The Effect of Occlusal Stabilization splint Therapy on the Occlusal Contact Stability and Masticatory Muscle Activities in the Patients with Temporomandibular disorders*

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INTRODUCTION

A significant progress has been achieved in the diagnosis and treatment of temporomandibular disorders since the time of Costen[1], nevertheless there are still a lot of things to have to be elucidated. The effect of the different modalities of the therapy on the temporomandibular disorder has been studied by many researchers, as a whole their methods of the evaluation were a little more empirical and subjective rather than scientific and objective.

The masticatory system is a functional unit composed of teeth, jaw, temporomandibular joints, masticatory muscles as well as nervous and vascular systems for all of these tissuse, and a harmonious interplay between all these components is essential.

Temporomandibular joint dose possess certain unique developmental, anatomical, and functional characteristics that distinguish it from the other joint system[2, 3]. For example, it is the only joint system with a rigid end point of closure, specifically, the calcified occlusal surface of closure. Thus the occlusal contact pattern strongly influences the joint's function and muscular control of mandibular position[4-8].

Since the elevator muscles have the capacity of providing heavy forces when they are contracted, there is a great potential for damage to occur at the joints and the teeth[9, 10]. Therefore it is important to establish occlusal conditions that can accept heavy forces without undue strain or injury to any of masticatory structures [11-14].

One of the criteria for the optimum functional occlusion according to Beyron[15], Riise[16] and Okeson[8] is a state of symmetrical and simultaneous contact of all possible teeth when the mouth closes in the intercuspal position. And the anterior teeth also contact but more lightly than the posterior teeth. This type of occlusal relationship furnishes maximum stability for the mandible while minimizing the amount of force placed on teeth during function[17-20].

The importance of the timing of occlusion is implicit in the definition of optimum functional occlusion as mentioned above, however there had been no studies about dynamic occlusal con-

tact using quantitative method with time variables until Maness and Benjamin[21] measured the duration of occlusal tooth contacts using the digital occlusal sensor[22-24].

Kim[25] and Youn[26] also measured the duration of occlusal tooth contacts during maximum and habitual clenching. In addition to the duration, Maness and Podoloff[27] designed the Total Left-Right(TLR) statistics to evaluate the bilateral stability of tooth contact points using T-Scan system(Tekscan Inc., Boston, Mass.). Recently Choi[28] reported an analysis on the timing and distribution of tooth contact points as well as on their correlation with muscle activities in the patients with temporomandibular disorders.

The purpose of this study is to evaluate the effect of occlusal stabilization splint therapy on the occlusal contact stability and maticatory muscle activities in the patients with temporomandibular disorders. The bilateral symmetry, the anteroposterior distribution , the simultaneity of occlusal tooth contacts were measured, and in addition to EMG activities, asymmetry indices of masseter and anterior temporal muscles during maximum clenching were investigated. This was accomplished by synchronous use of the T-Scan system and the Bioelectric Processor EM 2 connected with K6-Diagnostic system.

MATERIALS AND METHODS

MATERIALS

(1) Patient Group

Twenty eight patients with temporo mandibular disorders, who came to the Department of Oral medicine and Oral Diagnosis in Kyungpook National University Hospital during the period between November of 1991 and march of 1992, were included in this study. All the patients were treated conservatively using occlusal stabilization splint and followed up for four weeks after insertion of the splint.

Identification of temporomandibular disorder was done according to the criteria described by Solberg[19]. The patients who satisfied all the following three conditions were selected for this study : (1) normal tooth alignment with Angle Class I molar relation, (2) a full natural dentition of at least 28 teeth(only third molar could be missing), (3) No organic change of temporomandibular joint in the conventional radiography.

(2) Normal Group

Thirty one dental students of Kyungpook National University, who had normal tooth alignment with Angle Class I molar relation, a full natural dentition(except for some occasionally missing third molars), no symptom of temporomandibular disorder, no prior orthodontic treatment and no pathologic periodontal condition, participated in this study as a normal group.

METHODS

(1) Clinical Evaluation of the patients

In order to assess the objective signs of the patients, Three items were checked ; Range of comfortable mouth opening(CMO), Range of maximum mouth opening(MMO), and the Craniomandibular Index (CMI).

The Craniomandibular Index was developed by Fricton[29] to provide a standardized measure of severity of problems in movement, TMJ noise, muscle and joint tenderness for use in epidemiologic and clinical outcome studies. The method was designed to have clearly defined objective criteria, simple clinical use and ease in scoring. It consists of the Dysfunction index and the palpation index.

