Influence of the vertical dimension in the treatment of myofascial pain-dysfunction syndrome

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The occlusal splint is an accepted method of treatment for bruxism and myofascial pain-dysfunction (MPD) syndrome. Its use results in the decrease of pain and muscular spasm caused by hyperactivity of the mandibular muscles, especially of elevators.[1-4] The amount of occlusal opening required to produce the desired relief of symptoms has not been specifically defined. It has been suggested but also refuted that the occlusal splint opening should not exceed the postural or rest position of the mandible.

Goepfert and Goepfert[5] and Garnick and Ramfjord[6] demonstrated that the tonic electromyographic (EMG) activity of the masseter and temporal muscles decreases when the mandible is opened beyond the postural or resting position. They were not able, however, to determine a vertical dimension of least EMG activity. Garnick and Ramfjord[6] concluded that there is no electromyographically defined mandibular postural position but there is a resting range of 11.1 mm for the muscles studied.

Storey,[7] Garret et al.,[8] Manns and Spreng,[9] and Manns et al.[10] studied the relationship between vertical dimension and bite force during voluntary isometric contractions. They observed a decrease in EMG activity of the masseter and temporal muscles when the vertical dimension was increased beyond the postural position. Recently, Manns et al.[11,12] studied the relationship between basal tonic electromyographic (BT-EMG) activity and variations of vertical dimension in patients with normal function of the stomatognathic system and in patients with bruxism and MPD syndrome. Through static and dynamic variations of the vertical dimension, the exact site where minimum BT-EMG activity of the masseter muscle occurred was determined to be at a mean of 10 mm interocclusal distance in normal function and a mean of 8.45 mm in MPD syndrome. Results showed a gradual decrease of EMG activity from the occlusal position to a maximum reduction at a certain range of interocclusal distance. This minimal activity was followed by a gradual increase to the highest values near maximum mandibular opening. Therefore, a greater decrease in EMG activity was noted at a vertical dimension closer to the interocclusal distance. Rugh and Drago[13] also observed the least BT-EMG activity within a range of 4.5 to 12.6 mm in eight patients studied.

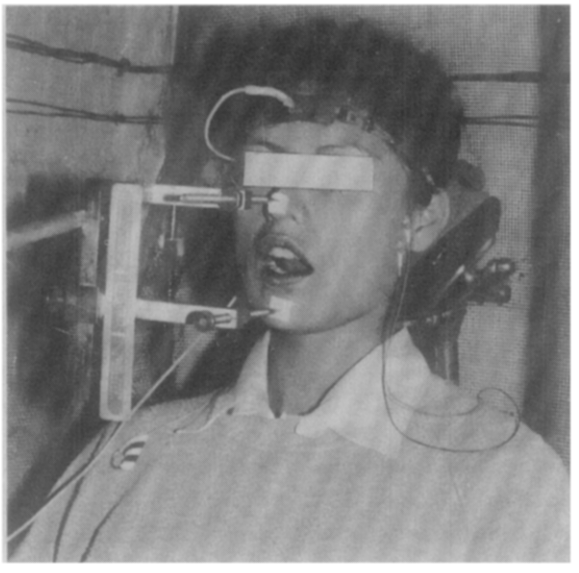

Fig. 1. Faraday cage is used to determine vertical dimension of least EMG activity.

Because of the potential increase or decrease in BT-EMG activity with changes in vertical dimension, use of occlusal splints to treat muscle spasm in MPD syndrome could result in an increase rather a decrease in symptoms. This study will evaluate the influence of the vertical dimension in the reduction of the symptoms of MPD syndrome by means of occlusal splints adjusted at different occlusal openings.

Supported by Servicio Desarrollo Científico, Artístico y de Cooperación Internacional Grant No. M-533791.

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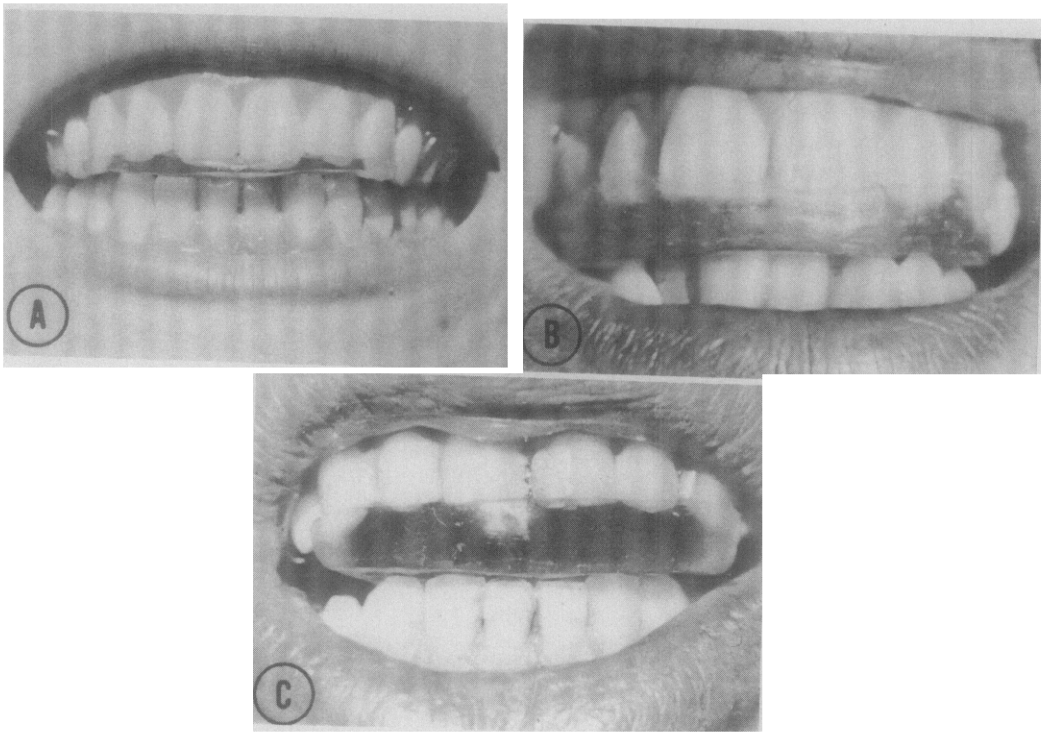

Fig. 2. Occlusal splints are shown for patients of groups I **(A)**, II **(B)**, and III **(C)**. Group I shows least amount of increase in vertical dimension, and group III shows greatest increase.

