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Reorganization of muscle activity in patients with chronic temporomandibular disorders

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ABSTRACT

Objective: To investigate whether reorganization of muscle activity occurs in patients with chronic temporomandibular disorders (TMD) and, if so, how it is affected by symptomatology severity.
Methods: Surface electromyography (sEMG) of masticatory muscles was made in 30 chronic TMD patients, diagnosed with disc displacement with reduction (DDR) and pain. Two 15-patient subgroups, with moderate (TMDmo) and severe (TMDse) signs and symptoms, were compared with a control group of 15 healthy subjects matched by age. The experimental tasks were: a 5 s inter-arch maximum voluntary clench (MVC); right and left 15 s unilateral gum chewing tests. Standardized sEMG indices characterizing masseter and temporalis muscles activity were calculated, and a comprehensive functional index (FI) was introduced to quantitatively summarize subjects' overall performance. Mastication was also clinically evaluated.
Results: During MVC, TMDse patients had a significantly larger asymmetry of temporalis muscles contraction. Both TMD groups showed reduced coordination between masseter and temporalis muscles' maximal contraction, and their muscular activity distribution shifted significantly from masseter to temporalis muscles. During chewing, TMDse patients recruited the balancing side muscles proportionally more than controls, specifically the masseter muscle. When comparing right and left side chewing, the muscles' recruitment pattern resulted less symmetric in TMD patients, especially in TMDse. Overall, the functional index of both TMDmo and TMDse patients was significantly lower than that obtained by controls.
Conclusions: Chronic TMD patients, specifically those with severe symptomatology, showed a reorganized activity, mainly resulting in worse functional performances.
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1. Introduction

Temporomandibular disorder (TMD) is a comprehensive term for musculoskeletal disorders in the jaw muscles and/or the temporomandibular joint (TMJ). A common subgroup of TMD is the disc displacement with reduction (DDR), manifesting with TMJ noise during jaw movement or function, with a prevalence ranging from 18% to 35% of the population. (Naeije, Te Veldhuis, Te Veldhuis, Visscher & Lobbezoo, 2013; Schiffman et al., 2014). TMD patients with both DDR diagnosis and pain as well as complaints of mandibular function impairment are common among those that seek treatment (Ferreira et al., 2014; Santana-Mora et al., 2014; Tartaglia, Lodetti, Paiva, De Felicio & Sforza, 2011).

Relevant information about patients and their functional limitations may be obtained by specific questionnaires for measurement of symptoms (Helkimo, 1974; De Felício, Melchior & Da Silva, 2009; Gonzalez et al., 2011; Ohrbach et al., 2011, 2013); and clinical evaluations (De Felício et al., 2012; Dworkin & LeResche, 1992; Ferreira et al., 2014). Whereas, functional analyses, like surface electromyography (EMG), have been employed in order to obtain a better understanding of TMD. EMG analysis is useful to elucidate the masticatory muscles function and

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adaptation in patients with TMD, using indices of muscular dominance and asymmetry as those proposed by Naeije, McCarroll, and Weijs (1989). to analyze maximum voluntary contraction (MVC) (Santana-Mora et al., 2009, 2014) and with the assessment of the concomitant co-ordination and co-operation of paired temporalis and masseter muscles during mastication (Kumai, 1993). Additionally, EMG has the potential to contribute to therapy plan (De Felício, Mapelli, Sidequersky, Tartaglia, & Sforza, 2013; Ferreira et al., 2014; Lodetti et al., 2014; Ries et al., 2014; Santana-Mora et al., 2014).

Previous studies showed decreased raw EMG activity of jaw muscles in TMD patients compared to control subjects, association between decreased activity and increased severity (Ardizone et al., 2010), and asymmetry between affected side and non-affected side in unilateral TMD patients (Santana-Mora et al., 2009). To distinguish real changes from biological and instrumental noise, standardized EMG has been strongly recommended (Ferrario, Tartaglia, Maglione, Simion & Sforza, 2004; Ferrario, Tartaglia, Galletta, Grassi & Sforza, 2006), mainly for inter-individual comparison. Particularly in chronic TMD (present for at least 6 months), impaired coordination in the masticatory muscles has been observed during MVC (De Felício et al., 2012; Lodetti et al., 2014; Santana-Mora et al., 2014; Tartaglia et al., 2011) and during chewing (Ferreira et al., 2014); these changes were not evident in non-chronic TMD of mild-moderate severity symptomatology (De Felício et al., 2013). Thus, both duration and severity that negatively influence the TMD prognostic (Rollman, Visscher, Gorter & Naeije, 2013; Von Korff & Dunn, 2008) may be associated with the orofacial motor function (De Felício et al., 2013; Ries et al., 2014).

