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POST-TREATMENT STABILITY OF TEMPOROMANDIBULAR JOINT AND OCCLUSION AFTER ONE-YEAR RETENTION BY HAWLEY RETAINER

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ABSTRACT

Objective: The stability of temporomandibular joint and occlusion is still uncertain even after delivering ideal orthodontic treatment. Thus, proper posttreatment follow-up has been advised. This study investigated the stability of temporomandibular joint and dental features one year posttreatment after using Hawley retainer as retention appliances. ***Material and methods:*** Records of 21 patients who had undergone orthodontic treatment and given Hawley retainer as a retention appliance were obtained. The sample comprised 14 females and 7 males who met the inclusion criteria with an average age of 18.5 ± 3.02 years. Two sets of upper and lower teeth models were obtained at two-time points: after completion of orthodontic treatment (T1) and one year after retainer wearing (T2). Dynamic occlusions were determined by using face bow transfer, articulator mounting and measure condyle displacement (MCD). Static occlusions were assessed by using objective grading system (OGS). Vertical, anteroposterior and transverse condyle displacement were measured by analysis of the graphic registrations, produced by MCD instrument. Quantitative occlusal parameters were measured by the analysis of models using American board of orthodontics (ABO) measuring gauge. ***Results:*** The maximal recorded mean centric occlusion-centric relation discrepancies (CO-CR shift) of patients after orthodontic treatment at horizontal, vertical and transverse planes were 1.10 ± 0.46 for right condyle, 1.09 ± 0.49 for left condyle and 0.23 ± 0.16 for transverse, respectively. After one year of wearing Hawley retainer, the maximal recorded slides in centric discrepancies of patients at three planes were 1.15 ± 0.54 for horizontally left condyle, 1.05 ± 0.45 for vertically left condyle and 0.26 ± 0.18 transversely. The vertical, horizontal or transverse displacement of the condyle on either left or right side had no statistical differences after wearing Hawley retainer one year posttreatment ($p > 0.05$). The overjet ($p = 0.031$) and total OGS scores ($p = 0.005$) decreased significantly during one year of wearing Hawley retainer. ***Conclusions:*** Condyle positions appear to be stable one year posttreatment following Hawley retainer wearing. Although, the quantitative orthodontic treatment outcome scores of dental features decreased in patients wearing Hawley retainer one year posttreatment, still the temporomandibular joint remained stable as evidenced by similar centric occlusion-centric relation, suggesting wearing Hawley retainer does not influence its stability.

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INTRODUCTION

Temporomandibular disorders (TMD) is now considered the third most common chronic pain problem after headache and backache (1). Many practitioners relate orthodontic treatment as the reason for TMD (2). In practice, orthodontic treatment should produce occlusion which is in harmony with the closure and movement pattern determined and dictated by temporomandibular joint (3). Harmony between neuromuscular system, temporomandibular joint and occlusion is the key to mandibular and dental stability, as such centric relation (CR) and centric occlusion (CO) should be coincidental or very closely related (4, 5). One among the elements of stability is to have a tripodism in which three structures should be properly seated,

one is the occlusion and the remaining two are the right and left temporomandibular joints. Tripodism is one of the most important goal to achieve during orthodontic treatment thus preventing relapse (6). Despite the fact that, long-term stability after orthodontic treatment is among the major goals of many orthodontist, temporomandibular joint stability is still inconclusive and not ensured even after delivering ideal orthodontic treatment (7, 8). Therefore, proper posttreatment follow-up has been suggested after orthodontic treatment to ensure retention and avoid relapse (9). To minimize relapse, almost every patient who receives orthodontic treatment will require some types of retention appliances (10, 11) Retention appliances prescribed are typically given to patients after active phase of orthodontic treatment to prevent relapses, promote further "settling" of the occlusion and making minor corrections in the dentition (12, 13). Various methods of retention appliances are in use today (14)(15) and the altitudes toward the use of retention appliances have changed over the years (10, 16). Hawley retainers are the most commonly used retention devices today (17). It was fabricated and described by Dr. Charles Hawley as an active removable appliance to open the bite and retract incisors. However, these retainers are made up of rigid acrylic plates with no occlusal coverage, which limits all movements except vertical movement, known as beneficial type of relapses. These relative vertical movements of teeth, also known as settling of occlusion after active phase of orthodontic treatment, results into either increase (18), decrease (19) or unchanged (19, 20) inter occlusal contacts.However, limited studies have investigated if these movements affect the temporomandibular stability.