MATERIAL AND METHODS

Seventy-five patients, nine men and 66 women with ages ranging from 13 to 53 years, were selected for this study. Patients were selected on the basis of[3, 14-17] (1) spontaneous preauricular facial pain, (2) moderate to severe tenderness to palpation of the elevator muscles, (3) changes in mandibular movement evidenced by mandibular deviation and/or restricted mandibular opening, (4) clicking or popping sounds of the temporomandibular joints (TMJ), and (5) bruxing or clenching of the teeth. Patients who had previously used an occlusal splint, showed radiographic changes of the TMJ, or used removable prostheses were not included.

A maxillary occlusal splint was made with heat-polymerized acrylic resin. It had a flat occlusal surface with a stable unlocked contact in centric occlusion with anterior and cuspid guidance. Disclusion of the posterior teeth was evident during requested and functional jaw movements. The splint was used 3 hours daily and continuously at night for 3 weeks.

The vertical dimension of minimum BT-EMG activity or "neuromuscular resting vertical dimension" was determined for each patient according to the technique described by Manns et al.[11] (Fig. 1). Bipolar surface electrodes (Grass 5e 5s, Grass Instrument Co., Quincy, Mass.) were placed on the masseter muscle for EMG recordings.[18, 19] EMG activity was filtered (80 Hz to 100 kHz), amplified 1,000 times, reamplified 10 to 50 times, integrated (time constant, 1,800 msec), and registered on a polygraph (Nihon Kohden RJG-4022, Nihon Kohden Kogyo Co. Ltd., Tokyo, Japan). The masseter muscle was used because it shows a more circumscribed EMG activity decrease than the temporal muscle.[11]

The patients were randomly divided into three groups according to the vertical dimension at which the occlusal splint was made (Fig. 2).

Group I. Group I included 25 patients with splints made at an increased vertical dimension of 1 mm. The group included three men and 22 women aged 13 to 52 years.

Group II. This group was composed of 25 patients with splints made at a vertical dimension equal to one half the difference between the occlusal vertical dimension and the vertical dimension of least BT-EMG activity of the masseter muscle. Group II included four men and 21 women aged 15 to 52 years. The average increase in vertical dimension was 4.42 mm.

Group III. Group III included 25 patients with

Table I. Patient evaluation of signs and symptoms of MPD syndrome graded on a scale of 0 to 3 (0 = absence of symptoms, 3 = greatest degree of symptoms)

Group No.	Control sessions		Mandibular deviation	Cranial pain	Facial pain	Neck pain	TMJ pain	Headache	Right articular clicking	Left articular clicking	Neck clicking	Restricted opening
I	Initial	$\bar{X}$	3.00	2.52	2.88	2.28	2.64	2.76	2.76	2.64	1.32	1.08
		SE	0.00	0.22	0.12	0.26	0.19	0.16	0.16	0.19	0.30	0.29
N = 25	24 hours	$\bar{X}$	2.92	1.60	2.16	1.68	2.08	1.76	2.64	2.56	1.04	0.76
		SE	0.05	0.28	0.22	0.27	0.25	0.27	0.18	0.20	0.28	0.24
	72 hours	$\bar{X}$	2.60	1.28	1.64	1.08	1.36	1.60	2.52	2.44	0.80	0.48
		SE	0.15	0.25	0.22	0.27	0.23	0.23	0.18	0.20	0.26	0.20
	First week	$\bar{X}$	2.60	1.12	1.20	0.92	0.96	1.48	2.32	2.28	0.52	0.20
		SE	0.12	0.22	0.20	0.20	0.21	0.23	0.18	0.22	0.22	0.11
	Second week	$\bar{X}$	2.24	0.84	1.00	0.76	0.88	1.00	2.12	2.04	0.36	0.16
		SE	0.15	0.22	0.22	0.21	0.20	0.23	0.19	0.19	0.18	0.12
	Third week	$\bar{X}$	2.12	0.64	0.84	0.52	0.88	0.92	1.76	1.88	0.32	0.12
		SE	0.19	0.18	0.21	0.18	0.18	0.21	0.22	0.21	0.18	0.12
II	Initial	$\bar{X}$	3.00	2.40	3.00	2.04	3.00	3.00	2.40	2.40	1.80	1.08
		SE	0.00	0.24	0.00	0.28	0.00	0.00	0.24	0.24	0.30	0.29
N = 25	24 hours	$\bar{X}$	3.00	1.28	1.80	1.04	1.88	1.60	2.04	2.04	1.28	0.92
		SE	0.00	0.24	0.25	0.26	0.24	0.26	0.26	0.27	0.29	0.27
	72 hours	$\bar{X}$	2.80	0.84	1.40	0.92	1.28	1.32	1.84	2.00	0.56	0.32
		SE	0.12	0.22	0.21	0.23	0.22	0.24	0.25	0.25	0.23	0.17
	First week	$\bar{X}$	2.68	0.40	0.96	0.60	0.64	0.92	1.84	1.80	0.44	0.08
		SE	0.13	0.14	0.19	0.20	0.20	0.25	0.23	0.25	0.20	0.08
	Second week	$\bar{X}$	2.44	0.24	0.40	0.40	0.44	0.68	1.44	1.52	0.12	0.08
		SE	0.18	0.13	0.11	0.17	0.13	0.21	0.20	0.20	0.12	0.08
	Third week	$\bar{X}$	2.12	0.16	0.20	0.32	0.28	0.44	1.12	1.16	0.12	0.08
		SE	0.21	0.12	0.10	0.17	0.12	0.16	0.22	0.22	0.12	0.08
III	Initial	$\bar{X}$	3.00	2.40	2.64	2.76	2.88	2.88	2.16	2.64	1.80	0.96
		SE	0.00	0.24	0.19	0.16	0.12	0.12	0.27	0.19	0.30	0.28
N = 25	24 hours	$\bar{X}$	2.92	1.40	1.32	1.52	1.76	1.40	1.92	2.28	1.32	0.64
		SE	0.05	0.28	0.26	0.25	0.22	0.28	0.27	0.22	0.28	0.22
	72 hours	$\bar{X}$	2.84	0.88	1.08	1.04	1.28	1.20	1.96	1.92	0.96	0.48
		SE	0.09	0.23	0.25	0.21	0.22	0.25	0.24	0.25	0.25	0.20
	First week	$\bar{X}$	2.68	0.52	0.56	0.80	0.52	0.40	1.60	1.76	0.92	0.32
		SE	0.11	0.17	0.17	0.19	0.17	0.17	0.25	0.25	0.25	0.16
	Second week	$\bar{X}$	2.36	0.28	0.12	0.64	0.40	0.48	1.08	1.32	0.52	0.32
		SE	0.19	0.14	0.06	0.16	0.10	0.19	0.22	0.24	0.19	0.16
	Third week	$\bar{X}$	2.26	0.24	0.04	0.36	0.28	0.40	0.96	1.20	0.40	0.24
		SE	0.19	0.14	0.04	0.15	0.12	0.15	0.22	0.24	0.17	0.14