(2) Measurement of Occlusal Contact Stability

The patients were put into this experiment at the initial day and at the end of first and fourth week of the splint therapy. At the initial day all the experimental items were measured twice, with and without occlusal splint inserted. Same procedures were repeated at the end of first week and fourth week of the splint therapy.

Tooth contact points were recorded on the T-Scan system during maximum clenching. T-Scan system(Version 3.07, FT Tekscan Inc., Boston, Mass.), a recently developed computerized device, enables us to analyze occlusal contact stability quantitatively using time as the primary diagnostic variable at the moment when dynamic tooth contact occurs. The computer records and shows occlusal contact points on the monitor.

The subjects were asked to sit upright in the dental chair and to close on the sensor in maximum clenching. Several practice of closures were made until a repeatable pattern of contact was seen on the video monitor, and then the most representative closure is selected and recorded in the time analysis mode(Fig. 1, 2).

In order to assess the bilateral and simultaneous contact, the author used the following statistics[27] ; TLR, PLR, TFB, PFB and ACI.

TLR(Total Left-Right) statistic is for assessment of bilateral symmetry of contacts. It is calculated as the sum of the distances of the contact points from the midsagittal plane with each distance weighted by the timing of the tooth contact. Because this measure is a time moment statistic, it adds a dynamic aspect to the description of occlusal contact distribution. A subject who exhibits equal distribution of tooth contacts will have a TLR of zero. The author used the absolute value of TLR statistic to compare the overall bilateral symmetry of tooth contacts regardless of whether the midline is shifted to the left or to the right side.

The calculation formula of TLR statistic is as follows ;

$$TLR = \frac{\sum_{i=1}^{n}((1-t_i)\ (x_i))}{\sum_{i=1}^{n}(1-t_i)}$$

where t=contact time(sec.) and x=distance from midline to contact point(㎜)

PLR(Partial Left-Right) statistic is the sum

Figure 1. Tooth contact points during maximum clenching are recorded using the T-Scan system, and bilateral EMG activity of masseter and anterior temporal muscle is synchronously recorded with EM 2.

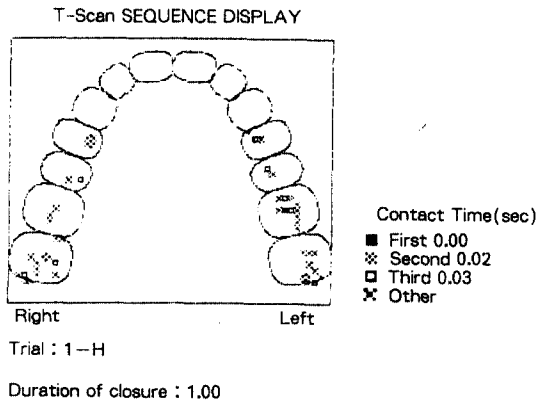

Figure 2. Time sequence display recorded by T-Scan system during maximum clenching.

of the first five contacts in the mediolateral plane. It is for evaluation of bilateral symmetry of the early tooth contacts.

TFB(Total Front-Back) statistic is the sum of LFB(Left Front-Back) statistic and RFB (Right Front-Back) statistic. LFB and RFB statistics are calculated as the sum of the distances of each contact point on the respective side of the midsagittal plane measured from the x axis, whose origin is at the labial plane of the central incisors, weighted by their onset times and divided by the total time of contacts. The actual magnitude of TFB would be dependent

on the relative distribution of the anterior and posterior tooth contacts.

$$\text{LFB, RFB} = \frac{\sum_{i=1}^{n}((1-t_i)\ (y_i))}{\sum_{i=1}^{n}(1-t_i)}$$

where t=contact time(sec.) and y=distance from the reference plane to contact point(㎜)

PFB(Partial Front-Back) statistic is the sum of the first five contacts on the right and left sides in the anteroposterior plane. It is for evaluation of anteroposterior distribution of the early tooth contacts.

ACI(Average of Contact intervals) is for assessment of simultaneity of tooth contacts. It is calculated by dividing the duration of closure by the number of tooth contacts minus one. In this way a subject who exhibits extremely simultaneous tooth contacts will have a ACI of zero. The calculation formula of ACI is as follows ;

$$\text{ACI(sec)} = \frac{\text{duration of closure(sec)}}{\text{number of tooth contact points} - 1}$$

(3) Measurement of Electromyographic Activities

Recording of the bilateral electromyograms of masseter and anterior temporal muscles during maximum clenching was performed synchronously with the recording of tooth contacts. Bipolar silver/silver chloride surface electrodes and Bioelectric processor Model EM 2 (Myo-tronics Research, Inc., Seattle, wash.) interfaced with K6-Diagnostic system were used to measure the average muscle activities.