A previous study showed an increase in actual near (ACNC) and total contacts during Hawley retainer use (21). Interestingly, there seems to be a definitive relationship between an increased occlusal contacts and posterior interferences (18). Moreover, studies that evaluate number, size, area and location of occlusal contact did not reveal whether these contacts were located at the correct positions (22). Some contacts change their locations between occlusal inclination and central grooves, thus suggesting minimal settling in the buccolingual direction (23). Since Hawley retainers allow vertical movement of teeth during retention, an increase of inter-occlusal contact points on posterior occlusion may result. It is unclear if the increase in inter-occlusal contact points during Hawley retainers wore period can result into mandible having two paths of closures, the centric shifting away from eccentric, thus prompting temporomandibular instability. To the best of our knowledge, reliable studies on this subject matter are currently lacking. Therefore, this study investigated the stability of temporomandibular joint and occlusion one year posttreatment after using Hawley retainer as retention appliance. We hypothesized that, CO and CR measurements might change after using Hawley retainer one year posttreatment and cause instability of temporomandibular joint.

MATERIALS AND METHODS

Study design and sampling procedures: Our study participants were selected from the archives of the Department of Orthodontics, Xiangya Stomatology Hospital of Central South University, Changsha, Hunan Province, China. Participants were selected after completion of full orthodontic treatment, with the treatment objectives being satisfied. They were enrolled in this study according to the following criteria: (1) Patients above 13 and under 40 years of age, free sexuality. (2) All patients treated with fixed banded and/or bonded appliances with or without auxiliary appliances. (3) Patients treated to the optimum occlusion with the treatment objectives satisfied. Patients in which treatment was discontinued before completion due to any reason such as poor patient compliance were not included. (4) Availability of patient for follow-up recordings after at least 12 months was important. (5) Patients with no obvious plaque, pigment, severe gingivitis and periodontitis. (6) Patients who agreed to wear Hawley retainer as retention device after completion of orthodontic treatment. Participants were excluded if they had any surgical corrections of the jaws, diagnosed with a cleft lip, palate or both and/or other craniofacial syndrome, history of periodontal and/or muscular dysfunction, temporomandibular joint dysfunction, large restorations on posterior teeth, noncompliant with the use of Hawley retainer, allergies history to materials used in the study, refused to participate in the study. Twenty-one patients (14 female and 7 males) met these criteria and were recruited between December 23, 2017 and April 14, 2018 (Table 1). Five were growing patients according to their hand and wrist x-rays. Their mean age at the beginning of treatment was 18.3 ± 3.02 (range, 13-26 years) and the mean treatment period during which the Hawley retainers were used was 11.39 ± 1.33 (range, 8-13 months). Patients were instructed to wear both maxillary and mandibular retainers for the entire day, except while eating during the first six months after treatment and only at night afterwards. This was a prospective observation study, not randomized clinical trial; the consecutive –patient approach was to verify that these patients ware not randomly selected on the basis of their treatment outcome.

