THE EFFECT OF AN INTEROCCLUSAL APPLIANCE ON HEAD AND NECK POSTURE

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Ⅰ. INTRODUCTION

The masticatory system, which includes maxilla, mandible, teeth, temporomandibular joint(TMJ), and all associated muscles, is directly related to the cervical spine. The neuromuscular influence of the cervical and masticatory regions actively participate in functions of mandibular movement and cervical positioning.[1~4] Mandibular movement is dictated by the neuromuscular control of the masticatory muscles until initial tooth contact occurs. The tooth inclines then guide the jaw into the maximum intercuspal position[5]. Many factors influence the masticatory muscles and affect the rest position of mandible and the path of mandibular closure.[4-8] There are body position, head posture, bite-raising appliance and denture insertion etc.

Current literatures suggest occlusal abnormality as a possible cause of headaches[9], TMJ dysfunction[7], facial pain pattern[9]. Unfortunately the influence of the cervical spine on masticatory structure is frequently ignored. The dentist should consider the relationship of cervical spine to masticatory structure in evaluation of mandibular rest position and movement. The physical therapist should also include the potential influence of the masticatory system when the function of the cervical spine are accessed.

When all the components that affect the mandibular function in proper relationship, the masticatory system demonstrates maximum efficiency with a minimal expenditure of energy.[1] However when the structure or function of this complex, such as cervical posture, is altered, the entire region maybe affected. In practice, the influence of posture and stress on musculoskeletal pain and dysfunction is a prime etiologic factor that is commonly overlooked.[8] Various investigators have tested the relationship between the cervical spine and the masticatory system ; cevical posture changes can affect the mandibular rest position[10], the mandibular path of closure[6] and masticatory muscle.[11~13]

Posselt,[14] in his studies of the mobility of human mandible noted that postural rest position was changed when the Frankfort plane of the head was altered. Brill[15] et al. stated that changes in head position in a relaxed subject would alter rest position of the mandible, and moreover when the head was inclined backwards, the mandible moved away from maxilla and freeway space was increased. Prieskel[6] and Dombrady[16] had confirmed this point and also reported that freeway space was decreased when the head was flexed. Other investigations[17] also found this point to be true. Brodie[18] demonstrated the relationship between head posture and rest position of mandible that the rest position of mandible was determined by muscular equilibrium between the muscles of mastication and the posterior cervical muscles, and he concluded that this muscular equilibrium was a function of the maintenance of head posture. Mohl[8] stated that head posture was the condition that appeared to have the most immediate effect upon postural rest position. Kraus[19] also stated their interrelation on his papers.

In 1927 Schwartz[20,21] demonstrated that dorsiflexion(backward bending) of the head and neck complex resulted in considerable separation of the teeth and posterior movement of mandible as in a class II case. In contrast ventroflexion(forward bending) of head and neck produced an opposite effect as in a class III case. In 1952 Posselt[14] confirmed these earlier findings by Schwartz; i.e., head-neck dorsiflexion shifted the mandible distally (posterior); ventroflexion shifted the mandible mesially(anterior). Rocabado[22] and Rocabado et al.[23] pointed out that there was a dynamic relationship between head posture and dental occlusion. In addition to, Prieskel[6] investigated the pathway of mandibular closure as affected by head posture and offered to similar explanation to Shwarz to changes in head posture. Mohl[8] suggested that a change in head posture would likewise alter the habitual closing path from rest position to maximum intercuspation. Ramfjord and Ash[25] stated that initial contact would depend on posture, and Mohamed and Christensen[26] stated that dorsiflexion caused the mandible to move away from the maxilla with resultant retrusion; in ventroflexion the opposite occured. Similar suggestions were demonstrated by McClean et al.[27] and other researchers.[28,29]

Several electromyographic (EMG) studies have investigated the effect of head posture on the masticatory muscles. Darnell[29] suggested that the activity of mandibular muscles was related to that of the neck and trunk muscles, so an imbalance in any of there muscles might have widespread effects. Many studies[30,31] have been done investigating the relationship between head posture and mandibular function, and it is well established that head-neck backward bending increases the EMG activity of the masticatory elevator muscles, especially the temporalis muscle.[11~13]

Funakoshi[11] et al. concluded that head-neck dorsiflexion increased the EMG activity of the temporalis muscles, whereas ventroflexion caused an increase in the EMG activity of the digastric muscles. Bratzavsky and Vander-EEcken[12] obtained similar findings but added that dorsiflexion also increased activity in the masseter muscles. Boyd et al.[13] were in agreement with these findings relative the dorsiflexion increasing EMG activity of temporalis, and ventroflexion increasing EMG activity in the digastrics but found, contrary to

Bratzlavsky and VanderEEcken, that ventroflexion rather than dorsiflexion increased the EMG activity of the masseters.

The effects of altering vertical dimension on head and neck posture have been to given attention on several studies.[32,33] Vig et al.[34] showed in healthy dental students adaptations in head posture to total nasal obstruction. Daly et al.[35] and Solow and Tallgren[36] found significant changes in head position in response to bite opening using an intraoral splint. Daly et al. began to examine the postural response of the head with a bite opening of 8mm, but without obstruction the nasal cavity. Results showed a significant extension of the head after one hour of bite opening in 90% of the subjects, in accordance with the Vig et al. study. Root et al.[37] found a tendency toward rasing of the head with using an intraoral splint (ⓐ no splint, ⓑ a splint at rest, ⓒ a splint at 8mm beyond rest), but not significantly differenced. Urbanowicz[38] suggested that an increase in vertical dimension was associated with extension of head on the neck. Kraus[19] believed that how head and neck posture responded to a change in vertical dimension was dependent upon the degree of cervical cpine dysfunction already presented in the individual. In addition to, Makofsky[39] et al., investigated the effect of sagittal plane head posture on initial tooth contact (muscle contact position; MCP) and suggested that over the age of 30 there was an increasingly significant relationship. Recently, Moya et al.[40] have demonstrate that the insertion of an occlusal splint, increasing occlusal vertical dimension, determines significant changes in the craniocervical relationships such as extension of the head on the cervical spine and decrease cevical lordosis.