splints made at the vertical dimension of least BT-EMG activity of the masseter muscle. This group included two men and 23 women 15 to 53 years of age. The average increase in vertical dimension was 8.15 mm.

Clinical symptoms were evaluated subjectively and objectively prior to fabrication of the occlusal splint and 24 hours, 72 hours, 1 week, 2 weeks, and 3 weeks after use of the occlusal splint. To maintain a double-blind study, different authors participated in the two phases of evaluation.

Subjectively, a clinical questionnaire was given to each patient in which he or she was asked to rate each of 21 signs and symptoms of MPD syndrome. The patients were asked to rank each sign or symptom on a scale of 0 to 3 (0 = absent, 1 = marked improvement, 2 = slight improvement, and 3 = present).

Based on the scale of 0 to 3, a mean value for degree of presence was recorded for each of the 21 signs and symptoms of the clinical questionnaire per session and for each group. In addition, a mean value and frequency of occurrence (3 = 100%) of the total of 21 signs and symptoms of the clinical questionnaire were expressed on the scale of 0 to 3 in each session and for each group (Table I).

Objectively, the masticatory muscles, neck muscles,

Masticatory disturbance	Matutinal muscular fatigue	Vespertine muscular fatigue	Nocturnal muscular fatigue	Hearing loss	Tinnitus	Dizziness	Dysphagia	Diurnal bruxism	Nocturnal bruxism	Interpositional habits	$\bar{X}$ SE	% SE
2.52	2.64	2.52	1.92	1.44	2.64	2.64	1.56	2.64	3.00	3.00	2.40	80.00
0.22	0.19	0.22	0.29	0.30	0.19	0.19	0.30	0.19	0.00	0.00	0.12	4.00
2.20	1.72	2.32	1.52	1.20	0.64	1.12	1.08	2.32	2.84	2.96	1.86	62.00
0.24	0.27	0.24	0.28	0.28	0.23	0.28	0.29	0.24	0.12	0.04	0.15	5.00
2.04	1.32	1.40	1.00	1.00	1.36	0.96	0.96	2.28	2.68	2.40	1.58	52.60
0.22	0.27	0.27	0.26	0.27	0.29	0.26	0.27	0.24	0.13	0.20	0.14	4.60
1.56	1.04	0.88	0.56	0.80	0.96	0.92	0.68	1.84	2.32	1.40	1.26	42.00
0.23	0.23	0.21	0.20	0.26	0.25	0.27	0.23	0.21	0.19	0.22	0.14	4.60
1.04	0.48	0.72	0.68	0.80	0.92	0.92	0.68	1.48	2.00	0.76	1.04	34.60
0.24	0.20	0.21	0.21	0.24	0.25	0.26	0.23	0.21	0.24	0.21	0.12	4.00
0.72	0.48	0.76	0.36	0.68	0.60	1.08	0.60	1.20	1.84	0.52	0.89	29.60
0.22	0.19	0.21	0.16	0.22	0.24	0.26	0.23	0.22	0.24	0.18	0.12	4.00
2.52	3.00	2.64	2.04	1.44	2.64	2.88	0.96	2.88	3.00	2.64	2.41	80.30
0.22	0.00	0.19	0.28	0.30	0.19	0.12	0.28	0.12	0.00	0.20	0.13	4.30
2.24	1.96	1.76	1.60	1.04	0.96	1.08	0.64	2.32	2.96	2.28	1.70	56.60
0.26	0.26	0.29	0.29	0.28	0.26	0.28	0.24	0.20	0.04	0.24	0.14	4.60
1.84	1.20	0.76	0.56	0.60	0.84	0.60	0.32	1.92	2.52	1.60	1.24	41.30
0.28	0.26	0.23	0.20	0.22	0.24	0.22	0.18	0.23	0.18	0.25	0.15	5.00
1.04	0.80	0.36	0.56	0.32	0.64	0.32	0.24	1.36	1.96	1.04	0.90	30.00
0.27	0.22	0.14	0.20	0.16	0.20	0.13	0.16	0.23	0.18	0.21	0.14	4.00
0.72	0.64	0.28	0.32	0.12	0.44	0.16	0.12	1.12	1.52	0.80	0.66	22.00
0.22	0.21	0.14	0.17	0.08	0.18	0.09	0.08	0.21	0.23	0.21	0.13	4.30
0.44	0.32	0.16	0.24	0.12	0.36	0.36	0.12	0.92	1.16	0.60	0.51	17.00
0.19	0.14	0.12	0.13	0.08	0.17	0.18	0.12	0.21	0.24	0.20	0.11	3.60
2.40	2.88	1.80	1.68	1.68	2.28	2.52	1.56	2.88	3.00	2.76	2.36	78.66
0.24	0.12	0.30	0.30	0.30	0.06	0.22	0.30	0.12	0.00	0.16	0.12	4.00
2.04	1.52	1.16	1.00	1.44	0.88	1.16	0.88	2.56	2.72	2.40	1.63	54.33
0.24	0.28	0.27	0.27	0.27	0.26	0.28	0.26	0.17	0.13	0.22	0.14	4.60
1.40	1.24	0.72	0.68	1.36	0.92	0.64	0.48	1.88	2.48	1.68	1.29	43.00
0.25	0.22	0.22	0.22	0.28	0.25	0.23	0.20	0.25	0.20	0.25	0.13	4.30
0.84	0.64	0.32	0.36	1.08	0.68	0.64	0.36	1.32	2.00	0.88	0.91	30.33
0.18	0.19	0.14	0.17	0.26	0.21	0.23	0.16	0.21	0.17	0.21	0.13	4.30
0.44	0.32	0.20	0.12	0.88	0.44	0.40	0.20	1.04	1.80	0.48	0.65	21.66
0.16	0.13	0.12	0.06	0.26	0.19	0.17	0.11	0.19	0.20	0.18	0.12	4.00
0.28	0.24	0.12	0.16	1.00	0.28	0.32	0.32	0.56	1.36	0.36	0.54	18.00
0.12	0.14	0.06	0.12	0.26	0.16	0.18	0.14	0.18	0.26	0.16	0.11	3.60