Table 1. Demographic data of the study sample and treatment duration

		Treatment	duration	
Demographics	N (%)	range	mean	SD
Male	7 (33)			
Female	14 (67)			
Growing patients (< age 16)	5 (24)			
Pretreatment age	21	13-26	18.5	3.02
Total wearing duration (T2-T1) (months)	21	8-13	11.39	1.33

Initially, two sets of upper and lower models of 21 patient's dental arches were casted from alginate impressions using Die- stone. The occlusal records were gathered at two time points, the first set of records at the time of removal of orthodontic appliance (T1) and the second set was obtained during the retention period approximately 12 months posttreatment (T2). Two sets of measurements were done at each time point, one for evaluating static occlusion using American board of orthodontics (ABO) objective grading system (OGS) measuring gauge and the other for evaluation of dynamic occlusion using face bow transfer, articulator mounting and measure condyle displacement (MCD). The full adjustable articulator and MCD were chosen to record the patients boarder movements and three dimensions plane of the condyle due to neuromuscular avoidance pattern to occlusal interferences that makes difficult if not impossible to locate many harmful occlusal interferences intraorally by manipulating the mandible (24).

Static occlusion evaluations: In this study, quantitative evaluations of orthodontic treatment outcomes of dental (occlusal) features were undertaken using to the ABO OGS (25). This system was used for scoring dental casts and panoramic radiographs in measuring static occlusion after orthodontic treatment. We choose ABO-OGS for evaluating static occlusion (tooth stability), although it is popular in America but it has been approved to the best and easier method for evaluating clinical case report and quantitative evaluation of static occlusion after orthodontic treatment (25).

Dynamic occlusion evaluations: The CO and CR techniques used for measuring condyle positions are described in more detail in AD2 MCD manual (24, 26). The methods involved four steps: an estimated hinge axis facebow transfer for mounting maxillary and mandibular casts on theAD2 USA articulator in the CR (Fig. 1a), bite registrationin CO (to prevent rocking of the casts during recording of the CPI), a bite registration in the CR (after deprogramming), articulator mounting and 3D condylar position registrations. Briefly, CO was recorded using softened modelling wax. The wax was trimmed until it matches the buccal-to-buccal dimension of the patient's maxillary arch and covers all the maxillary teeth. The relative position of the teeth was noted by first instructing the patient to close in the position of maximum intercuspation. Afterward the wax was warmed in hot water until it was soft enough to offer no resistance and positioned against the maxillary teeth but not pressed hard against the teeth to prevent perforation. A patient was then instructed to close into a position of maximum intercuspation and the

relative tooth position noted earlier verified. The maxillary and mandibular teeth automatically created "cuspal indents" in the registration material. The position was maintained while cooling the wax in air, then wax removed and examined for the presence of adequate cuspal indents and/or soft tissue contact.

slides in centric. During the analysis, Pearson correlations with r > 0.7 were considered strong, r = 0.5 and 0.7 moderate strong and r < 0.4 weak correlations. All the statistical analyses were done using the Statistical Package for the Social Science (SPSS, version 22.0, IBMCorp., Armonk, NY, USA). The significance level was set at $P \leq 0.05$.

Fig. 1. The centric relation recording (a), facebow registration (b), centric relation recording

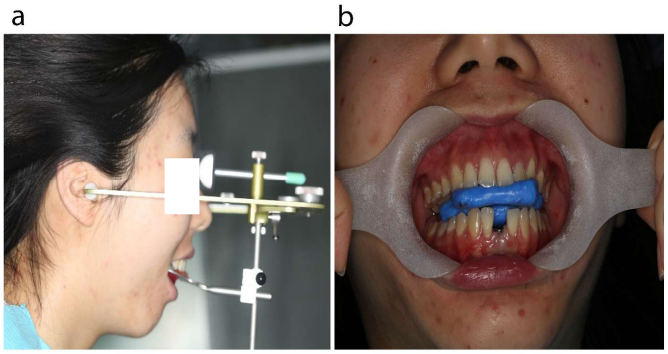

Table 2. The centric occlusion (CO) - centric relation (CR) shifts for less and more than 1 mm