If we were to accept this statements, we must logically conclude that in case of rest position is altered by a change in head posture, the habitual path of closure of the mandible must also be altered by such a change. It also alters muscle activity of head-neck muscles, probably MCP. The purpose of this study is to evaluate the influence of stabilization occlusal splint on craniocervical relationship, especially through the EMG muscle activity of representative mandibular positioning muscle groups.

Ⅱ. MATERIALS AND METHODS

This study was performed on 16 subjects, five women and eleven men, dental students at College of Dentistry, Chonbuk National University. The age of the students ranged from 21~26 years with a mean of 23 years. For this study, subjects were selected who were judged normal by following criteria:

(1) natural dentition, no missing tooth, absence of occlusal trauma, and no bad habits (especially, unilateral mastication etc.)
(2) No history, signs and symptoms of CMD and craniocervical disorders
(3) No pain and restriction on head and neck dorsiflexion / ventroflexion on full range

For each subject a full-arch maxillary stabilization occlusal splint was made of transparent thermopolymerizing acrylic resin, with flat occlusal surfaces, uniform, simultaneous and multiple occlusal contacts at centric occlusion and canine anterior guidance. The insertion time of the splint and the amount of increase in the occlusal vertical dimension by means of intraoral appliances, are important factors to consider in the craniocervical effects reported[37]. Therefore, the splint was worn for 1 hours in this experiments[37] and the thickness of splint ranged from 1.4~1.8mm on central fossa of the maxillary first molar which was within a therapeutic range.

Two experimental conditions were used; (1)

no splint, (2) a splint. At each condition there are also two modes for this studies; (1) at rest position, (2) at muscle contact position(MCP). At each condition three head-neck postural changes were obtained for each subject in upright(0 °), 30 ° ventroflexion and 45 ° dorsiflexion by a pendulum goniometer*. Furthermore the EMG recording in upright(0 °)served as the baseline record for each comparison.

EMG recordings in this study were taken using Bioelectric Microprocessor EM2®.** The electrical activities of the temporalis, masseter, anterior belly of digastric muscles were recorded by means of bipolar surface electrodes(Ag/AgCl). Electrodes were placed along the main direction of the muscle fibers with usual method. For improvement of electrical conduction the electrodes were on the patient skin for 3 to 5 minutes prior to testing. This time allowed the skin to absorb the electrode gel and reduced electrical resistance. In order to minimize methodological error the recordings of EMG muscle activity were made during all experimental procedures by the same examiner.

Subjects were fully informed of study protocol, expecially about rest and MCP prior to each experiment.

EMG data was measured in microvolt of average activity for the five seconds. Each procedure consisted of eight recordings and the mean values were compared with each other.

Each subject was comfortably seated in the chair with back supported and head upright without head-rest. The detail of EMG recordings was made following sequence:

1. Following skin cleansing, surface electrodes were placed bilaterally over the temporal and masseter and anterior digastric muscles by recommended method.
2. Subject was comfortably seated with back-supported in front of EM2 with the head pendulum goniometer placed over the head and maintained head in upright position and calibrated to the 0 ° starting position of head goniometer.
3. At rest position without splint each subject was submitted to 3 recordings of EMG activity by guiding the subject head-neck angle to 0 ° , 30 ° ventroflexion, 45 ° dorsiflexion with the teeth apartly.
4. At MCP without splint, each subject was submitted to repeat step 3.
5. The splint was inserted for a period of 1 hours in each subject.
6. Above 1 to 4 steps were repeated to obtain six EMG recordings with occlusal splint insertion.

Based on aforementioned procedures, each subject had 12 EMG recordings. Comparison of EMG muscle activities with and without occlusal splint was performed by means of one way ANOVA, paired t-test program in Statistical Packages for Social Sciences (SPSS). All probability levels of < 5% were regarded as statistically significant.

Ⅲ. RESULTS

Comparison of the EMG activities combining the left and right sides did not show differences between the conditions; (1) no splint, (2) a splint, and two modes; (1) at rest (2) at MCP (paired t-test, $P<0.05$).

But statistical analysis of EMG activities combining each condition and each mode did show some differences at < 5% of probability levels.

Table 1 show the mean values and standard deviation of EMG muscle activities for masticatory muscles on rest mode without splint

Table 1. At rest, the EMG activities of temporalis, masseter, anterior digastric muscles by angulation, without stabilization interocclusal splint.

ANG\MUS		TA X SD	MM X SD	DA X SD
0° (control)	Rt	1.09±0.61	1.30±1.05	1.52±0.93
	Lt	1.30±0.87	1.42±0.90	1.51±0.58
30°	Rt	1.00±0.67	0.90±0.70	3.28±2.29*
	Lt	1.26±1.52	0.87±0.32	3.26±2.10*
45°	Rt	1.59±0.84	3.02±2.06*	3.96±2.28*
	Lt	2.32±2.16	3.04±2.01*	3.98±2.66*

* $p < 0.05$ when compared with control.
MUS; muscles, ANG; angulation,
30° ; 30° ventroflexion, 45° ; 45° dorsiflexion
TA ; temporalis, MM; masseter, DA; anterior digastricus.

during head flexion and extension.

