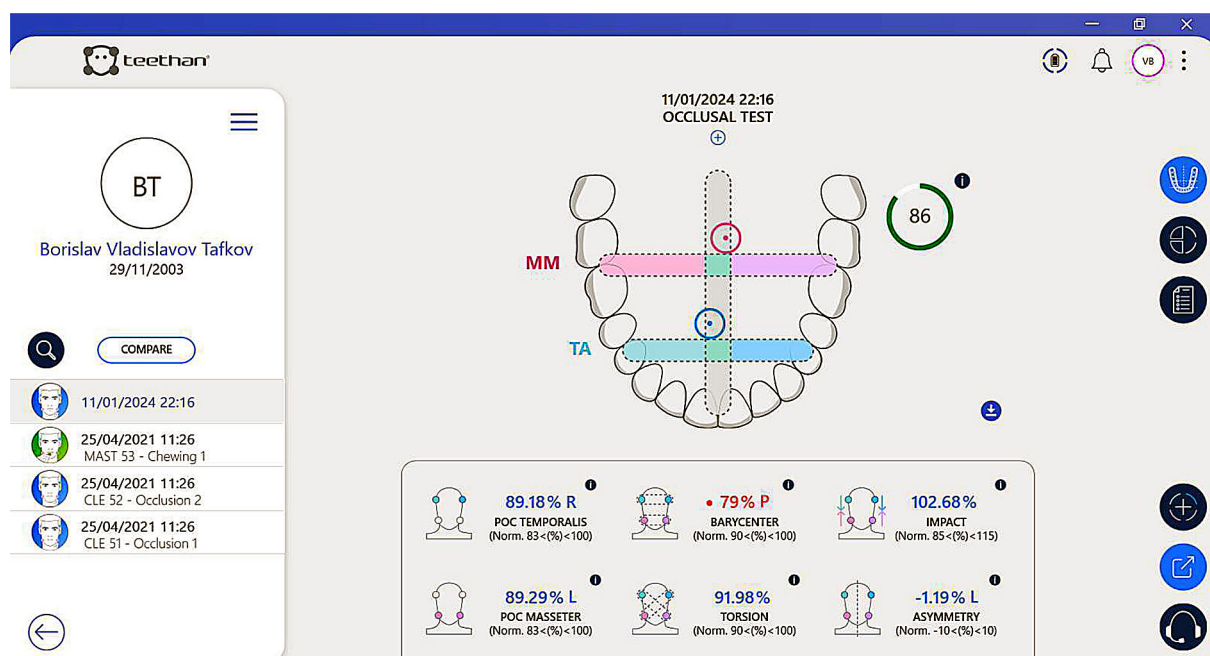
**Fig. 3.** Calibration tests. The best is considered the one with the most symmetrical contraction of the four muscles.



### Occlusal Test

To measure the balance of the dental occlusion, the patient must perform two clenching tests of five seconds each - the first on cotton rolls and the second in maximal intercuspation. Muscle activity is assessed in microvolts and the device's software analyzes the signal. Data is converted to indices based on the differences between the two test conditions (clench on cotton rolls and centric occlusion) [8]. At the end of the acquisition process, the report is automatically generated (Fig. 4).

**Fig. 4.** Report of the occlusal test



The indexes, calculated by the software as a result of the recorded muscle activity are as follows (according to the user manual):

**Percent Overlapping Coefficient (POC):** it is an index used to assess the symmetry of contraction standardized within the same muscle pair. It indicates the imbalance (right/left) within the examined muscle pair: in particular, the POC calculates the predominance of the right or left temporalis and that of the right or left masseter muscle. If the two muscles of the same muscle pair contract symmetrically, the expected theoretical result of POC is close to 100%. If the two muscles have standardized values with different percentage, the POC is considerably less than 100%. If POC exceeds 83%, there is a normal muscular symmetry induced by teeth contact

**Barycentre (BAR).** It assesses the position of the occlusal barycentre. It is obtained by calculating the percentage of overlapping coefficient between the activities of the two temporalis and the activities of the two masseter mus-

cles (unlike the POC index that compares individual analogous muscles). The normality value of the BAR index is greater than 90%.

