In comparing different imaging modalities presented in this article, we concluded that MRI provides the best soft tissue (disk) examination. The advantages of MRI are (1) noninvasiveness, (2) no radiation, (3) true disk-condyle relationship, (4) ability to image inflammation (histopathology), (5) no risk of infection or anaphylaxis, and (6) less operator error than arthrography. These advantages outweigh the disadvantages of (1) slightly higher cost, (2) static images, (3) nonimaging of perforations, and (4) inability to image areas with ferromagnetic metals.

Serial MRI examinations may be used to evaluate mandibular repositioning with splint therapy. MRI provides a noninvasive method for verification that the meniscus has been repositioned between the condyle and fossa. Inflammatory changes in the bilaminar zone can also be imaged. To date, this had been done only with arthrography or CT.

The authors conclude that MRI correlated with transcranial radiography or plain tomography is the most accurate and acceptable TMJ imaging presently available. No imaging modalities, however, can replace the patient history and clinical examination, which are essential to the successful diagnosis and treatment of any patient.

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Influence of group function and canine guidance on electromyographic activity of elevator muscles

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Canine guidance and group function both occur in the natural dentition.[1-6] Group function allows an even distribution of tooth contact in the region of the posterior teeth whereas canine guidance only allows contact between upper and lower canines. Inasmuch as periodontal mechanoreceptors play an important role in the regulation of the jaw muscles,[7-9] it could be postulated that electromyographic (EMG) activity may depend on the type of occlusal scheme.

Williamson[10] and Williamson and Lundquist[11] observed a reduction in EMG activity of the temporal and masseter muscles in patients with canine guidance when compared to others with group function. They did not however, make quantitative and statistic evaluations. Recently, Shupe et al.[12] studied the effect of occlusal guidances on jaw muscle activity and also showed a significant difference in elevator EMG activity between canine guidance and group function occlusion. They did not make simultaneous recordings of both laterotrusive and mediotrusive sides, and none of these works explained the neuromuscular mechanisms involved in observed EMG behavior.

To determine which of the two types of occlusal guidances cause a greater quantitative reduction in the bilateral activity of the elevator muscles, we designed a study in which the effects of both types of occlusal guidances were assessed.

MATERIAL AND METHODS

This study was performed on six subjects (four men and two women) in the age range of 17 to 35 years (mean age, 26 years), with healthy functional occlusions and no dysfunction of the stomatognathic system.

Bilateral EMG recordings of the masseter and anterior temporal muscles were performed by placing bipolar surface electrodes according to the technique described in previous works.[13,14] EMG activity was filtered (80 Hz to

Supported by the Alexander von Humboldt Foundation and Universitat Tübingen.

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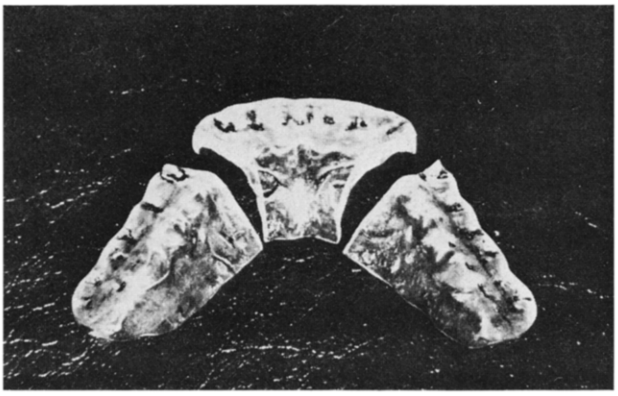

Fig. 1. Three parts of maxillary occlusal splint, split on both sides distal to canines.

