E. Ortu*, D. Pietropaoli*, E. Marchetti*,
N. Marchili*, G. Marzo**, A. Monaco***

Department, University of L'Aquila, L'Aquila, Italy
**DDM, PhD, MeSVA*
***MD, Professor, MeSVA*
****DDM, Professor, MeSVA*

email: eleortu@gmail.com

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Bruxism in children: Use of the Functional Plane of Monaco (FPM)

ABSTRACT

Background *Bruxism is a condition that results from hyperactivity in the central nervous system, and factors such as stress or other anxious conditions increase the frequency of episodes. When bruxism occurs at a young age, tooth wear can occur. The extent of wear can lead to the need for restorative dentistry and prosthetic treatments to restore the morphological and functional integrity of the teeth, with high costs associated with such treatments.*
Case report *A healthy 15-year-old boy presented to the orthodontist observation. His incisal ridges appeared thin, without mamelons, and with increased translucency. For treatment, the authors used only the Functional Plane of Monaco (FPM), a device which he had to wear 16 hours during the day.*
Conclusion *The orthodontist successfully treated an orthopaedic/orthodontic case with the FPM device.*

Keywords *Bruxism, Deep bite, FPM, TMD.*

Introduction

Bruxism, from the ancient Greek term βρυγμός (brugmós, "grinding" [teeth]), is a nosographic entity that has been defined as a stereotypical wandering movement of masticatory muscles. Bruxism affects both adults and adolescents and has been associated with several factors, including daytime stress, biopsychosocial anxiety, and obstructive sleep apnoea [Castroflorio et al., 2016; Monaco et al., 2002; Fernandes et al., 2016; Saulue et al., 2015; Vanderas and Manetas, 1995]. In individuals affected by bruxism, a group of five subcortical nuclei appear to be disturbed, and this contributes to an imbalance between direct and indirect pathways of the basal ganglia which coordinate movement. It has also been hypothesised that bruxism is part of a sleep arousal response and is modulated by various neurotransmitters in the central nervous system. Similarly, disturbances in the central dopaminergic system have been linked to bruxism [Monaco et al., 2002].

Bruxism often occurs during sleeping, and the condition is frequently associated with sleep disorders [Stuginski-Barbosa et al., 2017; Tachibana et al., 2016; Ferreira et al., 2015], muscular hypertonia of the stomatognathic system [Nishi et al., 2016; Castroflorio et al., 2015], hypertrophy of lower jaw elevator muscles [Katsetos et al., 2014; Cioffi et al., 2016; Palinkas et al., 2016], and temporomandibular disorders (TMD) [Dawson et al., 2016; Tavares et al., 2016; Fernandes et al., 2016]. In addition, with time, dental surface wear can occur. Among children between 8 and 12 years of age, and in some cases at younger ages, bruxism is seen in almost 40% of the population. Furthermore, onset of bruxism during adolescence, may increase the risk of a chronic dynamics evolution [Wieckiewicz et al., 2014], which can further worsen the signs and symptoms of TMD [Molina et al., 2000, Tavares et al., 2016, McCoy, 2007]. When bruxism occurs in younger children, the resulting tooth wear can require immediate restorative and eventually prosthetic treatments to restore the morphological and functional integrity of the tooh, which comes with high costs for families. Given the age and development of younger patients affected by bruxism [Manfredini et al., 2013a; Manfredini et al., 2013b; Monaco et al., 2007; Manfredini et al., 2015; Bortoletto et al., 2014], for the correct treatment planning both the dentition status and the developmental potential of the teeth involved must be considered [Saulue et al., 2015; Castroflorio et al., 2016].

Therapy is generally symptomatic/protective, with oral appliances and splints proposed to loosen muscular tension, avoid tooth wear, and reduce temporomandibular pain [Guaita and Hogl, 2016; Gomes et al., 2015; Trindade et al., 2015; Candirli et al., 2016; Solanki et al., 2017].

The case we report here involves a young Caucasian male with growth potential affected by bruxism and TMD. The goal of this study was to develop an oral device which can act on the symptoms of bruxism, thereby allowing children to maintain the function and potential of their dental tissues and save money which may be needed for restorative and prosthetics dentistry according to disease progression. Therefore, the patient was treated with an oral appliance to improve conditions related to bruxism and TMD.

