Chewing Movements in TMD Patients and a Control Group Before and After Use of a Stabilization Splint

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Purpose: This study assessed the effect of using an occlusal stabilization splint in the maxilla for 6 weeks on certain parameters of chewing movements in subjects with and without temporomandibular disorder symptoms. **Materials and Methods:** Twelve male and 30 female temporomandibular disorder patients with and without a prior whiplash incidence, and individuals without signs and symptoms of temporomandibular disorders participated. The participants formed three groups matched according to gender and age ($n = 3 \times 14$). A maxillary stabilization splint was used during sleep for 6 weeks. An optoelectronic system (MacReflex, Qualisys) was used to record chewing movements at baseline, before using the splint, and after 6-weeks' use of the splint. Calculated parameters were the duration of the chewing cycles, the spatial displacement, and the mean velocity of the mandible while chewing paraffin wax for 20 seconds. **Results:** On a group basis, the use of an occlusal stabilization splint for 6 weeks did not change the jaw movement parameters in a predictable pattern as recorded under the conditions of this study. On an intraindividual basis, large variations in changes of chewing parameters over time were observed. **Conclusion:** The use of an occlusal stabilization splint for 6 weeks did not alter the jaw movements when chewing a substance with a soft consistency. *Int J Prosthodont 1998;11:158–164.*

Complete-arch occlusal stabilization splints are commonly used in the management of patients with temporomandibular disorders (TMD) with a reported apparent effectiveness.[1,2] However, the therapeutic mechanism in the treatment of patients with such disorders remains uncertain.[3,4] Several hypotheses focus on eliminating or reducing the daily[5,6] or nocturnal[7] activities of the jaw muscles, possibly because of a deprogramming of the jaw muscles[8] or changes in the tactile afferent impulses from periodontal proprioceptors in relieved teeth.[9] Other investigators emphasize cognitive awareness[10] or a probable placebo effect[11] caused by carrying foreign elements in the oral cavity. Another hypothesis relates the apparent effectiveness to a frequent contact with the therapist or entry into the clinic environment.[12] In contrast, some investigators have recently suggested that the use of an occlusal stabilization splint does not have any therapeutic effects at all.[13]

It has been reported that the use of an occlusal stabilization splint results in changes of the condyle or jaw movements while chewing.[14–16] However, the study designs and results of these studies diverge. Furthermore, no conclusive evidence about the effect of splint use upon chewing movements has been presented.

It was hypothesized that if the use of a stabilization splint had any effect on chewing movements this would be most noticeable in individuals with different functional statuses of their masticatory systems. The authors therefore chose to study samples from populations with presumably disparate functional statuses of their masticatory systems. Three

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population groups were selected, ie, patients with TMD symptoms following a previous whiplash incident,[17] patients with a primary diagnosis of TMD according to the research diagnostic criteria for TMD (RDC-TMD) criteria,[18] and individuals without any signs and symptoms of TMD.

The aim of the study was to assess the effect of using an occlusal stabilization splint for 6 weeks on certain parameters of chewing movements in subjects with and without TMD symptoms.

Materials and Methods

The study material comprised 42 individuals, 30 women and 12 men. The age of the participants ranged from 28 to 60 years, with a mean of 42.7 years. The exclusion criteria were the presence of complete or removable partial prostheses with distal extensions, individuals receiving medication or other treatments for TMD during the study, and individuals with recent facial or cervical trauma. The participants were selected from three populations and matched according to gender and age, ie, each group consisted of 10 women and four men.

The first patient group (n =14) was recruited through announcements published in local newspapers. These participants had TMD symptoms following a whiplash incident. All patients had complaints of frequent pain (at least four times a week) in the jaw muscles of at least 1 to 3 years' duration. The second group consisted of TMD patients treated at the Faculty of Dentistry, University of Oslo (n =14). One participant dropped out of the study and was therefore not included in the analysis.

