The Efficacy of Bilateral Balanced and Canine Guidance Occlusal Splints in the Treatment of Temporomandibular Joint Disorder

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Abstract

Studies on the effects of stabilization splints on the neuromuscular system in patients with functional disorders indicate that the splints reestablish symmetric and reduced postural activity in the temporal and masseter muscles and significantly reduce the masseter muscle activity. This study was conducted on sixteen male dentulous patients who were suffering from subjective and objective signs of Temporomanbdibular Disorders (TMD). The patients were randomly divided into two groups, eight patients in each according to the fabrication of the occlusal design of the stabilization splint. All patients were subjected to clinical examination using Helkimo Dysfunction Index (HDI) and Pantographic examination through Pantographic Reproducibility Index (PRI) to assess the degree of TMD before and after splint therapy. The obtained results reported a significant improvement in the TMD symptoms as monitored by HDI scores and PRI scores in both groups after three months of using the different occlusal design stabilizing splint with Bilateral balanced and canine guidance stabilization splints during excursive movements. Also the results showed a significant and progressive improvement in the TMD symptoms between 3 weeks ($p=0.08$) and 3 months ($p=0.001$) after using the occlusal splint with canine guidance during excursive movements compared with bilateral balanced guidance as manifested by the coordination of mandibular movements by the pantographic tracings through Pantographic Reproducibility Index (PRI).

Key words: Helkimo dysfunction index, Occlusal splint, Pantographic reproducibility index, Temporomandibular joint disorders

Introduction

Temporomandibular Disorders (TMDs) have signs and symptoms that affect the masticatory muscles, Temporomandibular Joint (TMJ) or both. These signs and symptoms include complaints of facial and TMJ pain, tenderness to palpation on the face and TMJ, uncoordinated mandibular movement and the presence of joint sounds [1-5]. A diagnosis of TMD is subjective, and no instrument is available that identifies all of the signs or symptoms. Objective measurement of functional ability of many functional parameters is needed that could be measured to develop more reliable method for assessing functional capabilities of mandibular movement [6,7].

As TMD develops, the mandibular muscles develop spasms and lose their coordination. It appears that uncoordinated movement is one of the first signs and symptoms of TMD, and it may remain after most of clinically detectable signs and symptoms disappear [6,8].

As some patients can perform reproducible mandibular movements and others cannot, a hypothesis has been developed that a pantograph can be used to determine the coordination of mandibular movements. Pantographic tracings, quantitated by a pantographic reproducibility index (PRI), can be used to diagnose the presence and degree of TMD [6-10].

In addition, to facilitate the diagnosis and treatment of most disorders, Helkimo Dysfunction Index (HDI) which was effective aid in detecting the severity of TMD on clinical basis is used [11-14].

Many different therapies, some conservative and reversible, others irreversible, have been advocated for patients with TMD.A number of successful treatment outcomes have been reported, including occlusal splints, physiotherapy, muscle-relaxing appliances, and pharmacological interventions [2,4,15-17].

Occlusal splints have been used as an important modality for the management of TMD for over 100 years. The most common category, is a stabilization splint [1,18,19].

The real therapeutic effect and mechanisms of action of this modality are not fully understood, but it is believed that combination of several peripheral, central and behavioral modifications occurs that plays an important role in this scenario. Reduction in muscle activity, improvement in occlusal stability, an increase in the vertical dimension of occlusion, cognitive alterations and the placebo effect are listed as possible beneficial effects of occlusal splints [1,4,20-23].

Many studies have shown that the presence of occlusal interferences and a non-uniform distribution of tooth contacts along the dental arch tend to disturb the muscle symmetry in the masticatory system. As the stabilization splint, when properly adjusted, eliminates occlusal interferences and restores uniform tooth contacts, the splint is expected to improve muscle symmetry [9,15,23,24]. The purpose of this study was therefore to evaluate the efficacy of stabilization splint which designed with bilateral balanced guidance in reducing symptoms in patients with TMD compared with a traditional splint which is designed with canine guidance during excursive movements. Moreover, to evaluate the use of pantographic tracing through PRI as an objective method to monitor the success of occlusal splint therapy in management of TMD.