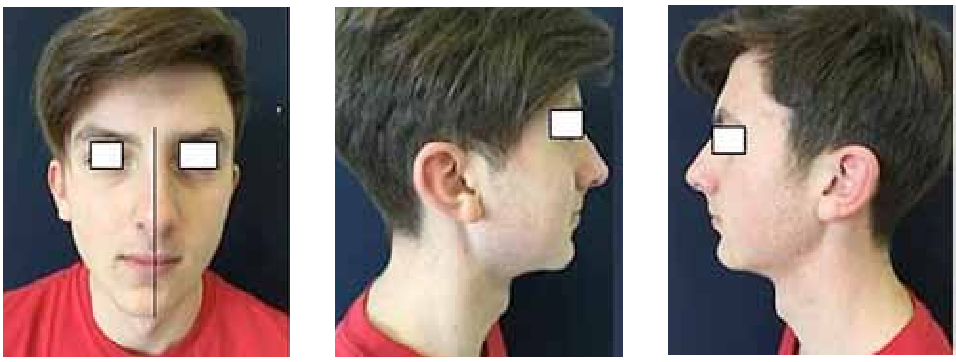

FIG. 1 Extraoral photographs before treatment.

FIG. 2 Intraoral photographs of the patient without (A-C) and with (D) the FPM device.

Case report

A 15-year-old Caucasian male came at the Dental Clinic of the University of L'Aquila (Italy) reporting tooth wear related to bruxism and pain at the temporomandibular joint (TMJ). The patient's medical history did not reveal any systemic disease, craniofacial syndromes, or congenital condition. The patient described a feeling of heaviness in his masseter muscle area and pain around his incisors upon waking for the past six months. He also reported headaches in the temporal region for the previous four months. This physical discomfort was affecting his concentration, school performance, and mood. At the same time, his sport performance worsened remarkably (jeopardising his role as mid-fielder in a football team). The patient further reported his concern regarding his incisors becoming thinner and thinner and the decrease in his enamel layer on many teeth. The extraoral clinical exam showed an evident rightward deviation of the mandible and a concave profile with no evident asymmetry in the facial third (Fig. 1). During the clinical intraoral examination, a deep bite, left and right Class I molar relationship, and some contraction of both arches were observed. The incisal ridges appeared thinner, without mamelons, and with accentuated translucency (Fig. 2), which are unmistakable signs of teeth grinding.

Orthodontic examination

During the orthodontic examination, an orthopantomography was taken and an alginate impression of dental arches was obtained. [Prasad, 2004].

TMJ examination

Palpation of the masticatory and cervical muscles revealed areas of tenderness and sustained contraction affecting the sternocleidomastoid, trapezius, and posterior cervical muscles, masseter at its attachments to the zygomatic arch, and at the angle of the mandible, as well ad the temporalis muscle both in the temporal fossa and intraorally along the ascending ramus of the mandible, and the medial pterygoid muscle. Areas of tenderness were also observed in asymptomatic regions far from the TMJ and stomatognathic muscles at the interosseous muscles of the hand and in the phalanx bones and muscles of the arm, consistent with a recent report by Harper et al. [Harper et al., 2016]. It has been increasingly well accepted in the scientific community that pain can be generated and maintained or suppressed, via other mechanisms, by changes in the central nervous system. As a result, a complete mismatch between peripheral nociceptive drive and perceived pain occurs [Monaco et al., 2015; Monaco et al., 2017]. In fact, there is no known chronic pain condition where the observed extent of peripheral damage reproducibly engenders the same level of pain across individuals. Patients with TMD range from those whose pain is generated peripherally to those whose pain is centralised. As a result, mechanistic variability in TMD pain aetiology has prevented adequate treatment of many individuals diagnosed with this condition [Monaco et al., 2015; Marchili et al., 2016].

Auscultation of the TMJ

The external auditory meatus is the nearest structure to the TMJ that can be approached anatomically. In addition, the auditory canal is more sensitive than the skin surface with respect to joint sounds. Therefore, by using a stethoscope, it is possible to auscultate clicking and popping sounds during mandibular motion in the right TMJ, and this was performed in the present case.

