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Relationship of dental occlusal factors and temporomandibular disorders : Lateral guidance, nonworking side contacts, and disclusion time

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교합 요소와 측두하악 장애의 상관성
: 측방운동 양상, 균형측 접촉, 이개시간

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이 논문을 치의학 석사학위신청 논문으로 제출함.

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Contents

List of Tables

List of Figures

국 문 초 록

교합 요소와 측두하악 장애의 상관성
: 측방운동 양상, 균형측 접촉, 이개 시간

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여러 가지 교합의 요소들과 측두하악관절 장애와의 관련성은 아직도 명확하게 밝혀지지 않고 있다. 본 연구에서는 측방유도 양상과, 측방운동 시 균형측 접촉과 이개시간과 같은 교합의 요소와 측두하악관절 장애와의 상관성에 대해 분석 하였다. 실험을 위해 30명의 측두하악관절 장애가 없는 정상인군 30명 (남성 : 15명, 여성 : 15명)과, 30명(남성 15명, 여성 15명)의 측두하악관절 장애를 가지고 있는 환자군을 선정하였다. 환자군의 경우 조선대학교 치과병원 구강내과에 내원하고 있고, 측두하악관절 장애가 있다고 판명되어 치료가 진행 중인 사람이었다. 각각의 대상자에게서 측방유도 양상과, 균형측에서 발생하는 접촉, 그리고 측방운동 시 이개 시간을 임상적 제반 검사 및 T-Scan Ⅱ(Teckscan, Inc.)를 사용하여 조사하였다. 측방운동 양상과 균형측 접촉의 경우의 경우, 정상인군과 환자군에서 유의한 차이가 나타나지 않았다. 이개시간의 경우 정상인군에 비해 환자군에서 좌측과 우측에서 모두 유의할 만한 차이로 길게 나타났다. 본 연구에서 얻어진 결론은 다음과 같았다. 1. 측두하악관절 장애와 측방유도 양상은 관련이 없었다. 2. 측두하악관절 장애와 균형측 접촉은 관련이 없었다. 3. 측두하악관절 장애와 이개시간은 통계적으로 유의한 관련이 있었다. 측두하악관절 장애를 가지고 있는 사람과 가지고 있지 않는 사람을 명확하게 구분 지을 수 있는 교합의 요소로서 이개

시간이 중요한 요소로서 간주될 수 있으리라 생각한다. 하지만 측두하악관절 장애와 이개 시간의 증가 간에서, 인과관계의 선후는 알 수 없었다. 따라서 이개시간을 감소시키는 교합치료를 통해 측두하악관절 장애를 치료하여 좋은 결과를 나타낼 수 있을지의 여부는 향후 더 많은 연구가 필요하리라 사료된다.

I . INTRODUCTION

Temporomandibular disorder (TMD) is a collective term that embraces a number of clinical problems that involve the masticatory musculature, temporomandibular joints (TMJ) and associated structures, or both.[28] Multiple factors have been suggested as the cause of TMD, including structural abnormalities, stress–induced muscle hyperactivity, and overloading of the joint from trauma.[10] The etiology of and treatment options for this disorder remain controversial, and also the role of dental occlusal factors remains unclear. This may be due to the varied adaptive capacity among patients.

The American Academy of Orofacial Pain has suggested that occlusion may play a role in the cause of TMD,[34] but the literature reports controversial and inconclusive results.[6,9,36,40,45,47] Significant associations of TMD with occlusion have been found,[9,36,47] especially with regard to the number of occlusal tooth contacts,[9,47] but these associations are only partially confirmed or not confirmed.[6,15,40,45] Nonhomogeneity in definitions, differences in data collection procedures, lack of control groups in some investigations,[6,15] diversity among populations, and varied admission criteria may have led to contradictory results. Moreover, the different methods and techniques used to record contacts,[26] the occlusal pressure used,[11,45] chair position, and head posture may all have influenced occlusal response.[4] There is an obvious need to re–examine the hypothetical relationship between TMD and occlusal factors.