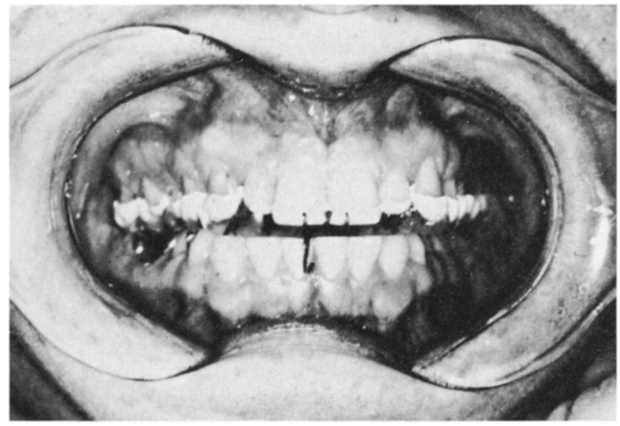

Fig. 2. Group function in right laterotrusion position with three parts of splint relined with Temp Bond in place. Note congruency of markings on upper and lower front teeth to reproduce degree of lateral jaw position.

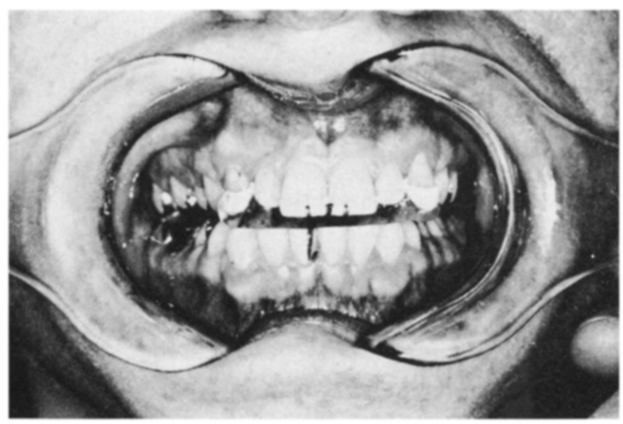

Fig. 3. Canine guidance in right laterotrusion position in same subject of Fig. 2, with only front section of splint in place. Congruency of markings indicates same degree of lateral jaw position.

100 KHz), amplified 1000 times, and then amplified again 10 times, integrated (time constant 1800 msec), and finally registered in a polygraph (model US 266, Fa. Schwarzer Munich, West Germany).

Thermopolymerizing acrylic resin occlusal splints were constructed by using a Whip-Mix (Whip-Mix Co., Louisville, Ky.) articulator. The occlusal adjustment of the splints took place on the articulator as well as intraorally to produce the following occlusal schemes: (1) uniform, simultaneous, and multiple contacts of posterior teeth at centric relation–centric occlusion, (2) laterotrusion with group function (from canine to second molar) without balancing contacts, and (3) protrusion with contact of the anterior teeth.

The increase in vertical dimension of occlusion introduced by the splints ranged from 1 to 2.1 mm at the first premolar region and the degree of increase of interocclusal distance when the mandibular canine was at the full extent of its laterotrusion side without crossover was $\overline{X}$ = 1.6 mm (measured between the tip of the first premolar to the occlusal surface of the splint). Each experimental subject wore the splint for a period of 5 days to allow for adaption before the recordings were made. Immediately after the adaption period and before EMG recordings were made, the splints were split on both sides distal to the canines and then the three parts were relined with Temp Bond liner (Kerr/Sybron, Romulus, Mich.) for better retention (Fig. 1). This procedure accomplished the following:

1. When all three parts of the splint were seated in place, it was possible to record right- and left-sided laterotrusion with group function (Fig. 2).
2. When only the front section of the splint (without both posterior sections) was seated, right- and left-sided laterotrusive recordings with canine guidance could be made (Fig. 3).

Each subject was seated in a dental chair with head support. In this way the subjects were able to maintain a comfortable and relaxed position in which the Frankfort horizontal plane was parallel to the floor.