	T1		T2		Difference (T2-T1)			
	Mean	SD	Mean	SD	Mean	SD	*t*	*P*
Less than 1 mm								
Horizontal-left	0.88	0.26	0.97	0.47	0.08	0.62	0.327	0.757
Horizontal-right	0.67	0.38	0.67	0.39	0.00	0.48	0.000	1.000
Vertical-left	0.58	0.39	0.82	0.48	0.23	0.60	0.960	0.381
Vertical-right	0.60	0.30	0.65	0.39	0.05	0.36	0.338	0.749
Transverse	0.17	0.19	0.23	0.26	0.07	0.23	0.698	0.516
More than 1 mm								
Horizontal-left	1.12	0.47	1.22	0.57	0.10	0.67	0.578	0.572
Horizontal-right	1.28	0.36	1.23	0.41	-0.05	0.35	-0.583	0.569
Vertical-left	1.29	0.37	1.14	0.42	-0.15	0.36	-1.560	0.141
Vertical-right	1.29	0.30	1.11	0.36	-0.17	0.41	-1.646	0.122
Transverse	0.26	0.15	0.27	0.14	0.01	0.15	0.174	0.865

Abbreviations: T1-Initial measurements, T2-Final measurements. $P < 0.05$, n = 6 for less than 1 mm and n = 15 for more than 1 mm.

Table 3. Overall centric relation –centric occlusion shifts

	T1		T2		Difference (T2-T1)		*t*-test	*P*
Parameters	Mean	SD	Mean	SD	Mean	SD		
Anteroposterior -left	1.05	0.42	1.15	0.54	0.10	0.64	0.680	0.504
Anteroposterior-right	1.10	0.46	1.07	0.47	-0.04	0.38	-0.458	0.652
Vertical-left	1.09	0.49	1.05	0.45	-0.04	0.46	-0.379	0.709
Vertical-right	1.09	0.43	0.98	0.42	-0.11	0.40	-1.255	0.224
Transverse	0.23	0.16	0.26	0.18	0.02	0.17	0.631	0.535

Abbreviations: T1-Initial measurements, T2-Final measurements. $P < 0.05$, n = 21.

Centric relation records: All patients were neuromuscularly deprogrammed at the chair before registration of the CR by bitingcontinually with a moderate pulsating biting force (5 seconds clench, 5 seconds relax) on a wooden tongue depressor for 5 to 10 minutes. The wax registration of the CR immediately followed neuromuscular deprogramming. The CR bite registration was undertaken by first inducing relaxation of the masticatory muscles through the gentle arcing of the mandible up and down, along the closing arc of the terminal hinge axis, using gentle bimanual manipulation while the patient was supine (modified Roth centric registration technique) (Fig. 1b). The method avoids tooth contact and allows the patient's own mandibular elevator muscles to seat the condyles in a reproducible (neuromuscular) position without dental interferences.

Statistical analyses: Results are presented as mean ± standard deviation (SD). The data were assessed for normality visually using histogram and tested statistically using Shapiro-Wilk test. Based on their skewness and kurtosis, most variables showed nonsignificant departures from normality for many variables. A parametric paired sample *t*-test was conducted to evaluate statistical differences between the mean CR -CO displacement and objective grading system scores before (T1) and after (T2) one year of Hawley retainer appliance wore. Pearson correlations were used to evaluate association of changes in measurements between OGS scores and

RESULTS

The centric occlusion-centric relation shift for less and more than 1 mm: The mean, standard deviation and their differences among measurements for selected slides in centric (CR-CO shift) variables at TI (before) and T2 (after) are shown in Table 2. The CR-CO shifts were divided into those with displacement of less than 1 mm and those with displacement of more than 1 mm. Interesting, the condyle displacement for less and more than 1 mm showed no significant differences during anteroposterior, vertical and transverse displacement on either left or right side of the condyle ($P > 0.05$).

Overall centric occlusion-centric relation shifts: During the study period, anteroposterior movements of condyle (absolute value) occurred at T1 and T2 both for the left and right condyles (Table 3). These mesial or distal movements of the condyle showed no significant differences on either left or right side of the condyle ($P > 0.05$). Similarly, vertical movements of the condyle (absolute value) also occurred for the left and right condyles during T1 and T2. Also, the vertical displacements of the condyle were statistically similar either on the right or left side during one year of retainer wore ($P > 0.05$). Likewise, condyle movements, also occurred transversely (absolute value), which is considered the most critical measurement during T1 and T2.