The literature reports controversial and diverse findings as to the association between a particular occlusal guidance (canine vs group function), the presence of nonworking side contacts (balancing side contacts or interferences), disclusion time and the development of TMD. Some studies have suggested that occlusal guidance influences elevator electromyographic (EMG) activity,[2,26,30,42] and that group function was associated with higher elevator EMG activity, and canine guidance with lower EMG activity when the subject performs lateral movements. Although occlusal guidance may influence elevator muscle activity, Seligman and Pullinger[41] state that it does not seem to have a relationship with TMD symptoms. Two common occlusal features that have been suggested to be related to TMD are nonworking or balancing side contacts and a slide between the retruded contact position and the intercuspal position.[35,43] Mohlin and Kopp[31] have suggested that patients with TMD have higher prevalence of nonworking side contacts compared with non−patient groups. However, some investigators have been unable to demonstrate a correlation between signs and symptoms of TMD and occlusal contacts, including nonworking side contacts.[6]

Disclusion time is defined as the duration of time that working and nonworking molars and premolars are in contact during a mandibular excursive movement that commences from the habitual closure position through the contact of anterior guiding surfaces.[18] Disclusion time measures the time in which posterior teeth separate from each other during jaw motion. Disclusion time was first described by Kerstein and Wright for T−Scan(Tekscan, Inc., Boston, Mass).[19,22,23,25] Force Movie occlusal analysis[24] of the right and left working excursions of seven female subjects. Long disclusion time was shown to increase contractile muscle activity in the masseter and temporalis muscles of seven women with chronic MPDS.[17,18] The reduction of long disclusion time to short disclusion time was successfully accomplished by the method of occlusal adjustment known as immediate complete anterior guidance development.[19] Disclusion time reductions will reduce contractile muscle activity significantly and result in a reduction of chronic muscle dysfunction often associated with chronic MPDS patients.[17,19] However, population studies on disclusion time have not been reported.

The purpose of this study is to compare the prevalence of occlusal guidance (canine vs group function), nonworking side contacts and disclusion time in symptomatic patients with TMD with asymptomatic volunteers without symptoms.

Ⅱ. MATERIALS AND METHODS

Thirty asymptomatic volunteers aged from 19 to 29 years old and 30 symptomatic TMD patients aged from 15 to 31 years old treated at the Chosun University, Dental Hospital, Department of Oral Diagnosis & Oral Medicine were included in this study. Asymptomatic volunteers answered a solicitation for examination and inclusion into the study. Age- and sex-matched volunteers were examined by 1 investigator and were accepted into the study after the completion of subjective questionnaire that documented the absence of jaw pain, joint noise, locking, and a positive history for TMD, and clinical and dental examination for signs and symptoms commonly associated with TMD or internal derangements.[39] All symptomatic subjects had localized jaw joint pain. Symptomatic patients were consecutive subjects who agreed to participate in the study.

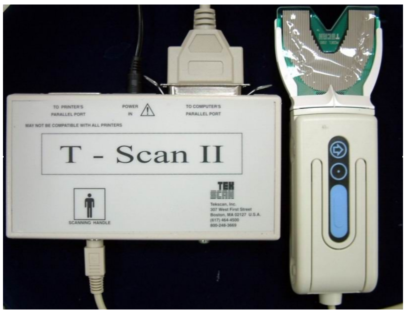


Figure 1. T-Scan Ⅱ (Tekscan, Inc., Boston, Mass)

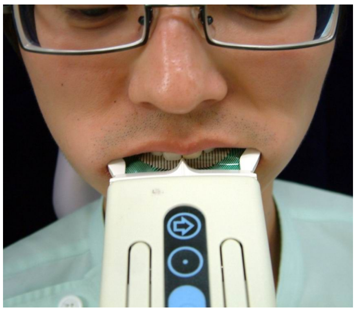


Figure 2. Application to patient

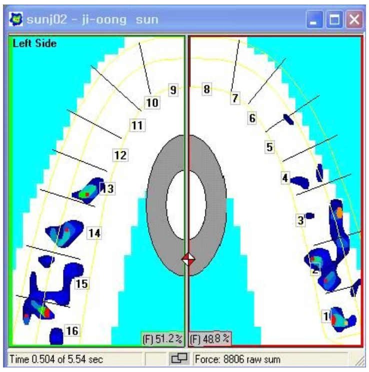
All 60 subjects retained all of their permanent anterior teeth, at least four permanent premolars, and at least eight permanent molars. All had, at most, one crown and no other prostheses present. All were dentate with generally healthy oral conditions.