and the TMJ were examined by palpating and quantifying the bilateral tenderness to palpation (Table II). Each response was graded according to severity on a scale of 0 to 5 (0 = absent, 1 = slight, 2 = slight to moderate, 3 = moderate, 4 = moderate to severe, and 5 = severe).

Based on the scale of 0 to 5, a mean value for tenderness was recorded for each muscle and the TMJ per session and for each group. A mean value and relative severity (5 = 100%) of all muscle joint symptoms (seven muscles and the TMJ) were also expressed on the scale of 0 to 5 for each session and for each group (Table II).

RESULTS

Clinical questionnaire

When the mean values of all 21 signs and symptoms of the clinical questionnaire (expressed as a percentage) are compared (Fig. 3), a gradual decrease in symptoms from the initial to the last session for the three treatment groups is noted. This is especially evident in groups II and III, where a 50% reduction of initial symptoms of groups II and III was more rapid than that occurring in group I. Groups II and III experienced a 50% decrease in symptoms 72 hours after use of an occlusal splint. Group I required 1 week of splint use to experience a comparable result.

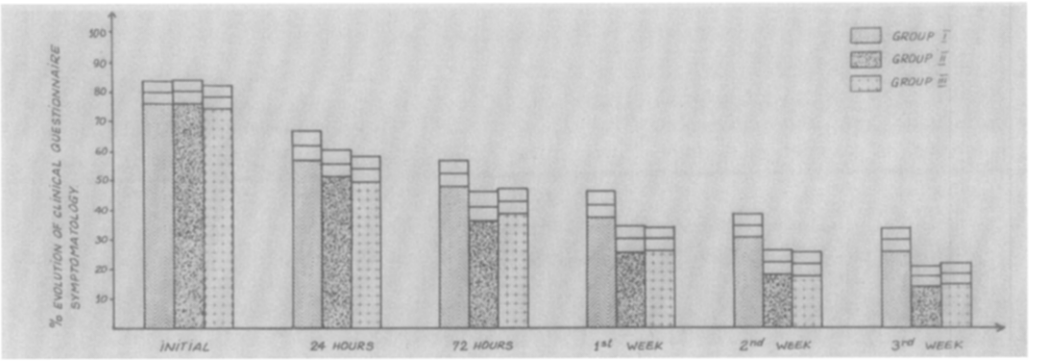

Fig. 3. Comparison of total symptoms (measured by clinical questionnaire) among three treatment groups with MPD syndrome.

Table II. Operator evaluation of tenderness to palpation of muscles and TMJ on a scale of 0 to 5 (0 = absence of tenderness, 5 = severe tenderness)