The examination and diagnoses of the patients were made in general according to the RDC-TMD criteria described by Dworkin and LeResche.[18] Muscle tenderness was graded into three categories: slight tenderness, moderate tenderness, and severe tenderness represented by a redrawal reflex. All masticatory muscles and muscles in the neck and the shoulders were palpated, 26 sites in all. Joint sounds and limitation of mandibular movement were recorded for all participants. Ranges of mandibular movement (maximal unassisted opening, maximal assisted opening, lateral and protrusive excursions) were assessed using a millimeter ruler. The RCD-TMD diagnoses made in the whiplash and the "ordinary" TMD group were: myofascial pain (n = 12 and 9), myofascial pain and disc displacement with reduction (n = 2 and 3), and disc displacement with reduction (n = 0 and 1).

The participants in the third (control) group were selected primarily among the faculty. They did not have any symptoms of TMD, such as joint clicking or limitation of border movement range (n = 14). Regarding muscle tenderness, less than four muscle points slightly tender to palpation was considered as normal.

A maxillary occlusal stabilization splint modified from the Michigan occlusal splint[9] was made for all participants. The splints were constructed to provide separation of the posterior teeth during protrusion and a canine rise during lateral excursions. Before use the splints were adjusted to freedom in centric and to include multiple bilateral occlusal contacts in the retruded contact position. All participants were instructed to wear the splint during the night for 6 weeks.

Recordings of the chewing movements were performed using an optoelectronic system (MacReflex, Qualisys) operating at 50 Hz. The equipment consisted of three basic units: *(1)* two video cameras with a detecting lens sensitive to infrared light, *(2)* a video processor, and *(3)* a software program run on a Macintosh computer. An infrared flashlight placed around the lenses and synchronized with the electronic shutter illuminated the field of view. Integrated coordinate signals from the two video cameras enabled an analysis of the chewing movements in three dimensions. The system was calibrated before each recording using a reference structure consisting of fixed spherical markers with known positions. Reflecting markers were attached to the participant's chin and onto a frame located on the forehead. The movements of these latter markers were subtracted from the chin marker movements to compensate for potential head movements.

The participant was placed comfortably in a dental chair. Head movements were not restricted, and there was a free choice of chewing side. The chewing substance was a cylindrical piece of paraffin wax, 18 × 8 mm, that was chewed to a bolus before the recording started. Each recording period lasted for 20 seconds and was repeated five times. The first 10 chewing cycles during the recordings were not used in the analysis. This was done to exclude possible effects on the participant's chewing caused by the unfamiliar test substance.[19] At the start of the recording the participant kept the mandible in maximal intercuspation and started chewing upon a sign given by the operator.

Recordings of the chewing movements were made on three occasions: *(1)* at base line, *(2)* 2 weeks later before use of the splint was begun, and *(3)* after 6 weeks of using the occlusal splint.

In the computer software program, each masticatory cycle was categorized into three separate