Each of obtained data compared with head upright condition(0 ° head-neck position) which was used by control. The result of comparison of the mean values in two head postures and control revealed significant differences. Therefore 30 ° ventroflexion led to increased muscle activity in anterior digastic muscles (Lt. 3.26±2.10, Rt. 3.28±2.29, p<0.05) and 45 ° dorsiflexion was shown to significant increase in EMG activities of masseter (Lt. 3.04±2.01, Rt. 3.02±2.06, p<0.05) and anterior digastric muscles (Lt. 3.98±2.66, Rt. 3.96±2.28, p<0.05) (Table 1). In addition to 30 ° ventroflexion led to decreased muscle activity in masseter muscles (Lt. 0.87±0.32, Rt. 0.90±0.70, p>0.05) and 45 ° dorsiflexion led to increased muscle activity in temporalis muscle(Lt. 2.32±2.16, Rt. 1.59±0.84, p>0.05), but there was no statistic difference (Fig. 1).

At MCP without splint 30 ° ventroflexion led to significantly increased muscle activity in anterior digastric muscles (Lt. 3.72±2.80, Rt. 4.11±3.07, P<0.05) and led to decreased muscle activities in masseter (Lt. 1.10±0.47, Rt. 1.10±0.74) and temporalis muscles (Lt. 2.07±2.05, Rt. 2.02±1.46). On the other hand 45 ° dorsiflexion was shown to significant increase in anterior digastric (Lt. 4.11±2.23, Rt. 4.36±2.60, P<0.05) and masseter muscle activities (Lt. 5.05±3.06, 4.92±3.29, P<0.05). On the contrary to other conditions, the EMG activities for the masseter muscles on MCP were higher value than digastric muscles. And at MCP masseter muscle activity (Lt. 5.05±3.06, 4.92±3.29, P<0.05) had higher value than anterior digastric muscle activity (Lt. 4.11±2.23, Rt. 4.36±2.60, P<0.05) on 45 ° dorsiflexion (table 2). Table 2 shows the mean values and standard deviation of EMG activities under conditions of MCP and no splint for head flexion and extension.

At rest with stabilization splint 30 ° ventroflexion led to significantly increased muscle activity in anterior digastric muscles (Lt. 5.15±3.32, Rt. 4.78±3.88, P<0.05). 45 ° dorsiflexion led to significantly increased muscle activities in anterior digastric muscles (Lt. 5.67±3.45, Rt. 4.97±2.85, P<0.05) and in masseter muscles (Lt. 3.03±2.33, Rt. 2.72±2.37, P<0.05) (table 3).

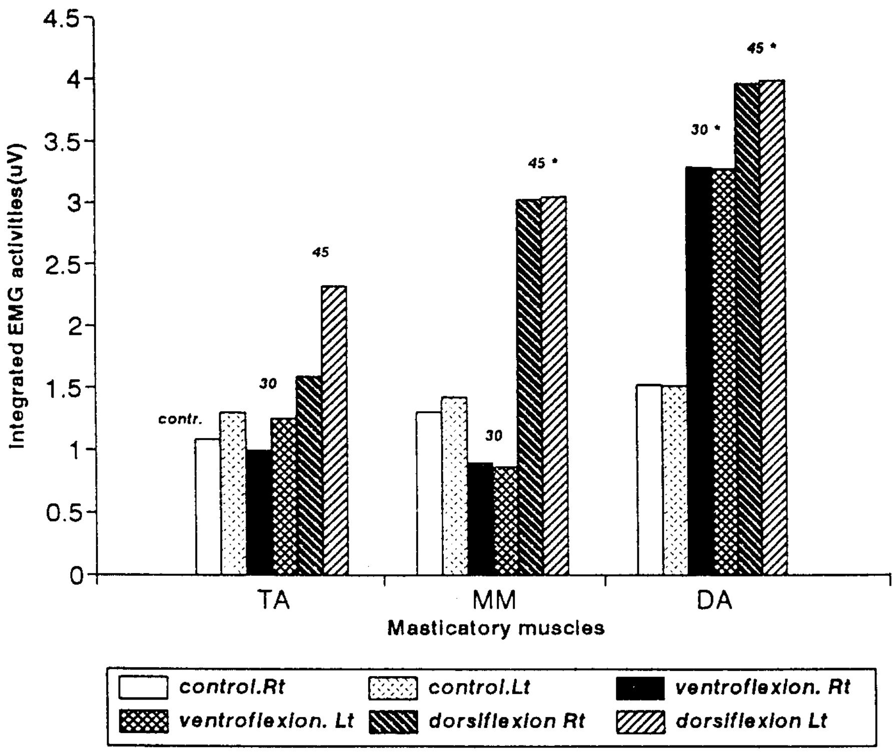

Fig. 1. At rest, the EMG activities of temporalis, masseter, anterior digastric muscles by angulation, without stabilization interocclusal splint. (*p(0.05)

Table 2. At MCP the EMG activities of temporalis, masseter, anterior digastric muscles by angulation, without stabilization interocclusal splint.

