Electromyographic Comparative Study on Elevator Muscles Before and After Occlusal Splint Therapy in Group Function Patients

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CONTENTS

Ⅰ. INTRODUCTION

Both canine guidance and group function occlusion occur in the natural dentition[1-6]. Two basic concepts of occlusal guidance presently advocated are canine-protected occlusion, in which only the working side canine contact during lateral excursion[1,7-9] and group function occlusion, in which the working side posterior teeth contact during lateral excursion[7-11]. Selection of one of those concepts in occlusal treatment has been based mainly on clinical observation and theories that periodontal mechanoreceptors influence the regulation of the jaw muscles[12-14].

Williamson[15] and Williamson and Lundquist[16] observed a reduction in electromyographic (EMG) activity of temporalis and masseter muscles in patients with canine guidance when compared to others with group function occlusion. Recently, Shupe et al.[17] studied the effect of occlusal guidance on jaw muscle activity and also showed a significant difference in elevator EMG activity between canine guidance and group function occlusion.

The different modalities of the therapy on the craniomandibular disorder(CMD) have been studied by many researchers[3]. The occlusal splint is one of the most universally accepted methods of treatment for CMD[18-20].

Many studies have described the treatment effects of occlusal splints. Some authors have studied on the relationship between occlusal splints and bruxism[20,21]. Others have examined the effects of occlusal splints on EMG activity[22-24].

There is general agreement that an occlusal splint eliminates occlusal interferences with a minimal amount of opening of the vertical dimension of occlusion[18], and that this causes a change in the degree of afferent impulses from the periodontal mechanoreceptors[1] and thus muscular relaxation. If the elimination of occlusal interferences by means of an occlusal splint causes a decrease in the degree of tactile afferent impulses from periodontal receptors[1], the masseter and temporalis activity during maximum voluntary clenching with the splint should be reduced more than without a splint in patients with CMD[25].

Although there is both canine guidance and group function occlusion in natural dentition of patients with CMD, occlusal scheme is mainly canine guidance in splint therapy of patients with CMD. The important clinical question regarding the uniqueness of canine guidance during splint therapy remains unanswered. Also in much of previous study, though there has been compared the effects between canine guidance and group function occlusion in normal function subjects, there has been not studied in CMD subjects.

So, in order to justify splint for treatment of canine guidance to occlusal splint for treatment of CMD patients with group function occlusion, this study was, electromyographically and clinically, designed to compare the EMG activity on elevator muscles and clinical craniomandibular index(CMI)[26] before, during and after occlusal splint therapy in CMD patients with group function occlusion.

II. MATERIALS AND METHODS

The subjects were divided into two groups; one patient group with CMD and the other a control group without CMD. The CMD group subjects who were treated at department of oral medicine, Chonbuk National University Hospital, consisted of 10 men and 10 women, aged 18-39 years. Their average age was 24 years. The control group subjects who were students of College of Dentistry, Chonbuk National University, consisted of 6 men and 4 women, aged 22-27 years. The average age was 23 years.

The subjects in CMD group were selected by the following criteria :

(1) all patients were actively seeking treatment for their pain;
(2) muscle or joint pain could be elicited by palpation;
(3) no more than one tooth was missing per quadrant;
(4) no patient was wearing any removable restorations;
(5) group function occlusion in the natural dentition.

Control group subjects were free from pain and dysfunction of the temporomandibular joint and had complete dentition.

On entering the clinic each patient was underwent an examination to determine CMI[26]. The list of the CMI is divided into items that reflects jaw and joint functioning problems which represents dysfunction index(DI) and palpation index(PI). The DI includes items related to limits in range of motion, deviation in movements, pain in range of motion, and TMJ noise in range of motion. The PI includes items related to tenderness with palpation of intraoral and the extraoral jaw muscles, neck muscles, and the TMJ capsule.

The scoring of the CMI is the sum of the positive responses related to mandibular movement and TMJ noise divided by the total of positive responses related to palpation of extraoral and intraoral jaw muscles, neck muscles, and the TMJ capsule divided by the total number of items. The CMI is, then, the sum of the DI and PI divided by 2.