The three integrated EMG activity recordings for both masseter muscles as well as temporal muscles in each of the following series took place during maximal voluntary clenching (MVC) within a time period of 4 seconds, with a 20-second rest between clenchings to avoid muscular fatigue:

Series 1. Static recordings (×3) of the integrated EMG activity during MCV in centric occlusion (Fig. 4)

Series 2. Static recordings (×3) of the integrated EMG activity during MVC in the right and left laterotrusive position with group function (Fig. 4)

Series 3. Static recordings (×3) of the integrated EMG activity during MVC in the right and left laterotrusive position with canine guidance (Fig. 5)

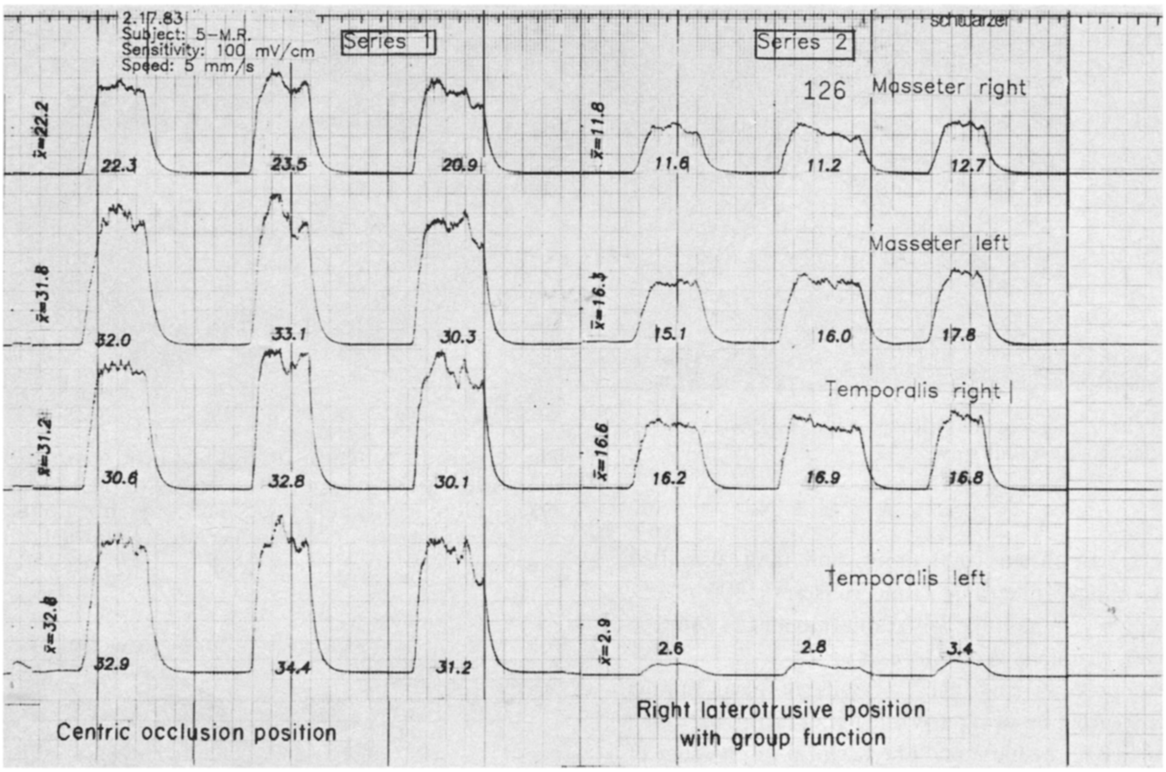

Fig. 4. Recordings of integrated EMG activity of both masseter and anterior temporal muscles for series 1 and 2 of subject No. 5.