Table 4. The total cast and radiograph evaluation

Variables	T1		T2		Difference (T2-T1)		*t*-test	*P*
	Mean	SD	Mean	SD	Mean	SD		
Alignment/Rotation	6.03	2.43	5.76	2.21	-0.76	3.13	1.116	0.278
Marginal Ridges	3.42	1.60	2.90	1.37	-0.52	1.63	1.471	0.157
Buccolingual Inclination	4.39	2.50	4.05	2.96	-0.10	2.64	0.165	0.871
Overjet	3.42	2.29	2.76	1.87	-1.10	2.17	2.317	0.031*
Occlusal Contact	3.82	2.53	3.29	1.31	0.05	1.99	-0.110	0.914
Occlusal Relationship	1.21	1.47	1.33	1.53	-0.05	1.63	0.134	0.895
Inter Proximal Contact	0.32	0.70	0.10	0.30	-0.29	0.64	2.034	0.055
Root Angulation	1.42	1.43	1.43	1.44	-0.01	0.68	0.125	0.469
Total Cast Radiograph Evaluation	24.03	6.68	21.52	4.52	-3.19	4.64	3.149	0.005*

Abbreviations: T1-Initial measurements, T2-Final measurements. * $P < 0.05$, n = 21.

In similar fashion, these mediolateral movements of the condyle showed no statistical differences during one year of Hawley retainer wore ($P > 0.05$). A closer look at the patients transversely, indicated that eight subjects (38%) had CR-CO discrepancies that were coincidental at T1 and T2. No subject had a condylar position that was coincident in CO and CR at vertical or horizontal planes. All 42 condyles had displacements between the CR and CO in either the horizontal or vertical planes.

Total cast and radiograph evaluation using objective grading scores: The results on objective grading scores during one year of Hawley retainer woreare given in Table 4. During the study period, overjet scores between T1 and T2 decreased significantly ($P = 0.031$). Similarly, the total OGS scores also decreased significantly between T1 and T2 ($P = 0.005$).

Correlations between centric occlusion –centric relation shifts and objective grading scores: Several associations among measured variables were determined during the study. The Pearson correlations verified nonsignificant negative and positive relationships. The correlation of condylar displacement with a change in overjet at both right and left condyles in anteroposterior (r = -0.233, $P = 0.309$), vertical (r = 0.121, $P = 0.601$) and transverse (r = -0.077, $P = 0.704$) were not statistically significant. The correlations between total cast radiograph evaluation (TCRE) and condylar displacement in any of the three planes; vertical (r = 0.253, $P = 0.269$), anteroposterior (r = -0.117, $P = 0.614$), or transverse (r = -0.241, $P = 0.293$) showed no significant differences. None of the correlations obtained in this study between T1 and T2, had values in a strong or moderate range.

DISCUSSION

In this study we investigated the stability of temporomandibular joint and dental features after one year posttreatment among 21 patients who had been given Hawley retainer as a retention applianceafter orthodontic treatment. Results showed no significant differences in the temporomandibular joint shift/displacement during (CR-CO) measurements following Hawley retainer appliance wore one year posttreatment. However, significant differences were noted for OGS scores at overjet and TCRE between T1 and T2 after retainer wore periods. The null hypothesis that CO and CR measurements might change after using Hawley retainer during one yearposttreatment, causing instability of temporomandibular joint was rejected. The effect of orthodontic treatment on the stability of temporomandibular joint has been a controversy for many years among practitioners. First, there are possibilities that certain orthodontic appliances or techniques (Class III mechanics, extractions, chincups, and retainers) directly cause TMD (4, 27). Most previous studies have demonstrated increase in contacts at CR (actual and near contact) in the groups that were given Hawley retainers as the retention appliances (21, 28). However, we observed decrease in overjet and total cast radiograph evaluation scores. This may be attributed to jaw growth, age, settling of occlusion, faults in the retainer or improper wearing of the retainer. These results show that, the quantitative occlusal features improved and the final results were better after using Hawley retainers.