Group No.		Initial		24 hours		72 hours		First week		Second week		Third week	
		$\bar{X}$ ± SE		$\bar{X}$ ± SE		$\bar{X}$ ± SE		$\bar{X}$ ± SD		$\bar{X}$ ± SD		$\bar{X}$ ± SD	
I	Masseter	4.46	0.13	4.02	0.17	3.20	0.25	2.33	0.25	1.62	0.24	1.11	0.19
N = 25	Temporal	4.11	0.21	3.80	0.24	2.98	0.28	2.35	0.32	1.92	0.33	1.22	0.29
	Medial pterygoid	4.25	0.12	3.92	0.15	3.37	0.14	2.96	0.18	2.52	0.18	1.67	0.17
	Lateral pterygoid	4.56	0.17	4.44	0.18	3.90	0.27	3.30	0.30	3.02	0.34	2.72	0.30
	Digastric	2.68	0.24	2.59	0.24	1.91	0.24	1.40	0.19	1.16	0.18	0.86	0.15
	Sternomastoid	3.34	0.28	3.00	0.27	2.48	0.28	1.97	0.28	1.61	0.29	1.15	0.24
	Trapezius	4.33	0.11	4.21	0.12	3.75	0.13	3.20	0.18	2.95	0.20	2.51	0.21
	TMJ	3.36	0.17	3.04	0.18	2.53	0.21	2.05	0.20	1.76	0.19	1.32	0.17
	$\bar{X}$ ± SE	3.88	0.23	3.62	0.20	3.01	0.24	2.44	0.23	2.07	0.24	1.57	0.24
	%	77.60	4.60	72.50	4.00	60.20	4.80	48.80	4.60	41.40	4.80	31.40	4.80
II	Masseter	4.47	0.13	3.70	0.16	2.55	0.24	1.75	0.24	0.97	0.21	0.52	0.15
N = 25	Temporal	4.11	0.16	3.09	0.23	2.06	0.19	1.38	0.24	0.95	0.25	0.35	0.15
	Medial pterygoid	4.28	0.10	3.84	0.13	2.72	0.16	1.89	0.16	1.30	0.12	0.73	0.10
	Lateral pterygoid	4.58	0.12	4.52	0.13	3.96	0.19	3.18	0.27	2.36	0.27	1.44	0.23
	Digastric	2.85	0.15	2.28	0.20	1.47	0.15	0.99	0.16	0.67	0.14	0.26	0.07
	Sternomastoid	3.55	0.22	2.68	0.26	1.77	0.20	1.21	0.23	0.75	0.16	0.45	0.14
	Trapezius	4.27	0.12	3.61	0.13	3.16	0.14	2.84	0.17	2.25	0.17	1.60	0.16
	TMJ	3.29	0.15	2.65	0.17	1.83	0.15	1.34	0.15	1.04	0.12	0.56	0.09
	$\bar{X}$ ± SE	3.92	0.21	3.29	0.26	2.44	0.29	1.82	0.27	1.28	0.23	0.73	0.17
	%	78.40	4.20	65.80	5.20	48.80	5.80	36.40	5.40	25.60	4.60	14.60	3.40
III	Masseter	4.30	0.15	3.16	0.23	2.44	0.27	1.37	0.21	0.75	0.17	0.33	0.10
N = 25	Temporal	4.03	0.21	2.96	0.26	2.22	0.27	1.22	0.22	0.74	0.19	0.33	0.11
	Medial pterygoid	4.14	0.13	3.35	0.13	2.68	0.17	1.61	0.14	1.06	0.13	0.61	0.10
	Lateral pterygoid	4.56	0.16	4.04	0.24	3.64	0.22	2.74	0.24	2.18	0.19	1.50	0.16
	Digastric	2.48	0.25	1.70	0.24	1.22	0.17	0.65	0.12	0.34	0.08	0.13	0.04
	Sternomastoid	3.36	0.26	2.59	0.27	2.01	0.30	1.32	0.24	0.80	0.17	0.35	0.12
	Trapezius	3.85	0.13	3.36	0.15	3.00	0.16	2.43	0.18	2.03	0.19	1.32	0.17
	TMJ	3.44	0.17	2.64	0.19	2.03	0.19	1.56	0.18	1.26	0.15	0.73	0.11
	$\bar{X}$ ± SE	3.77	0.23	2.97	0.24	2.40	0.25	1.61	0.23	1.14	0.22	0.66	0.17
	%	75.40	4.60	59.40	4.80	48.00	5.00	32.20	4.60	22.80	4.40	13.20	3.40

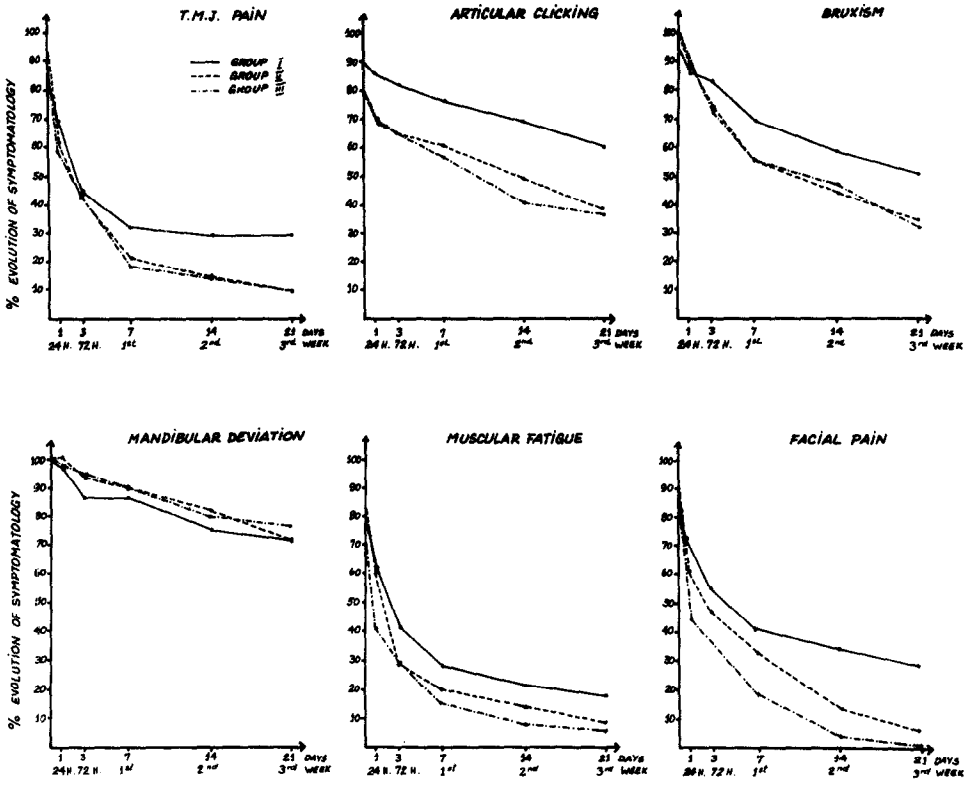

Fig. 4. Subjective progress of six most important signs or symptoms is shown in three treatment groups.

Table III. Comparison of initial and final symptoms as rated by each group of patients

Group No.	Initial		Final		Initial vs. final		
	% SE	*t* value	% SE	*t* value	% SE	% SE	*t* value
I	80.00 ± 4.00	(I-II: −0.06)	29.66 ± 4.00	(I-II: 2.40*)	80.00 ± 4.00	29.66 ± 4.00	(I-I: 9.15†)
II	80.33 ± 4.33	(II-III: 0.29)	17.00 ± 3.66	(II-III: −0.19)	80.33 ± 4.33	17.00 ± 3.66	(II-II: 11.49†)
III	78.66 ± 4.00	(I-III: 0.24)	18.00 ± 3.66	(I-III: 2.21*)	78.66 ± 4.00	18.00 ± 3.66	(III-III: 11.51†)

*$p < .05$.
†$p < .001$.