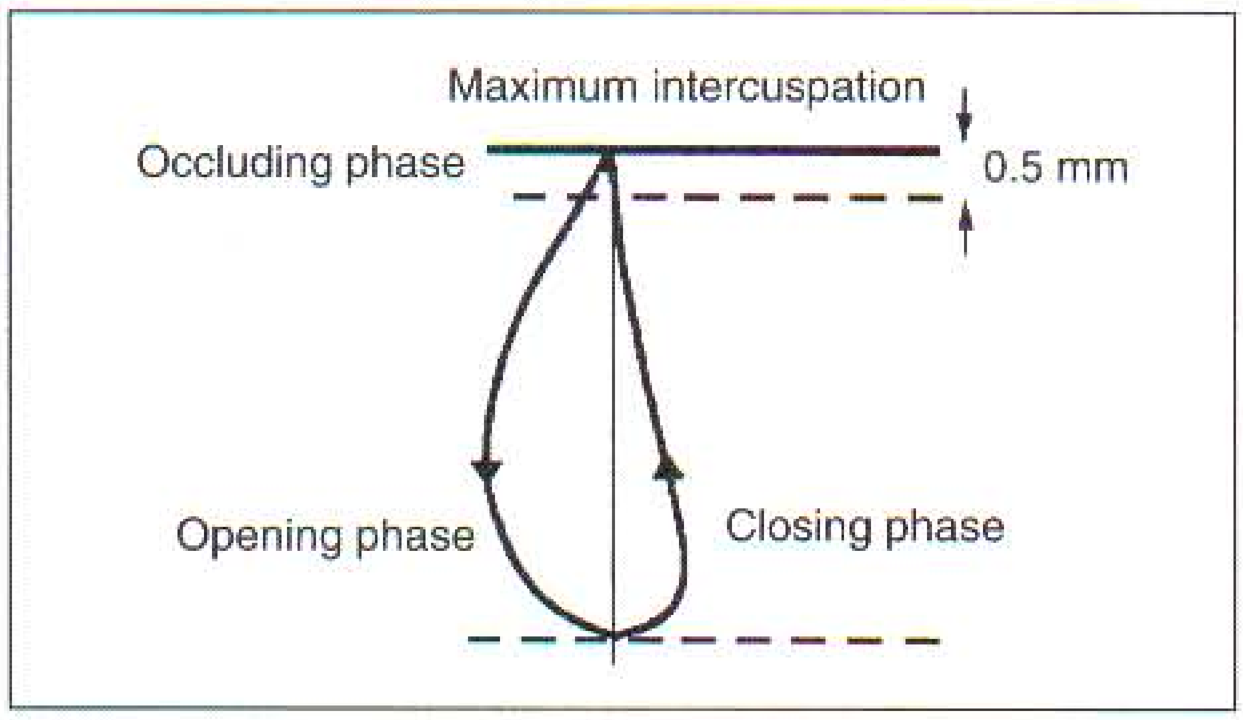

Fig 1 The three chewing phases indicated by one single chewing envelope in frontal view. The opening phase starts at 0.5 mm from the maximum intercuspation (MI), and ends at the most inferior point of the chewing cycle. The closing phase starts at the most inferior point of the chewing cycle and ends 0.5 mm from MI. The occluding phase was defined as an area within 0.5 mm from MI.

Table 1 Confidence Interval Limits (95%) of the Differences of Mean Measurements of Jaw Spatial Displacement, Chewing Cycle Duration, and Jaw Velocity

		Cycle duration (sec)			Velocity (mm/sec)	
Spatial displacement	(mm)	Open phase	Closing phase	Full cycle	Open phase	Closing phase
Control individuals (n = 14)						
a	–0.6 to 1.2	–0.02 to 0.01	–0.01 to 0.02	–0.05 to 0.04	–2.1 to 5.6	–4.9 to 5.0
b	–0.4 to 0.6	–0.01 to 0.03	–0.01 to 0.03	0.00 to 5.7	–4.9 to 2.0	–4.4 to 0.8
c	–0.8 to 1.5	–0.02 to 0.03	–0.02 to 0.05	–0.04 to 0.07	–3.1 to 3.7	–8.1 to 4.6
TMD patients (n = 13)						
a	–3.0 to 1.6	–0.01 to 0.03	–0.01 to 0.05	–0.05 to 0.1	–11.6 to 7.2	–12.9 to 5.4
b	–0.3 to 1.4	–0.01 to 0.04	0.02 to 0.09	0.02 to 0.1	–5.3 to 4.7	–13.2 to 5.2
c	–2.4 to 2.0	–0.01 to 0.06	0.03 to 0.1	0.01 to 0.2	–12.9 to 8.0	–16.8 to 2.7
Whiplash group (n = 14)						
a	–2.2 to 1.6	–0.02 to 0.05	–0.01 to 0.04	–0.04 to 0.1	–8.4 to 4.2	–6.2 to 3.2
b	–1.4 to 2.5	–0.03 to 0.05	–0.03 to 0.05	–0.05 to 0.7	–5.7 to 9.6	–3.5 to 4.6
c	–1.5 to 1.8	–0.01 to 0.05	0.00 to 0.05	0.00 to 0.1	–5.8 to 5.4	–6.4 to 4.4

Differences measured between *(1)* baseline and before starting the use of an occlusal stabilization splint, *(2)* before starting to use the splint and after 6 weeks use of the splint, and *(3)* baseline and after 6 weeks' use of the splint. Values are presented for the three different population samples.

phases, ie, opening, closing, and occlusal level phase. The occlusal level phase was defined as when the mandible was located within 0.5 mm inferior to the maximum intercuspation (Fig 1). The following parameters of the jaw movements were measured: *(1)* mean duration; *(2)* spatial displacement; and *(3)* velocity of the mandible during the chewing cycle, as well as for the three separate phases of the chewing cycle.