The subjects were selected to observe the integrated masticatory muscle EMG activity during maximum voluntary clenching(MVC) and lateral excursive position clenching with and without an occlusal splint.

EMG activity was recorded by EM2 Bioelectric Processor® (Myotronics, U.S.A). Due-trode silver/silver chloride EMG electrode was attached on the both masseter and anterior temporalis muscles according to the technique described in previous works[27,28].

The stabilization splint was made with heat-polymerized acrylic resin and had a flat occlusal surface with occlusal contact in centric occlusion for all of the opposing teeth and with uniform anterior and canine guidance[18].

Each subject in control group wore the splint for a period of 7 days to allow for adaptation before the recordings that were made immediately after the adaptation period. EMG recordings in each subject accomplished the following;

(1) Static recordings(x3) of the integrated EMG activity during MVC in centric occlusion without occlusal splint.
(2) Static recordings(x3) of the integrated EMG activity during MVC in the right and left laterotrusive position guided by group function occlusion without splint.
(3) Static recordings(x3) of the integrated EMG activity during MVC in the right and left laterotrusive position guided by canine guidance occlusion with splint. 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 reproduce consistently the degree of lateral jaw position, congruent markings were made on the upper and lower front teeth. 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 without splint. The mean values of series 2 and 3 were referred to as percentages of the assigned 100%.

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 in each of the following series took placed during MVC within a time period of 4 seconds, with a 20 second rest between clenching to avoid muscular fatigue.

Each patient was asked to wear the occlusal splint constinuously, except during eating and oral hygiene procedures. Patients were seen at weekly intervals for necessary adjustment of the occlusal splint and recording of EMG activity of elevator muscles.

To determine the statistical significance between EMG mean vales for each muscle with group function occlusion before splint therapy, canine guidance occlusion during splint therapy, and group function occlusion after splint therapy, ANOVA with Sheffe multiple range test was applied, and to determine the statistical significance for CMI between before and after splint therapy, paired t-test was applied, also to determine the relationship between mean EMG activity and CMI before and after splint therapy, Pearson's coefficient was calculated.

Ⅲ. RESULTS

Table 1 for control group and Table 2 for

Table 1. Integrated EMG activity of masseter and anterior temporalis muscles of control group

	Working side							Balancing side					
	Before		During		After			Before		During		After	
	Ma*	Ta**	Ma	Ta	Ma	Ta		Ma	Ta	Ma	Ta	Ma	Ta
Total	30.6 ± 8.17	44.7 ± 11.9	21.7 ± 7.08	35.4 ± 11.2	30.4 ± 8.37	44.1 ± 12.5	Total	35.2 ± 11.4	18.3 ± 7.22	27.6 ± 8.74	12.6 ± 6.08	35.7 ± 11.0	19.2 ± 5.67
Laterotrusion Right	36.3 ± 8.53	50.7 ± 8.23	22.6 ± 3.25	35.2 ± 8.24	34.2 ± 8.17	47.9 ± 6.87	Laterotrusion Right	42.6 ± 7.17	21.6 ± 7.81	28.4 ± 5.12	13.5 ± 4.52	40.5 ± 7.31	20.4 ± 5.27
Laterotrusion Left	29.2 ± 5.94	45.3 ± 8.73	22.5 ± 7.14	38.4 ± 7.29	28.5 ± 6.29	43.7 ± 8.47	Laterotrusion Left	32.6 ± 9.53	17.1 ± 5.52	28.9 ± 7.73	12.6 ± 7.57	33.2 ± 9.98	19.2 ± 4.72

* Masseter muscle
** Anterior temporalis muscle

Table 2. Statistical analysis of integrated EMG activity variation of masseter and anterior temporalis muscles of control group