When initial symptoms among the three groups are compared, no statistical differences are noted (Table III). In contrast, when the final symptoms among the three groups are compared, significant differences between groups I and II and between groups I and III are noted but no significant difference is found between groups II and III. Furthermore, when initial symptoms are compared with final symptoms in each of the three groups, the difference is highly significant in all groups.

When the six most important signs or symptoms of the clinical questionnaire were evaluated, the time of occlusal splint use required to obtain a 50% reduction in initial symptoms was noted (Fig. 4). To obtain a 50% reduction in symptoms, group I patients required a time lapse of 72 hours for muscle fatigue and TMJ pain, between 72 hours and 1 week for facial pain, and 3 weeks for bruxism. There was no 50% reduction in clicking or popping of the TMJ or in the degree of mandibular deviation by the end of the study. To obtain a 50% reduction in symptoms, group II patients required a time lapse of between 24 and 72 hours for muscle fatigue and TMJ pain, 72 hours for facial pain, between 1 and 2 weeks for bruxism, and between 2 and 3 weeks for clicking or popping of the TMJ. There was no 50% reduction in mandibular deviation by the

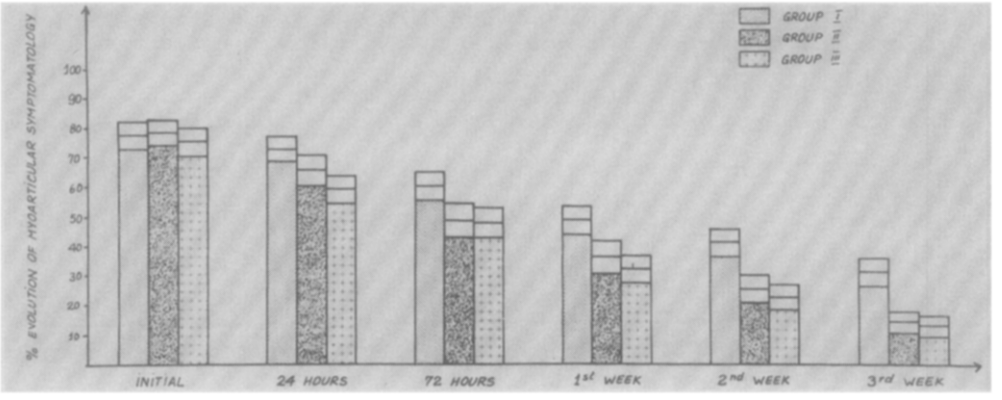

Fig. 5. Comparison of muscle and joint tenderness to palpation of three groups of patients with MPD syndrome.

Table IV. Comparison of initial and final muscle-joint tenderness to palpation found in each group of patients

Group No.	Initial		Final		Initial vs. final		
	% SE	*t* value	% SE	*t* value	% SE	% SE	*t* value
I	77.60 ± 4.60	(I-II: −0.12)	31.40 ± 4.80	(I-II: 2.86*)	77.60 ± 4.60	31.40 ± 4.80	(I-I: 69.5‡)
II	78.40 ± 4.20	(II-III: 0.48)	14.60 ± 3.40	(II-III: 0.29)	78.40 ± 4.20	14.60 ± 3.40	(II-II: 11.83‡)
III	75.40 ± 4.60	(I-III: 0.33)	13.20 ± 3.40	(I-III: 3.10†)	75.40 ± 4.60	13.20 ± 3.40	(III-III: 10.89‡)

*$p < .05$.
†$p < .02$.
‡$p < .001$.

end of the study. To obtain a 50% reduction in symptoms, group III patients required a time lapse of 24 hours for facial pain, between 24 and 72 hours for muscle fatigue and TMJ pain, between 1 and 2 weeks for bruxism, and 2 weeks for clicking or popping of the TMJ. Mandibular deviation was not reduced 50% by the end of the study.

Clinical examination

When the degree of tenderness to palpation of seven muscles and the TMJ was compared, a gradual decrease of the mean value of total muscle-joint symptoms from initial to final sessions was noted for the three treatment groups (Fig. 5). This was especially evident for groups II and III. In addition, a 50% reduction in initial symptoms was noted earlier in groups II and III than in group I. Group II and III patients experienced a 50% reduction in symptoms between 72 hours and 1 week after use of the occlusal splint. Group I patients required 2 weeks to achieve a comparable result.

When initial muscle-joint symptoms of the three groups were compared, no statistical differences were noted (Table IV). However, when final muscle-joint symptoms were compared, statistically different averages were noted between groups I and II and between groups I and III. There were no statistically significant differences between groups II and III. Comparison of initial and final muscle-joint symptoms in each of the three groups show highly significant differences in all groups.

The time of occlusal splint use required to obtain a 50% reduction in initial muscle-joint tenderness was noted for each group (Fig. 6). To obtain a 50% reduction in tenderness to palpation, group I patients required a time lapse of 1 week for the masseter and digastric muscles, between 1 and 2 weeks for the temporal muscle, 2 weeks for the sternomastoid muscle, and between 2 and 3 weeks for the medial pterygoid muscle and the TMJ. The lateral pterygoid and trapezius muscles did not have a 50% reduction in symptoms by the end of the study. To obtain a 50% reduction in tenderness to palpation, group II patients required a time lapse of 72 hours for the temporal, digastric, and sternomastoid muscles; between 72 hours and 1 week for the masseter and medial pterygoid