ANG\MUS		TA	MM	DA
		X SD	X SD	X SD
0°	Rt	2.67±2.01	2.48±2.11	1.66±0.85
(control)	Lt	2.96±2.84	2.23±1.16	1.66±0.58
30°	Rt	2.02±1.46	1.10±0.74	4.11±3.07*
	Lt	2.07±2.05	1.10±0.47	3.72±2.80*
45°	Rt	2.77±1.59	4.92±3.29*	4.36±2.60*
	Lt	3.09±2.21	5.05±3.06*	4.11±2.23*

* $p < 0.05$ when compared with control.
MUS; muscles, ANG; angulation,
30° ; 30° ventroflexion, 45° ; 45° dorsiflexion
TA ; temporalis, MM; masseter, DA; anterior digastricus.

Table 3. At rest the EMG activities of temporalis, masseter, anterior digastric muscles by angulation, with stabilization interocclusal splint.

ANG\MUS		TA	MM	DA
		X SD	X SD	X SD
0° (control)	Rt	1.32±1.31	1.41±0.81	2.34±1.56
	Lt	1.38±1.32	1.46±0.93	2.44±0.93
30°	Rt	0.94±0.77	0.92±0.65	4.78±3.88*
	Lt	1.16±0.96	1.71±2.36	5.15±3.32*
45°	Rt	1.50±1.32	2.72±2.37*	4.97±2.85*
	Lt	1.42±1.00	3.03±2.33*	5.67±3.45*

* $p < 0.05$ when compared with control.
MUS; muscles, ANG; angulation,
30° ; 30° ventroflexion, 45° ; 45° dorsiflexion
TA ; temporalis, MM; masseter, DA; anterior digastricus.

Table 4. At MCP the EMG activities of temporalis, masseter, anterior digastric muscles by angulation, with stabilization interocclusal splint.

ANG\MUS		TA	MM	DA
		X SD	X SD	X SD
0° (control)	Rt	1.78±1.78	2.02±1.89	2.42±1.40
	Lt	1.81±2.22	2.50±2.38	2.87±1.14
30°	Rt	1.36±1.29	2.00±4.46	5.38±3.98*
	Lt	1.33±1.46	1.48±1.24	4.60±3.25*
45°	Rt	2.59±2.71	4.26±3.28	5.45±3.10*
	Lt	2.53±2.55	4.41±3.00	5.32±2.73*

* $p < 0.05$ when compared with control.
MUS; muscles, ANG; angulation,
30° ; 30° ventroflexion, 45° ; 45° dorsiflexion
TA ; temporalis, MM; masseter, DA; anterior digastricus.

At the MCP with stabilization splint 30° ventroflexion led to significantly increased muscle activity in anterior diagastric muscles (Lt. 4.60±3.25, Rt. 5.38±3.98, P<0.05) and showed to decreased muscle activities in temporalis (Lt. 1.33±1.46, Rt. 1.36±1.29) and masseter muscles (Lt. 1.48±1.24, Rt. 2.00±4.46), but not significant. 45° dorsiflexion led to increased muscle activities in masseter muscles (Lt. 4.41±3.00, Rt. 4.26±3.28), temporalis muscles (Lt. 2.53±2.55, Rt. 2.59±2.71) and to significantly increased in anterior digastric muscles (Lt. 5.32±2.73, Rt. 5.47±3.10, P<0.05) (Table 4).

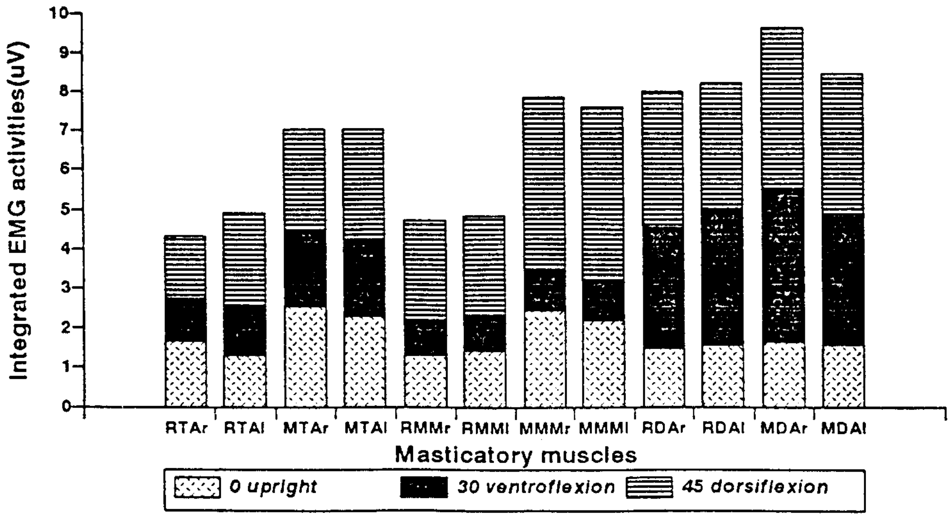

Fig. 2. The EMG activities of temporalis, masseter, anterior digastric muscles between resting and MCP with stabilization interocclusal splint.

Table 5. The EMG activities of temporalis, masseter, anterior digastric muscles between resting and MCP without stabilization interocclusal splint.

