ORIGINAL RESEARCH

Effect of Occlusal Splints on Posture Balance in Patients with Temporomandibular Joint Disorder: A Prospective Study

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Abstract

Aim and objective: Force platforms are widely used to evaluate the relationship between bodily posture and jaw positions. The aim and objective of this clinical prospective study was to evaluate the effect of occlusal splints on bodily posture using force platforms.

Materials and methods: Forty-seven female patients with temporomandibular disorders (TMD) underwent a clinical and postural examination before and during an occlusal treatment with an upper splint. Six postural stabilometric examinations were performed under different visual conditions. Postural stability was assessed using a force platform (SATEL). Subjects were evaluated in static and dynamic conditions, with open and closed eyes, at baseline, at 1 week, and at 3 months. Changes in stabilometric parameters (sway area and sway length) were assessed and compared.

Results: In static and dynamic positions, the sway surface area decreased significantly after the occlusal guard placement with closed eyes (*p*-value, 0.012). Likewise, the sway surface area decreased significantly in the dynamic lateral position with closed eyes (*p*-value, 0.018) and in anteroposterior dynamic position with open eyes (*p*-value, 0.031). The mean sway length decreased significantly after the placement of the occlusal guard when participants were in the lateral position with open eyes (*p*-value, 0.025) and in the anteroposterior position with open eyes (*p*-value, 0.014). On a 3-month assessment, the mean surface and mean length decreased significantly after the placement of the occlusal guard for practically all the static and dynamic positions.

Conclusion: The sway surface area and sway length decreased significantly with the use of occlusal splints

Clinical significance: In female patients with TMD, the use of an occlusal splint is associated with a postural improvement evaluated by posturo-stabilometric tests.

Keywords: Occlusal splint, Posture, Study type other, Temporomandibular disorders, Temporomandibular joints.

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Introduction

Until lately, the correlation between jaws position and temporomandibular disorders (TMDs) has been much debated, with some alleging that temporomandibular joint (TMJ) position is an adaptation to excessive constraints on the joint,[1–4] while others correlate TMDs to defective bodily posture.[5–10] The human posture encompasses the bodily position and the spatial configuration between its various anatomical segments to maintain a proper balance under static and dynamic conditions. While untreated TMDs are associated with deviations in normal body posture,[6,11,12] chiefly along the longitudinal plantar arches,[13,14] the stomatognathic system and body posture have reciprocal effects on one another,[15] so that any occlusion imbalance may overload the TMJs, thus influencing the musculoskeletal system.[16] As such, the mandible represents a balancing pole affecting posture and vice versa.[5,12,17] Moreover, the mouth and the mouth breathing can create changes in the postural balance.[18] Thus, the occlusion–craniomandibular relationship is linked with posture control and maintenance system via the stomatognathic system receptors,[19] which behave as important proprioceptive elements of the postural system.

Additionally, changes in occlusion interfere with vision,[20,21] with significant alterations in the binocular function being reported.[22]

Occlusal splints have been previously used to address the disorders resulting from TMD,[8,9,23–27] but there still remains controversy surrounding the relationship between the TMJs and bodily posture,[28,29] which motivated the execution of the current clinical prospective study aiming to assess the relationship between occlusion and bodily posture, taking into account the influence of the visual system.

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Materials and Methods

Study Settings

This is a clinical prospective study conducted by TMJ dental residents and staff in a university medical center (Saint Joseph University, Beirut, Lebanon) over a period of 3 years, extending from 2015 until 2018. The study was approved by the Saint Joseph University ethical committee (Decision USJ-2015-49), and an informed consent was obtained from

all the participants. The study was supported by a grant from Saint Joseph University (Conseil de la Recherche Grant FMD118).

Inclusion and Exclusion Criteria

Inclusion criteria: Subjects with a history of TMD, aged 18 to 60 years, and signing an informed consent form were eligible for the study. Following an initially focused anamnesis and clinical examination, the following exclusion criteria were applied: an ongoing orthodontic treatment; trauma, surgery, or any other disorder known to influence bodily posture; past or current postural problems; neuropsychological disorders; and craniomandibular disorders.

The subjects complaining of TMD and consulting in our care center are essentially women, which correspond to the international pattern of TMD made up mainly of women.

Sample Size

From 2015 to 2018, 47 female subjects satisfied the inclusion or exclusion criteria and completed the study.

Clinical and Occlusal Splint Workup

A screening diagnostic form was used to assess the patient history and dysfunctions, and the examiners conducted a clinical examination. Palpation was carried out on the TMJ, masticatory, and cervical muscles to confirm the TMD diagnosis. An orthopantomogram was performed to exclude eventual dental or bone pathologies.

