The Occlusal Appliance Effect on Myofascial Pain

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ABSTRACT: There are limited studies about the effects of occlusal appliance (OA) after three months of use. This study aimed to compare myofascial pain (MP) according to RDC/TMD, craniocervical relationships (CR) and masseter and temporalis bilateral electromyographic (EMG) activity, before and after three months of occlusal appliance use. Nineteen patients participated in this study. Cephalometric and RDC/TMD diagnostics were performed previously (baseline) and at the end of the study period (three months). EMG recordings at clinical mandibular rest position (MRP), during swallowing of saliva (SW) and during maximum voluntary clenching (MVC) were performed as follows: after one hour of use of an OA; after three months of using the OA for a minimum of 16 hours each day; and immediately after removal from the mouth. MP was relieved in all patients at the end of the study period. CR did not change significantly between baseline and after removal of the OA at the end of the study period. EMG activity during MRP, SW, and MVC decreased in both muscles after one hour using the OA and maintained the same level for the three-month period. When comparing baseline versus final EMG activity without OA, a significant decrease was only observed in the masseter muscle. The results observed in the present study are relevant to clinicians because they imply that the therapeutic effect of OA does not significantly affect the homeostasis of the craniocervical system.

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Temporomandibular disorders (TMD) are currently defined as "a collective term embracing a number of clinical problems that involve the muscles of mastication, the temporomandibular joints (TMJ) and associated structures, or both."[1]

Myofascial pain is a common diagnosis of TMD, and for management, occlusal appliances (OA) are frequently used. The clinical successes of occlusal appliances in the treatment of TMD have been associated with a temporary increase in the occlusal vertical dimension (iOVD),[2,3] and so far, the effect of the use of an occlusal appliance on craniocervical relationships, muscular pain improvement, and electromyographic (EMG) activity is still controversial on a long-term basis.[4]

There is an important consensus paramount to reproducible selection diagnostic criteria to obtain a homogenous group of patients[5] to compare among clinical trials. Therefore, the authors designed the current clinical prospective study to compare pain diagnosis in young patients with a homogenous diagnosis of myofascial pain (RDC/TMD)[6] after three months of use of an OA. Additionally, the authors wanted to control the possible

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effects that an OA may produce on the craniocervical relationship and EMG activity. This knowledge could be important and could lead to a better understanding of the effects when the treatment plan involves the temporary use of an OA (iOVD). There is a recently reported study using an experimental model in rats in which iOVD causes a transient change on the sensitivity of afferents from the muscle spindles of the masseter muscle[7] and from TMJ proprioceptors.[8] Both studies showed an adaptation of afferent discharges from the receptors to long-term iOVD.

Materials and Methods

Subjects

Thirteen young women and six men (mean age 25.2 yrs.; range 18 to 30 years) with natural dentition and bilateral molar support and research diagnostic criteria for temporomandibular disorders (RDC/TMD) axis I diagnosis of myofascial pain were selected for this study. According to the RDC/TMD criteria, all patients studied presented "no TMJ diagnosis."[6]

Two calibrated clinicians performed the RDC/TMD diagnosis protocol. Agreement of both examiners was needed for subject selection. Consistency in the clinical diagnosis across the examiners was high, and when there was no agreement, the subject was excluded.

Exclusion criteria included the following: (i) previous experience with occlusal splint therapy; (ii) any obvious dental decay or periodontal disease to which facial pain could be attributed; (iii) history of trauma in the pain area within less than 30 days prior; (iv) any systemic condition associated with widespread pain (e.g., fibromyalgia); or (v) medical history of current drug addiction.

The Institutional Review Board approved the study protocol, and informed consent was obtained from all enrolled participants.