The asymmetry index introduced by Naeije et al[30]. was used to quantitatively describe the asymmetry in masticatory muscle activity during maximum clenching.

$$\text{Asymmetry index} = \frac{(EMG_{right} - EMG_{left})}{(EMG_{right} + EMG_{left})} \times 100$$

The asymmetry index has a range from −100 % to +100%, where a positive number indicates a right-side muscle dominance and vice versa. In this study only the absolute value of the asymmetry index was used, because it was investigated if there was any difference of muscle activity between right and left side.

(4) Statistical Analysis of Data

Data of each variable were statistically analyzed with an IBM PC/AT personal computer using the SPSS/PC PLUS(Microsoft Corp.) program. Using Student's tests, patients and normal subjects were compared on the basis of the TLR, PLR, TFB, PFB, ACI and the electromyographic activity and asymmetry index for masseter and anterior temporal muscle. The difference of each value between every visit was compared using paired t test.

RESULTS

The clinical evaluation of patients is presented in Table 1. Initally the mean CMO was 35.13±7.62㎜, the mean MMO was 38.57±8.28 ㎜, the mean CMI was 0.13±0.09, whereas after a four−week splint therapy CMO and MMO increased to 39.60±6.07㎜, 42.79±4.15㎜ respectively($p<0.05$), and CMI decreased to 0.06±0.05($p<0.01$, Table 1).

Table 1. Clinical evaluation of patients before and after a four-week splint therapy

	CMO(㎜)	MMO(㎜)	CMI
Before	35.13 ±7.62	38.57 ±8.28	0.13 ±0.09
After	39.60* ±6.07	42.79* ±4.15	0.06** ±0.05

Data are expressed as mean±standard deviation.
CMO : comfortable mouth opening
MMO : maximum mouth opening
CMI : craniomandibular index
* : $p<0.05$
** : $p<0.01$

The mean values for TLR, PLR, TFB and PFB during maximum clenching on the natural

dentition are shown in Table 2. The mean for TLR statistic of patients was 5.48㎜ with a standard deviation of 3.17㎜, whereas the mean for TLR statistic in normal subjects was 2.79㎜ with a standard deviation of 2.07㎜($p<0.001$). However the means for the PLR, TFB and PFB statistics in patients were not significantly different from those in normal subjects. During four weeks of occlusal splint therapy there were no significant changes in TLR and PLR statistics between every visit. After four weeks of occlusal splint therapy, TFB and PFB increased significantly($p<0.01$, $p<0.05$ respectively).

Table 2. Comparison of patients with normal subjects in TLR, PLR, TFB & PFB(㎜)

	Normal	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
TLR	2.79	5.48^{+++}	5.69	5.22
	±2.07	±3.17	±4.23	±2.57
PLR	6.31	8.33	8.78	8.33
	±4.72	±3.72	±5.79	±5.22
TFB	29.10	29.80	30.45	32.16**
	±5.79	±4.33	±6.25	±4.41
PFB	28.87	28.92	32.50	32.77*
	±6.07	±6.45	±13.61	±5.24

Data are expressed as mean±standard deviation/
Pt. day 0 : The initial day in the patients
* : $p<0.05$, comparison with Pt. day 0
** : $p<0.01$, comparison with Pt. day 0
+++ : $p<0.001$, comparison with normal

The mean values for TLR, PLR, TFB and PFB of patients measured with occlusal splint inserted are presented in table 3. The initial mean of TLR measured immediately after insertion of occlusal splint was 3.84±2.00㎜, and after a four-week splint therapy the value decreased to 2.74±1.57㎜($p<0.01$). The initial mean of PFB was 24.16±5.85㎜, and after a four-week splint therapy the value increased to 28.40±6.96㎜($p<0.05$).