Lateral guidance and nonworking contacts were evaluated by letting the patient perform 3 mm right and left lateral excursions from the centric occlusal position. The 3 mm movement was used because occlusal contacts have been suggested to occur approximately 1 to 3 mm from the centric occlusion position during chewing.[44] A 3 mm mark to the right and to the left of the mandibular midline on the maxillary central incisors was used as a guide for the lateral movements. Patients sat upright on a dental chair with the Frankfort Horizontal plane parallel to the floor.

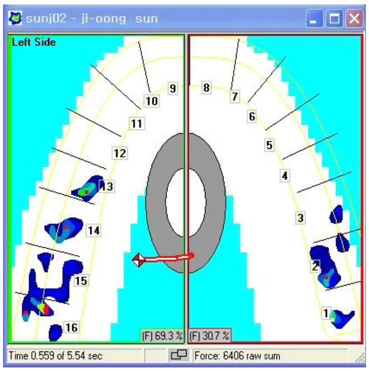
Nonworking contacts and lateral excursion contacts were evaluated with articulating paper, dental floss, and also T-Sacn Ⅱ. This was practiced several times before recording the observation. Canine guidance was defined as contact of 1 maxillary and 1 mandibular canine in the lateral excursion when the mandible was moved 3 mm to the right or left. Group function was defined as 2 or more contacts in the lateral excursion when the mandible was moved 3 mm to the right or left. A canine did not have to be in contact to be classified as group function.

Disclusion time was analysed by the T-Scan Ⅱ(Fig. 3). Disclusion times of the right and left mandibular excursions were measured twice for each patient. Mean of the two measurements was used for analysis.

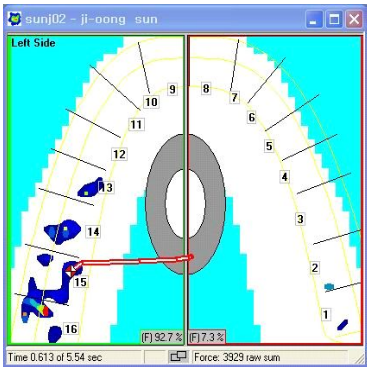
Data for lateral guidance and balancing contacts were analyzed with chi-square tests to assess differences. Statistical significance was set at $P<0.05$ with adjustment for multiple comparison. Right and left disclusion times of patients were analyzed by the analysis of variance (ANOVA) with repeated measures for one factor.($P<0.05$)



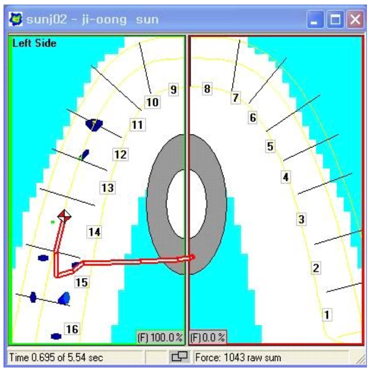
ⅰ. State of intercuspation(0.504 sec)



ⅱ. Start of lateral movement



ⅲ. Just before disclusion



ⅳ. Just after disclusion(0.695 sec)

Disclusion time = 0.695 – 0.504 = 0.191 sec

Figure 3. Left force movie frames illustrating disclusion time.

Ⅲ. RESULTS

No patients had balancing side contacts that prevented the working side from contacting. Simultaneous contacts of the balancing and working side were common. The distribution of lateral guidance on the right and left sides are presented in Table 1. Asymptomatic and symptomatic patients had a similar ratio of distribution of canine guidance and group function. Approximately, group function appeared twice more than canine guidance. But, between the two groups, there was no statistical difference.