Material and Methods

Ethical approval was granted by Ethical Committee at King Abdulaziz University Dental Hospital. Each subject gave her/his written informed consent for participating in this study.

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Sixteen male patients were recruited from Dental patients attending the dental prosthodontics clinics, faculty of dentistry, King Abdulaziz University. Their ages ranged from 32-50 years old. The patient who met the inclusion criteria was entered into the study. The inclusion criteria were the presence of two or more TMD signs/symptoms identified by two experienced dentists such as pain on movement of the mandible, muscle pain or pain in palpation of Tempromandibular Joint (TMJ). The selected patients were due to the routine radio graphical examination of TMJ in the positions of the maximum closure and maximum opening at the first visit to exclude any organic pathosis and to evaluate the position of both condyles and joint spaces.

The study was performed with a double-blind design with one consultant performing screening, history-taking, and clinical examination as well as evaluation after the treatment. Another consultant delivered and readjusted the appliances for the patients without any other contribution in the treatment. Therefore, the first consultant had no information about which group the patient belong to.

For all subjects, maxillary and mandibular primary impressions were made using irreversible hydrocolloid impression material (Alginmajor high precision alginate, Italy) in modified stock trays. These impressions were poured in plaster to form study casts upon which special trays were fabricated in auto-polymerizing acrylic resin (Ostron 100™, Japan) and final impressions were recorded using Polyvinyl Silicosane impression material (Examix™, Monophase, GC, America Inc).

The final impressions were poured in dental stone and mounted on a semi-adjustable articulator (Hanau TM wide-vue,Water Pik Technologies, Inc, Fort Collins, Colo) by using an ear piece face-bow(Hanau; Water Pik Technologies,Inc) and centric relation record, made by two-sheets of thick wax rim bite wafer (Coltene/whale dent Inc., USA) was adapted to the mandibular arch and guided to close. This wax record was reinforced with polyvinylesiloxane (Addition Type) bite registration material (Coltene/whle dent Inc, USA). A full arch mandibular plane occlusal splint (Stabilization type) in heat cured acrylic (Acrostone, heat cure transparent, England, UK) was made for each subject over the occlusal and incisal surface of the teeth. The patients were instructed to wear the stabilization splint (SS) three hours daily and continuously at night for three months, and instructed to come after 48 hours for further adjustments.

Patients were instructed not to take any medications such as tranquilizers or muscle relaxants during the period of splint therapy. Moreover, they had been asked not to take any sedative drugs during the day of clinical examinations to avoid the influence of such medication on muscles during the clinical examination.

The patients were randomly divided into two equal groups, eight patients in each according to the type of opposing arch occlusion with the Stabilization splint.

Group I: Eight subjects were treated with acrylic full-covered stabilization splint with canine guidance on the mandibular arch. This design allowed disocclusion of all posterior teeth by the contact between canines during lateral movements and between anterior teeth during protrusive movement.

Group II: Eight subjects were treated with acrylic full-covered stabilization splint with bilateral balanced occlusion on mandibular arch. With this design, the maxillary palatal cusps and incisal edges contacted a flat surface, even contacts on posterior and anterior regions, allowing for simultaneous contact of the maxillary teeth in all segments of the splint during excursive movements (right lateral, left lateral and protrusive excursions.

The parameters were made for each patient before stabilization splint therapy, three weeks and three months after splint therapy.

Clinical Examination using Helkimo Dysfunction Index

For all the patients, the index for clinical dysfunction of masticatory system validated by Helkimo [11] was obtained to determine the degree of TMD based on the presence of five symptoms which were:

Impaired range of movement of the mandible,
Impaired function of TMJ,
Pain on movement of the mandible,
Muscle pain and
Pain on palpation of TMJ.

The Helkimo clinical dysfunction index scores were evaluated prior to fabrication of the splint, three weeks and three months after use of the stabilization splint therapy to assess the degree of TMD.

Immediately following the clinical and radio graphical examination, mandibular movements were recorded graphically for each patient using Denar-Pantograph (Denar Corporation, Anaheim, California, USA) to assess the degree of TMD through Pantographic Reproducibility Index (PRI) [6,25].