Table 3. TLR, PLR, TFB and PFB of patients with occlusal splint inserted(㎜)

	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
TLR	3.84	3.87	2.74**
	±2.00	±1.79	±1.57
PLR	6.80	7.24	6.48
	±2.98	±3.70	±3.30
TFB	24.29	25.31	25.35
	±4.00	±5.06	±5.78
PFB	24.16	26.12	28.40*
	±5.85	±6.33	±6.96

Data are expressed as mean±standard deviation.
* : $p<0.05$, comparison with Pt. day 0
** : $p<0.01$, comparison with Pt. day 0

The mean values for average of contact intervals, number of contact points, duration of closure during maximum clenching on the natural dentition are shown in Table 4. The value for average of contact intervals was significantly longer in patients than in normal subjects,

with 0.037±0.015 sec. in patients and 0.022 ±0.010 sec. in normal subjects($p<0.001$) The mean for number of tooth contact points was much less in patients than in normal subjects, with initial 18.96±6.99 in patients and 33.62±

Table 4. Comparison of patients with normal subjects in average of contact intervals, number of contact points, duration of closure

	Normal	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
Average of contact intervals(sec.)	0.022 ±0.010	0.037^{+++} ±0.015	0.039 ±0.022	0.035 ±0.018
Nuber of contact points	33.62 ±11.32	18.96^{+++} ±6.99	18.83 ±9.90	18.29 ±7.24
Duration of closure(sec.)	0.68 ±0.26	0.63 ±0.22	0.61 ±0.29	0.53 ±0.25

Data are expressed as mean±standard deviation.
+++ : $p<0.001$, comparison with normal

11.32 in normal subjects($p<0.001$). No statistic difference was found between normal subjects and patients in duration of closure. All the three kinds of mean values for patients did not change significantly between every visit.

The mean values for average of contact intervals, number of contact points, duration of closure when measured with occlusal splint inserted in patients are presented in Table 5.

Table 5. Average of contact intervals, number of contact point, duration of closure with occlusal splint inserted in patients

	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
Average of contact intervals(sec.)	0.043 ±0.032	0.044 ±0.021	0.028* ±0.013
Number of contact points	15.26 ±5.06	16.46 ±4.33	17.25 ±4.90
Duration of closure(sec.)	0.53 ±0.23	0.63 ±0.23	0.45 ±0.19

Data are expressed as mean±standard deviation.
* : $p<0.05$, comparison with Pt. day 0

The initial mean value for average of contact intervals measured immediately after insertion of occlusal splint was 0.043±0.032sec. and after a four-week splint therapy the value became shorter to 0.028±0.013sec.($p<0.05$).

The mean values for EMG activities of masticatory muscles during maximum clenching on the natural dention are presented in Table 6. All the initial mean values were significantly lower in patient group when compared with normal group($p<0.01$ or 0.001). The mean for EMG activity of right masseter muscle of patients remained lower than the initial mean at the end of the fourth week($p<0.05$). Although the differences were not statistically significant, on the whole all the examined muscle activities showed gradually decreasing tendency during four weeks of experimental period.

Table 6. Comparison of patients with normal subjects in EMG activities during maximum clenching(μV)

	Normal	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
Rt. Masseter	181.15 ±64.94	118.33+++ ±70.55	107.66 ±67.88	93.58* ±37.21
Lt. Masseter	161.30 ±62.95	15.23+++ ±73.74	113.36 ±77.89	96.82 ±46.48
Rt. Temporal	162.95 ±49.55	113.41++ ±65.56	120.95 ±65.20	94.75 ±30.01
Lt. Temporal	151.95 ±48.57	109.12++ ±60.48	116.54 ±63.29	84.82 ±27.92

Data are expressed as mean±SD(in microvoltage).
* : $p<0.05$, comparison with Pt. day 0
++ : $p<0.01$, comparison with normal
+++ : $p<0.001$, comparison with normal

The mean values for EMG activities of masticatory muscles during maximum clenching with occlusal splint inserted are presented in table. 7. Although the differences were not statistically significant, on the whole all the examined muscle activities showed gradually decreasing tendency during four weeks of occlusal splint therapy.

Table 7. EMG activities of patients during maximun clenching with occlusal splint inserted(μV)

	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
Rt. Masseter	113.30 ±101.98	101.07 ±83.22	86.92 ±34.82
Lt. Masseter	114.12 ±95.74	104.30 ±87.61	91.69 ±41.48
Rt. Temporal	115.06 ±92.04	112.53 ±80.70	87.53 ±29.65
Lt. Temporal	114.28 ±90.34	107.27 ±77.06	79.03 ±21.94

Data are expressed as mean±SD(in microvoltage).