The intraindividual changes between baseline recordings before splint use and after splint use were recorded. The differences of the chewing parameters over time were assessed by calculating the 95% confidence interval limits, and tested statistically using Friedman's two-way analysis of variance (ANOVA).

Results

No statistically significant differences among the three participant groups ($P > 0.05$) were noted for the baseline values of the mean spatial displacement and the velocity of the jaw during the three separate chewing cycle phases and for the mean duration of the full chewing cycle and the three separate chewing cycle phases. The spatial displacement and velocity during the opening and closing phases and duration of the separate phases of the chewing cycle for the three participant groups is shown in Figs 2 to 4.

The confidence interval limits (95%) of the differences between the baseline values, before starting the use of the occlusal splint, and after 6 weeks' use of the splint were either negligible or included the value of zero. Thus, no significant changes were apparent when calculated for all participants, for the whiplash and TMD patients together, and for the three separate participant groups (Table 1).

The intraindividual changes in any of the recorded jaw movement parameters between baseline and before use of the splint as well as after 6

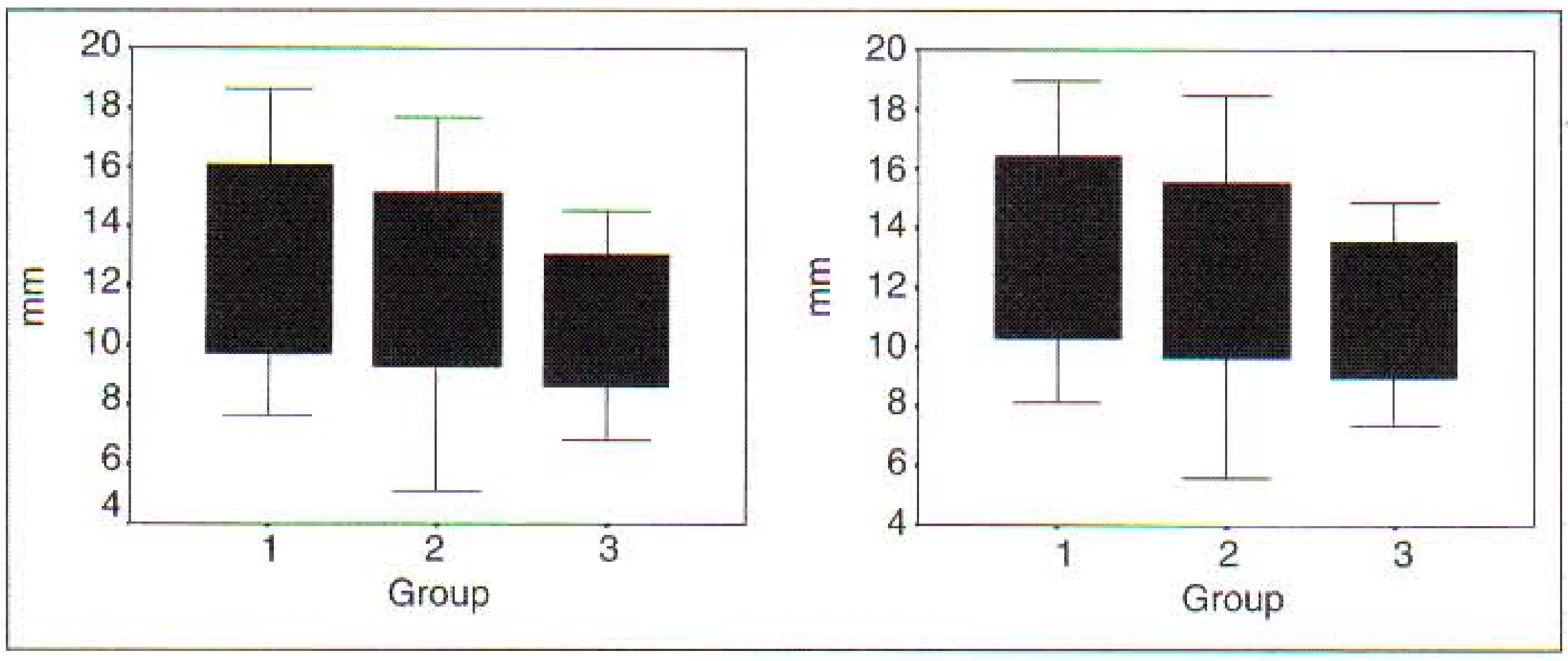

Fig 2 Boxplot of the mean mandibular spatial displacement (mm) during the opening *(left)* and closing *(right)* phase of the chewing cycle measured at baseline. The groups are *(1)* individuals without TMD (n =14); *(2)* TMD patients (n = 13); and *(3)* whiplash TMD patients (n = 14). The height of the box is the interquartile range (IQR). The whiskers indicate the largest observed value that falls within 1.5 IQR

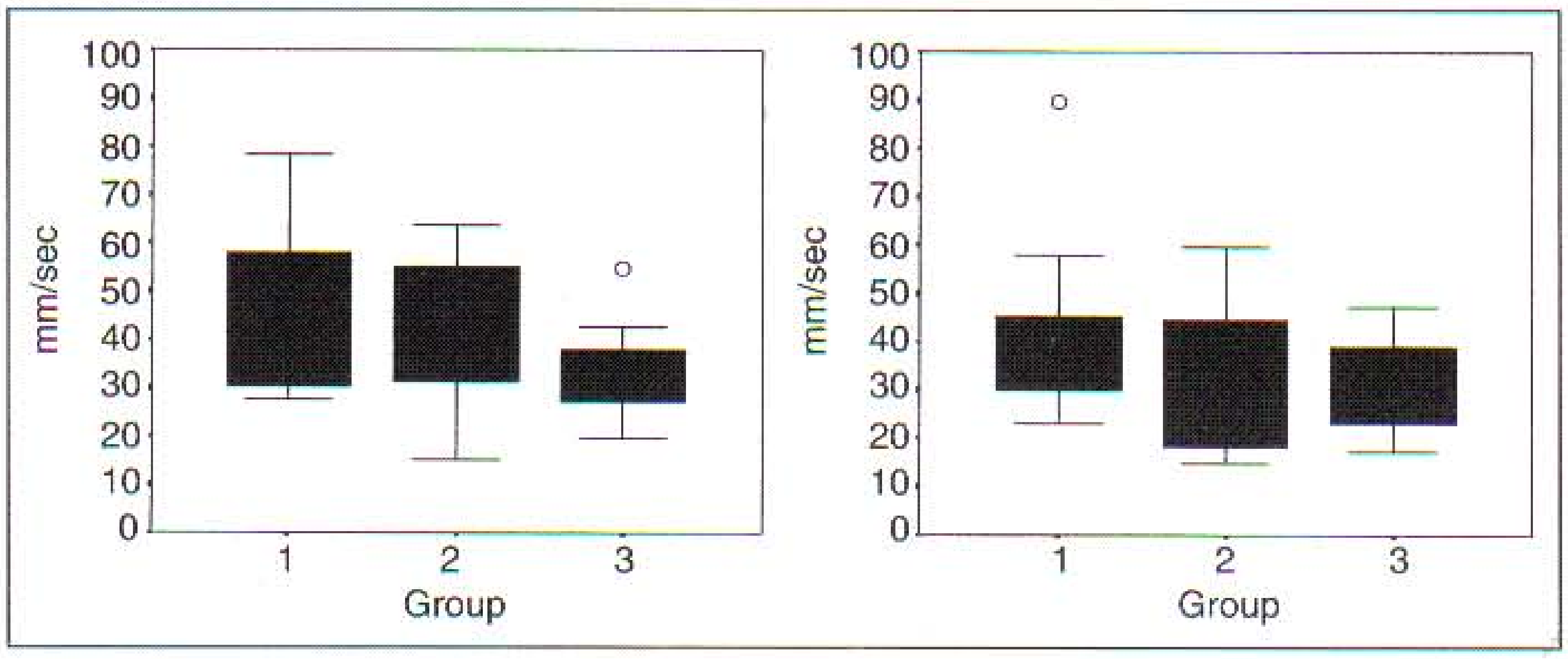

Fig 3 Boxplot of the mean mandibular velocity (mm/sec) during the opening *(left)* and closing *(right)* phase of the chewing cycle measured at baseline. The groups are *(1)* individuals without TMD (n = 14); *(2)* TMD patients (n = 13); and *(3)* whiplash TMD patients (n =14). The height of the box is the interquartile range (IQR). The whiskers indicate the largest observed value that falls within 1.5 IQR. The sign o indicates values more than 1.5 IQR (outliers).