Splint therapy	Muscles	DF	F
Before vs During	Masseter - Masseter (working side) (working side)	(2,57)	11.7 $p<0.01$
	Masseter - Masseter (balancing side) (balancing side)	(2,57)	9.6 $p< 0.01$
	Temporalis - Temporalis (working side) (working side)	(2,57)	6.1 $p< 0.01$
	Temporalis - Temporalis (balancing side) (balancing side)	(2,57)	7.1 $p< 0.01$
Before vs After	Masseter - Masseter (working side) (working side)	(2,57)	11.7 N/S
	Masseter - Masseter (balancing side) (balancing side)	(2,57)	9.6 N/S
	Temporalis - Temporalis (working side) (working side)	(2,57)	6.1 N/S
	Temporalis - Temporalis (balancing side) (balancing side)	(2,57)	7.1 N/S

Table 2-1. Statistical analysis of integrated EMG activity variation of masseter and anterior temporalis muscles of control group

Splint therapy	Muscles	DF	F
Before	Temporalis - Temporalis (working side) (balancing side)	(3,76)	36.6 p< 0.01
	Temporalis - Masseter (working side) (working side)	(3,76)	36.6 p< 0.01
During	Temporalis - Temporalis (working side) (balancing side)	(3,76)	43.5 p< 0.01
	Temporalis - Masseter (working side) (working side)	(3,76)	43.5 p< 0.01
After	Temporalis - Temporalis (working side) (balancing side)	(3,76)	36.5 p< 0.01
	Temporalis - Masseter (working side) (working side)	(3,76)	36.5 p< 0.01

Table 3. Integrated EMG activity of masseter and anterior temporalis muscles of CMD group

	Working side							Balancing side					
	Before		During		After			Before		During		After	
	Ma*	Ta**	Ma	Ta	Ma	Ta		Ma	Ta	Ma	Ta	Ma	Ta
Total	51.8 ± 20.8	59.1 ± 21.2	29.8 ± 13.4	41.5 ± 14.5	36.2 ± 11.9	46.0 ± 15.3	Total	57.7 ± 17.5	37.5 ± 27.4	32.5 ± 13.6	16.3 ± 10.9	38.9 ± 12.2	20.2 ± 11.0
Laterotrusion Right	53.3 ± 22.3	65.6 ± 18.3	28.9 ± 11.5	43.1 ± 11.6	35.9 ± 12.6	47.6 ± 11.3	Laterotrusion Right	57.4 ± 18.2	31.8 ± 26.1	32.2 ± 13.9	16.3 ± 12.9	37.8 ± 11.0	21.1 ± 8.45
Laterotrusion Left	52.0 ± 19.1	56.5 ± 21.9	31.6 ± 15.0	41.3 ± 16.2	37.8 ± 11.9	46.1 ± 15.3	Laterotrusion Left	60.6 ± 15.0	43.0 ± 28.8	33.6 ± 13.3	16.5 ± 9.07	37.8 ± 11.0	21.1 ± 20.2

* Masseter muscle
** Anterior temporalis muscle

Table 4. Statistical analysis of integrated EMG activity variation of masseter and anterior temporalis muscles of CMD group

Splint therapy	Muscles	DF	F
Before vs During	Masseter - Masseter (working side) (working side)	(2,117)	21.8 p< 0.01
	Masseter - Masseter (balancing side) (balancing side)	(2,117)	13.4 p< 0.01
	Temporalis - Temporalis (working side) (working side)	(2,117)	35.6 p< 0.01
	Temporalis - Temporalis (balancing side) (balancing side)	(2,117)	13.9 p< 0.01
Before vs After	Masseter - Masseter (working side) (working side)	(2,117)	21.8 N/S
	Masseter - Masseter (balancing side) (balancing side)	(2,117)	13.4 N/S
	Temporalis - Temporalis (working side) (working side)	(2,117)	35.6 N/S
	Temporalis - Temporalis (balancing side) (balancing side)	(2,117)	13.9 N/S

Table 4-1. Statistical analysis of integrated EMG activity variation of masseter and anterior temporalis muscles of CMD group