The mean asymmetry index of masticatory muscles during maximum clenching on the natural dentition are presented in Table. 8. Initially the mean asymmetry index of anterior temporal muscle in the patients was 14.31±12.40%, whereas that of normal subjects was 5.36%±3.87%($p<0.001$). The mean asymmetry index of masseter muscle was not occlusal splint therapy no statistical differences were found in mean ASI for anterior temporal and masseter muscle between every visit. However the mean ASI for anterior temporal muscle showed decreasing tendency during four weeks of treatment period.

The mean values for asymmetry indices of masticatory muscles during maximum clenching with occlusal splint inserted are presented in table. 9. Analysis of data showed no statistical differences in mean ASIs for anterior temporal and masseter muscles between every visit.

Table 8. Comparison of patients with normal subjects in ASI during maximum clenching

	Normal	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
Masseter	11.06	10.68	10.52	10.73
	±9.02	±12.03	±8.73	±9.26
Temporal	5.36	14.31***	12.14	10.84
	±3.87	±12.40	±10.65	±8.34

Data are expressed as mean±standard deviation(in percent).

ASI : Asymmetry index

*** : $p<0.001$, comparison with normal

Table 9. Asymmetry index of patients during maximum clenching with occlusal splint inserted

	Pt. day 0	Pt. 1 Wk	Pt. 4 Wk
Masseter	14.28	9.65	13.98
	±10.98	±7.10	±14.11
Temporal	12.85	11.94	10.09
	±7.76	±9.63	±5.83

Data are expressed as mean±standard deviation(in percent).

DISCUSSION

Temporomandibular joint kinematics require strict harmony between the dentition and muscle action for normal functioning of the masticatory apparatus to take place[7]. Therefore understanding the nature of occlusal tooth contacts of natural dentition is important for correct diagnosis and treatment of diseases developed in stomatognathic system[31-36].

Normal occlusion implies bilateral simultaneous tooth contacts. Even and simultaneous contact of all posterior teeth in the intercuspal position is considered as an important prerequisite for functionally optimum occlusion[5, 15, 16]. Okeson[8] stated that this type of occlusal relationship furnishes maximum stability for the mandible while minimizing the amount of force placed on each tooth during function. According to Mølller and Bakke[37], the maximum attainable activity in anterior temporal and masseter muscles was significantly influenced by the number and the distribution of tooth contact points, and they also described that maximum elevator activity coincides with maximum occlusal stability.

Considering these aspects of the optimum occlusion, it is likely that the loss of contact stability at the moment of dynamic tooth contact could correlate with the dysfunction of the masticatory system. Therefore the dynamic analysis of tooth contacts, not in the static occlusal position, should be included in the evaluation of the occlusal condition of patients with temporomandibular disorders.

Recently a new computerized device called T-Scan system has been developed by Maness[38], and he recorded the duration of tooth contacts. the device enables us to analyze occlusal contact stability quantitatively using time variable[21, 27, 39].

Using T-Scan system the author performed time analysis of tooth contact points at the moment of dynamic tooth contact and measured

the masticatory EMG activities synchronously in the patients with temporomandibular disorders. And then the effect of occlusal splint therapy was evaluated in respect to the occlusal contact stability and masticatoty muscle activities.

Occlusal stabilization splints have been used in the management of temporomandibular disorders. Since occlusal interferences and uneven distribution of tooth contacts along the dental arch tend to disturb the masticatory muscle symmetry, many clinicians use the splint to eliminate occlusal interferences and to provide stable occlusal relationships with uniform tooth contacts throughout the dental arch[40]. A lot of studies have reported resolution of symptoms after insertion of a splint. Clark[41] reviewed studies about the splint in the literature through 1980 and pointed out that in general there was 70-90 percent rate of clinical success in treatment of temporomandibular disorder.

While treatement effect of the occlusal splint is predictable, the explanation of the biologic basis of the treatment response is not fully understood[42]. Since the splint causes physiologic changes in the occlusal contact pattern, maticatory muscle dynamics, and the position of the condyle-disc-fossa, this study focused on whether properly adjusted occlusal splints actually improve the symmetry and simultaneity of tooth contacts as well as the symmetry of masticatory muscle activities, and whether masticatory EMG activities increase or decrease during treatment period.

The patients, who were involved in this study, were treated conservatively for four weeks using occlusal splint. After the splint therapy their signs and symptoms were improved significantly as demonstrated in the increased mouth opening range and the decreased craniomandibular index(Table 1).