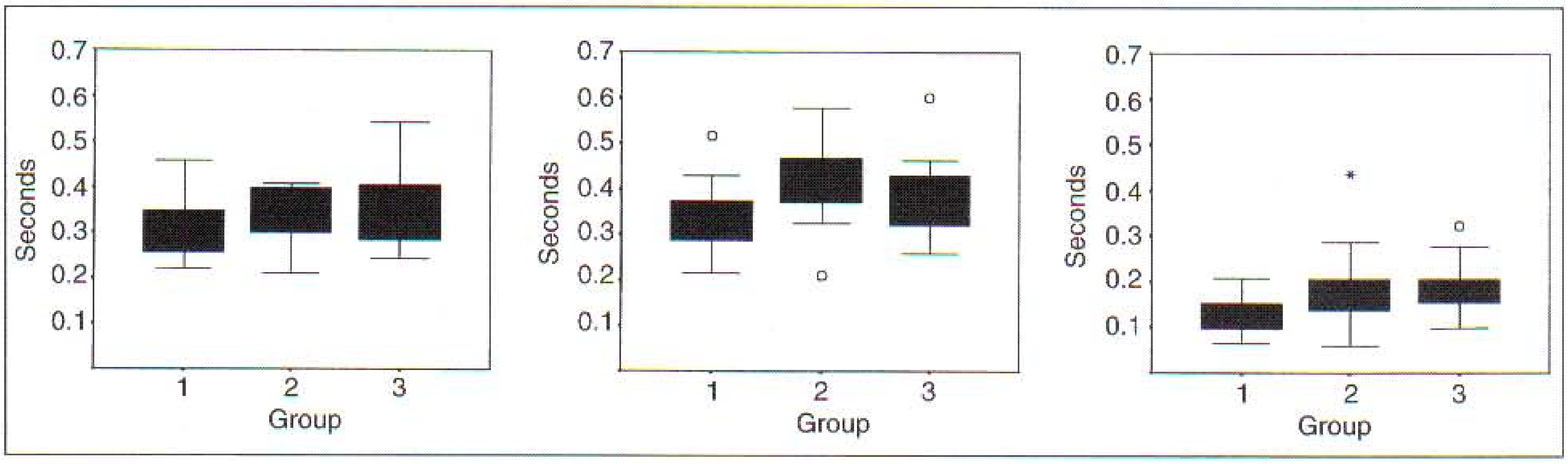

Fig 4 Boxplot of the mean duration (seconds) of the opening *(left)*, closing *(center)*, and occlusal phases *(right)* of the chewing cycle measured at baseline. The groups are *(1)* individuals without TMD (n = 14); *(2)* TMD patients (n = 13); and *(3)* whiplash TMD patients (n = 14). The height of the box is the interquartile range (IQR). The whiskers indicate the largest observed value that falls within 1.5 IQR. The signs o and * indicate values more than 1.5 (outliers) and 3 (extremes) IQR, respectively.