**Torsion (TORS):** this assesses the torsion attitude of the mandible in the horizontal plane when it is in occlusion with the upper jaw. It is the result of the comparison of the force couple of crossed muscle pairs: comparison between the right temporal and left masseter pair and between the left temporal and the right masseter pair. When this index is > 90%, there are no force couples on the jaw.

**Impact (IMP).** It indicates the muscular activity of masticatory muscles and is proportional to the bite force. The normality values of the index are over the range of 100%-115%

**Global index.** It represents the mean value of the four mentioned above indices.

**Asymmetry (ASIM).** This index allows for comparing the activity of the right muscles with that of the left ones. A positive value indicates a greater activation of the right-

hand side, while a negative value indicates a greater activation of the left-hand side. Normality ranges from -10 to +10.

**Experimental protocol.** The patient sits in a dental chair with the head upright, without head support. The legs are not crossed, and the arms rest on the knees.

After calibration on cotton rolls, another test on rolls was recorded. This time, the recording was made as a test, not a calibration. The second recording is made without rolls in MVC. The results are then compared. In this way, it becomes possible to differentiate which deviations result from muscle asymmetry and which are due to occlusal contacts.

**Statistical Analysis.** For statistical analysis, IBM

SPSS Statistics, 23.0. The mean values, standard deviation and coefficient of variation (CV) were calculated for the outcome variables. Pearson's correlation analysis was used to check the pairwise linear correlation between the two trials.

## RESULTS

Asymmetry index (ASIM) values are interpreted as absolute value (not as positive value for right prevalence and negative value for left prevalence) since the norm is zero. Table 1 presents age, mean values, standard deviation ( $\overline{SD}$ ) and coefficient of variation (CV) for each electromyographic index from all recordings.

**Table 1.** Age and indices presented in the study

Index	Reference values	Results					
		MVC on rolls			MVC in centric occlusion		
		mean	$\overline{SD}$	CV %	mean	$\overline{SD}$	CV %
Age	-	21.3	7.62	35.7	21.3	7.62	35.7
POC TA	83-100%	82.57	7.73	9.4	83.61	8.08	9.66
POC MM	83-100%	81.12	10.66	13.1	79.53	14.43	18.14
BAR	90-100%	84.91	10.62	12.51	80.55	16.71	20.74
TORS	90-100%	87.16	8.92	10.25	87.32	8.26	9.46
Global Index	83-100%	84.15	8.25	31.9	82.24	10.35	42.7
IMPACT	85-115%	98.77	31.49	85.14	126.25	53.97	109.90
ASIM	$\pm 10$	10.50	8.94	9.8	12.02	13.21	12.59

MVC – maximal voluntary clench

POC TA – symmetry of contraction of right and left temporalis anterior, standardized within the muscle pair

POC MM - symmetry of contraction of right and left masseter muscle, standardized within the muscle pair

BAR – position of the occlusal barycenter assessment

TORS – assessment the torsion attitude of the mandible in the horizontal plane in occlusion

Global index – mean values of the first four indices

IMPACT – assessment of muscle activity related to bite force.

ASIM – comparison of the activity of the right and left masticatory muscles.

It is of interest to note, that some of the results on cotton rolls are below normal values provided by the manufacturer. In the user manual of Teethan device are given reference values for the indices in percentages. These percentages represent measurements in centric occlusion compared to the result on cotton rolls during MVC.

In this study when biting on rolls POC TA is slightly lower than the normal values and the values in centric occlusion. Both POC MM results are lower than the normal range, the test with cotton rolls being even lower. Barycentre evaluation is low during the two tests, even though with high values of the standard deviation. Values of the torsion (TORS) are below the norm both for MVC on cotton rolls and in centric occlusion. Within the normal range are only the Global index and IMPACT. Global Index with cotton rolls is within normal values due to elimination of the occlusal contacts, whether in centric occlusion the mean value is slightly below the norm. In both tests the standard deviation value is high – 8.25 and 10.35 respectively. When compared to MVC in centric occlusion, some of the indices were higher than when biting on cotton rolls (POC MM, BAR, Global index).