Cephalometry

Two teleradiographs were taken on each patient, the first in maximum intercuspal position as a baseline, and the second after three months using an OA (in the first occlusal tooth contact, immediately after removal from the mouth). Both teleradiographs were taken with a self-balanced positioning technique.[9] The self-balanced position was obtained by having each subject stand with his/her visual axis horizontal with no external intervention or modification of his/her posture. All teleradiographs were taken using an Ortopantomograph, model Cranex Tome Ceph (SOREDEX, USA), distance 163 cm focus-film; the film distance to mid-sagittal plane of the subject's head was 18 cm. Radiographic films were exposed at standardized 70KVp, 10mA, 1 sec. For all patients, Konica Minolta Medical Film (24 x 30 cm) (Konica Minolta Medical Imaging USA, Inc.) was used. In order to indicate the true vertical on the x-ray, a steel chain of 1 mm was used.

The cephalometric analysis was performed manually, according to the protocol described in a previous work.10 The angles and line measurements used in this study are shown in **Figure 1**: Angle 1, formed by the intersection of the McGregor's Plane (McG) and Odontoid plane (PO), to determine the degree of extension or flexion of the head on the cervical spine; Angle 2, formed by the intersection of the nasion-sella plane (NS) with the true vertical (VER), to determine the degree of extension or flexion of the head with respect to the true vertical; Angle 3, formed by the intersection of the tangent plane to the cervical spine; (TCC) with the true horizontal (HOR), to determine the forward or the backward inclination of the cervical spine. Angle 4, formed by the intersection of the tangent to the lower edge of the body of C2 (VC2pi-VC2ai) with the plane tangent to the upper edge of the body of C6 (VC6ps-VC6as), to indicate the lordosis degree of the cervical spine. C0-C2 is the distance between C0 and the posterior and superior points of the spinous process of the Axis, measured to determine the degree of head rotation on the superior cervical segment; H-H, distance in the hyoid triangle, formed by connecting the retrognathic point (RGN), hyoid point (H), and the anteroinferior point of the third cervical vertebra body (CV3ai) is used to determine the relationship between the hyoid bone and cervical spine.

Occlusal Appliance

A full maxillary coverage OA was made for each patient with transparent, thermo-cured dental resin, with flat occlusal surfaces and bilateral, simultaneous, and multiple occlusal contacts of the lower teeth against the OA. Anterior teeth were in light touch with the splint. The OA was adjusted with incisal guidance (mesioincisal function, with contact only in the mesial angles of both inferior central incisors) during the protrusive movement and cuspid guidance during the laterotrusive movement. Disclusion of the posterior teeth was evident during protrusive jaw movement. During laterotrusive jaw movement, disclusion was also evident on the non-working side. There were no changes in the habitual trajectory of closure, with the exception of the occlusal vertical increase.

The increase in the vertical dimension of occlusion produced by the OA was 6 mm ±1 mm measured in the central incisor region. The measurement was based on a previous study, which showed that the thickness of the