The TLR statistics is a quantitative method to assess the bilateral symmetry of the total tooth contact and the PLR statistics is to assess the bilateral symmetry of the early tooth contacts. The TLR was much higher in patients, whereas the PLR was not significantly different between the patients and the normal subjects. The higher mean of TLR in the patients is in agreement with the result of Choi[28]. These results demonstrate that overall bilateral symmetry of tooth contacts during maximum clenching was lower in patients with temporomandibular disorders when compared with normal subjects. However, the bilateral symmetry of the early tooth contacts in patients was not significantly different from that in normal subjects(Table 2. 3).

The change in the mean TLR statistic was evaluated in the patients after a one week and a four week splint therapy. The mean TLR after a four week splint therapy was not different from the mean of the initial TLR. But the mean TLR statistic, when measured with occlusal splint inserted, decreased after a four week spint therapy.

The TFB statistics is another quantitative method to assess the anteroposterior distribution of total tooth contact, and PFB is to assess the anteroposterior distribution of the early tooth contacts. In this study, the anteroposterior distribution of the tooth contacts seemed to be not different between patients and normal subjects. TFB and PFB increased significantly after a four-week splint therapy. It means distribution of tooth contact points shifted posteriorly and the posterior tooth contacts became relatively heavier than the anterior ones. In the view point of optimum functional occlusion, posteriorly heavier bite seems to be not bad, but watchful attention should be paid to the development of anterior open bite.

The measurement of the time intervals between contact points is another quantitative method to assess the simultaneity of tooth contacts. In this study the average of contact intervals was longer in patients than in normal subjects. The mean ACI after a four-week splint therapy was not statistically different from the

mean of initial ACI, whereas ACI became shorter under the condition of occlusal splint inserted after a four-week splint therapy(Table 4, 5).

The results of TLR, TFB, PFB and ACI measured with T-scan show that the upper and the lower teeth make occlusal contacts less symmetrically and less simultaneously in patients with temporomandibular disorders(Fig. 3.). Thus the moment of tooth contacts upon jaw closure was more unstable in the patients when compared with normal subjects, and their occlusion was not in a functionally optimum state. After a fourweek splint therapy, significant improvement in occlusal contact stability was gained under the condition of occlusal splint inserted. These results might suggest that the improvement in TLR was attributed to the properly adjusted splint during treatment period, however the observed improvement in TLR strongly suggests that the inserted splint is positively contributing to the occlusal contact stability. The application of a full upper stabilization splint created an effective occlusal stability of the mandible in the intercuspal position through bilateral, simultaneous and symmetrically distributed occlusal contacts of equal intensity of the lower teeth over the functional surface of the splint[43].

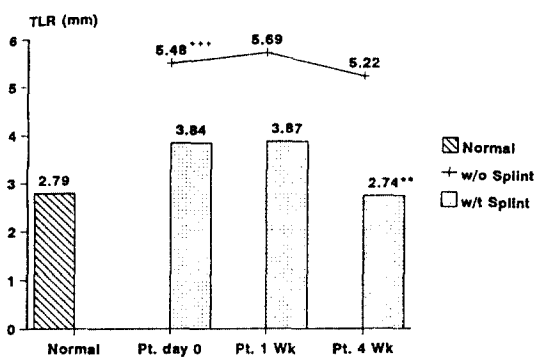

Figure 3. The values for Total Left-Right statistic of the patients and the normal subjects(㎜).

Pt. day 0 : The initial day in the patients
* * : $p<0.01$, comparison with Pt. day 0
+ + + : $p<0.001$, comparison with normal
w/o Splint : without the splint,
w/t Splint : with the splint inserted

Then the bilateral electromyograms of the masseter and the anterior temporal muscles at the moment of tooth contacts were taken during maximum clenching. The mean EMG activities during maximum clenching were significantly lower in patients than in normal subjects for all the muscles examined, and these values showed decreasing tendency during four weeks of treatment period(Table 6, 7).

Many authors reported the effect of occlusal splint therapy on masticatory muscle activities. Several EMG studies of normal subjects have shown that the activity of mandibular elevator muscles during maximum clenching in the intercuspal position on natural dentition is similar to the activity produced with the splint inserted, if contacts are bilaterally and symmetrically distributed on the splint, and there is minimum increase of vertical dimension[44, 45]. However other authors have described greater muscle activity during maximum clenching with splint than on natural dentition[46, 47].

On the other hand, another studies on the effects of occlusal stabilization splint for the patients with temporomandibular disorders indicate that the splints reduce postural activity in the temporal and masseter muscle and significantly reduce the masseter muscle activity during maximum clenching[45, 48, 49].