Visual Analog Scale (VAS)

The patient was asked to assess his level of pain according to the VAS, a one-dimensional measure of pain intensity which has been widely used in diverse populations. This scale is comprised of a horizontal or vertical line, usually 10

FIG. 3 Extraoral (A-C) and intraoral (D) photographs of the patient after six months of treatment with the FPM device.

centimeters (100 mm) in length, and it is anchored by two verbal descriptors, one for each extreme symptom [Berben et al., 2011]. As a single-item scale, the pain VAS varies from "no pain" (scored as 0) to "pain as bad as it could be" or "worst imaginable pain" (scored as 100 [100-mm scale]). Generally, respondents are asked to report "current" pain intensity or pain intensity "in the last 24 hours" [Rezazadeh et al., 2017; Monaco et al., 2017]. Our patient reported a pain intensity of 40.

Central Sensitisation Inventory (CSI)

To evaluate central sensitisation, such as cutaneous allodynia and hyperalgesia in the trigeminal and extra-trigeminal areas, a CSI was administered. Central sensitization (CS) is a proposed physiological phenomenon in which neurons of the central nervous system become hyper-excitable, thereby resulting in hypersensitivity to both noxious and non-noxious stimuli [Neblett et al., 2013]. Central sensitivity syndrome (CSS) describes a group of medically-indistinct (or nonspecific) disorders, such as fibromyalgia, chronic fatigue, and irritable bowel, for which CS may be a common aetiology. Our patient's score according to the CSI was 30, thereby revealing a slight form of central sensitisation [Neblett et al., 2013; Neblett et al., 2016].

Depression, Anxiety, Stress Scale 42 items (DASS42)

The DASS is a 42-item self-reported inventory that evaluates three factors: depression, anxiety, and stress. This inventory is based on the perspective that physical anxiety (fear symptomatology) and mental stress (nervous tension and nervous energy) represent two distinct domains. This screening and outcome measure also reflects the patient's condition over the previous seven days. An Italian version of DASS42 was employed to evaluate depression, anxiety, and stress in our patient.

Diagnostic criteria (DC)

Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) were previously proposed by Dworkin and LeResche for research regarding orofacial pain. We decided to apply an updated version of these criteria, DC/TMD [Dworkin, 2010, Lovgren et al., 2016; Schiffman et al., 2014] to the clinical data of the present case. The DC scores obtained showed that the temporomandibular features of our patient are consistent with an occlusal aetiology since somatisation, depression, and anxiety scores were very low. TMD whose origin is stomatognathic often respond to ultralow frequency transcutaneous electrical nerve stimulation (ULFTENS) with an increase in free way space and more balanced and symmetric muscle tone. In contrast, TMD related to CS and sympathetically maintained chronic pain rarely improve with ULFTENS [Monaco et al., 2017].

Electromyographic evaluation

Electromyographic activity (EMG) was recorded with an eight channel K7 system (Myotronics Inc., Seattle, WA, USA) and pre-gelled adhesive surface bipolar electrodes that were spaced at least 20 mm apart. Briefly, the skin surface was cleaned prior to placement of the electrodes on the left and right masseter muscles (LMM and RMM, respectively), on the left and right anterior temporal muscles (LTA and RTA, respectively) as described by Castroflorio et al. [2016], on the left and right anterior digastric muscles (RDA and LDA, respectively), and on the left and right sternocleidomastoid muscles (LSC and RSC, respectively) bilaterally parallel to the muscular fibers and over the lower portion of the muscle, according to Falla et al. [Barbero et al., 2016], to avoid innervation points. A template was used so that the electrodes would be in the same positions when measurements were repeated at different times, or if an electrode had to be removed due to malfunction [Castroflorio et al., 2012; Monaco et al., 2008a; Ortu et al., 2015; Marchili et al., 2016; Tecco et al., 2011]. Electrical signals were amplified, recorded, and digitised with a K7 clinical software package (Myotronics Inc.). Root mean square (RMS) values (in μV) were used as indices of signal amplitude [Masci et al., 2013b; Monaco et al., 2012a]. The sEMG exam for the patient started with an evaluation of muscular activity while at rest (SCAN 9).

Results

The patient was only treated with the functional plane of Monaco (FPM) device, which he wore 16 hours during the day (Fig. 2). Various exams were performed prior to his use of the device, and then again after six months of treatment. The following observations were made based on comparisons of these two evaluations.