The pairwise correlation test shows the correlation values between the two trials (Table 2).

**Table 2.** Results of the correlation tests between the two trials

Indices	Pairwise correlations
POC TA	0.604**
POC MM	0.422*
BAR	0.513**
TORS	0.877**
Global Index	0.649**
IMPACT	0.244
ASIM	0.594**

\*Correlation is significant at the 0.05 level

\*\*Correlation is significant at the 0.01 level

POC TA – symmetry of contraction of right and left temporalis anterior, standardized within the muscle pair

POC MM - symmetry of contraction of right and left masseter muscle, standardized within the muscle pair

BAR – assessment of the position of occlusal barycenter

TORS – assessment of the torsion attitude of the mandible in the horizontal plane in occlusion

Global index – mean values of the first four indices

IMPACT – assessment of the muscle activity related to bite force.

ASIM – comparison of the activity of the right and left masticatory muscles.

Out of all indices, TORS showed the highest level of between-trial correlation (0.877). The other indices presenting a high degree of correlation are the Global index, POC TA and BAR. POC MM showed a medium degree of correlation. The absence of correlation showed only IMPACT. The bite force, related to muscle activity, is influenced by the cotton rolls between dental arches.

## DISCUSSION

Electromyographic device Teethan® gives guidance in oral rehabilitation procedures, including increasing the vertical dimension of the occlusion, as well as TMD and neck pain patients [11, 12]. What makes the evaluation objective is the elimination of the alterations of the signal and proven repeatability by normalization of the signal. This is achieved by additional MVC on cotton rolls used for the calibration of the device. Then, the values of the MVC in centric occlusion are presented as a percentage of the values on a cotton roll. This method is registered as Synchronomyography.

The EMG protocol, proposed by Ferrario VF et al. (2000), and the normal values are used as a base of this study. In our sample of participants, MVC in centric occlusion showed only POC TA in the normal range when mean values of the whole group were estimated. It is known that standardized potentials of the anterior temporal muscle are larger than the potentials of the masseter muscle, as they are compared to MVC on cotton rolls. In this case, the temporalis usually contracts with a lower intensity; thus, the reference (denominator) value is lower, so the resulting percentage potentials are larger [8]. Our results are similar when comparing indices POC TA and POC MM with and without rolls. The standardized EMG potentials with cotton rolls in MVC were higher in terms

of POC MM, BAR, and Global index. Ferrario VF et al. (2000) conclude that indexes in centric occlusion are usually lower in value, which is partially confirmed by our findings in this study.

When examining the correlation relationship, we found a significant positive correlation between indices, with the exception of the IMPACT index. All other indexes are based on balanced right-left side muscles, which, in healthy individuals without complaints and with sound dentition as in our sample, are expected to be within normal range. IMPACT index is representative of vertical dimension (in case POC, TOR and BAR are in norm) and muscle work. The fact that the contact is not on the whole dentition and the tightly compressed cotton roll increases the vertical dimensions of the muscles is related to this absence of correlation.

Recording a test with cotton rolls after calibration of the appliance provides information about the muscle balance eliminating the effect of the occlusion. In this way after the test in MVC, the examiner can differentiate the muscle imbalance of the masticatory muscles without the influence of occlusion and that resulting from occlusal contacts. In the group examined in this study, the values of the indices in both studies are very similar, which we believe is results from selection of participants without deviations in muscle balance.

## CONCLUSIONS

The calibration of the Teethan® device makes results reliable and reproducible. Test during MVC in centric occlusion will provide information which indices are influenced by occlusal factors. Recording a MVC test on cotton rolls gives valuable information for muscle balance without the influence of occlusion.

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