All the eligible patients showed an indication for occlusal splint therapy. An alginate (Tulip Cavex®) impression was taken with a perforated (Rimlock®) metallic impression tray, poured immediately with plaster (Orthoplast Vertex®). The models were trimmed and prepared for vacuum forming. The upper model of each patient was vacuum-pressed in a 2 mm thermoplastic sheet in order to obtain the occlusal splint. After trimming the borders, the occlusal splints were adjusted with acrylic resin. The acrylic resin was placed in its plastic state on the splint, and the patient was guided to centric occlusion to allow maximum contact. Once the resin became solid, the splint was taken out and corrections were made using an acrylic bur mounted on a handpiece until a single contact was obtained on every tooth without indentations. The occlusion was checked using a 101.6-micron thick articulating paper (Prehma 04-00122®). Afterward, the splints were polished and the patient was advised to wear it for a nighttime period. The occlusal splints were reviewed and adjusted as necessary within the treatment period.

Posturo-stabilometric Tests

All the included subjects underwent a posturo-stabilometric test using a SATEL® pedometer, a force platform of 48 cm of length, 48 cm of width, and a height of 6.5 cm (Satel® platform, SATEL—6 rue du Limousin 31700 Blagnac, France, satel-posture@wanadoo.fr, Phone: +33 (0) 534605265/+33 (0) 977450620 - Fax: +33 (0) 970327474, Sensor: HBM/SP4C3/100KG, Amplification card: ERCIM/CASµ-xx, PSU20112 power supply board: RADIOSP ARES/106-3838, Switch A-xx: RADIOSPARES/167-6636, V7.00 Satel® software).

We used a Satel® brand stabilometer that allows to define the oscillation surface of the projection of the "body center of gravity" through a definition of the "center of pressure of the feet—CPF." It is the integration of data from the three force sensors that enable the determination of the CPF. This point was recorded for 52 seconds with a sampling frequency of 40 Hz and under two successive conditions: eyes open and eyes closed. The subjects were placed upright, without movement, barefoot, standardized position of the feet, and having their posture straightened according to their feelings. Our objective is to determine the modifications carried out on this CPF between the status "with dental splint" and that "without dental splint."

The SATEL system assesses the equilibrium of a subject on a mobile platform as well as the static and dynamic postures. The posturo-stabilometric test was performed under conditions of open and closed eyes, before and after treatment with a full-contact occlusal splint. Before every acquisition, calibration was required by the software connected to the platform via a USB cable. This platform allows the study of the center of pressure changes for the x-axis in the mediolateral plane and the y-axis in the anterior-posterior plane.

The tests were carried out by the biomedical engineering personnel at the author's institution. The test results are automated by the software and provided in the form of a standardized report indicating the various parameters of the acquisition as well as the date and time. Note that these results cannot be modified after the acquisition.

The patients were asked to stand several times on the platform and were therefore evaluated in static (recorded without the platform) and dynamic positions (mediolateral and anteroposterior recorded on the platform). The test was repeated (twice) in these three positions with eyes open and closed. Each recording lasted 51.2 seconds. Quiet conditions were maintained during the examination, thus eliminating any disturbing element potentially affecting the posture. The measurements were scheduled at baseline, at 1 week, and at 3 months of use of the occlusal splint.

The posture of the subjects on the force plate was standardized using the following parameters:

- The posture during sitting was upright, erect, and bilaterally symmetrical
- The shoulders were relaxed with the arms alongside the body
- The arms were positioned close as possible to the body
- The forearms were slightly elevated and comfortable
- The upper body had to be perpendicular on the chair and the spine not curved during any forward movement
- The angle between the thighs and the calves was approximately 105 to 110°
- The legs were at an angle of 30 to 45° and were to be slightly apart
- The feet should be flat resting on the floor
- The patient's head resting comfortable, adequately rotated in 3 directions, and was bent at approximately 20 to 25°
- The dental operating light was properly focused and parallel to the working area for good visibility
- The sitting position was between 09.00 and 12.00 o'clock and for left-handed persons between 03.00 and 12.00 o'clock
- The patient's head and the sitting position were adjusted before starting any procedure
- Instruments to be held at three supporting points and with a proper grasp to increase the working efficiency

Statistical Analysis

The distribution of continuous variables was assessed using the Kolmogorov–Smirnov test and visually inspected using the quartile-quartile plot. Continuous variables not departing from normality assumptions are presented as mean with its standard deviation, whereas continuous variables departing from normality were expressed as median with its interquartile range (first quartile–third quartile). The length and the surface in static and dynamic positions (anteroposterior and lateral) were compared in the subjects with TMJ disorders before and during placement of occlusal guards (within-subject effects). Comparisons were carried out with the eyes closed or open using the paired *t*-test. The statistical analysis was performed using the IBM SPSS software (IBM Corp. Released 2019, SPSS Statistics for Windows version 26.0, Armonk, New York).