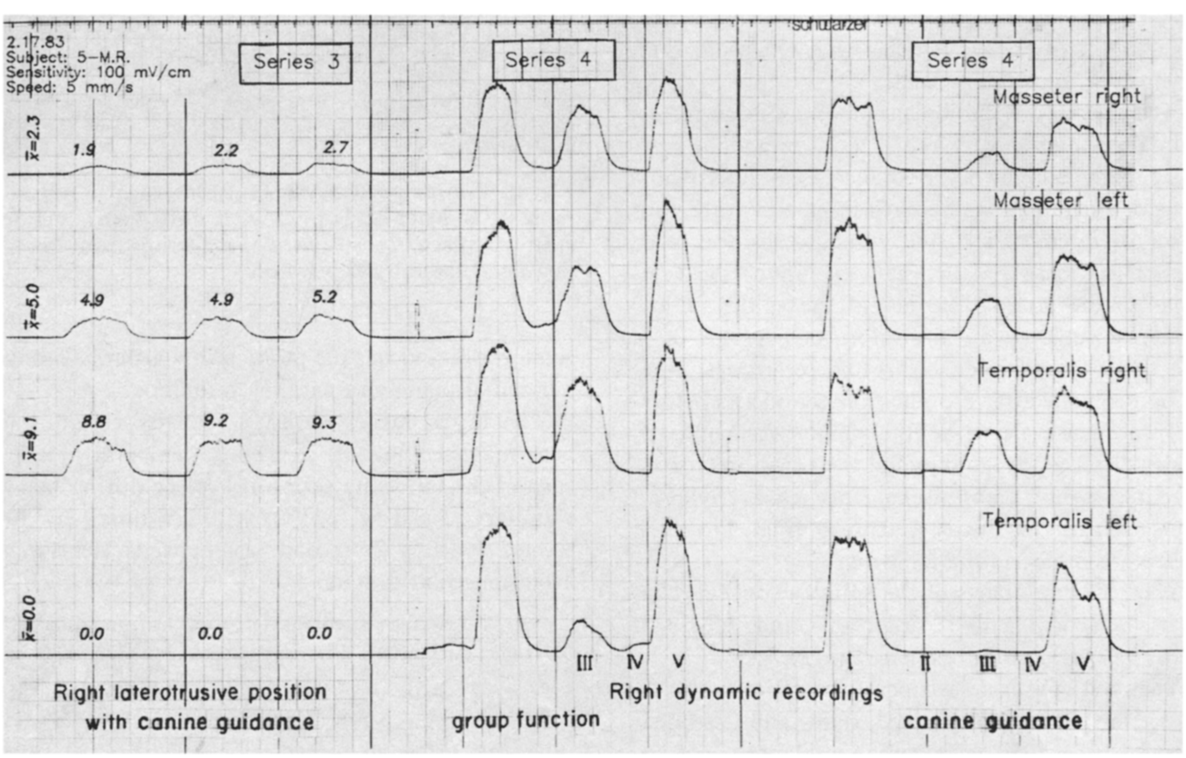

Fig. 5. Recordings of integrated EMG activity of both masseter and anterior temporal muscles for series 3 and 4 of subject of Fig. 4. Series 4 shows different phases (I to V) of dynamic recordings during right laterotrusion with both occlusal guidances.

Table I. Integrated EMG activity of masseter and temporalis muscles: Group function during maximal clenching (series 2)

	EMG (%)	Laterotrusive side		Mediotrusive side		
	Subject No.	Masseter	Temporalis	Masseter	Temporalis	X Of all elevators
Laterotrusion right	1	78.3	80.8	60.2	37.2	64.1
	2	75.9	80.7	74.5	19.9	62.8
	3	32.4	62.9	64.9	7.3	41.9
	4	33.2	70.7	43.9	12.4	40.1
	5	53.2	53.2	51.3	8.8	41.6
	6	36.6	53.9	50.5	20.5	40.3
	$\bar{X}$	51.6	67.0	57.6	17.7	48.5
	SD	21.2	12.4	11.2	11.0	11.6
Laterotrusion left	1	67.1	73.3	62.0	37.1	59.9
	2	68.6	90.8	46.9	9.0	53.8
	3	51.6	83.3	61.5	13.8	52.5
	4	30.7	72.7	46.3	20.7	42.6
	5	33.3	41.2	39.7	4.5	29.4
	6	34.8	65.4	43.4	15.8	39.9
	$\bar{X}$	47.7	71.1	49.8	16.8	46.4
	SD	17.3	17.1	9.7	11.3	11.1
Total	$\bar{X}$	49.6	69.1	53.7	17.3	47.4
	SD	18.5	14.4	10.8	10.7	10.9