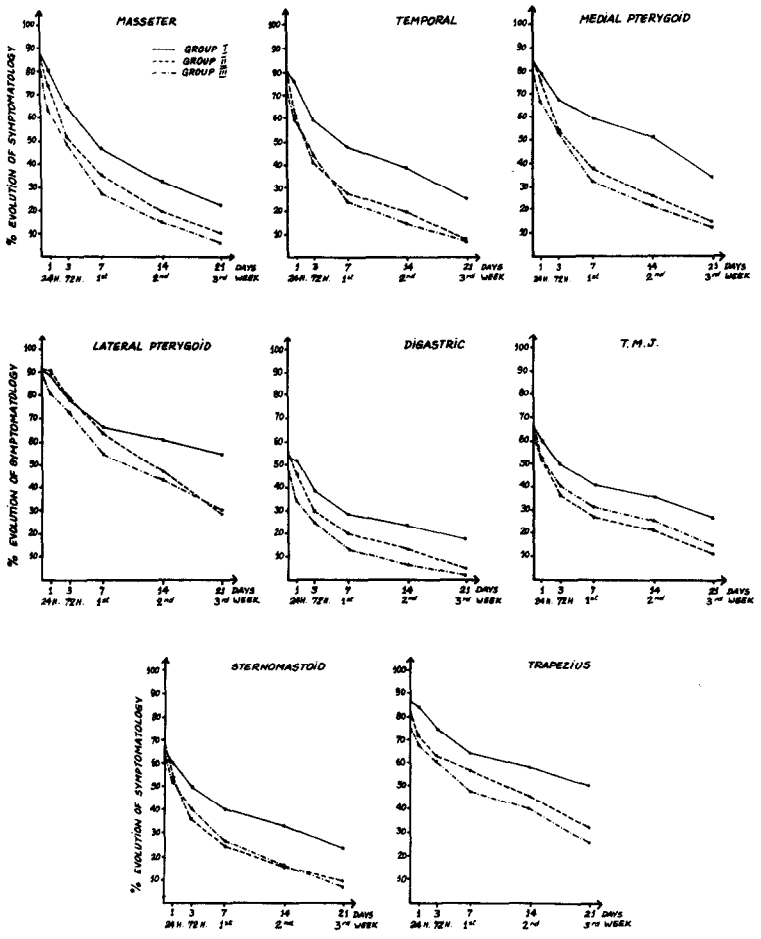

Fig. 6. Progress of muscle and TMJ tenderness to palpation among three treatment groups.

muscles and the TMJ; 2 weeks for the lateral pterygoid muscle; and between 2 and 3 weeks for the trapezius muscle. To obtain a 50% reduction in tenderness to palpation, group III patients required a time lapse of 72 hours for the temporal and digastric muscles; between 72 hours and 1 week for the masseter, medial pterygoid, and sternomastoid muscles and the TMJ; between 1 and 2 weeks for the lateral pterygoid muscle; and 2 weeks for the trapezius muscle.

DISCUSSION

Several explanations have been offered for the clinical effectiveness of occlusal splints in the reduction of pain and dysfunction associated with the TMJ.

Occlusal splints create neuromuscular balance by eliminating occlusal interferences and producing a change in the degree of tactile afferent impulses from the periodontal proprioceptive fibers.[20-22] In addition, occlusal splints reduce bruxing, an important etiologic factor in myospasm that may lead to MPD syndrome.[4,17] Occlusal splints are also believed to improve maxillomandibular relationships and thus alter the relationship of the condyle to the fossa.[23] Furthermore, occlusal splints encourage muscular relaxation, which reduces muscle spasm, as evidenced by a decrease in EMG activity of the mandibular muscles.[11,20,24]

Because it is accepted that occlusal splints are effective in producing neuromuscular relaxation, this study addressed only the effect of a change in vertical dimension on the relative effectiveness of treatment for bruxism and MPD syndrome. The significant reduction of clinical symptoms at the end of treatment in patients from groups II and III in relation to group I can be explained only by the increased vertical dimension. In groups II and III, the elevator muscles were elongated beyond the postural or mandibular rest position (interocclusal distance of 1 to 3 mm) without exceeding the vertical dimension of neuromuscular rest

or the vertical dimension of least EMG activity (interocclusal distance of 8 to 10 mm). Therefore, it appears that splints adjusted at or near the vertical dimension of least EMG activity are more effective in promoting neuromuscular relaxation. This finding has clinical significance because MPD syndrome has been associated with muscular hyperactivity and is considered a pathologic condition of the muscles rather than of the TMJ.[1,4,25] Manns et al.[26] have also shown less EMG activity of the masseter muscle during maximum clenching on occlusal splints constructed with greater increases in the vertical dimension.

Results of this study disagree with the concept that an increase in vertical dimension beyond the rest position causes muscular hyperactivity because of increased stretch. Patients of group II and especially group III showed an earlier and faster reduction of symptoms than patients in group I. This reduction indicates greater neuromuscular relaxation and a decreased intensity and frequency of bruxing. There was a 50% reduction in the symptoms of bruxing at 1 to 2 weeks in groups II and III, but 3 weeks were required for group I.

One might expect that an increase in vertical dimension in groups II and III would produce an increase in TMJ tenderness to palpation. On the contrary, both groups obtained a 50% decrease in initial symptoms between 72 hours and 1 week when compared to group I, where a 50% reduction in symptoms occurred between the second and third weeks of treatment. The more rapid improvement in groups II and III was likely caused by a slight downward and forward condylar displacement as a result of the increase in vertical dimension. This finding agrees with that of Weinberg,[27] who concluded that there was a reduction in intracapsular pressure with an increase in vertical dimension because more joint space is created and lessens the effects of the increased synovial fluid that accompanies joint injury. Pain is therefore reduced because there is less pressure to stimulate nerve endings in the capsule and the disk. Ramfjord and Blankenship[28] have also confirmed that an increase in occluding vertical dimension does not have a pathologic effect on the TMJ.

Although symptoms improved more significantly for patients in groups II and III, patients of group I, whose occlusal splints did not exceed the clinical rest position, also showed positive therapeutic results. This finding indicates that an increase in vertical dimension must be considered an important factor in effecting a more rapid and more complete remission of the muscle-joint symptoms.