For recording the mandibular movements the patient's head was firmly seated on a headrest and was asked to protrude and retrude the mandible to the most retruded position for recording this position similarly, the lateral excursive movements were recorded.

Evaluation of pantographic tracing

An easier scoring method was made by Clayton et al (1976) [25]. This scoring method was termed "pantographic reproducibility index" (PRI) for Temporomandibular Joint (TMJ) Dysfunction.

The PRI scores were divided into ranges representing the severity of dysfunction:

=Scores ranging from (0 to 15) were considered reproducible tracings and the patient free from TMJ dysfunction (no dysfunction).

= Scores ranging from (16 to 30) were considered "slight dysfunction".

= Scores ranging from (31 to 60) were considered "moderate dysfunction".

= Scores ranging from (61 to 144) were considered "severe dysfunction".

The graphic recording of mandibular movements using (PRI) scores were evaluated prior to fabrication of the splint, three weeks and three months after using the stabilization splint therapy to assess the degree of TMD (*Figure 1*).

Statistical analysis

The Chi-square test was used for comparing between different periods. The Mann-Whitney test was used to determine the

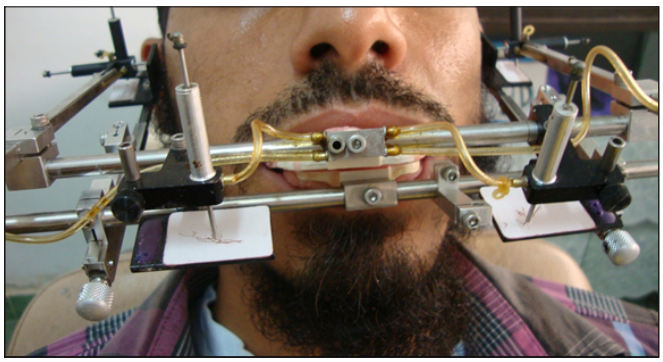

Figure 1. *Assembly of Denar pantograph on the patient's face.*

significance of differences between the two studied groups. For comparison within the groups, Wilcoxon's signed-rank test was used for comparing between different study periods of each group. Differences at $p<0.05$ level of probability considered statistically significant.

Results

Table 1 showed the results of the mean scores of Helkimo Dysfunction Index (HDI) in group (1) including eight patients with TMD before using the canine guidance stabilization splint at baseline, 3 weeks and 3 month after using the splint. The mean of these scores of HDI were 13.0 ± 6.44, 3.88 ± 2.36 and 0.50 ± 0.93 respectively.

On comparing the mean difference of HDI scores of patients with TMD before using the canine Guidance Stabilization Splint, 3 weeks and 3 month after using the splint, the results showed that there was a significant difference of reduction of HDI scores after 3 weeks and 3 month following the splint therapy t(p_1) 0.012 and t (p_1) 0.012 respectively.

When comparing HDI mean scores 3 weeks and 3 month after using the splint therapy , there was significant reduction in the amount of dysfunction t (p_2) 0.012.

Also, *Table 1* showed the results of the mean scores of HDI in group (2) including other eight patients with TMD before using the bilateral balanced Stabilization Splint at baseline, 3 weeks and 3 month after using the splint. The mean of these scores of HDI were 13.75 ± 7.25, 7.38 ± 4.81 and 1.75 ± 1.91 respectively.

On comparing the mean difference of HDI scores of patients with TMD before using the bilateral balanced Occlusion Stabilization Splint, 3 weeks and 3 month after using the splint, the results showed that there was a significant difference of reduction of HDI scores after 3 weeks and 3 month following the splint therapy t (p_1) 0.011 and t (p_1) 0.011 respectively.

When comparing HDI mean scores 3 weeks and 3 month after using the splint therapy, there was significant reduction in the amount of dysfunction t (p_2) 0.011.

On comparing the mean difference of HDI between the patients in group (1) and (2), the result showed that there was no significant difference of reduction of HDI scores between the patients of the 2 groups in the three periods of investigation (baseline before splint therapy, 3 weeks and 3 month) t(p) 0.790, 0.102 and 0.146 respectively.