Table II. Integrated EMG activity of masseter and temporalis muscles: Canine guidance during maximal clenching (series 3)

	EMG (%)	Laterotrusive side		Mediotrusive side		
	Subject	Masseter	Temporalis	Masseter	Temporalis	X Of all elevators
Laterotrusion right	1	46.5	40.4	29.2	18.7	33.8
	2	24.6	44.8	54.9	9.2	33.4
	3	29.0	42.2	44.6	5.8	30.4
	4	19.6	44.8	33.5	5.7	25.9
	5	10.4	29.2	15.7	0.0	13.8
	6	29.2	36.1	30.2	12.2	26.9
	$\bar{X}$	26.6	39.5	34.8	8.6	27.4
	SD	12.0	6.0	13.5	6.4	7.4
Laterotrusion left	1	52.9	45.6	52.1	18.7	42.3
	2	23.5	50.4	18.3	5.7	24.5
	3	28.6	65.0	49.7	9.5	38.2
	4	17.3	38.7	23.7	6.9	21.7
	5	3.5	18.6	18.5	0.0	10.2
	6	26.1	40.0	24.4	10.4	25.2
	$\bar{X}$	25.3	43.1	31.1	8.5	27.0
	SD	16.2	15.3	15.6	6.2	11.6
Total	$\bar{X}$	25.9	41.3	32.9	8.6	27.2
	SD	13.6	11.2	14.0	6.0	9.3

In both latter series the subjects were instructed to move the mandible laterally until the desired lateral jaw position was reached (full extent of the mandibular canine without crossover) and then to clench maximally. To consistently reproduce the degree of lateral jaw position, congruent markings were made on the upper and lower front teeth (Figs. 2 and 3).

Series 4. Dynamic recordings (×2) of the integrated EMG activity during right and left laterotrusion with group function or with canine guidance

The subjects were instructed to clench maximally in centric occlusion (phase I); then, under maximum force, to move the mandible into the marked lateral position (phase II); to clench maximally again (phase III); and then return

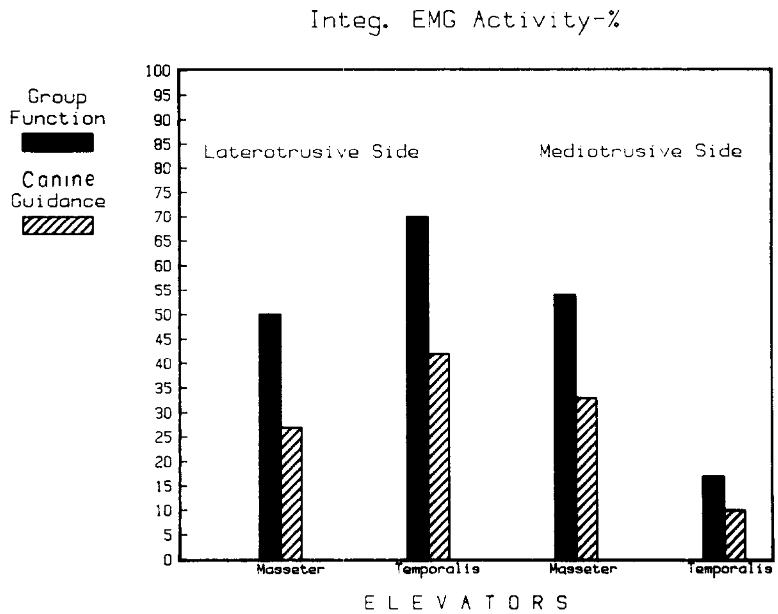

Fig. 6. Bar graph shows comparison of total integrated EMG activity (right plus left laterotrusive recordings) of each muscle tested and of all patients (n = 6) between group function and canine guidance.

to centric occlusion (phase IV). Finally, maximal clenching was recorded in centric occlusion (phase V) (Fig. 5).