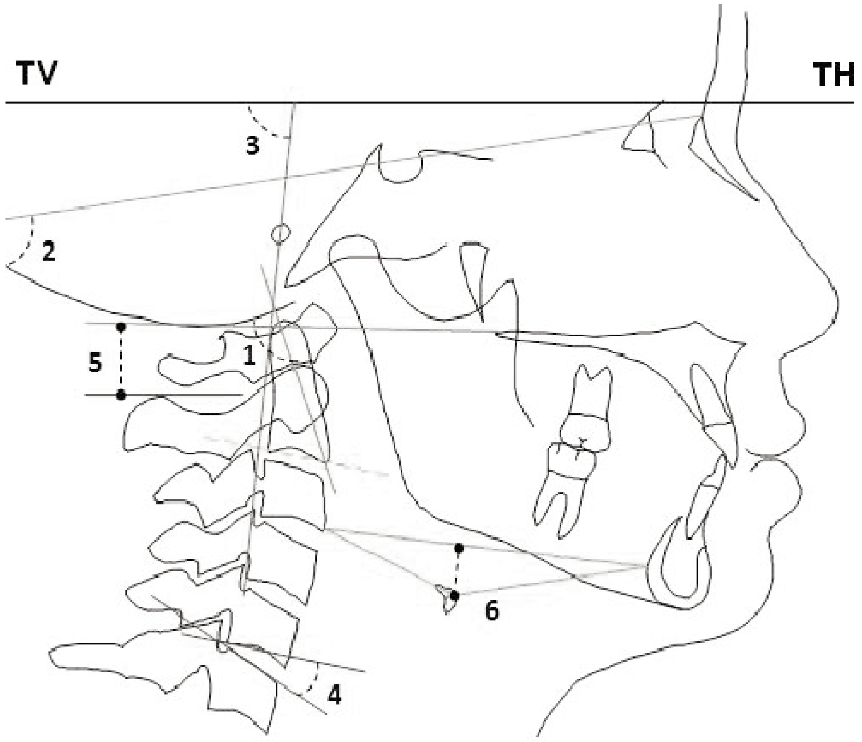

Figure 1
Angle 1: Formed by the intersection of the McGregor (**McG**) plane and Odontoid plane (**PO**); **Angle 2**: Formed by the intersection of the nasion-sella plane (**NS**) with the true vertical (**VER**); **Angle 3**: Formed by the intersection of the tangent plane to the cervical spine (**TCC**) with the true horizontal (**HOR**); **Angle 4**: Formed by the intersection of the tangent to the lower edge of the body of **C2** (**VC2pi-VC2ai**) with the plane tangent to the upper edge of the body of **C6** (**VC6ps-VC6as**); **C0-C2**: The distance between **C0** and the posterior and superior point of the spinous process of the Axis; **H-H`**: The distance in the hyoid triangle, formed by connecting retrognation point (**RGN**), hyoid point (**H**) and anteroinferior point of the third cervical vertebra body (**CV3ai**). **TV**: True Vertical; **TH**: True Horizontal.

OA is an important factor in effecting a faster and better improvement of the muscle-joint symptoms.[2]

The study length was three months, and the protocol of clinical and occlusal adjustment of the OA was performed after 24 hours, 72 hours, 7 days, 2 weeks, 1 month, 2 months, and 3 months. In each control session, the occlusal surface of the OA was observed and the occlusal contacts were checked and modified, if necessary, using AccuFilm II Double-Sided (Parkell Inc., Edgewood, NY). Each patient was instructed to use the OA for at least 16 hours/day throughout the study period.

Electromyography

Bipolar surface electrodes (BioFLEX, BioResearch Associates, Inc., Brown Deer, WI) were used on the left and right anterior temporalis and superficial masseter muscles. The skin area was cleaned with alcohol. The electrodes were placed in the anterior temporalis, parallel to fibers according to the technique described in a recent work.[11] On the masseter muscle, the electrodes were placed parallel to fibers according to the technique described by Ferrario, et al.[12] A surface ground electrode was attached to the forehead.

The EMG signals were amplified (Model 7P5B preamplifier, Grass Instrument Co., Quincy, MA) and then integrated. During mandibular rest position (MRP) and swallowing of saliva (SW), the signals were integrated with a time constant of 0.1 seconds, whereas during maximum voluntary clenching (MVC) with a time constant of 1 second. EMG activity was recorded while the subject was in a standing position, maintaining their stance with feet at 10 cm apart, with their eyes open, looking straight ahead. The self-balanced position was obtained by having each subject standing with his/her visual axis horizontal, with no external intervention or modification of his/her posture.

Each subject underwent three EMG recordings of the anterior temporalis and masseter muscles during MRP, SW, and MVC in the following experimental conditions:

- Task 1: Baseline record prior OA insertion.
- Task 2: Initial record after 1 hour of OA insertion.
- Task 3: Final record with OA inserted, after 3 months of use.
- Task 4: Final record, immediately after OA removal from the mouth.

To avoid muscular fatigue during the MVC recordings, a rest period of 30 seconds between each clench was allowed.[13] To obtain the average value of each curve, measurements were taken every 0.1 seconds from the initial to the end of the recording using a computer program. The mean value of the three curves obtained for each subject at each task was used.