After six months of wearing the FPM device, the patient's jaw was re-centered, his overbite became more balanced, and with no deep bite or lower incisors impingement of the palate (Fig. 3). The canine and molar cuspids were also protected, with the FPM device preventing enamel wear (Fig. 3). All of the self-evaluation scales showed

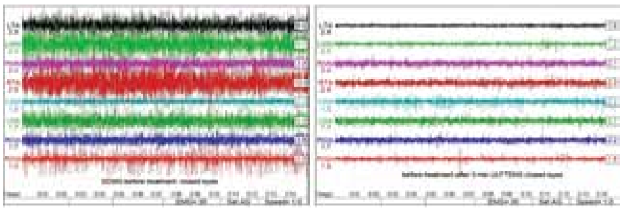

FIG. 4 Before treatment. Comparison between SEMG before and after ULFTENS. Myoelectrical hyperactivity (left panel) at baseline was improved after 3 min of ULFTENS (right).

Instrumental evaluations	Before Treatment	After Treatment
EMG data*		
SCAN 9 (Eight channels media)	5.78	2.01
SCAN 10 (Eight channels media)	1.91	1.67
SCAN 11 (Four channels media)	109.62	195.12
Masseter/temporalis	50%	81%
Kinesiograpy data		
Voluntary mouth opening (mm)	35	44
Mandible maximum velocity (mm/sec)		
Opening	325	352
Closing	348	406
Freeway space (FWS) after ULFTENS (mm)		
Verticality	4.0	1.0
Anterior	1.5	0.4
Laterality	2.3	0.3
V/A (verticality/Anterior)	5:1	2:1
*EMG data represent mean values obtained from eight recorded channels.		

TAB. 1 EMG and kinesiography data collected before and after treatment.

improvement after six weeks of treatment, especially regarding the patient's level of stress. Scores of the DASS 42 before treatment were: 1 for depression, 5 for anxiety, and 17 for somatisation. These scores represent normal values for anxiety and depression, and a mild value for stress. Moreover, the latter value is consistent with pain perception by the autonomous nervous system related to TMDs [Brown et al., 1997). After treatment, the patient's scores were 1, 5, and 10, respectively, thereby reflecting a reduction in stress. The patient's VAS score also decreased from 40 to 25 and his CSI test score decreased from 30 to 27 after six weeks of treatment.

Table 2 summarises the instrumental investigations that were conducted involving EMG and ULFTENS. At baseline, the patient's mean EMG value was 5.78 μV (Fig. 4). After the application of ULFTENS, the mean EMG value was 1.91 mV (Fig. 5), which represents a reduction of approximately 67% of the signal mean width. After treatment, the mean EMG value before ULFTENS was 2.01 mV and after ULFTENS it was 1.67 (Fig. 6), thereby indicating a reduction of approximately 16% of the mean value. Meanwhile, the reduction in the EMG mean value from baseline prior to ULFTENS (5.78) to after treatment (2.01) was approximately 66%. The patient's mean EMG value with voluntary clenching was 109.62 before treatment (Fig. 7) and 195.12 after treatment (Fig. 8). Thus, approximately a 46% increase in the mean myoelectric value was achieved with treatment. Regarding the masseter/temporalis (MM/TA) EMG ratio, it improved from a baseline value of approximately 50% (MM 72.85/TA 36.75) to approximately 81% (MM 107.37/ TA 87.85) after treatment. Voluntary opening of the mouth was affected by treatment as well. The maximum voluntary opening of the mouth before treatment was 35 mm (Fig. 9) and this increased to approximately 44 mm after treatment (Fig. 10), thereby representing an increase of approximately 20%. Furthermore, the average speed of voluntary mouth opening and closing was 325 mm/sec and 348 mm/sec, respectively before treatment (Fig. 9). After treatment, the values increased to 352 mm/sec and 406 mm/sec, respectively (Fig. 10). The differences in these values represent increases of approximately 8% and 14%, respectively.

Freeway space (FWS) was evaluated after ULFTENS both before (Fig. 5) and after (Fig. 11) treatment with the FPM device. Before treatment, the vertical dimension of movement from the resting position of the jaw to the occlusal contact was 4.0 mm (based on excess FWS with respect to the neuromuscular paradigm of approximately 2.5–3.0 mm and subsequent reduction in the vertical occlusion dimension of the corresponding 2.5–3.0 mm). An anterior shift of approximately 1.5 mm in the resting position of the jaw after ULFTENS, and a lateral shift of approximately 2.3 mm to the left in the resting position of the jaw, were also observed. After treatment, the resting position of the jaw after ULFTENS was approximately 1 mm less than the occlusal position, and approximately 0.4 mm posteriorly and 0.3 mm to the left. These changes in