Splint therapy	Muscles	DF	F
Before	Temporalis - Temporalis (working side) (balancing side)	(3,156)	9.28 p< 0.01
	Temporalis - Masseter (working side) (working side)	(3,156)	9.28 p< 0.01
During	Temporalis - Temporalis (working side) (balancing side)	(3,156)	26.3 p< 0.01
	Temporalis - Masseter (working side) (working side)	(3,156)	26.3 p< 0.01
After	Temporalis - Temporalis (working side) (balancing side)	(3,156)	30.9 p< 0.01
	Temporalis - Masseter (working side) (working side)	(3,156)	30.9 p< 0.01

Table 5. Craniomandibular index(CMI) before and after splint therapy

Subjects	CMI	
	Before	After
1	0.35	0.24
2	0.43	0.33
3	0.53	0.28
4	0.20	0.07
5	0.58	0.18
6	0.50	0.36
7	0.65	0.47
8	0.25	0.20
9	0.53	0.34
10	0.42	0.27
11	0.40	0.28
12	0.27	0.15
13	0.20	0
14	0.23	0.16
15	0.30	0.08
16	0.29	0.10
17	0.44	0.12
18	0.22	0.09
19	0.32	0.13
20	0.40	0.20
X	0.38	0.20
SD	0.13	0.11

CMD group present the mean values of the integrated EMG activity for the masseter and anterior temporalis muscles during maximal clenching in the lateral position before, during and after splint therapy. The integrated EMG activity is given in percentage values relative to the 100% activity in the centric occlusion before splint therapy.

The EMG mean values of each subject were divided into two categories; right and left laterotrusion. For each laterotrusion, a total mean values(X) and standard deviation(SD) were calculated. The results shown in control group(Table 1) are compatible with recent studies[27-29]. There is statistical analysis of integrated EMG activity variation of masseter and anterior temporalis muscles of control group at Table 2.

The results shown in CMD group(Table 3) allow the following statements. Reductions in integrated EMG activity for before, during and after splint therapy were significantly different. All tested elevator muscle activity during clenching in laterotrusive position was reduced by an average of 52.5%±23.9 before splint therapy and 30.2%±16.0 during splint therapy and 35.8%±15.8 after splint therapy. Average reduction of EMG activity of individual muscle for the laterotrusive clenching phase before, during and after splint therapy were as follows; working side masseter muscle(39.6%±18.5) and working side temporalis muscle(50.0%±18.6), balancing side masseter muscle(43.8%±18.0), and balancing side temporalis(24.7%±20.7). Statistically the reduction is most highly significant(f, 13.4; DF (2,117); $p<0.01$) for the temporalis muscle on the laterotrusive side and for the masseter on the mediotrusive side(f, 35.6; DF(2,117); $p<0.01$). Highly significant is the reduction for the masseter on the working side(f, 21.8; DF(2,117); $p<0.01$) and significant (f, 13.9; DF(2,117); $p<0.01$) for the temporalis muscle on the balancing side. Table 4 shows a summary of the statistical analysis. The significantly greater reduction in activity for each muscle during splint therapy in comparison with those before and after splint therapy is easily recognized in Fig.1.

Table 5 reveals CMI in subjects of CMD group when comparing CMI after splint therapy with those before splint therapy, and we see a significant reduction after splint therapy(t, 8.89; DF,19; $p<0.01$). In considering of correlation between CMI and EMG activity of each subject, there was no correlation significantly.

IV. DISCUSSION

This study presents that canine guidance occlusion during splint therapy compared with group function occlusion before and after splint therapy casuses a greater EMG activity reduction of the elevator muscles. Reduced activity was especially noticeable in the temporalis muscles of the balancing side, compared with the masseter muscles of the same side. In contrast, the masseter muscles of the working side revealed a greater reduction in activity than the temporalis muscles. These observations are similar to those reported by other authors[16,17].

In the present study, the following explanation may account for those 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[12,13]. This reflex protects the teeth from excessive and unphysiologic loads.

In this study, the periodontal stimulation was caused by maximal clenching on centric occlusion. The transferred pressure to the periodontium is directly proportional to the isometric tension of the surface area of the periodontium over which the pressure is distributed. In the lateral position with group function occlusion before and after splint therapy, 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 influlence of the periontal mechanoreceptors with canine guidance occlusion during splint therapy, the pressure is concentrated in small periodontal surface area. Thus a small amount of pressure or isometric contraction of the elevator muscles is needed to activate the periodontal receptors.