RDC/TMD

RDC/TMD or Research Diagnostic Criteria for Temporomandibular Disorders aims for standardization and reproducibility of diagnoses for research of the most common muscle and joint disorders of the stomatognathic system. Among different clinical diagnoses of this protocol, one is the diagnosis of myofascial pain. The diagnostic test includes a survey of questions and a guideline for clinical examination. The diagnostic criteria to determine the presence of myofascial pain is as follows: suffering pain in the face, jaw, temple, in front of the ear or in the ear in the past month; the presence of at least three sites painful to the examination on the same side; and opening of at least 40 mm without restriction. For further information about this protocol, please use the International RDC-TMD Consortium website at the address *http://www.rdc-tmdinternational.org*

Statistical Analysis

The data was analyzed using STATA, version 13.0 (StataCorp LP, College Station, Texas). Gender had no significant affect on cephalometric measurements and EMG activity (Chi-square; p=0.862). The cephalometric data had a normal distribution (Shapiro-Wilk test), so the angles and distances were compared using the Student's *t*-test. EMG data presented a non-normal distribution (Shapiro-Wilk test), so EMG activity was compared using the Wilcoxon rank-sum test.

Results

Myofascial Pain

All patients initially diagnosed with myofascial pain, according to RDC/TMD criteria, no longer presented this diagnosis at the end of the study period.

Cephalometry

Table 1 shows that the comparison of baseline and final cephalometric measurements presented no significant difference (p>0.05; *t*-test).

Electromyography

Tables 2 and **3** show that bilateral anterior temporalis and masseter EMG activity at rest, during swallowing of saliva, as well as during maximal voluntary clenching, presented a significant decrease during task 2 (initial record after one hour of OA insertion) than did task 1 (baseline record prior OA insertion), except in the left anterior temporalis at rest. EMG activity in the right anterior temporalis muscle significantly decreased in task 3

Table 1
Comparison of Initial and Final Mean Values of Cephalometric Measurements in the Sample Studied (Student's *t*-Test)

n = 19	Mean	Mean difference	95% confidence interval Lower limit	Upper limit	SD of difference	t	p-value
McG/OPi	98.053	1.132	-0.574	2.873	3.539	1.394	0.180 (NS)
McG/OPf	96.921						
NS/VERi	99.316	0.132	-2.022	2.285	4.469	0.128	0.899 (NS)
NS/VERf	99.184						
TCC/HORi	84.132	0.447	-0.987	1.882	2.976	0.655	0.521 (NS)
TCC/HORf	83.684						
C2-C6i	8.868	0.579	-3.480	4.638	8.422	0.300	0.768 (NS)
C2-C6f	8.289						
C0-C2i	20.421	0.026	-1.150	1.203	2.441	0.047	0.963 (NS)
C0-C2f	20.395						
H-H`i	4.447	-1.605	-3.406	0.196	3.736	-1.873	0.077 (NS)
H-H`f	6.053						

SD: standard deviation
NS: not significant

than in task 1 during swallowing and maximal voluntary clenching. EMG activity during task 4 (final record immediately after the removal of the OA) was significantly lower than task 1 in the right anterior temporalis during swallowing of saliva. Bilateral EMG activity in the masseter muscle during task 4 was significantly lower than task 1 during maximal voluntary clenching (p<0.05).

Discussion

Myofascial Pain

The remission of myofascial pain in all patients after using clear and reproducible diagnosis taxonomy allows a reliable comparison with other studies using the same protocol. The current study results agree with those observed in previous studies.[14-16]

Table 2
Comparison of Anterior Temporal EMG Activity Recorded Among Tasks During Rest Position, Swallowing, and Maximal Voluntary Clenching