Table 1 represent the result of Pantographic Reproducibility Index (PRI) mean score of eight patients with TMD in group (1) before using the canine guidance stabilization splint at baseline, 3 weeks and 3 month after using this type of splint. The mean scores of PRI were 74.13 ± 23.52, 31.25 ± 11.57 and 6.88 ± 4.85 respectively.

When comparing the mean difference of PRI scores of the patients with TMD before using the canine guidance stabilization splint (baseline) with 3 weeks and 3 month after using the splint, the result showed that there was a significant difference of reduction of PRI scores after 3 weeks and 3 month following the splint therapy t (p_1) 0.012 and t (p_1) 0.012 respectively (*Figures 2A and 2B*).

On comparing the PRI mean scores 3 weeks and 3 month after using the splint therapy, there was a significant reduction in the amount of dysfunction t(p_2) 0.012.

In addition, *Table 1* showed also the results of PRI mean scores of the eight patients with TMD (group 2) before using the bilateral balanced occlusion stabilization splint as a base line, 3 weeks and 3 month after using the splint. The mean scores of PRI were 75.75 ± 25.14, 48.38 ± 20.37 and 48.38 ± 20.37 respectively.

When comparing the mean scores of these patients with TMD before using the bilateral balanced Occlusion Stabilization Splint (baseline) with 3 weeks and 3 month after using the splint therapy, the results showed that there was a significant difference of reduction of PRI scores after 3 weeks and 3 month following the splint therapy t (p_1) 0.012 and t (p_1) 0.012 respectively (*Figures 3A and 3B*).

When comparing the PRI mean scores between 3 weeks with 3 month after using the Balanced Occlusion Stabilization Splint there was no statistical significant difference in the amount of dysfunction t(p_2) 1.000.

When comparing the mean difference of PRI scores among patients of group 1 and group 2, the result showed that there was no statistical significant difference of reduction PRI scores between the two groups before splint use and 3 weeks after using the 2 different types of splints, t (p) 1.000 and 0.080 respectively.

While on comparing the mean difference of PRI scores among the two groups after 3 month of 2 different types of splints, there was statistical significant difference t(p) 0.001.

Discussion

The use of occlusal splints is one of the most widely accepted methods of treatment for the signs and symptoms of TMD [19,26]. Clinical reports suggest that stabilization splints are useful for treatment of pain on TMD, [14,27,28] masticatory muscles [29,30] or both. Researches do not agree, however, on how the splints work or which would be a better occlusal design [31,32].

The hard type stabilization splint was selected in this study for its superior benefit than the soft appliance referenced by many authors in previous study who concluded that the use of soft stabilization appliances result in occlusal changes, [33] increase pain and increase nocturnal electromyographic recordings compared with hard splints [34]. Splint in this study was fabricated on the mandibular arch for reasons of enhanced esthetics and less effect on speech [23].

The evidence from various studies suggests no differences in reduction of symptoms between either of these 2 designs (maxillary or mandibular SS) [35]. The appliance is fabricated so that the opposing dentition occludes uniformly, evenly, and

Table 1. *Comparison between the two studied groups according to Helkimo dysfunction index (HDI) and to Pantographic reproducibility index scores (PRI).*

Type of test	Type of group		Baseline before splint using	3 weeks after splint using	3 month after splint using	χ^2p
HDI	**Group 1**	**Canine guidance stabilization splint**				
		Min. – Max.	6.0 – 22.0	1.0 – 8.0	0.0 – 2.0	<0.001*
		Mean ± SD.	13.0 ± 6.44	3.88 ± 2.36	0.50 ± 0.93	
		Median	12.0	3.50	0.0	
PRI		p_1		0.012*	0.012*	
		p_2		0.012*		
		Canine guidance stabilization splint				
		Min. – Max.	52.0 – 123.0	16.0 – 50.0	3.0 – 16.0	<0.001*
		Mean ± SD.	74.13 ± 23.52	31.25 ± 11.57	6.88 ± 4.85	
		Median	67.50	32.0	5.0	
		p_1		0.012*	0.012*	
		p_2		0.012*		
HDI	**Group 2**	**Bilateral balanced stabilization splint**				
		Min. – Max.	7.0 – 25.0	3.0 – 16.0	0.0 – 4.0	<0.001*
		Mean ± SD.	13.75 ± 7.25	7.38 ± 4.81	1.75 ± 1.91	
		Median	12.0	6.0	1.50	
		p_1		0.011*	0.011*	
		p_2		0.011*		
PRI		**Bilateral balanced stabilization splint**				
		Min. – Max.	52.0 – 123.0	30.0 – 80.0	30.0 – 80.0	<0.001*
		Mean ± SD.	75.75 ± 25.14	48.38 ± 20.37	48.38 ± 20.37	
		Median	67.50	42.0	42.0	
		p_1		0.012*	0.012*	
		p_2		1.000		
P for HDI		**P**	0.790	0.102	0.146	
P for PRI		**P**	1.000	0.080	0.001*	