In this study, the overall horizontal or vertical discrepancies were found to be less than 1.5 mm and transverse displacement less than 0.5 mm. By using these parameters, we observed that all the patients exhibited no significant shift/displacement at the condylar positions in all the three planes. Most previous studies showed discrepancies of 1.5 mm in the horizontal plane, 1.5 mm in the vertical plane and 0.5 mm in the transverse plane and others have identified 1 mm (vertical and sagittal) and 0.5 mm transversely as considerable clinically significant (29, 30). There are debates about orthodontic treatment as a risk factor for TMD. It could be argued that non-gnathologicocclusal finishing indirectly produces an iatrogenic functional occlusion (functional balancing interferences) and eccentric condyle (or CR) position that predisposes to TMD. Some studies have investigated the effect of orthodontic treatment posttreatment between orthodontic patients and control groups (31-33), others have investigated this effect after using orthodontic retainer (22).Parenthetically, results from previous studies showed that orthodontic treatment was not an important etiologic factor for TMD (33). Interestingly our data show similar results that the wore of Hawley retainer one year posttreatment, changes in some occlusion parameters occur but had no significant effect on causing CR-CO discrepancies that prompt to instability of the temporomandibular joint. This result suggests that, wore of Hawley retainer within one year has no influence on temporomandibular joint stability.

We observed no correlations between overjet, TCRE and slides in centric during one year of Hawley retainer wore. The increase in overjet and decrease in overbite has been reported previously (24) when there is slides in CO to CR. The non-correlations found in this study can be related to the absence of significance differences in the majority of the variables analyzed. In the previous studies, correlations in vertical inferior (downward) displacement of the condyle in CR and posterior displacement of the condyle at CO among asymptomatic patient have been observed (24, 34). Moreover, correlation between angle classifications and slides in centric had been investigated before among asymptomatic patients (24). No correlations between OGS scores and slides in centric had been investigated in previous studies. Overall, these indicate that, no associations exist between OGS scores and CR-CO discrepancies after using Hawley retainer among the measured parameters. Despite the knowledge gained from this study, it should be interpreted with caution due to the following limitations. Firstly, a small sample size was used. This is because of the nature of procedure to be followed on each subject and the time involved three to four days working per subject. Small sample resulted into small to medium effect size which signify that large sample size is required to find significant results. Secondly,young adults (growing patient) were also included in this study. Since age has significant effect on the joint morphology due to degenerative and remodeling changes on joint's bony components, this may have contributed significant effect on posttreatment results. Studies involving two groups, non-growing and growing subjects are recommended in future. Thirdly, the CR recording in the present study was done by an experienced practitioner from the department of orthodontics and rechecked before the patient was discharged. The orthodontic gnathologic view that ‘‘power centric bite registration’’ that seats patients’ condyles in an anteroposterior CR needs to be verified by magnetic resonance imaging data (35). However, this

technique was not done in the present study. Further studies thatclearly confirm the condyle positions using a magnetic resonance imaging are recommended. Moreover, separation of skeletal and dental classification groups was not done in this study. Future studies that will separate these groups are recommended because different classifications present dissimilar growth patterns. Finally, the patient's compliance, missed appointment and drop-out from the study as described to all retention studies were also observed.

CONCLUSION

Our study shows that, on a short-term basis of one year's retention, the condyles positions appear to be stable one year posttreatment following Hawley retainer wearing. Although, quantitative orthodontic treatment outcome scores of dental features decreased among patients wearing Hawley retainer one year posttreatment, still the temporomandibular joint remained stable.

Competing Interest: We authors declare that, we have no any issues concerning conflict of interest.

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