Analysis of data

Inasmuch as recordings of integrated EMG activity obtained in the series 1, 2, and 3 lasted approximately 4 seconds, they were divided into 400 msec steps. Values in the ordinate were obtained by manual measuring, and the mean amplitude was then calculated for each recorded curve.[13,14] Subsequently, with the mean amplitude value of the three corresponding recording curves, it was possible to calculate a mean value in each series for each patient and for each muscle, because standard deviation values were similar and negligible (Figs. 4 and 5). To standardize the mean amplitude values of the three recordings obtained in each series, 100% was fixed as the mean amplitude registered in centric occlusion (series 1). The mean values of series 2 and 3 were referred to as percentages of the assigned 100%.

To determine the statistical significance between EMG mean values for each muscle with group function, canine guidance, and also for both occlusal guidances, the *t*-test was applied.

Because the dynamic recordings (series 4) showed similar integrated EMG values to those of the static recordings of the series 1, 2, and 3, quantitative evaluation of these EMG recordings was not done.

RESULTS

Tables I and II present the mean values of the integrated EMG activity for the masseter and temporal muscles (laterotrusive or working side as well as mediotrusive or nonworking side) during maximal clenching in the lateral position with group function and canine guidance. The integrated EMG activity is given in percentage values relative to the 100% activity in the centric occlusion.

The EMG mean values of each of the six subjects were divided into two categories: right and left laterotrusion. For each laterotrusion, a total mean value ($\overline{X}$) and standard deviation (SD) were calculated. Because there was no statistical difference between the EMG mean values for the tested elevator muscles of the right and left laterotrusion, a total mean value of both laterotrusion sides was calculated for individual muscles as well as the entire bilaterally elevator EMG activity.

The results shown in Table I allow the following statements. In comparison with 100% activity when clenching maximally in centric occlusion, maximal clenching in the lateral position with group function results in a reduction (47.4%) of the EMG activity for all the elevator muscles tested (masseter and temporal muscles). Reduction in activity is greatest in the temporal muscle of the mediotrusive side (17.3%) and is least in the temporal muscle of the laterotrusive side (69.1%).

Table II, on the other hand, reveals that the mentioned reduction of the EMG activity for all the elevator muscles occurs to a significantly higher and much greater degree during maximal clenching with canine guidance (27.2%) in comparison to group function. The probability of error for this statement is below 1% (*t*,

Table III. Statistical analysis (t-test) of masseter and temporalis muscles integrated EMG activity variations under group function and canine guidance

Occlusal guidance	Muscles $\overline{X} \pm DS$		Muscles $\overline{X} \pm DS$	t values
Group function vs canine guidance	All elevators 47.4 ± 10.9	–	All Elevators 27.2 ± 9.3	4.88 p < 0.001
Group function vs canine guidance	Temporalis (Laterotrusive side) 69.1 ± 14.4	–	Temporalis (Laterotrusive side) 41.3 ± 11.2	5.28 p < 0.001
	Masseter (Mediotrusive side) 53.7 ± 10.8	–	Masseter (Mediotrusive side) 32.9 ± 14.0	4.08 p < 0.001
	Masseter (Laterotrusive side) 49.6 ± 18.5	–	Masseter (Laterotrusive side) 25.9 ± 13.6	3.58 p < 0.01
	Temporalis (Mediotrusive side) 17.3 ± 10.7	–	Temporalis (Mediotrusive side) 8.6 ± 6.0	2.46 p < 0.05
Group function	Temporalis (Laterotrusive side) 69.1 ± 14.4	–	Temporalis (Mediotrusive side) 17.3 ± 10.7	10.20 p < 0.001
	Temporalis (Laterotrusive side) 69.1 ± 14.4	–	Masseter (Laterotrusive side) 49.6 ± 18.5	2.94 p < 0.01
Canine guidance	Temporalis (Laterotrusive side) 41.3 ± 11.2	–	Temporalis (Mediotrusive side) 8.6 ± 6.0	9.10 p < 0.001
	Temporalis (Laterotrusive side) 41.3 ± 11.2	–	Masseter (Laterotrusive side) 25.9 ± 13.6	3.09 p < 0.01