MUS\ANG		30° ventroflexion	0° upright	45° dorsiflexion
R	TAr	1.07±0.65[a)]	1.67±0.74[c)]	1.59±0.82[e)]
	TAl	1.28±1.49[b)]	1.30±0.92[d)]	2.38±2.28
M	TAr	1.92±1.45[a)]	2.54±1.99[c)]	2.60±1.60[e)]
	TAl	1.91±2.01[b)]	2.29±2.20[d)]	2.90±2.18
R	MMr	0.88±0.66[f)]	1.32±1.02[g)]	2.59±1.61[i)]
	MMl	0.88±0.31	1.40±0.86[h)]	2.61±1.25[j)]
M	MMr	1.05±0.74[f)]	2.45±3.13[g)]	4.41±2.89[i)]
	MMl	1.04±0.48	2.18±1.20[h)]	4.41±2.54[j)]
R	DAr	3.07±1.88	1.49±0.91	3.49±1.95
	DAl	3.49±2.08	1.58±0.58	3.20±1.44
M	DAr	3.90±3.20	1.63±0.81	4.10±1.93
	DAl	3.24±2.52	1.55±0.66	3.66±1.74

a,b,c,d,e,f,g,h,i,j: $p<0.05$(paired t-test)
R; rest position, M; MCP
MUS; muscles, ANG; angulation,
TAr; Rt. temporalis, TAl; Lt. temporalis,
MMr; Rt. masseter, MMl; Lt. masseter,
DAr; Rt. anterior digastricus, DAl; Lt. anterior digastricus.

Table 6. The EMG muscle activities of temporalis, masseter, anterior digastric muscles between resting and MCP with stabilization interocclusal splint.

MUS\ANG		30° ventroflexion	0° upright	45° dorsiflexion
R	TAr	0.95±0.75[a)]	1.21±1.28[b)]	1.40±1.29[c)]
	TAl	1.05±0.95	1.25±1.31	1.31±1.00
M	TAr	1.37±1.26[a)]	1.92±1.84[b)]	2.56±2.57[c)]
	TAl	1.31±1.42	1.82±2.20	2.45±2.47
R	MMr	0.87±0.65	1.07±0.76[d)]	2.71±2.30[f)]
	MMl	1.13±0.60	1.34±0.87e)	2.74±1.77g)
M	MMr	1.00±0.59	1.93±1.82d)	4.21±3.37f)
	MMl	1.74±2.36	2.40±2.28e)	4.08±2.59g)
R	DAr	4.16±2.84	2.22±1.56	4.44±2.60
	DAl	4.35±2.38	2.35±0.94h)	4.52±2.20
M	DAr	4.67±3.46	2.34±1.37	4.55±2.39
	DAl	3.98±2.91	2.86±1.09h)	4.68±1.98

a,b,c,d,e,f,g,h,i,j: p<0.05(paired t-test)
R; rest position, M; MCP
MUS; muscles, ANG; angulation,
TAr; Rt. temporalis, TAl; Lt. temporalis,
MMr; Rt. masseter, MMl; Lt. masseter,
DAr; Rt. anterior digastricus, DAl; Lt. anterior digastricus.

The paired comparison between MCP and rest during cervical flexion and extension in subject with and without splint was significantly different(paired t-test, p<0.05).

At MCP, the integrated myoelectrical values for all muscles was higher than at rest(Table 5,6).

Characteristically at MCP EMG activities of temporalis and masseter muscles, were higher than at rest independently of head posture. but there was little changes in anterior digastric muscles (p<0.05). Fig. 2 was shown to those schematically.

When the comparison was made between the resting values and MCP values with splint, temporalis and masseter muscle activities were higher than those at rest such as without splint. And there were also little changes in anterior digastric muscles(Table 6).

When the comparison was made between the values with and without splint, there was a significant difference (paired t-test, p<0.05) At first at rest mode with splint insertion led to decreased muscle activity in temporalis and to 45° dorsiflexion, with statistical significance. During upright head poture, EMG activity of anterior digastric muscles was shown the differences before and after splint insertion, significantly(Table 7).

There was also a difference between with and without splint during MCP. In the both of cervical extension and flexion, EMG activities with stabilization splint were higher values than those of values without stabilization splint in anterior digastric muscles during upright and 45° dorsiflexion, significantly (p<0.05). The EMG activity of temporalis muscles was changed after splint insertion at MCP. So, the EMG activity of temporalis was decreased 30° ventroflexion, significantly(p<

Table 7. At rest the EMG activities of temporalis, masseter, anterior digastric muscles with and without stabilization interocclusal splint.

	MUS\ANG	30° ventroflexion	0° upright	45° dorsiflexion
R	TAr	1.07±0.65	1.17±0.74	1.62±0.82
	TAl	1.28±1.49	1.36±0.95	2.38±2.28a)
M	TAr	0.95±0.75	1.21±1.28	1.40±1.29
	TAl	1.05±0.95	1.25±1.31	1.31±1.00a)
R	MMr	0.89±0.66	1.32±1.02	2.79±1.69
	MMl	0.88±0.31	1.40±0.86	2.79±1.49
M	MMr	0.87±0.63	1.07±1.07	2.66±2.31
	MMl	1.13±0.60	1.34±0.87	2.92±2.26
R	DAr	3.12±1.92	1.49±0.91b)	3.49±1.95
	DAl	3.62±2.09	1.58±0.58c)	3.18±1.48d)
M	DAr	3.85±2.93	2.22±1.56b)	4.38±2.66
	DAl	4.22±2.38	2.35±0.94c)	4.42±2.22d)

a,b,c,d,e,f,g,h,i,j: $p<0.05$(paired t-test)
R; rest position, M; MCP
MUS; muscles, ANG; angulation,
TAr; Rt. temporalis, TAl; Lt. temporalis,
MMr; Rt. masseter, MMl; Lt. masseter,
DAr; Rt. anterior digastricus, DAl; Lt. anterior digastricus.