In this study decreased EMG actvity was consistently observed during treatment period (Fig. 4), and this finding agrees with the result of Shan and Yun[49]. One possible explanation for the reduction in EMG activity is that occlusal splint eliminates occlusal interferences with a minimum increase of vertical dimension, and this causes a change in tactile afferent impulses from the periodontal recep-

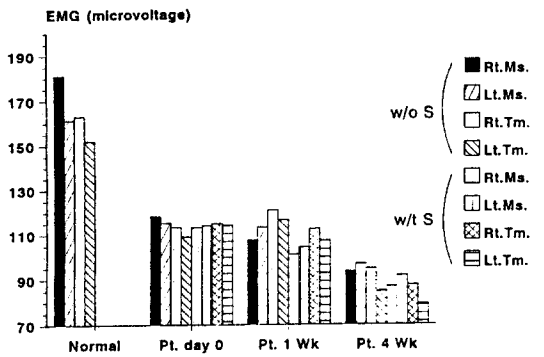

Figure 4. The masticatory muscle activities of the normal subject and the patients (microvoltage).

Rt. Ms. : right masseter,
Lt. Ms. : left masseter
Rt. Tm. : right temporal,
Lt. Tm. : left Temporal
w/oS : without the splint,
w/tS : with the splint inserted

tors, and finally the muscle relaxation effect occurs. However this explanation is based on a concept established through general experiences of many clinicians, and yet the exact physiologic mechanism of reduction in EMG activity is not clearly understood. Since there have been few studies on the changes in masticatory muscle activities after a long term use of occlusal splint, further investigation would be necessary in this field.

The initial mean for asymmetry index of anterior temporal muscle in patients was significantly higher than in normal subjects(Fig. 5), whereas the mean for the asymmetry index of masster muscle was not significantly different from those in normal subjects. Even though no statistical difference was found in the mean values of ASI between every visit, the mean ASI of anterior temporal muscle showed decreasing tendency during four weeks of treatment period(Table 8, 9).

The reduction in mean ASI of anterior temporal muscle during treatment period suggests that properly adjusted occlusal splint improve the symmetry of the muscle activity.

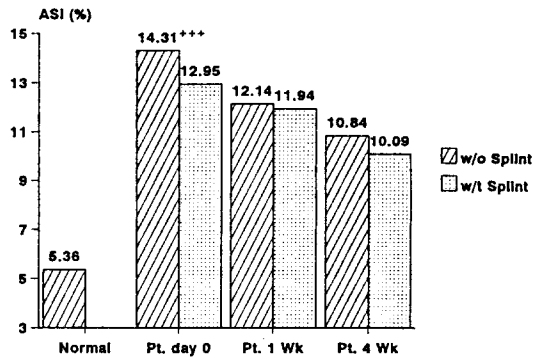

Figure 5. The Asymmetry index of anterior temporal muscle for the patients and the normal subjects(percent).

+ + + : $p<0.001$, comparison with normal
w/o Splint : without the splint,
w/t Splint : with the splint inserted

It also suggests that the anterior temporal muscle is more sensitively associated with the occlusal contact stability during maximum clenching than the masseter muscle. The observed reduction in mean ASI of anterior temporal muscle agrees with the finding of Sheikholeslam et al.[50], who suggested the anterior temporal muscle is the principal positioner of the mandible during elevation whereas the principal function of the masseter muscle is in powerful elevation of mandible. Contrary to this suggestion, Jiménez[51] stated that mandibular stabilizing role was attributed to the posterior temporal muscle. Humsi et al.[40] observed the stabilization splint caused an immediate improvement in masseter muscle symmetry at the time of delivery.

McCaroll et al.[52] evaluated the symmetry of muscle activity at 10 percent and 50 percent of maximum clenching. He measured EMG activity in intercuspal position on the stabilization splint and compared with the

same clench on a one millimeter laterally repositioned splint. The result showed significant asymmetry of anterior temporal muscle function in the lateral position. But the masseter muscle remained symmetrically active, when there were bilateral and stable occlusal contacts, even though the jaw was positioned laterally. Thus it is apparent that in centric relation during maximum clenching, the location of teeth that comes into contacts has the greater influence on the isometric contraction of the masticatory muscles[47, 58]. Futhermore Buero[42] and Manns et al.[43] stressed that in order to develop greatest occlusal force in centric relation, it is important to establish bilateral and symmetrical occlusal contacts on the posterior teeth and the number of tooth contacts is less important than their location.