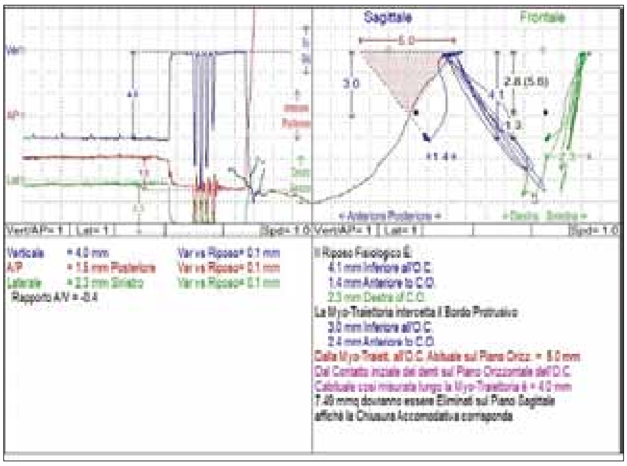

FIG. 5 Before treatment. After ULFTENS FWS in sweep mode and in sagittal-frontal projection. The black dot in the right figure is the point that was selected for recording the occlusal vertical dimension according to the neuromuscular paradigm.

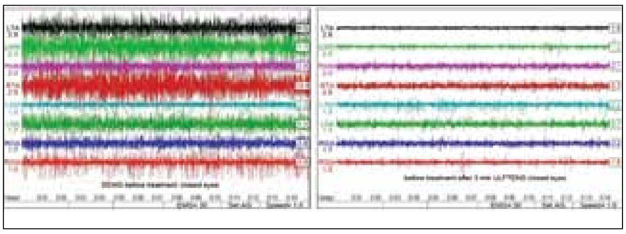

FIG. 6 After treatment. SEMG before and after ULFTENS. Correct myoelectrical activity is observed during rest for the mandible position. ULFTENS did not change the basic characteristics of SMG.

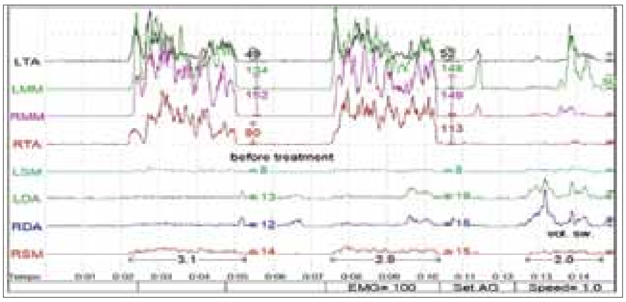

FIG. 7 Before treatment. Maximum voluntary clenching and swallowing.

FWS after ULFTENS are consistent with a neuromuscular paradigm (FWS after ULFTENS was approximately 1.0–1.5 mm, with a vertical-anteroposterior ratio of 2:1). A left lateralization of 0.3 mm remains.

Discussion

In this case, the clinical outcome of treatment for a 15-year-old male affected by bruxism resulted in an absence of further tooth wear for six months, heaviness in the masseter muscle area was eliminated, and the faint toothache around the incisors disappeared. In addition, the patient no longer had a deep bite and the overall look of the patient's face became more attractive, thereby resulting in biopsychosocial improvement in the patient [Shaw et al., 1991]. Electromyography and kinesiography data obtained for the patient further support this neuromuscular approach, with the patient's stomatognathic and postural muscles becoming more relaxed and balanced after treatment. As a result, an increase in the vertical jaw dimension of the patient was achieved [Monaco et al., 2008b; Ortu et al., 2016; Aprile et al., 2017; Ortu et al., 2017]. Thus, in the present clinical case, the results obtained are consistent with a neuromuscular paradigm for the treatment of bruxism in adolescents.