Table 8. At MCP the EMG activities of temporalis, masseter, anterior digastric muscles with and without stabilization interocclusal splint.

	MUS\ANG	30° ventroflexion	0° upright	45° dorsiflexion
R	TAr	1.92±1.45a)	2.54±1.99	2.60±1.60
	TAl	1.91±2.01	2.29±2.20	2.90±2.18
M	TAr	1.37±1.26a)	1.92±1.84	2.13±1.61
	TAl	1.31±1.42	1.68±2.15	2.45±2.47
R	MMr	1.07±0.75	2.45±2.13b)	4.42±2.89
	MMl	1.04±0.48	2.18±1.20	4.67±2.72
M	MMr	1.00±0.59	1.93±1.82b)	3.64±2.97
	MMl	1.74±2.36	2.40±2.28	3.79±2.29
R	DAr	4.25±1.26	1.63±0.81c)	4.05±1.89
	DAl	3.36±2.54	1.55±0.66d)	3.54±1.56d)
M	DAr	4.70±3.36	2.34±1.37c)	4.55±2.39
	DAl	4.24±2.82	2.86±1.09d)	4.68±1.98d)

a,b,c,d,e,f,g,h,i,j: $p<0.05$(paired t-test)
R; rest position, M; MCP
MUS; muscles, ANG; angulation,
TAr; Rt. temporalis, TAl; Lt. temporalis,
MMr; Rt. masseter, MMl; Lt. masseter,
DAr; Rt. anterior digastricus, DAl; Lt. anterior digastricus.

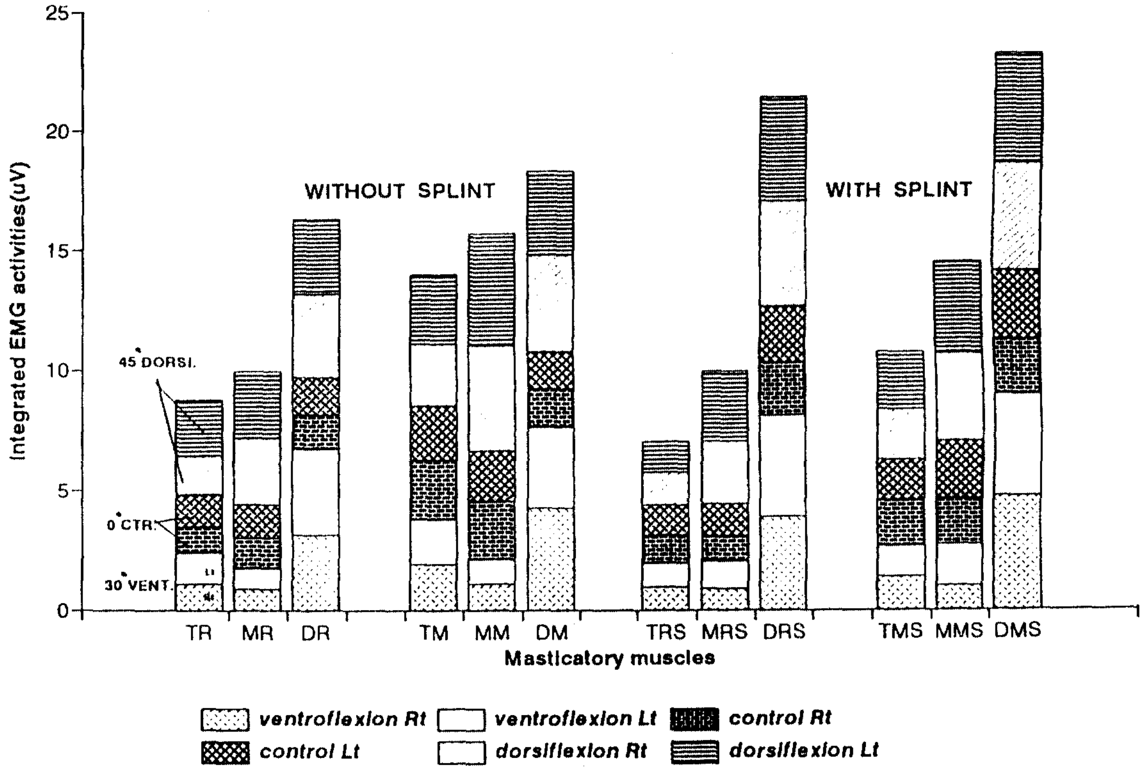

Fig. 3. The EMG activities of temporalis, masseter, anterior digastric muscles before and after splint insertion.

0.05). Table 8 showed the mean values and standard deviation of EMG activities of each muscle.

Ⅳ. DISCUSSION

Various muscles and ligaments connect head to neck. Also mandible is suspended on head and neck with muscles and ligaments. Therefore, the cervical muscles maintaining head balance and the muscles of the stomatognathic system in which intervention at any level will bring about a change in the whole system including mandible. Because one of the main symptoms of craniomandibular disorder(CMD) is muscular tenderness, the status of the cervicovertebral region and head posture would most probably be affected in patients suffering from such a condition. Thus the relationship between head posture and mandibular position and function is of great interest to disciplines concerned with the treatment of patients with craniocervical pains. In this sense Goldstein et al[24] state that "Although the exact mechanism by which head position affect the movement of the mandible is not completely understood, proper head-neck positioning appears important to all phases of dentistry."