p: p value for Mann Whitney test for comparing between the two studied groups
χ^2: Chi square for Friedman test for comparing between different periods
p_1: p value for Wilcoxon signed ranks test for comparing between baseline before splint using and each other periods
p_2: p value for Wilcoxon signed ranks test for comparing between 3weeks after splint using and 3months after splint using
*: Statistically significant at $p \leq 0.05$

simultaneously with the occluding surface of the appliance [19,22,23].

Despite reports of high rates of clinical success of full-coverage stabilization splints on the reduction of TMD signs and symptoms, little is known about their efficacy, especially concerning the effects of lateral and protrusive guidance. In this study, we evaluated the efficacy of occlusal design of stabilization splints with bilateral balanced guidance in the treatment of TMD compared with a traditional splint with canine guidance during excursive movements.

Moreover, this study evaluate aspects of the management of TMD, it was decided to record each patient's subjective response to treatment (splint therapy) using Helkimo dysfunction index (HDI) and in addition to objective method using pantographic reproducibility index (PRI) as predictor of the treatment outcome.

This assumption was based on previous studies that showed PRI was effective aid in detecting the TMD and symptoms of muscle uncoordination [6,9-11].

The result of this study revealed that, individuals wearing stabilization splints in both groups reported a significant improvement in the TMD symptoms. The within group analysis demonstrated a significant decrease in the clinical symptoms monitored by HDI scores and PRI scores after 3 weeks of wearing the stabilization splint in comparison with the baseline and the same occurred after 3 months in comparison with 3 weeks.

This result may be attributed to improvement in stability of the occlusion by elimination of supra and infra occlusal contacts, so increase of the extent of occlusal contacts. It suggested that the elimination of occlusal interferences by stabilization splint therapy caused reduction in muscular activity and the coordination observed in the tracings of mandibular movements in all patients in the study must be considered an important factor in effecting a more rapid remission of TMD symptoms.

The study is in agreement with some authors who reported that stabilization devices are well documented as an effective modality in the management of masticatory muscle pain [36,37]. The possible mechanisms of action of this modality

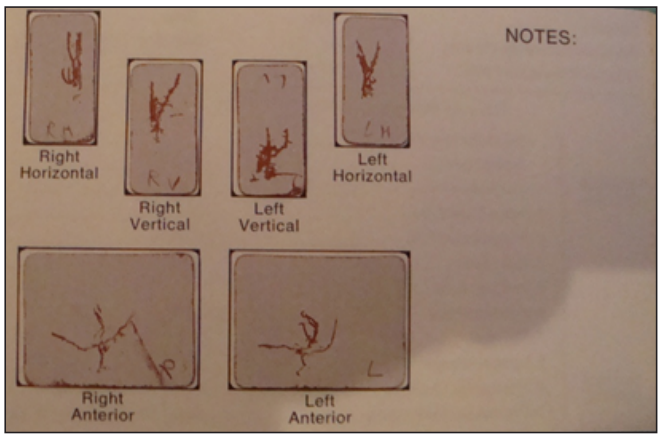

Figure 2A. *Initial pantographic tracing for a subject before using the stabilization splint with canine guidance during excursive movements. The tracings shows increase in width of lines and multiple lines of uncoordinated muscle movements.*