SUMMARY

Occlusal splints constructed at three different vertical heights were used to study the influence of vertical dimension in the etiology of bruxism and MPD syndrome.

The vertical dimension of least EMG activity was determined for each of 75 patients who were randomly divided into three groups according to the vertical dimension at which the occlusal splint was constructed. Group I occlusal splints were constructed at 1 mm from the occlusal vertical dimension, group II splints at 4.42 mm, and group III splints at 8.15 mm. Results showed a faster and more complete reduction in clinical symptoms for groups II and III than for group I.

The temporary use of occlusal splints with a vertical height exceeding the physiologic rest position did not encourage a greater muscular tonus or hyperactivity of jaw muscles. It can be concluded that elongation of elevator muscles to or near the vertical dimension of least EMG activity by means of occlusal splints is more effective in producing neuromuscular relaxation.

We acknowledge Dr. Hernán Palomino for his help in statistical analysis of the data, Dr. Fernando Lolas for reading and commenting on this paper, and Mrs. Susana Aronsohn for reading the manuscript.

REFERENCES

1. Clark, G., Beemsterboer, P., and Rugh, J.: Nocturnal masseter muscle activity and the symptoms of masticatory dysfunction. J Oral Rehabil **8**:279, 1981.
2. Greene, C., and Laskin, D.: Splint therapy for the myofascial pain dysfunction syndrome: A comparative study. J Am Dent Assoc **84**:625, 1972.
3. Schwartz, L., and Chayes, C. M.: Fascial Pain and Mandibular Dysfunction. Philadelphia, 1968, W. B. Saunders Co.
4. Solberg, W., Clark, G., and Rugh, J.: Nocturnal electromyographic evaluation of bruxism patients undergoing short-term splint therapy. J Oral Rehabil **2**:215, 1975.
5. Goepfert, H., and Goepfert, C.: Funktionelle Beziehungen zwischen Masseter and Temporal-muskulatur in der Darstellung ihrer Aktionsströme. Dtsch Zahnäztl Z **10**:1530, 1955.
6. Garnick, J., and Ramfjord, S. P.: Rest position. An electromyographic and clinical investigation. J PROSTHET DENT **12**:895, 1962.
7. Storey, A. T.: Physiology of a changing vertical dimension. J PROSTHET DENT **12**:912, 1962.
8. Garret, F. A., Angelone, L., and Allen, W. L.: The effect of bite opening, bite pressure and malocclusion on the electrical response of the masseter muscles. Am J Orthod **50**:435, 1964.
9. Manns, A., and Spreng, M.: EMG amplitude and frequency at different muscular elongations under constant masticatory force or EMG activity. Acta Physiol Lat Am **27**:259, 1977.
10. Manns, A., Miralles, R., and Palazzi, C.: EMG, bite force and elongation of the masseter muscle under isometric voluntary contractions and variations of vertical dimension. J PROSTHET DENT **42**:674, 1979.

11. Manns, A., Miralles, R., and Guerrero, F.: The changes in electrical activity of the postural muscles of the mandible upon varying the vertical dimension. J PROSTHET DENT **45:**438, 1981.
12. Manns, A., Miralles, R., Santander, H., and Valdivia, J.: Masseter electromyographic changes as a function of vertical dimension in patients with myofascial pain-dysfunction syndrome. IRCS Med Sci **9:**354, 1981.
13. Rugh, J., and Drago, J.: Vertical dimension: A study of clinical rest position and jaw muscle activity. J PROSTHET DENT **45:**670, 1981.
14. Bell, W.: Clinical diagnosis of the pain-dysfunction syndrome. J Am Dent Assoc **79:**154, 1969.
15. Brooke, R. I., Stenn, P. G., and Mothersill, K. J.: The diagnosis and conservative treatment of myofascial pain-dysfunction syndrome. Oral Surg **44:**844, 1977.
16. Laskin, D.: Etiology of the pain-dysfunction syndrome. J Am Dent Assoc **79:**147, 1969.
17. Manns, A., Miralles, R., and Adrián, H.: The application of audiostimulation and EMG biofeedback to bruxism and myofascial pain-dysfunction syndrome. Oral Surg **52:**247, 1981.
18. Miralles, R., Manns, A., Pavic, J., and Palomino, H.: EMG, bite force and its relation to craniofacial characteristics. IRCS Med Sci **9:**836, 1981.
19. Miralles, R., Manns, A., and Guerrero, F.: Study of EMG postural activity in mandibular muscles at different body position. IRCS Med Sci **8:**122. 1980.
20. Newton. A.: Predisposing causes for temporomandibular joint dysfunction. J PROSTHET DENT **22:**647, 1969.
21. Ramfjord, S., and Ash, M.: Occlusion, ed 2. Philadelphia, 1971, W. B. Saunders Co.
22. Posselt, V.: Fisiología de la oclusión y rehabilitación. Barcelona, 1973, Editorial JIMS.
23. Weinberg, L.: The etiology, diagnosis, and treatment of TMJ dysfunction pain syndrome. Part III: Treatment. J PROSTHET DENT **43:**186, 1980.
24. Christensen, L. V.: Effects of an occlusal splint on integrated electromyography of masseter muscle in experimental tooth clenching in man. J Oral Rehabil **7:**281, 1980.
25. Clark, G., Beemsterboer, P., Solberg, W., and Rugh, J.: Nocturnal electromyographic evaluation of myofascial pain dysfunction in patients undergoing occlusal splint therapy. J Am Dent Assoc **99:**607, 1979.
26. Manns, A., Miralles, R., Valdivia, J., and Santander, H.: Influence of occlusal splint adjusted to different vertical dimensions on electromyographic activity during maximum clenching in patients with MPD syndrome. IRCS Med Sci **9:**848, 1981.
27. Weinberg, L.: Vertical dimension: A research and clinical analysis. J PROSTHET DENT **47:**290, 1982.
28. Ramfjord, S., and Blankenship, J.: Increased occlusal vertical dimension in adult monkeys. J PROSTHET DENT **45:**74, 1981.

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