The first aim of this study is to compare the effect of head posture on integrated myoelectrical vlaues in elevators and depressors. In this study sagittal plane head-neck movements(dorsi and ventroflexion) were selected because these are the movements have been researched extensively in the literature[6,10,11,12,13,14], and the determination of a range of movement from 45° dorsiflexion to 30° ventroflexion was made upon a clinical judgement that it is the maximum range that the vast majority of subjects can easily perform. In addition to this, within the spectrum of head positions occuring during the act of ingestion, a flexion of aproximately 30° seems to be the anterior parameter of postural variation. As for the posterior extreme of the postural spectrum, head extension by at least 45° seems to occur during the end of drinking act. Considering that actual mastication occurs somewhere within this spectrum and that perhaps more importantly that swallowing takes place during a wide variety of head positions, the possible effect of these function deserves our attention.[8] In practice many previous studies have demonstrate their interrelationship between head position and stomatognathic system; mandibular resting position, mandibular path of closure, masticatory muscle, occlusion.

The pendulum goniometer was used to measure head-neck dorsi and ventroflexion for reasons of accuracy, cost and ease of application.[41] In present study reliability appeared 85~90% level on each head position.

In this study, head-neck flexion and extension determined significant changes in EMG activities of elevators and depressor muscles. 30° ventroflexion at rest or at MCP led to increased muscle activity in digastric muscle, and these result agreed with Funakoshi[11], Boyd et el.[13] 45° dorsiflexion at rest or at MCP led to increased muscle activities in masseter muscle and temporalis muscle, but there was not significant statistical difference in case of temporalis muscle. Anyway, these results also agreed with VanderEEcken.[12] Dorsiflexion rather than ventroflexion was showed to increased muscle activity of the masseter muscle, and these results disagreed with Boyd et al.[13] According to Makofsky[42] the temporalis muscle has been implicated as a possible examination for the occlusal changes observed with head dorsiflexion. As head is tipped back the contraction of temporalis muscle pulls the mandible back to cause the posterior occlusal contacts observed by the aforementioned researchers. Also this study also demonstrated increase of EMG activity of temporalis compared with no postural change (control) during 45° ventroflexion both rest and MCP. But there was not the statistical difference in this study. Therefore it was difficult to expect that these EMG changes, especially in the temporalis muscle, were believed to alter mandibular position so that the initial tooth contacts would shift as the lower teeth were closed to the upper teeth, in this study.

The physiologic rest position has been attributed to three possible mechanisms; postural tonicity of the muscles, myotatic (stretch) reflexes, gravity-elasticity, and/or a combination of all of three.[42] Proprioception of mandibular position is determined by sensors in the joint capsule, muscle spindles, periodontal membrane and oral mucosa.[42]In this study, EMG activity of temporalis muscle at MCP was higher than at rest and than that of masseter muscle. This is believed to be following mechanisms. At MCP of mandible the pressoreceptors in the periodontal membrane will be stimulated. In this point, the contraction of temporalis and masseter muscle is resulted during MCP rather than rest condition.

45° dorsiflexion as contrasted to other studies also led to markedly increased muscle activity in anterior digastric muscle. Furthermore, dorsiflexion rather than ventroflexion was shown to higher muscle activity. This contraction of the digastric muscles in response to changes in head posture is believed to be following mechanisms. Dorsiflexion with contraction of post-cervical muscle will lead to immediate unequilibrium condition of head-neck posture to the increased gravitational force. Gravitational force pulls the mandible downward and this movement will be increased inframandibular soft tissue tension(supra /infrahyoid muscles and fascia). Consequently ,infrahyoid, surprahyoid muscle will be contracted for this factor and mouth opening may be increased, and such a condition stimulates myotatic reflex in elevator muscles, and it leads to muscle contraction such as masseter muscle. Proprioceptive mechanisms in the mandibular muscles are highly developed, and informations about the tension and/or length of the muscle are quickly transmitted from the muscle proprioceptors to the central nervous system. Both the position of the mandible and maintanance of the freeway space are controlled by the proprioceptive function of the mandibular muscles. Ventroflexion, absolutely, includes anterior cervical muscle contraction considering body position.

Full-arch maxillary stabilization splints are frequently used in the management of CMD. They provide a good tool for the elimination of occlusal interference to reduce neuromuscular activity, and to obtain stable occlusal relationship with uniform tooth contact throughout the dental arch.

Many studies using splints which increase in vertical dimension indicate that those results are associated with extension of the head on the neck.[32,37] Recently Moya et al.[40] also comfirmed and demonstrated that the insertion of an occulusal splint determined significant changes in craniocervical relationships-extension of the head on the cervical spine in subjects with muscle spasms. In this study EMG changes of masticatory muscle according to changes in head position was observed after splint insertion.

Previous study showed that the insertion time of the splint might also influence the obtained results.[37] And Craniocervical changes after one hour of experimental bite-opening had been mentioned in earlier study, and the above duration may be enough time for postural changes in head and neck. In this study, splint wearing time was 1 hour also and the increase in occlusal vertical dimension used in this study was within the therapeutic range. Tongue position often inhibits proper mandibular position, so anterior palatal margin of splint was fitted to cervical margin of anterior maxillary teeth.