Table 1. Distribution of subjects with canine guidance versus group function in symptomatic and asymptomatic patients

Group	Canine guidance		Group function		Total subjects/sides
	Left	Right	Left	Right	
Asymptomatic	12(40%)	10(33.3%)	18(60%)	20(66.7%)	30(60)
Symptomatic	9(30%)	10(33.3%)	21(70%)	20(66.7%)	30(60)

Chi−square = 0.000, df = 1, P = 1.000 for asymptomatic vs symptomatic in right
Chi−square = 0.659, df = 1, P = 0.417 for asymptomatic vs symptomatic in left

The prevalence of nonworking side contacts on the right and left sides are presented in Table 2. and Table 3. For asymptomatic subjects, the presence of 1 contact was more prevalent than symptomatic patients in left side. And, for symptomatic patients, the presence of 1 contact was more prevalent than symptomatic patients in right side. However, there were no statistical differences.

Table 2. Nonworking side contacts for asymptomatic and symptomatic patients with temporomandibular joint disorders (right side)

Group	0	1	>1	Total
Asymptomatic	19(63.3%)	7(23.3%)	4(13.3%)	30
Symptomatic	15(50%)	12(40%)	3(10%)	30

Chi-square = 1.929, df = 2, P = 0.381 for asymptomatic vs symptomatic

Table 3. Nonworking side contacts for asymptomatic and symptomatic patients with temporomandibular joint disorders (left side)

Group	0	1	>1	Total
Asymptomatic	17(56.7%)	9(30%)	4(13.3%)	30
Symptomatic	21(70%)	3(10%)	6(20%)	30

Chi-square = 3.821, df = 2, P = 0.148 for asymptomatic vs symptomatic

Differences of disclusion time among symptomatic patients and asymptomatic subjects were determined by a three-factorial mixed-design ANOVA (Table 4). The principle conclusion from this analysis is that the mean disclusion time for the symptomatic patient group is significantly longer than that for the asymptomatic group. The mean disclusion time was 0.583 seconds for symptomatic patients and 0.474 seconds for asymptomatic subjects (P=0.020). The absence of significant interaction effects with patient type (TMD, non-TMD) indicated that the difference between patient types do not vary significantly with gender or right or left excursions (Table 5).

Table 4. Analysis of right and left disclusion times(in seconds) for men and women, symptomatic and asymptomatic patients

Source	*df*	Mean square	F	*P*
Patient type	1	0.355	5.766	*0.020*
Gender	1	9.075×10^{-4}−04	0.15	0.904
Type×gender	1	3.997×10^{-4}−02	0.649	0.424
Error(between)	56	6.162×10^{-4}−02		
Side	1	1.408×10^{-4}−04	0.012	0.912
Side×type	1	4.687×10^{-4}−03	0.413	0.523
Side×gender	1	6.601×10^{-4}−03	0.581	0.449
Side×type×gender	1	1.875×10^{-4}−04	0.017	0.898
Error(within)	56	1.136×10^{-4}−02		

Table 5. Summary of descriptive statistics for right and left disclusion time(in seconds)

	Women		Men	
	Left	Right	Left	Right
Asymptomatic				
Mean	0.454	0.451	0.479	0.511
SD	0.101	0.109	0.173	0.166
N	15	15	15	15
Symptomatic				
MEAN	0.609	0.587	0.610	0.568
SD	0.213	0.278	0.213	0.230
N	15	15	15	15