4.88; DF, 22; $p < .001$). Most noticeable is the reduction in activity for the temporal muscle of the mediotrusive side (8.6%) and the less marked reduction for the temporal muscle on the laterotrusive side (41.3%).

When comparing each elevator muscle in lateral position having group function (Table I) with those possessing canine guidance (Table II), we see in all muscles a significant reduction in activity with canine guidance.

Statistically the reduction is most highly significant (t, 5.28; DF, 22; $p < .001$) for the temporal muscle on the laterotrusive side and for the masseter on the mediotrusive side (t, 4.08; DF, 22; $p < .001$). Highly significant is the reduction for the masseter on the laterotrusive side (t, 3.58; DF, 22; $0.01 > p > .001$) and significant for the temporal muscle on the mediotrusive side (t, 2.46; DF 22; $0.05 > p > .01$).

The significantly greater reduction in activity for each muscle with canine guidance, in comparison with those with group function is easily recognized in Fig. 6. This reduction in activity of the elevator muscles is most marked on the laterotrusive side, then on the mediotrusive side. On the other hand, when considering the EMG activity of both lateral positions, the following similarities in the pattern of activity were noted: the temporal muscle on the laterotrusive side possessed a higher activity than that of the mediotrusive side (t, 9.10; DF, 22; $p < .001$). Both masseter muscles revealed an almost constant activity, however. On the laterotrusive side, the temporal muscle shows the highest activity (t, 2.94; DF, 22; $0.01 > p > .001$ for group function and t, 3.09; DF, 22; $0.01 > p > .001$ for canine guidance) in comparison to the masseter muscle which is more prevalent on the mediotrusive side.

Table III shows a summary of the statistical analysis.

Figs. 4 and 5 present an example of the recording series 1, 2, 3, and 4 on one subject No. 5. In these illustrations the significant EMG activity reduction of the elevator muscles with canine guidance, as described previously, is seen in both the static (series 3) and dynamic (series 4) recordings. Furthermore, the characteristic pattern of activity mentioned is quite noticeable.

DISCUSSION

This preliminary study suggests that canine guidance, compared with group function, causes a greater EMG activity reduction of the elevator muscles. Reduced activity was especially noticeable in the temporal muscles of the mediotrusive or nonworking side, compared with the masseter muscle of the same side. In contrast, the masseter muscle of the laterotrusive side revealed a greater reduction in activity than the temporal muscle. These observations are similar to those reported by other authors.[11,12]

In the present study, both occlusal guidances in the laterotrusive position determined the same increase in the interocclusal distance. In this way the elongation of the elevator muscles displayed the same influence over its EMG activity, as pointed out in previous works.[14-16] On the other hand, the degree of lateral jaw position was kept constant in both occlusal guidances, because the amount of lateral mandibular displacement influences the activity of the elevator muscles.[17,18]

The following explanation may account for these observations:

The periodontal mechanoreceptors are sensitive to pressure, and their afferent information is carried to the motor nucleus via the sensitive nuclei of the trigeminal nerve. As soon as the mechanical stimulation of the periodontium reaches a certain physiologic pressure-tolerance level, the mechanoreceptors discharge and reflexly inhibit the motoneurons of the elevator muscles.[7,8] This reflex protects the teeth from excessive and unphysiologic loads.