Williamson et al.[16] and Moeller[30] observed that the fewer the occlusal contacts, the less the amount of elevator muscle activity was. Controversly, a multiplicity of occlusal contact points resulted in higher activity.

Studies on mechanosensitivity thresholds of the teeth demonstrate that the canines pressure sensitivity and sterotactility- in other words, an essentially finer sensitivity- than posterior teeth[14,32-34]. Because these are the first teeth to contact in lateral movements, and act as an important protective mechanism against excessive forces. Thereby occlusal splint therapy decreased pain and tenderness in the muscles and joints of the CMD patients in this study apparently allowing an increase in their maximal comfortable mouth opening. As a result, CMI is decreased after splint therapy.

Although there was higher correlation between score of CMI and the severity of craniomandibular pain and dysfunction[15], there was low correlation between surface EMG activity and the susceptivility to severity of symtoms of CMD.

Because it is seen although lateral pterygoid muscles act as major muscles of problem of CMD[35], EMG activity of anterior temporalis and masseter muscles only has been recorded in this study. In future study, EMG activity used by needle electrode for lateral pterygoid muscles should be recorded in diagnostic procedure of CMD patients.

V. CONCLUSIONS

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

Full-coverage occlusal splints were made for 10 subjects with group function occlusion of normal function, 20 subjects with group function occlusion of CMD patients. Left- and right-side integrated EMG recordings were made of masseter and anterior temporalis muscles during clenching and lateral excursion with maximal contractions.

The results showed an EMG activity reduction of the elevator muscles with group function occlusion at clenching of laterotrusive position before and after splint therapy relative to their activity in centric occlusion.

A more marked reduction was observed on the balancing side, mainly in the temporalis muscle with canine guidance occlusion during splint therapy, the reduction in elevator muscle activity is much greater, more significant, and mainly in the temporalis muscle of the balancing side. The clinical implications of this study suggest the use of canine guidance occlusion during splint therapy in laterotrusion for therapy with full-coverage occlusal splints.

The results might be summarized as follows:

1. Laterotrusive position with canine guidance during splint therapy, in contrast to group function occlusion before and after splint therapy in control group without CMD with group function occlusion, produce significantly the greater reduction of elevator muscle activity($P<0.01$).
2. Laterotrusive position with canine guidance during splint therapy, in contrast to group function occlusion before and after splint therapy in CMD patients with group function occlusion, produce significantly the greater reduction of elevator muscle activity($p<0.01$).
3. Craniomandibular index was decreased after splint therapy in contrast to before splint therapy($P<0.01$).

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국 문 초 록

Group function군에 대한 교합장치치료 전후에서 저작근의 근전도학적 연구

전북대학교 치과대학 구강진단학 · 구강내과학 교실

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저자는 두개하악장애환자에 대한 교합장치치료시 group function교합이 있는 환자에서도 canine guidance교합으로 변화시켜 치료함이 정당한지를 근전도학적 측면과 임상적 측면에서 알아보고자 group function교합을 가진 20명의 두개하악장애환자와 10명의 정상인을 대상으로 교합장치치료 전, 도중, 후의 좌우측 교근 및 전측두근의 근전도를 측정하고, 두개하악장애지수를 조사한 후 이들 자료를 분석, 평가하여 다음과 같은 결론을 얻었다.

1. 정상인군에서 최대이악물기상태의 좌우측 교근 및 전측두근의 근전도는 교합장치치료 도중의 canine guidance교합시가 교합장치치료전후의 group function교합시에 비해 낮게 나타났다($P<0.01$).
2. 두개하악장애군에서 최대이악물기 상태의 좌우측 교근 및 전측두근의 근전도는 교합장치치료 도중의 canine guidance교합시가 교합장치치료전후의 group function교합시에 비해 낮게 나타났다 ($P<0.01$).
3. 두개하악장애지수는 교합장치치료 전에 비해 치료 후 감소되는 경향을 나타내었다($P<0.01$).