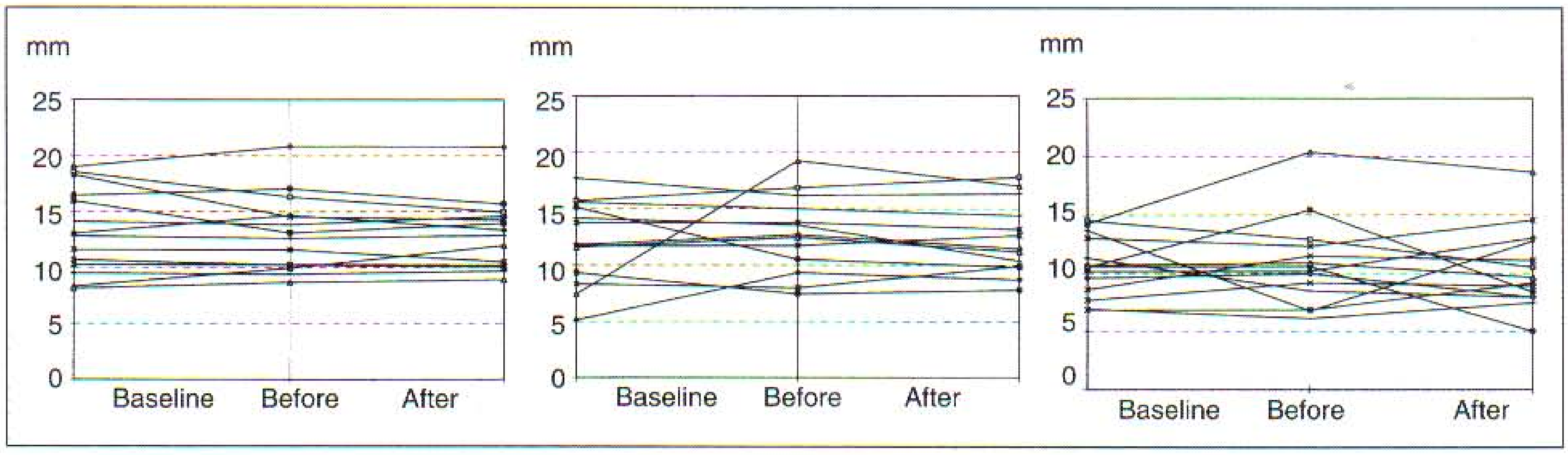

Fig 5 The mandibular spatial displacement (mm) during chewing at baseline, before starting to use an occlusal splint, and after 6 weeks' use of an occlusal splint. Individuals without TMD ($n = 14$, *left*), TMD patients ($n = 13$, *center*), and whiplash TMD patients ($n = 14$, *right*).

weeks of using the splint were highly variable in the three participant groups (Fig 5). The hypothesis tests indicated no significant changes in any of the recorded jaw movement parameters ($P > 0.05$).

Discussion

The whiplash patients in the present study were probably not representative of all whiplash patients because the patients were not randomly selected, but had responded to an advertisement in the newspaper. This may indicate that their motivation to seek help was especially high, and that they were highly concerned with their illness.

The matching of the two other groups to the whiplash group regarding age and gender signifies that none of the samples can be regarded as representative for their respective populations. Thus, extrapolation of the recorded mean values must be evaluated cautiously. The aim of the present study was to elucidate the mechanism of using occlusal splints, not to compare sample populations. Thus, it was considered more important to select individuals with as potentially disparate functional status of their masticatory systems as possible and study the intraindividual changes, rather than to compare the mean values in population samples. Power calculations were not used to assess the adequate sample or total study size. The reason was that there are no references in the literature as to the choice of appropriate outcome measure, in this case change of jaw movement parameters, for the evaluation of the effects of splint use.[20] However, by testing intraindividual changes instead of intergroup differences, sample sizes can be reduced without increasing the risk of statistical type II errors.[21]

The placement of the IR-reflective marker on the chin instead of on a mandibular incisor is simpler and less time consuming under clinical circumstances. The precision is considered adequate if an area close to or below the chin point is used where the soft tissue translation in relation to the underlying skeletal parts is minimal.[22] Previous studies have shown that the set-up of the jaw-recording system in the present study resulted in 0.7-mm vertical and 0.6-mm sagittal differences between chin and tooth marker recordings.[23] These differences are larger than the intraindividual and intergroup differences in chewing movement parameters, indicating that the method error is higher than the changes recorded.

During chewing of food, the size of the bolus varies during consecutive chewing cycles, resulting in varying jaw movements used in preparation for swallowing.[24] Therefore, a test food with a constant volume seemed to be most suitable for the analysis of jaw motion during chewing. In addition, using a standardized size of a material that does not degrade while chewing minimizes the risk of unpredictable jaw motion caused by changes of the test food itself.[25] The advantage of using paraffin wax is that the consistency remains unchanged during chewing. A negative aspect may be that the chewing could be influenced by the lack of taste and softness. The test food used in the present study had a relatively soft consistency. It is uncertain if larger differences would appear if the test food had been of a harder consistency. However, this was avoided to prevent aggravating pain in the chewing muscles and/or temporomandibular joints of the TMD patients.