When a comparison was made before and after splint insertion on each of head flexion and extension, there were some difference with statistical significance. Firstly, splint insertion did not change the EMG activity of masticatory muscle during 30° ventroflexion at rest. But during 45° dorsiflexion splint insertion led to decreased muscle activity in temporalis muscle and led to increased in digastric muscle at rest. Splint insertion also changed the EMG pattern at MCP. During 30° ventroflexion splint insertion led to decreased muscle activity in temporalis at MCP. Otherwise, during 45° dorsiflexion led to increased muscle activity in digastric muscle at MCP. Both at rest and at MCP mode, dorsiflexion was shown to increase digastric muscle activity. The question arises as to why there was such a difference in comparison to without splint condition in case of anterior digastric muscle. Increased gravitational forces on the head appeared to affect the masticatory muscles. Neurologically the cervical apophyseal joint could directly alter muscular activity about jaw, because increased masticatory EMG levels was noted with cervical backward bending. This means, at least, that after splint insertion downward backward force applies on the mandible larger than before splint insertion, and it's direction agreeed with gravitational force independent of rest or MCP and agree with vectors of mandibular retrusion and opening, or head upright. In practice mandibular protrusion and retrusion also increased the suprahyoid musculature.[31] Thus, splint insertion might be change the mandibular positioning muscle, especially digastric muscle contraction during dorsiflexion, and it's change might be affect the equilibrium of head-neck musculature and might be mandibular position , even head posture also. But in this study the exact influence of the inframandibular muscles on the mandible as the head was tipped backward could not be known due to this study did not consider of hyoid movement and occulusal horizontal movement. And this study did not show that head extension might be change the mandibular position in backward and that retruded MCP would increase temporalis muscle activity. Of course, Makofsky et al. demonstrated that age was important factor in occlusal change follwed by head postural change.[39]

This study offered some possibility that splint insertion would change the mandibular positioning muscle activity and that, at least, would affect the equilibrium of head positioning muscles including anterior and posterior cervical muscles. But the detail of the influence of the inframandibular muscles(esp, digastric muscle) on mandible was not known as the head was tipped backward. Now, the author can conclude that although the exact mechanism by which head position affects the movement of mandible is not completely understood, the position of the mandible and the EMG activity of masticatory muscles are greatly affected by the posture of the head.

EMG activity on masticatory muscles, especially digastric muscle, changed by splint insertion, this also showed new craniocervical, mandibular relationship.

Further comprehensive study should be made under EMG study in masticatory muscles including infrahyoid muscles and under occlusal analysis for certain objective changes, coincidently.

V. CONCLUSION

There is a dynamic interrelationship between mandibular posture and head-neck posture. Alteration of anteroposterior head-neck posture on sagittal plane appears to have an immediate effect on mandibular position in a normal population. Therefore, head posture and it's effect on mandibular posture and function are of immense importance in the field of dentistry as well as physical therapy. This study was performed 20(6 women, 14 men) normal subjects using $EM_2^{®}$ and pendulum goniometer. In this study followings were resulted:

1. Before insertion of stabilization splint 30° ventroflexion of head led to increased muscle activity in anterior digastric muscle and 45° dorsiflexion of head led to increased muscle activities in masseter and anterior digastric muscle under the condition of mandibular rest position and MCP.
2. After insertion of stabilization splint 30° ventroflexion of head led to increased muscle activity in anterior digastric muscle

under the condition of mandibular rest position. On the other hands 45° dorsiflexion of head led to increased muscle activities in masseter and digastric muscle at mandibular rest position, but only in digastric muscle at MCP($p<0.05$).

3. Both before and after insertion of stabilization splint, head flexion and extension during MCP resulted in markedly increased EMG activities of temporalis and masseter muscle compared with mandibular rest ($p<0.05$).

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국 문 초 록

교합장치물이 두경부 자세에 미치는 영향

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두개하악장애는 환자의 신체적 소인, 관련조직의 구조적 변화, 정신적 스트레스 등의 복합적 요인에 의해 발생하는 다인성 질환으로 최근 대두되는 원인중의 하나가 신체, 특히 두경부의 자세이상이다.

비정상적인 두경부자세는 하악의 위치변화를 수반하여 종종 두개하악장애를 야기시키게 되나 이를 설명할 수 있는 과학적 증거는 아직 부족한 실정이다.

저자는 두경부 자세가 교합장치물에 의해 변화되는지를 저작근의 근전도학적 측면에서 규명하고자 21세에서 26세의 치과대학생으로 치아상실 및 교합간섭이 없고 두개하악장애의 증후 및 경부운동제한을 가지지 않은 정상인 20명을 대상으로 각도계를 사용하여 시상면상에서 인위적으로 유도한 세 가지의 두경부자세변화 (0°, 30° 굴절, 45° 신전)에 따른 교합안정장치의 장착(1시간)전후 및 안정위와 근접촉위(초기치아접촉위)에서의 두경부 근육(측두근, 교근, 악이복근)의 근전도를 Bioelectric Microprocessor EM2® 를 사용하여 측정한 후 통계학적으로 비교, 분석, 평가하여 다음과 같은 결과를 얻었다.

1. 교합안정장치 장착전 하악 안정위 및 근접촉위에서 두부의 30° 굴절은 악이복근의 근활성도를, 45° 신전은 교근 및 악이복근의 근활성도를 증가시켰다($p<0.05$)
2. 교합안정장치 장착후 하악 안정위에서 두부의 30° 굴절은 악이복근의 근활성도를, 45° 신전은 교근 및 악이복근의 근 활성도를 증가시켰으며, 하악 근접촉위에서 두부의 45° 신전은 악이복근의 근활성도를 증가 시켰다($p<0.05$)
3. 교합안정장치 장착 전후 및 두부의 30° 굴절, 45° 신전에 따른 측두근 및 교근의 하악 근접촉위에서의 근활성도가 안정위에서의 근활성도에 비해 유의한 증가를 나타냈다($p<0.05$).