In this study, the periodontal stimulation was caused by maximal clenching on the splint. The transferred pressure to the periodontium is directly proportional to the isometric tension of the elevator muscles and indirectly proportional to the surface area of the periodontium over which the pressure is distributed. In the lateral position with group function, the pressure is distributed over a larger periodontal surface. This allows for greater pressure or increased isometric elevator muscle contraction to reach the tolerance level, which in turn releases the inhibitory influence of the periodontal mechanoreceptors.

With canine-guided occlusion, the pressure is concentrated in a small periodontal surface area. Thus a small amount of pressure or isometric contraction of the elevator muscles is needed to activate the periodontal receptors. Schulte[19] and Moeller[20] 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.

Studies on mechanosensitivity thresholds of the teeth demonstrate that the canines possess a much higher pressure sensitivity and stereotactility—in other words, an essentially finer sensitivity—than posterior teeth.[9,21-23] 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.

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 also could be a reason for the lower elevator muscle activity registered in this lateral occlusal scheme.

SUMMARY

A comparative EMG study was done between two types of occlusal guidances: group function and canine guidance. The purpose was to determine which of the two occlusal schemes causes a greater reduction in muscle activity and thereby a decrease in muscle tension in eccentric mandibular positions.

Full-coverage occlusal splints were made for six test subjects with normal function of the stomatognathic system.

Left- and right-side integrated EMG recordings were made of the masseter and temporal muscles during static (clenching) and dynamic (lateral excursion and clenching) maximal contractions.

The results showed an EMG activity reduction of the elevator muscles with group function relative to their activity in centric occlusion. A more marked reduction was observed on the mediotrusive side, mainly in the temporal muscle. With canine guidance, the reduction in elevator muscle activity is much greater, more significant, and mainly in the temporal muscle of the mediotrusive side.

The clinical implications of this study suggest the use of canine guidance in laterotrusion for therapy with full-coverage occlusal splints.

CONCLUSIONS

1. Laterotrusive position with canine guidance, in contrast to group function, produces significantly lower elevator muscle activity.
2. The reduction in activity with canine guidance suggests that the stomatognathic system is more effectively protected against unphysiologic muscle tension in this eccentric position.
3. Canine guidance should probably be included in full-coverage occlusal splints.

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Ernest syndrome as a consequence of stylomandibular ligament injury: A report of 68 patients

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The disorder associated with pain of the styloid process is termed Eagle's syndrome.[1-3] It involves the mineralization of the stylohyoid ligament, elongation of the styloid process, or even the continued growth and subsequent ossification of the second brachial arch cartilage.[4-6] Clinically this condition, which frequently occurs bilaterally, is known to cause facial pain, pain on swallowing, turning the head, or opening the mouth, otalgia, temporal headache, and even vertigo.[4]

A similar, but different disorder that also involves the styloid process has also been described.[7,8] In contrast to Eagle's syndrome, this condition involves the stylomandibular ligament, particularly its mandibular insertion. It is referred to as the Ernest syndrome.[9,10]

Clinically, the patient has symptoms similar to Eagle's syndrome and internal derangements of the temporomandibular joint (TMJ)[10-13]: pain in and around the TMJ, the ear, the temple, the body of the mandible, and pain in the eye. In addition, pain in the throat and even in the shoulder are common. In this study, 68 patients with the Ernest syndrome were investigated to determine (1) specific symptoms associated with injury to the stylomandibular ligament, (2) various epidemiologic data that would be useful in differential diagnosis, and (3) various modes of treatment.

MATERIAL AND METHODS

Sixty-eight patients were diagnosed as suffering from Ernest's syndrome according to these criteria: (1) a history of reporting pain in the specific anatomic regions