Pain in the temporomandibular joint or muscles of mastication is often associated with a restriction of mandibular movement. Therefore, it seemed logical to investigate jaw movements and to analyze motion to try to identify indicators of the disease. Sophisticated instrumentation has been used to record various aspects of mandibular movement and analyze jaw movement patterns. Some authors conclude that TMD patients have characteristic chewing patterns,[26–29] while others refute such findings.[30] The present observations (see Figs 2 to 4) do not support the hypothesis that chewing movements are notably affected, at least regarding jaw spatial displacement and chewing cycle time. On the other hand, it is possible that selecting TMD patients with diagnoses, initial intensity of symptoms, or etiology different than those in the present study would have resulted in larger differences in the chewing parameters.

It is apparent that the jaw parameters measured in the present study did not change over time (see Table 1). An exception is a minimal increased duration of the closing phase and full chewing cycle among the TMD patients. However, the 95% confidence interval is in the 0.01-to-0.2-second range, which is clinically insignificant in relation to the measured values ranging between 0.3 and 0.6 seconds (closing phase) and between 0.6 and 1.3 seconds (full cycle).

The measured parameters varied more or less for most participants. However, none of the parameters changed in a predictable pattern (see Fig 5). Thus, the data do not indicate that the use of the splint has any influence on the recorded chewing parameters. This contrasts the results of Ow et al,[14] who reported a shortening of the duration of the opening phase as well as the total chewing cycle and an increase in the mean opening velocity after using an occlusal splint for 5 to 8 weeks. The results also contrast the results of Koyano et al,[16] who reported a shorter occlusal level phase duration after the 24-hour use of an occlusal splint. The different results may be explained by different periods of splint use and compliance with using the splint during the test period.

The recordings in the control group were not consistent at all observations, indicating that these parameters were not stable. Moreover, a great variation in changes of the chewing parameters between baseline and before as well as after use of the splint in the patient groups was noted (see Fig 5). There may be differences among the sample populations (see Figs 2 to 4), which possibly would be statistically significant if the sample sizes were increased. However, the clinical value of such a finding would be minimal since all recordings of jaw movements for diagnostic or monitoring purposes would be inadequate because of poor diagnostic validity.[31]

Conclusion

On an intraindividual basis, large variations in changes of chewing parameters were observed after using an occlusal stabilization splint for 6 weeks. On a group basis, the use of an occlusal stabilization splint for 6 weeks does not predictably change jaw movement parameters as recorded under the conditions of this study.

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Literature Abstract

The rehabilitation of the severely resorbed maxilla by simultaneous placement of autogenous bone grafts and implants: A 10-year evaluation

In 20 consecutive patients with advanced maxillary resorption, 13 were treated with onlay grafts and seven with sinus inlay grafts. Another seven consecutive patients with maxillary discontinuity (either from a congenital defect or a tumor) were also treated with bone grafts. In all cases corticocancellous hip grafts were used and implants were placed simultaneously, thereby also fixating the grafts. Two surgical teams were involved, one at the oral site and the other at the hip site, to reduce the extracorporal time. The observation period was 1 to 10 years. The cumulative success rate for the implants was 95% for both the onlay and the sinus inlay groups but less than 50% for the the group with maxillary discontinuities. The success rate for the two first groups was higher than previously reported, which was explained by the short extracorporal time for the grafts. Also discussed is the possibility that hyperbaric oxygen might improve the poor results for the discontinuity group.

van Steenberghe D, Naert I, Bossuyt M, De Mars G, Calberson L, Ghyselen J, Brånemark P.I. *Clin Oral Invest* 1997;1:102–108. **References:** 25. **Reprint requests:** Dr D. van Steenberghe, Catholic University Leuven, Department of Periodontology, Capucijnenvoer 7, B-3000 Leuven, Belgium—*SP*