To date, there is no agreement regarding therapy for bruxism in adolescents [Bortoletto et al., 2014; Candirli et al., 2016; Raphael et al., 2016; Saulue et al., 2015; Sugarman and Sugarman, 1970; Trindade et al., 2015; Vanderas and Manetas, 1995]. Several therapeutic strategies have been proposed, especially strategies involving drugs which regulate dopamine metabolism [Dawson et al., 2016; Lobbezoo and Naeije, 2001; Sakai et al., 2016]. In adults, use of oral splints has been proposed [Candirli et al., 2016; Fujii et al., 2005; Gomes et al., 2015; Guaita and Hogl, 2016; Kurita et al., 1997; Trindade et al., 2015], although these splints could prevent the natural growth of jaws and dental arches in adolescents. Alterations in vertical jaw dimension have the potential to increase muscle tone [Biondi et al., 2016], although for patients with bruxism this can worsen their condition [Castroflorio et al., 2015; Cooper and Kleinberg, 2008]. Conversely, positioning the occlusal plane where neuromuscular structures are more relaxed could enhance the signs and symptoms of TMD [Chipaila et al., 2014; Masci et al., 2013a; Monaco et al., 2007; Monaco et al., 2008a; Monaco et al., 2008b; Monaco et al., 2012b; Monaco et al., 2013]. Neuromuscular bite planes have been shown to reduce the electric activity of muscles and patients' pain [Monaco et al., 2007; Monaco et al., 2008a; Monaco et al., 2012b; Palinkas et al., 2016], and in the field of neuromuscular dentistry, vertical jaw dimension is increased only if the muscles and mandible dynamics involved are improved by this modification. Orthodontics can correct neuromuscular parameters to improve signs and symptoms of TMD while enhancing aesthetics [Chipaila et al., 2014; Masci et al., 2013a]. Traditional orthodontics also strongly advocate that a deep bite should be corrected, with the neuromuscular position of the jaw considered in treatment plans to achieve the functional growth potential of children [Monaco et al., 2007;, Monaco et al., 2008a; Ortu et al., 2014a; Ortu et al., 2014b; Mummolo et al., 2014].

In the case presented, the EMG values at baseline were largely reduced after treatment (from 5.78 to 2.01), thereby resulting in a change in condition from electrical hypertonia to normal tone. The maximum voluntary clenching values also increased after treatment by almost 50%, and the muscular load distribution appeared to be more homogeneous in the mandibular elevator and depressor muscles. Taken together, these data are consistent with the results of previous studies [Ferrario et al., 2002; Ferrario et al., 2006] and they suggest that base neuromuscular conditions, as well as conditions during clenching, were improved with our treatment. The kinesiographic data obtained also appear to indicate that improvements in mandible dynamics and kinetics were achieved. In fact, the maximum voluntary opening of the patient increased by approximately 20% (35 mm to 44 mm) after treatment, and this increase produced an opening that is comparable to a normal opening distance for the patient's age. Therefore, independent from the neuromuscular paradigm, the present data suggest that the six-month treatment regimen improved the function of the patient's stomatognathic system. However, our data also appear to be specifically aligned with a neuromuscular paradigm for treatment. For example, the ULFTENS regimen reduced the patient's EMG values from those associated with hypertonia to those associated with normal tone. An increase in FWS was also observed after ULFTENS. In our previous papers, these improvements would have resulted in the labeling of this patient as an, "ULFTENS responder", based on the normality of the patient's DASS 42 values and limited CSI score. We previously suggested that these subjects may represent a subgroup of patients whose problems are mainly peripheral and are associated with the neuro-muscular-bone structures of their stomatognathic system [Monaco et al., 2017]. For these subjects, a "gnathological" treatment should be applied. In relation to the neuromuscular paradigm, this treatment would involve construction of the occlusion by using the spatial coordinates obtained in response to ULFTENS [Ortu et al., 2017]. In the present case, the occlusal vertical dimension was measured by applying computerised kinesiography in the area marked in black in Figure 5.

Conclusion

There were limitations associated with the present study. One is that sleep bruxism was not assessed with portable devices that are currently available for monitoring sEMG activity [Stuginski-Barbosa et al., 2017; Manfredini et al., 2016]. The diagnosis in the present case was based on anamnesis, clinical investigations, and parental reports,

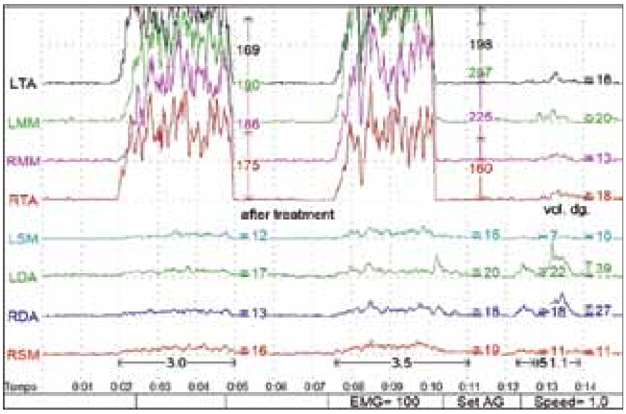

FIG. 8 After treatment. Maximum voluntary clenching and swallowing. A comparison of before and after treatment shows that SEMG activity improved during maximum voluntary clenching and a more symmetrical SEG pattern was observed during swallowing.