Rest position					
Right side	p-value	Significance	Left side	p-value	Significance
Task 1 vs. Task 2	0.027	*	Task 1 vs. Task 2	0.084	NS
Task 1 vs. Task 3	0.936	NS	Task 1 vs. Task 3	0.376	NS
Task 1 vs. Task 4	0.557	NS	Task 1 vs. Task 4	0.573	NS
Task 2 vs. Task 3	0.171	NS	Task 2 vs. Task 3	0.171	NS
Task 2 vs. Task 4	0.124	NS	Task 2 vs. Task 4	0.260	NS
Task 3 vs. Task 4	0.778	NS	Task 3 vs. Task 4	0.191	NS
Swallowing					
Right side	p-value	Significance	Left side	p-value	Significance
Task 1 vs. Task 2	0.003	**	Task 1 vs. Task 2	0.005	**
Task 1 vs. Task 3	0.030	*	Task 1 vs. Task 3	0.107	NS
Task 1 vs. Task 4	0.005	**	Task 1 vs. Task 4	0.059	NS
Task 2 vs. Task 3	0.159	NS	Task 2 vs. Task 3	0.227	NS
Task 2 vs. Task 4	0.421	NS	Task 2 vs. Task 4	0.198	NS
Task 3 vs. Task 4	0.059	NS	Task 3 vs. Task 4	0.314	NS
Maximal voluntary clenching					
Right side	p-value	Significance	Left side	p-value	Significance
Task 1 vs. Task 2	0.003	**	Task 1 vs. Task 2	0.008	**
Task 1 vs. Task 3	0.024	*	Task 1 vs. Task 3	0.147	NS
Task 1 vs. Task 4	0.053	NS	Task 1 vs. Task 4	0.334	NS
Task 2 vs. Task 3	0.355	NS	Task 2 vs. Task 3	0.295	NS

Median values:					
Rest position	Right side	Task 1 (6.13)	Task 2 (5.63)	Task 3 (6.13)	Task 4 (5.17)
	Left side	Task 1 (8.23)	Task 2 (8.07)	Task 3 (9.10)	Task 4 (8.27)
Swallowing	Right side	Task 1 (16.70)	Task 2 (7.87)	Task 3 (10.50)	Task 4 (8.53)
	Left side	Task 1 (19.83)	Task 2 (9.67)	Task 3 (12.10)	Task 4 (12.33)
Maximal voluntary clenching					
	Right side	Task 1 (45.57)	Task 2 (30.87)	Task 3 (33.73)	Task 4 (36.97)
	Left side	Task 1 (62.20)	Task 2 (38.00)	Task 3 (60.03)	Task 4 (62.17)

*p<0.05; **p<0.01; NS: not significant

The exact mechanical action of occlusal splints is not yet completely understood.[17-21] Some theories proposed to explain the mechanism include alteration or improvement of occlusal condition, change in peripheral (motor or afferent) impulses to the central nervous system, alteration or rise in the vertical dimension, alteration of the TMJ condylar position and increase in cognitive awareness, placebo effect, and regression to the mean.[2,3,22-24] Undoubtedly, the remission of myofascial pain was also partly due to the protocol of clinical and careful occlusal adjustment of the OA at 24 hours, 72 hours, 7 days, 2 weeks, 1 month, 2 months and 3 months.

Table 3
Comparison of Masseter EMG Activity Recorded Among Tasks During Rest Position, Swallowing, and Maximal Voluntary Clenching

Rest position

Right side	p-value	Significance	Left side	p-value	Significance
Task 1 vs. Task 2	0.040	*	Task 1 vs. Task 2	0.005	**
Task 1 vs. Task 3	0.872	NS	Task 1 vs. Task 3	0.658	NS
Task 1 vs. Task 4	0.687	NS	Task 1 vs. Task 4	0.227	NS
Task 2 vs. Task 3	0.099	NS	Task 2 vs. Task 3	0.171	NS
Task 2 vs. Task 4	0.398	NS	Task 2 vs. Task 4	0.212	NS
Task 3 vs. Task 4	0.073	NS	Task 3 vs. Task 4	0.398	NS

Swallowing

Right side	p-value	Significance	Left side	p-value	Significance
Task 1 vs. Task 2	0.011	*	Task 1 vs. Task 2	0.006	**
Task 1 vs. Task 3	0.469	NS	Task 1 vs. Task 3	0.494	NS
Task 1 vs. Task 4	0.212	NS	Task 1 vs. Task 4	0.171	NS
Task 2 vs. Task 3	0.131	NS	Task 2 vs. Task 3	0.064	NS
Task 2 vs. Task 4	0.968	NS	Task 2 vs. Task 4	0.314	NS
Task 3 vs. Task 4	0.520	NS	Task 3 vs. Task 4	0.099	NS