Results

There were 47 female subjects who satisfied the inclusion or exclusion criteria and completed the study. As depicted in Table 1, in a static position, the sway surface area decreased significantly after the occlusal guard placement with closed eyes (*p*-value, 0.012) but not with eyes open (*p*-value, 0.169). Likewise, the sway surface area decreased significantly in a dynamic lateral position with closed eyes (*p*-value, 0.018) and in the anteroposterior dynamic position with open eyes (*p*-value, 0.031). Although the sway surface area decreased after placement of the occlusal splint for the other configurations, the difference was not significant (Table 1).

The mean sway length decreased significantly after the placement of the occlusal guard when participants were in a lateral position with open eyes (*p*-value, 0.025) and in the anteroposterior position with open eyes (*p*-value, 0.014). Although the length decreased after placing the occlusal splint for the other configurations, the difference was not statistically significant in a static position with closed or open eyes, neither for the lateral position with closed eyes nor for the anteroposterior position with closed eyes (Table 2).

On a 3-month assessment, no subjects were lost to follow-up. The mean surface and mean length decreased significantly after the placement of the occlusal guard for practically all the static and dynamic positions, as shown in Tables 3 and 4.

Table 1: Surface area measured in static, dynamic lateral, and dynamic anteroposterior positions, with eyes open and closed, respectively, at baseline (no occlusal guard) and at 1-week post-occlusal guards' placement

Position	*Eyes status*	*Baseline: No occlusal guard*	*1-week post-occlusal guard*	*p value*
Static	Open	212.57 ± 119.40	201.47 ± 173.03	0.169
	Closed	280.79 ± 245.09	236.17 ± 238.57	0.012
Dynamic lateral	Open	450.81 ± 388.78	405.02 ± 249.83	0.355
	Closed	2086.7 ± 1177.9	1809.3 ± 906.7	0.018
Dynamic antero-posterior	Open	471.47 ± 259.24	383.70 ± 199.91	0.031
	Closed	1655.6 ± 978.7	1524.1 ± 774.4	0.346

Sample size = 47. Data are presented as mean with its standard deviation. *p* values are derived from the paired *t*-test comparisons

Table 2: Sway length measured in static, dynamic lateral, and dynamic anteroposterior positions, with eyes open and closed, respectively, at baseline (no occlusal guard) and at 1-week post-occlusal guards' placement

Position	*Eyes status*	*Baseline: No occlusal guard*	*1-week post-occlusal guard*	*p value*
Static	Open	400.15 ± 341.65	437.19 ± 465.96	0.097
	Closed	495.77 ± 191.30	479.89 ± 166.11	0.224
Dynamic lateral	Open	527.36 ± 140.79	485.77 ± 145.48	0.025
	Closed	1148.60 ± 261.92	1113.21 ± 277.67	0.210
Dynamic antero-posterior	Open	557.02 ± 149.35	496.85 ± 142.15	0.014
	Closed	1114.04 ± 277.02	1095.15 ± 344.98	0.240

Sample size = 47. Data are presented as mean with its standard deviation. *p* values are derived from the paired *t*-test comparisons

Discussion

In the current study, the posture was assessed at baseline, at 1-week post-treatment, and at 3-month post-treatment. The posturo-stabilometric tests obtained by the SATEL pedometer showed postural improvement following the use of the occlusal splint, indicating an effect of the occlusal splint resulting in postural alterations.

Furthermore, the dynamic stabilometric parameters were influenced by vision: when the patients close their eyes, a loss of postural control was demonstrated by an increase in the sway area and sway length, a result compatible with the assumption that vision represents a fundamental component of the tonic postural

Table 3: Sway area measured in static, dynamic lateral, and dynamic anteroposterior positions, with eyes open and closed, respectively, at baseline (no occlusal guard) and at 3-month post-occlusal guards' placement

Position	*Eyes status*	*Baseline: No occlusal guard*	*3-month post-occlusal guard*	*p value*
Static	Open	259.19 ± 145.56	186.86 ± 145.25	0.010
	Closed	332.10 ± 301.49	209.48 ± 151.34	0.001
Dynamic lateral	Open	525.90 ± 520.23	416.24 ± 235.78	0.197
	Closed	2281.9 ± 1483.9	1696.19 ± 965.34	0.006
Dynamic antero-posterior	Open	542.24 ± 307.40	345.14 ± 167.59	0.003
	Closed	1769.9 ± 1223.2	1090.2 ± 544.6	<0.001

Data are presented as mean with its standard deviation. *p* values are derived from the paired t-test comparisons. The comparisons are carried out horizontally (that is, before the occlusal guard and 3-month post-occlusal guard) for each visual status (eyes open, closed eyes) and for the three positions (static, dynamic lateral, and dynamic anteroposterior)