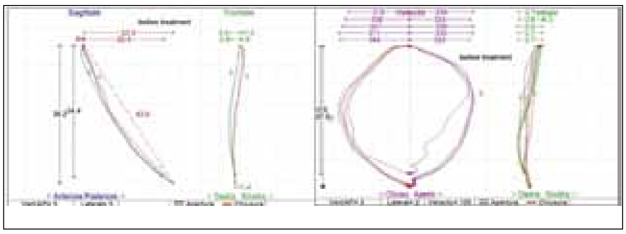

FIG. 9 Before treatment. Maximum opening and velocity of opening and closing of the jaw.

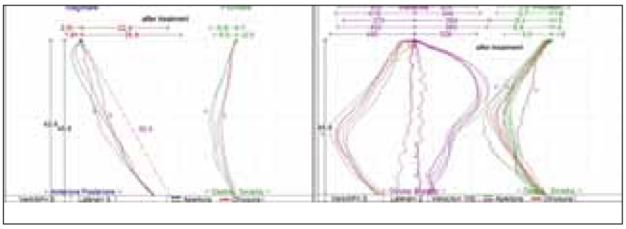

FIG. 10 After treatment. Maximum opening and velocity of opening and closing of the jaw.

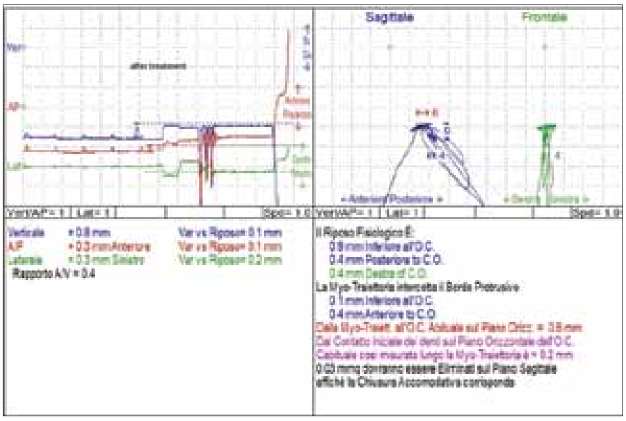

FIG. 11 After treatment. According to the neuromuscular paradigm, the freeway space (FWS) after ULFTENS is correct. In the lateral projection, a 0.4 mm left shift from rest to the occlusal position was observed. A comparison of before and after treatment shows an improvement in the left lateral shift from 2.4 mm to 0.4 mm.

and these are not reliable sources of information [Huynh et al., 2016]. However, the principal goal of this study was not to treat the central cause of bruxism [Lobbezoo and Naeije, 2001], but rather to reduce signs and symptoms of associated TMDs with use of an oral appliance that would prevent further tooth wear without blocking the growth potential of young patients [Aidi et al., 2011; Castroflorio et al., 2016; Fernandes et al., 2016; Saulue et al., 2015; Slavicek, 2011; Vanderas and Manetas, 1995]. Another limitation of the present study is related to the age of the patient. Being 15-years-old, the patient was at a developmental stage between childhood and adulthood with permanent dentition yet residual growth potential [Cevidanes et al., 2005] and neuromuscular plasticity [Ismail et al., 2016]. Further studies are needed to examine children with mixed dentition and adults without residual jaw growth who are affected by bruxism in order to verify the potential efficacy of structural and neuromuscular adjustments. In addition, the effects of a FPM device in patients with characteristics that differ from the present case are needed in order to confirm and generalise the present findings. However, despite these limitations, the FPM device was found to be useful for the treatment of bruxism and TMDs in a growing youth [Cooper and International College of Cranio-Mandibular, 2011; Cooper and Kleinberg, 2008; Cooper, 1998; Cooper, 1997; Cooper, 1995; Orthlieb et al., 2016; McCoy, 2015; Guaita and Hogl, 2016; Nishi et al., 2016].

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Authors' contributions

AM and GM designed the study. The patients were under the care of AM. EO, NM and DP wrote the manuscript. EO and EM revised it.

Conflict of interest

The authors do not have a conflict of interest regarding the content of this manuscript.

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