Maximal voluntary clenching

Right side	p-value	Significance	Left side	p-value	Significance
Task 1 vs. Task 2	0.049	*	Task 1 vs. Task 2	0.049	*
Task 1 vs. Task 3	0.084	NS	Task 1 vs. Task 3	0.091	NS
Task 1 vs. Task 4	0.033	*	Task 1 vs. Task 4	0.022	*
Task 2 vs. Task 3	0.809	NS	Task 2 vs. Task 3	0.687	NS
Task 2 vs. Task 4	0.314	NS	Task 2 vs. Task 4	0.629	NS
Task 3 vs. Task 4	0.778	NS	Task 3 vs. Task 4	0.687	NS

Median values:

Rest position	Right side	Task 1 (8.40)	Task 2 (5.40)	Task 3 (6.35)	Task 4 (6.50)
	Left side	Task 1 (7.77)	Task 2 (5.43)	Task 3 (7.23)	Task 4 (5.60)
Swallowing	Right side	Task 1 (22.70)	Task 2 (8.83)	Task 3 (9.67)	Task 4 (9.63)
	Left side	Task 1 (9.27)	Task 2 (8.30)	Task 3 (9.40)	Task 4 (7.47)
Maximal voluntary clenching					
	Right side	Task 1 (46.52)	Task 2 (40.83)	Task 3 (40.73)	Task 4 (35.50)
	Left side	Task 1 (33.47)	Task 2 (25.20)	Task 3 (32.00)	Task 4 (27.53)

*p<0.05; **p<0.01; NS: not significant

Cephalometry

It is noteworthy that all cephalometric measurements studied were not significantly different after three months using the OA. In a previous short-term study, after eight minutes of OA usage, there was no significant difference found in the craniovertebral angle,[25] whereas in another study, after one hour of OA usage, a straightening of the cervical spine and head extension was observed.[10]

The craniocervical relationship stability observed in the present study, after three months of using an OA, is relevant to clinicians because it implies that the therapeutic effect of an OA does not significantly affect the homeostasis of the craniocervical system. This is probably due to an adaptative mechanism because the initial use of an OA produces significant changes in the craniocervical relationship as described by Moya, et al.[10]

The fact that the criteria for inclusion in the studied sample was the presence of myofascial pain could possibly explain the large variability observed in the cephalometric measurements among different patients.

Electromyography

The significant decrease of EMG activity observed at one hour after the OA insertion is in line with the results observed in previous studies.[24,26-27] Importantly, final EMG activity without the OA was not significantly different from the initial activity, except in the masseter muscle during MVC.

It is well-known that sensory inputs from low-threshold orofacial proprioceptors, such as the muscle spindles and mechanoreceptors in the temporomandibular joint (TMJ), are important afferents in the regulation of iOVD,[28,29] so the authors would have expected a change in the afferent by iOVD, evidenced by a change in EMG activity. Yabushita, et al.[7] used an animal model of iOVD to investigate the change in the sensitivity of afferents from muscle spindles of the masseter muscle. They found that there were no significant long-term differences in the firing rate of the units. Recently, Naito, et al.[8] suggested that TMJ mechanoreceptors in adult rats may ultimately adapt to iOVD. The results of both studies are consistent with the current study findings because there were no significant long-term differences in EMG activity. It is noteworthy that EMG activity output depends not only as a result of the influence of trigeminal input, but also from central neuromechanisms related to OA.[30]

From an overall point of view, interactions in the human biological systems are complex, and therefore, it is no surprise that the interrelationship among craniocervical EMG activity and pain is far from being simple or even lineal.

Given the fact that the main objective of the current study was to assess myofascial pain, the results obtained in the study with respect to craniocervical measurements and EMG activity are not necessarily applicable to full-time wear of the OA.

Conclusion

The remission of myofascial pain in all patients at the end of the study period (three months) was observed without significant changes in the craniocervical measurements and EMG activity.

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