Table 4: Sway length measured in static, dynamic lateral, and dynamic anteroposterior positions, with eyes open and closed, respectively, at baseline (no occlusal guard) and at 3-month post-occlusal guards' placement

Position	*Eyes status*	*Baseline: No occlusal guard*	*3-month post-occlusal guard*	*p value*
Static	Open	355.57 ± 93.05	382.33 ± 151.77	0.196
	Closed	503.67 ± 174.43	469.24 ± 164.40	0.058
Dynamic lateral	Open	522.29 ± 139.80	461.00 ± 121.23	0.009
	Closed	1151.86 ± 254.04	1065.90 ± 305.19	0.039
Dynamic antero-posterior	Open	589.90 ± 168.40	464.57 ± 111.14	0.001
	Closed	1113.1 ± 208.6	946.86 ± 198.90	0.001

Data are presented as mean with its standard deviation. *p* values are derived from the paired t-test comparisons. The comparisons are carried out horizontally (that is, before the occlusal guard and 3-month post-occlusal guard) for each visual status (eyes open, closed eyes) and for the three positions (static, dynamic lateral, and dynamic anteroposterior) system, and excluding the vision prevents the superior system from controlling the posture.

In the majority of studies assessing the influence of dental occlusion on posture, the force platform is the principal instrument used to analyze these correlations,[28,30,31] with an acceptable intersession reliability.[31] In the meta-analysis by Perinetti et al.,[32] a threshold of 25% variation in recordings is warranted to enhance the reliability of static posturographic parameters.

The correlation between the position of the mandible and bodily posture was studied as early as 1927, but did not gain attention until the advent of statokinesiometry. Starting in 1977, Gelb considered the possible correlation between TMJs,[33] posture, and muscle performance at work during sports and physical activity; that is, with poor dental occlusion, mandibular posture requires chronic muscular adjustment leading to disorders of the postural system *per se*.[34] However, this finding is not consistently corroborated by other investigators.[28,29]

Using occlusal splints for mandibular repositioning has been associated with a modification of the plantar pressure mapping, though Dias et al. were not able to reproduce the results.[35] The latter scheme is compatible with the hypothesis that stability and harmony of the support surfaces of the body are related to the difference between the spatial relations of the jawbones in non-occlusion and occlusion.[36]

The osteopathic concept of occlusion, coined by Clauzade and Darraillans,[37] showcases the place of the occlusal equilibrium in the postural balance. Synchronous to the occlusal origins of craniofacial asymmetries in relation to postural imbalance,[38] several studies evaluated the influence of changes in occlusion on posture and oculomotricity.[39] Reconciling the concept of the mandibulo-craniosacral system with the posturo-kinesiological concept, the manducator system resurfaces as a key element of the postural balance.[40]

On another level, changes in occlusion interfere with vision[21,22,41] and eventually bodily posture.[42] According to Gagey et al., occlusion modification by the means of an occlusal splint influences the surface parameter and the frequency spectra in the 0.3 Hz zone in open eyes only.[43] According to Faugouin cited by Roumiguie,[44] the usual intercuspidation does not change the stabilometric results nor the postural clinical examination in subjects with malocclusion. The occlusal defects thus become pathological only if they are added to other factors (stress, trauma, etc.). The postural tests are more revealing and show a modification of the muscular tone of the extensors of the hands and of the external rotator muscles of the hip causing a homolateral hypotonia to the interposition in open eyes situation only. This confirms the relationship between the manducator device and the oculomotor system, as well as the muscular tone. The difference between open and closed eyes could be a differential test to confirm the occlusal origin of a postural disorder. However, a modification of the occlusal balance resonates with the postural balance by adapting the morphostatic pattern of the subject, that is, by modifying the distribution of the muscular tonic balance.

The current study has several limitations, first of which is its moderate sample size that limits the power of statistical comparisons. Second, the participants were all female subjects. While being unintentional and representative of the underlying population consulting locally for TMJ disorders, enriching the sample with male subjects could have increased the generalizability of the results to both sexes in the local population. Third, subgroup analysis by age categories was not possible due to sample size considerations. Last and most importantly, the absence of a control group has not allowed to assess risk factors and modifiers of the associations found in the current study.

Conclusions

The current prospective study showed that in female patients with TMD, the use of an occlusal splint was associated with a significant postural improvement using posturo-stabilometric tests carried out with a force platform.

Clinical Significance

Dental occlusion and postural body balance are intimately interrelated, with correction of the prior translating into a modification of the latter. The clinical significance of the current study relies on it, suggesting a new parameter to be considered in the management of TMD, by linking the posture of the mandible secured and corrected by an occlusal splint on one hand, and the software-calculated body posture on the other hand. Future studies should focus on the development of new experimental protocols (e.g., 3D analysis) to further disentangle the reciprocal influence between dental occlusion and posture.

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