Ⅳ. DISCUSSION

This study evaluated the prevalence of 3 dental occlusal factors : lateral guidance, nonworking side contacts, and disclusion time. A cause–and–effect relationship were suggested for their presence or absence and the development of TMD. Although there is an agreement that guidance patterns can alter muscle activity,[2] there is no evidence as to the impact of these occlusal schemes on either the success or failure of restorative dental treatment or the prevention of TMD. Butler *et al.*[3] found no differences in mandibular range of motion, joint sound prevalence, TMJ, or masticatory muscle tenderness when lateral guidance patterns were compared. Roberts *et al.*[38] also found no differences in occlusal guidance pattern between patients with disc displacement and symptomatic patients with normal disk position. These studies suggest that the presence of signs and symptoms are not prevented by occlusal scheme. Donegan *et al.*[5] reported that the prevalence of canine guidance in non–patients and symptomatic patients was 30% and 22%, respectively. Another study uses a classification system that regulates the lateral positioning of the mandible at 0.5, 2, and 3 mm.[13] The prevalence of canine guidance was 10.5%. Ingervall[32] has suggested that non–patients demonstrated canine guidance bilaterally in 2% and unilaterally in 18%. These studies suggest that patients without symptoms do not have a predominance of canine guidance. This suggests that no occlusal scheme should not be considered to be superior. This also suggests that canine guidance may not protect one from developing TMD.

In a study of young adults with nonworking side contacts with no signs or symptoms of TMD, it was suggested that the system had an adaptive capacity.[14] Magnusson and Enbom[20] found that bilateral insertion of nonworking side contacts resulted in various subjective symptoms and clinical signs of dysfunction in many, but not all, subjects in a 2−week study. Some subjects developed both subjective symptoms and clinical signs of dysfunction even though no interference was placed. It was concluded that there is no simple relationship between occlusal contacts and signs and symptoms of TMD.

In our study, symptomatic patients had fewer nonworking side contacts compared with asymptomatic subjects in left side. These results are in agreement with those of Agerberg and Sandstrom,[1] who found a prevalence of nonworking contacts to be 88% to 89% of the non−patient population consisted of 60 teenagers and 80 young adults. These subjects had at least 1 unilateral nonworking contact. It was concluded that such contacts could not be established as an etiologic factor for TMD. Our study ranged from 43.3% in asymptomatic group to 50% in symptomatic group. Hochman *et al.*[12] found nonworking side contacts in 94% of 96 patients evaluated, which shows these contacts were common. Kirveskari *et al.*[16] also offered support by suggesting that most studies are unable to find interference−free subjects in asymptomatic subjects. In a longitudinal 10−year follow−up study of 84 subjects, Magnusson *et al.*[21] found 32% increase on nonworking side contacts. If heavy working and/or balancing side contacts promote the development of TMD, then patients having orthodontic treatment should develop signs and symptoms because the teeth are uneven for most of the treatment time. Egermark and Ronnerman[7] concluded that, although there is a high prevalence of high occlusal contacts during orthodontic treatment, this seemed to be of little importance for development of TMD. Minagi *et al.*[29]

suggest that certain types of nonworking side contacts may be protective of the TMJ, although they offer no good explanation. Wedel and Carlsson[48] suggested no such relationship. The suggestion has also been made that occlusal factors do not predict dysfunction or symptom severity.

To solve the dilemma of the significance of any occlusal condition, it will be necessary to establish the relative risk of any combination of occlusal features. It seems obvious that no single occlusal feature is the single etiologic factor in the development of TMD. There may be several alternate explanations that will require further examination. First, there may be no ethnologic relationship. Second, the intercuspal stability, loading sequence, and/or loading distribution of the teeth may play some role. There are clinical and theoretical examples in the literature. In a clinical study, Kerstein[37] has evaluated 7 myofascial pain dysfunction patients 1 year after occlusal adjustment. Of 7 subjects, 6 had no change in disclusion times and were free of pain. In a theoretical study, Ferrario and Sforza[8] proposed a model that would evaluate muscular and clenching forces and the effect on the TMJ. If these models are going to suggest that muscle activity and/or uneven occlusal contacts are going to cause internal derangement, the authors will have to explain the presence of derangement in children. Third, neurogenic inflammation and arthritis may produce pain in the TMJ, which may be anteroposterior changes in the dental arches (retrognathia, open bite), and/or sagittal changes (midline shifts, cross bites) that are a result of the arthritic changes. These arthritic changes may increase the degree and severity of CR–CO discrepancies. This suggests sagittal and transverse changes may be a result of arthritic changes, not the cause.