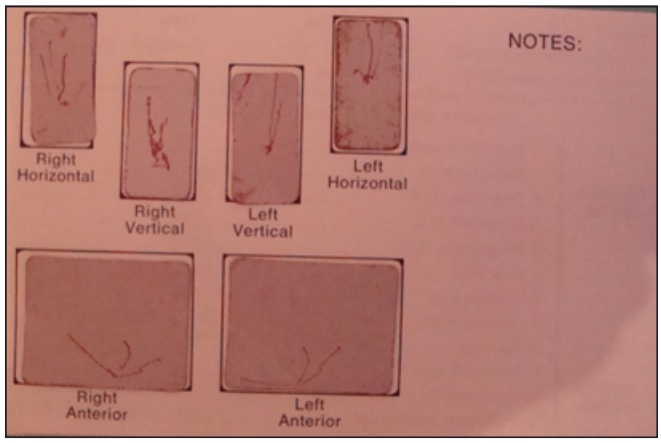

Figure 2B. *Pantographic tracing for the same subject 3 months after using the stabilization splint with canine guidance during excursive movements. The tracings represent coordination of muscle movements*

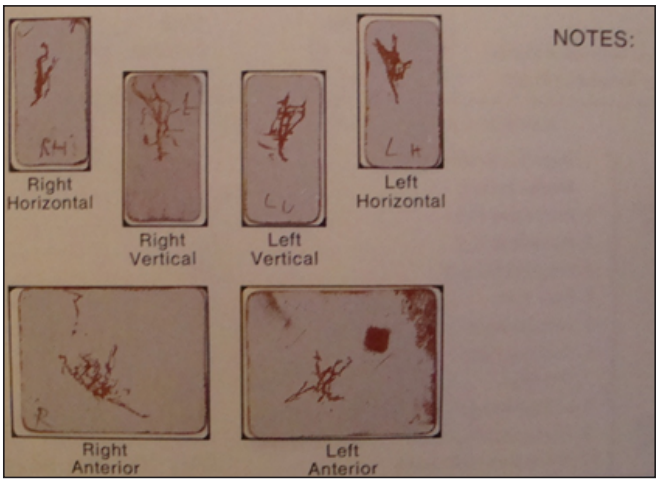

Figure 3A. *Initial pantographic tracing for a subject before using the stabilization splint with bilateral balanced stabilization splint during excursive movements. The tracings shows increase in width of lines and multiple lines of uncoordinated muscle movements.*

are listed as follows: the re-establishment of a proper occlusal relationship and a stable physiological mandibular posture, the cognitive effect, making the patient aware of oral Para functional habits, the reduction in muscular activity, and the placebo effect. The actual results are likely due to a combination of all of these mechanisms [4,5,15,18,22,23,38-41].

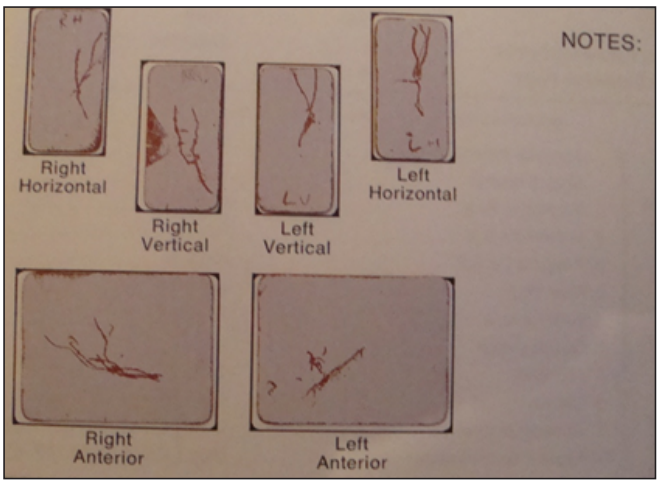

Figure 3B. *Pantographic tracing for the same subject 3 months after using the bilateral balanced stabilization splint during excursive movements. The tracings represent coordination of muscle movements.*

The improvement of TMD symptoms in group II as monitored by HDI scores and PRI scores may be due to that in the lateral position with bilateral balanced stabilization splint, the pressure is distributed over a larger periodontal surface and this could help joint protection which manifested by the reduction of clinical symptoms by HDI and the coordination mandibular movements recorded by PRI.