On the basis of the results of this study as well as other studies mentioned above, the improvement in clinical signs and symptoms of the patients might best be explained by that the occlusal stabilization splint made occlusal contact stability better and then resulted in neuromuscular relaxation and favorable coordination in the masticatory muscles.

CONCLUSIONS

The purpose of this study was to evaluate the effect of occlusal stabilization splint therapy on the occlusal contact stability and masticatory muscle activities in the patients with temporomandibular disorders. The bilateral symmetry, the anteroposterior distribution, the simultaneity of occlusal tooth contacts were measured, and in addition to EMG activities, asymmetry indices of masseter and anterior temporal muscle during maximum clenching were investigated. This was accomplished by synchronous use of the T-Scan system and the Bioelectric Processor EM 2 with K6-Diagnostic system.

Twenty eight patients with temporomandibular disorders and thirty one dental student were involved in this study.

All the patients were treated conservatively using occlusal stabilization splint for four weeks.

The results might be summarized as follows :

1. The patients were treated conservatively for four weeks using the occlusal stbilization splint. After the splint therapy their clinical signs and symptoms were improved significantly as demonstrated in the increased mouth opening range and the decreased craniomandibular index.
2. Both total left-ritht statistic and average of contact intervals during maximum clenching were higher in the patients with temporomandibular disorders than in the normal subjects.
3. Significant improvement in occlusal contact stability was noticed under the condition of occlusal splint inserted after a four-week splint therapy.
4. Anteroposterior distribution of tooth contact points shifted posteriorly in the patients with temporomandibular disorders after a four-week splint therapy.
5. The mean value for masticatory muscle activities during maximum clenching were significantly lower in patients than in normal subjects. These values showed decreasing tendency during four weeks of treatment period.
6. Muscular incoordination of the anterior temporal muscles of the patients was significantly greater than that of normal subjects. Asymmetry index of anterior temporal muscle showed decreasing tendency during four weeks of treatment period.

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측두하악장애 환자에 있어서 교합안정장치가 교합안정성 및 저작근활성에 미치는 영향

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[국문초록]

저자는 28명의 측두하악장애 환자와 31명의 정산인을 대상으로 최적기능교합의 개념에 입각하여 교합시의 치아접촉점을 동적이며 정량적인 방법으로 평가하여 교합안정장치의 사용으로 인한 교합안정성의 개선여부를 알아보고자 하였다. 이와 동시에 교근과 전측두근의 활성도를 측정하여 치료의 경과에 따른 근활성의 변화를 알아보기 위해 본 연구를 시행하였다.

측정항목은 개구범위, 두개하악장애지수, 치아접촉점 좌우균형치, 치아접촉점 전후균형치, 치아접촉점 평균시간간격, 치아접촉점의 갯수, 접촉시간, 좌우측 교근과 좌우측 전측두근의 근활성, 근활성 비대칭 지수 등이었다.

이의 측정을 위해 T-Scan System, K-6 Diagnostic System 그리고 EM 2등을 사용하였으며 얻어진 자료에 대해 검정한 후 다음과 같은 결론을 얻었다.

1. 교합안정장치를 이용하여 측두하악장애 환자들을 4주간 치료한 결과 전반적인 임상증상이 호전되어 개구범위와 두개하악장애지수에 있어서 뚜렷한 개선이 있었다.
2. 측두하악장애 환자에서 최대 악물기시의 치아접촉점 좌우균형치및 평균시간 간격이 큰 것으로 나타나 치아접촉이 일어나는 순간의 교합안정성이 좋지 않은 것으로 평가되었다.
3. 치료 4주후 교합안정장치를 장착한 상태에서 측정한 치아접촉점 좌우균형치및 치아접촉점 평균시간간격은 치료전에 비해 개선된 것으로 나타났다.
4. 치료 4주후 치아접촉점의 전후방 분포가 구치부위로 이동되는 양상을 보였다.
5. 측두하악장애 환자에서 최대 악물기시의 좌우측 교근 및 전측두근의 근활성은 정상인에 비해 낮게 나타났으며, 이는 치료기간 동안 감소되는 경향을 나타내었다.
6. 측두하악장애 환자에서 전측두근의 근활성 비대칭지수는 정상인에 비해 상당히 높게 나타났으며 이는 치료기간 동안 감소되는 경향을 나타내었다.