The comparisons of disclusion times revealed that the TMD patients had significantly longer disclusion time than that of the non-patients.

This evidence suggests that long disclusion time may be of diagnostic importance in the evaluation of potentially different etiologies for the TMD patient.

It was reported that if disclusion time is long (>0.5 seconds), elevated levels of contractile muscle activity are present in the masseter and temporal muscles. The finding that some normal group in this study had long disclusion times (with potentially elevated levels of muscle activity) suggests that a threshold mechanism of symptomatic muscle dysfunction may be in place. The clinical symptoms may not appear unless the patient's individual threshold for building up toxic by-products from excessive muscle contractions is exceeded. This could eventually occur naturally in an occlusal scheme, with long disclusion time building large amounts of muscle contractions. Also, an individual patient's threshold could be lowered by external factors such as jaw trauma. Previously unseen symptoms may become clinically apparent with the threshold lowered.

In this study, it appears that the TMD patient group had longer disclusion time than the normal group. But, there was no significant difference between men and women in disclusion time. Also, between right and left side, there was no significant difference in disclusion time too.

Kerstein and Wright[19] have shown that contractile muscle activity is proportional to the disclusion time. From this determination, occlusal schemes with poor anterior guidance capability should be predisposed to high levels of muscle activity and clinical symptoms. In this study, numerous patients with extended disclusion times did not exhibit symptoms, which supports the theory that threshold mechanism of clinical symptom appearance from extended disclusion time may exist.

Okeson[32] described the phenomenon of physiologic tolerance as a variable in each patient's ability to adapt to malocclusions and functional disturbances. Each person has a unique ability to adapt to imperfections within his or her physiology. This adaptive capability may vary widely from patient to patient. The clinical appearance of TMD symptoms may be an indication that an individual's physiologic tolerance to the etiologic variables has been exceeded, which would be the nature of the disclusion time / TMJ muscle activity threshold mechanism. With long disclusion time present in an occlusal scheme, excessive muscle contraction occurs over time and leads to the building up of toxic TMJ muscle contraction by-products (namely lactic acid) within the muscle fibers. In given day, a patient's level of toxins will exceed the muscle's ability to metabolize these toxic substances. This would then initiate an ishemic state followed by the clinical appearance of TMD symptoms. Continued daily, weekly, monthly, and yearly, long occlusal compressions of the posterior teeth and their periodontal ligaments, as a result of long disclusion time, would perpetuate the high level of TMJ muscle contractions and establish an ongoing state of chronic ischemia and TMJ muscle dysfunction.

A lack of clinical symptoms despite the presence of long disclusion time in an individual occlusal scheme would indicate that either the patient's physiologic tolerance has not yet been exceeded or the other potential contributory etiologic factors, such as TMJ derangements, degenerative joint disease, and/or other musculoskeletal disorders, are not present. However, if present, it suggests that these factors have not exceeded the patient's physiologic tolerance. A larger population should be studied to verify the observed trends.

V. CONCLUSIONS

The purpose of this study was to compare the prevalence of occlusal guidance (canine vs group function), nonworking side contacts and disclusion time in TMD patients group and normal group. Followings were concluded.

There was a predominance of group function on both right and left sides in the two groups. For normal group, the presence of 1 contact was more prevalent than patients group in left side. And, for patients group, the presence of 1 contact was more prevalent than patients group in right side. However, between the two groups, there was no statistical difference.

Right and left disclusion times were longer in patients group than in normal group. A threshold mechanism for each patient may be present that, if exceeded, allows the symptoms of TMD to become clinically apparent. Some normal subjects had longer disclusion times than those previously reported to be neuromuscularly healthy (less than 0.5 seconds).

Long disclusion time may be a diagnostic factor in the total clinical assessment of a patient who experiences the symptoms associated with TMD. Pretreatment disclusion time analysis may allow the dentist to ascertain whether potential TMD symptoms are being completely or partially activated by the existing occlusal scheme.

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