Studies have found that the use of bilateral balanced stabilization splint in patients with disk displacement, the contact on the non working side would decrease the load transmitted to the TMJ at the contralateral side therefore provide more stability to the joints, especially during tooth clenching on the canine edge to edge position. This decreased joint loading could improve and enhance the healing process in patients with signs and symptoms of TMJ pain [5].

There was statistical significant difference in HDI scores and PRI scores of both groups in all time intervals except between 3weeks and 3 months after using bilateral balanced stabilization splint therapy, the result showed that there was no significant difference in the PRI scores of both groups.

These results may be due to laterotrusive position with canine guidance stabilization splint in contrast to bilateral balanced stabilization splint produced significant reduction in the muscle activity and more effectively protected against excessive forces which cause unphysiologic muscle tension in eccentric position where the subject can trace reproducible mandibular border movement as recorded by the pantograph through PRI. This means that the canine guidance stabilization splint causes more significant reduction in the PRI score so provides more improvement of TMD symptoms.

Our result is in agreement with some authors who reported that the role of the canine guidance in splints to decrease muscle activity and pain has to be considered.

Their studies on mechanosensitivity thresholds of the teeth demonstrate that the canines possess a much higher pressure sensitivity and stereo tactility-in other words, an essentially finer sensitivity than posterior teeth. Because these are the first teeth to contact in lateral movements, the canines can take over regulatory functions and act as an important protective mechanism against excessive forces [5,42].

Furthermore, in the laterotrusion with canine guidance

(with an only occlusal contact between the canine and the splint), the mandible is in a much less stable position. This could be a reason for the more improvements and the progressive reduction in the TMD symptoms as manifested by the coordination of mandibular movements by the pantographic tracings [42].

Moeller [43] observed that the fewer the occlusal contacts, the less was the amount of elevator muscle activity. Conversely, a multiplicity of occlusal contact points resulted in higher activity.

Other studies have found that mechanoreceptors in the periodontal ligaments of canine teeth could produce a measurable reduction in the contraction of elevator muscles [42,44,45]. This observed reduction in muscle contraction, if caused by these receptors, could be responsible for the decreased intra-articular pressure in patients using also bilateral balanced splints to level similar to what the mechanical configuration of the canine guidance stabilization splints could produce [5].

Although the mean scores of HDI and PRI in both groups under investigation showed significant reduction in the amount of dysfunction after 3 months of using different occlusal design stabilization splints (bilateral balanced and canine guidance stabilization splints), there was no significant difference in HDI scores and PRI scores between both groups at different time intervals. However, the results also reported that there was significant difference in the amount of dysfunction recorded by PRI scores between the two studied groups after 3 months of splint therapy. These results indicated that the pantographic tracings and PRI scores provide a graphic and quantitative method used to determine (monitor) the success of occlusal splint between changes in PRI scores between the two groups after 3 months.

Ledermann and Clayton [46] concluded that the PRI indicated the presence of Temporomandibular Joint (TMJ) dysfunction in 70% of patients with no subjective complaints, indicating that patients do not always know that they have Temporomandibular joint dysfunction, so the pantographic reproducibility index was more reliable than clinical and subjective signs or symptoms in detecting TMJ dysfunction specially in the slight dysfunction category.

Conclusion

Patients with signs and symptoms of Temporomandibular disorders ,the occlusal design of the stabilization splint could affect and provide improvement of TMD. All subjects had general improvement in the Helkimo dysfunction index scores and pantographic reproducibility index scores. Subjects with canine guidance stabilization splint group had better results than subjects with bilateral balanced stabilization splint group. It can be concluded that the canine guidance stabilization splint produces significant reduction in the TMD symptoms than bilateral balanced stabilization splint, therefore, canine guidance Stabilization splints should probably be included in eccentric position (with an only occlusal contact between the canine and the splint).The pantographic tracing through (PRI) is considered an important diagnostic objective method to monitor the success of occlusal splint therapy through the tracing of the functional capability of mandibular movements.

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