Despite the previous findings and the near consensus about association between unilateral chewing preference and TMD (Casanova-Rosado et al., 2006; Ferreira et al., 2014; Ratnasari et al., 2011; Santana-Mora et al., 2009) the relationship between the masticatory muscles in chronic TMD exhibiting different grades of severity is not trivial. Therefore, researchers have investigated the relationship between orofacial motor function and pain by means of EMG analysis, in standardized settings, without the interference of confounding factors. Based on these studies (Sae-Lee et al., 2008; Shimada, Baad-Hansen & Svensson, 2015; Shimada, Hara & Svensson, 2013) and theories (Hodges & Smeets, 2015; Hodges & Tucker, 2011; Peck, Murray & Gerzina, 2008) it has been proposed that pain in jaw muscles, rather than a stereotyped change, may involve differential effects as increased, decreased, or redistributed activity with re-organization of activity occurring within and between muscles. Authors (Sae-Lee et al., 2008; Shimada et al., 2013, 2015) have suggested that investigations with patients are required.

The objective of the current cross-sectional study was to investigate whether re-organization of muscle activity occurs in chronic TMD patients with clinically detected DDR and, if so, how it is affected by symptomatology severity. New fit-for-purpose EMG indices were introduced, a global functional index (FI, %) was elaborated and its ability to represent comprehensive functionality of the masticatory muscles was tested.

2. Materials and methods

2.1. Subjects

The study was approved by the institutional Ethics Committee and all subjects gave written informed consent to participate.

Thirty chronic TMD patients (pain duration >6 months, mean ± SD 59.2 ± 52.7, range 7–240 months) with DDR (disc displacement with reduction) were selected among consecutive patients who came to our institution for treatment of orofacial pain and TMD. Fifteen healthy subjects, paired for age and sex, were recruited for the control group (C, 14 women and 1 man).

The inclusion criteria for the patient group were to present chronic TMD pain (myalgia and/or arthralgia) with DDR diagnosis, based on history and clinical examination; for C group were good general health and absence of TMD history. Subjects with tooth absence (except the third molars), dental pain or periodontal problems, denture use, dentofacial deformities, crossbite, open bite, pacemaker use, neurological or cognitive deficits, previous or current tumors or traumas in the head and neck region, pregnancy, current or previous orthodontic, orofacial myofunctional or TMD treatments, current use of analgesic, anti-inflammatory and psychiatric drugs were excluded from the study.

2.2. History and clinical examination

Participants were interviewed and examined by independent experienced examiners, one for each protocol, blinded to the outcome of the other ones. Individuals' TMD symptomatology was screened and measured with a validated self-report questionnaire about TMD signs and symptoms and orofacial functional status (ProTMDmulti) (De Felício et al., 2009, 2012). The total ProTMD-multi score ranges from 0 (no pain referred) to 400 (worst pain perception), and the median of the 30 patients' scores (109) was used to classify patients into two groups: TMDmo (moderate, subjects with score <109) and TMDse (severe, subjects with score >109).

Clinical examination was performed in accordance with the Research Diagnostic Criteria for TMD (RDC/TMD), axis I (http://www.rdc-tmdinternational.org/) (Dworkin & LeResche, 1992). A clinical examination protocol was also adopted. (Ohrbach, Gonzalez, List, Michelotti & Schiffman, 2014). The diagnostic procedures were based on the "Diagnostic Criteria for the Most Common Pain-Related Temporomandibular Disorders" – DC/TMD (Schiffman et al., 2014).

The demographic of each group and the patients' distribution of TMD severity and diagnosis are shown in Table 1.

2.3. sEMG recordings and measurement instrumentation

The masseter and anterior temporalis muscles of both sides (left and right) were examined. EMG activity was recorded using a wireless EMG system (FreeEMG, BTS S.p.A., Garbagnate Milanese, Italy), with light probes (weight, 5 g) clipped to the electrodes. Paired disposable Ag/AgCl pre-gelled electrodes (sensor area, 3.14 cm^2; inter-electrode distance, 2 cm; Kendall, Covidien, Mansfield, Canada) were placed on the skin along the main direction of the muscular fibers, detected by palpation during MVC. Before electrode placement, the skin was scrubbed with an alcohol soaked gauze pad. Men were kindly requested to attend clean-shaven, to facilitate electrode placement. For each subject, the electrodes were positioned at the beginning of the experimental session, and all trials were performed without any modification of the electrodes and/or of their position. The analog EMG signal was amplified and digitized (gain 150, resolution 16 bit, sensitivity 1 mV, temporal resolution 1 ms) using a differential amplifier with a high common mode rejection ratio (CMRR > 110 dB in the range 0–50 Hz, input impedance > 10 GΩ). All the recorded EMG signals were digitally band-pass filtered between 80 and 400 Hz with a 2nd order Butterworth filter, and rectified by calculating the root mean square (RMS) in temporal windows of 25 ms.

The subject, who sat on a chair with his/her head in a natural erect position, was asked to perform two experimental tasks: a 5-s inter-arch maximum voluntary clench (MVC) and two 15-s unilateral (right and left) gum chewing tests.

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