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Analysis of occlusal factors in unilateral temporomandibular disorder using T-scan II system

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김 현 정

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T-scan II 를 이용한 편측 TMD 환자의 교합요인 분석

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김 현 정

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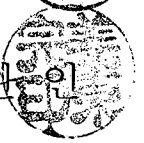
위 원 조선대학교 교수 강 동 완 

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T-scan II를 이용한 편측 TMD 환자의 교합 분석

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TMD와 교합과의 중요한 관계가 발견되었었지만 이들 관계는 부분적으로 확인되고 확인되지 않았다. 자료수집방법의 차이, 몇몇 연구에서 대조군 수의 부족, 모집단의 다양성, 다양한 승인기준 등이 모순된 결과를 가져왔다. 게다가 접촉측정, 교합압력 측정, chair position, head posture의 다양한 방법과 기술이 교합 반응에 영향을 미칠 수 있다.

본 연구에서는 편측 TMD 증상이나 증후가 있는 피실험자와 건강한 피실험자와의 어떠한 교합 차이점이 있는지에 대해서 연구하고자 한다.

컴퓨터화된 교합분석 시스템인 T-scan II 시스템을 사용하여 15명의 편측 TMD 환자와 정상교합자 15명의 대조군 사이에 중심교합상태에서 교합양상의 특이점을 평가하였다.

이 연구에 한정하여 본다면, 정상치열과 정상교합을 지닌 젊은 성인에서 편측성 TMD와 교합력 비대칭은 약한 관계로 밝혀졌다. TMD 환자나 건강한 사람에서 교합력의 양측성 대칭의 부재는 이례라기보다는 정상이었다. 그러나 편측성 TMD를 가진 환자는 상대적으로 좀 더 비대칭적으로 나타났다. 교합접촉과 TMD 의 어떤 관련의 존재와 원인은 더 추적되어져야한다.

I . INTRODUCTION

Temporomandibular disorder (TMD) is a collective term which embraces a number of clinical problems that involve the masticatory musculature, the temporomandibular joint (TMJ) and associated structure, or both[1].

Occlusion has been advocated as a causative factor in TMD[2-5]. The American Academy of Orofacial Pain has suggested that occlusion may play a role in the cause of TMD[6], but the literature reports controversial and inconclusive results[5,7-22]. Significant associations of TMD with occlusion have been found[5,9,10,13,16,18,19], but these associations are only partially confirmed or not confirmed[7,8,11,12,14,15,17,20]. Nonhomogeneity in definitions, differences in data collection procedures, lack of control group in some investigations[7,12,17], diversity among populations, and varied admission criteria may have led to contradictory results. Moreover, the different methods and techniques used to record contacts[23], the occlusal pressure used[24,25], chair position, and head posture all may have influenced occlusal response[26].

There is an obvious need to re-examine the hypothetical relationship between TMD and occlusion. Indeed, although several studies investigated patterns of occlusion in healthy subjects[23,27-34], little information is available in subjects with TMD[4-13,16-18], and controlled trials are lacking.

The conventional methods of occlusal analysis such as marking paper, wax, paste[35], articulating paper, foil, and silk strip can only establish the location and number of tooth contact, and have a great deal of errors, especially on wet condition[36]. Millstein (1983)[37] showed inordinate variation in reproducibility of marking paper in vitro. More importantly, the conventional methods of occlusal analysis can not represent time and force. However, a computerized occlusal analysis system has the capacity to reveal quantitative time data and relative force data to challenge the conventional methods for its perceived descriptive capacity[38]. An accuracy of time record, force record and stability of force

recording of a computerized occlusal analysis system, T-SCAN II (Tekscan Inc, Boston, MA, U.S.A.), was proved[39]. The system is capable of simultaneously measuring these parameters for teeth separated by less than 0.1mm, and thus it has potential in research on centric occlusion.

T-Scan II software offers several advancements for analysis of the occlusion and load distribution over the previous version, including center of force analysis, center of force trajectory, and color coding of occlusal contacts according to magnitude.

This study assessed the possible association between unilateral TMD and a lack of bilateral symmetry in occlusal force. The study population comprised young adults with complete natural dentitions and Angle Class I occlusion.

II. MATERIAL AND METHODS

A. Subjects

Fifteen subjects(12 men , 3 women) for control group and unilateral TMD fifteen subjects who have unilateral TMD(9 men, 6 women) were selected from the 500 dental students consecutively enrolled at the Chosun University (Table 1.).

Table 1. Classification of subject group.

Group	Normal	Unilateral TMD(Lt. Side)
Male	12(26.6)	9(26.11)
Female	3(24.0)	6(25.6)
Sum	15(26.13)	15(25.93)

The following eligibility criteria were used: complete natural dentition except for occasionally missing third molars; normal physiological occlusion as defined by Mohl[40] and bilateral Angle Class I molar and canine relation; no periodontal disease; good compliance with oral hygiene; no dental treatment in the 3 months before clinical evaluation; and unilateral presence of at least 2 signs or symptoms of TMD (TMJ sounds, pain on palpation of the TMJ or masticatory muscles, and/or painful limitation of mandibular movement)[41]. Exclusion criteria were the presence of neurologic or cervical disturbances, any disabling complaint, and the presence of recurrent headaches.

Each subject with TMD was age-and sex-matched with a control subject who met modified admission criteria (signs and symptoms of TMD were excluded) and who was randomly selected (same chance within each age and sex stratum) from healthy students. The matched case-control design was

adopted because it was believed to be a useful design for small investigations[42]. All participants gave oral informed consent.

Neurologic and cervical disturbances, as well as recurrent headaches, were identified as exclusion criteria because they were considered potential confounders. In fact, previous studies have suggested that these complaints may be associated with TMD or craniomandibular asymmetry[43-47].

One experienced dentists (>10years of clinical practice) assessed dental and TMD status.

B. T-Scan II System

The T-Scan II uses the proprietary force sensor technology and software to quantify the occlusal contact data[48]. The technique involves placing a sensor in the patient's mouth and asking the patient to close in maximum intercuspation (MIP) while the computer records a series of frames of the patient's tooth contacts.

Occlusal contacts are represented as topographical images that describe the shape of the contact area, relative force, and surface area. Differences in occlusal force are shown by color ranging from red as the greatest force to blue as the least force, using the standard order of colors of th spectrum. These contour images of the tooth contacts provide an instant view of the areas of greatest tooth contact and relative force. The images are easily analyzed by the software by summing the force weighted surface area for comparison.

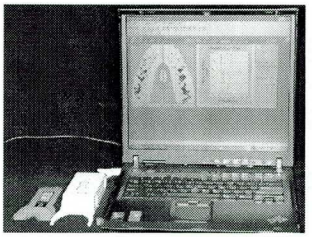

Fig. 1. T-Scan II.

Fig. 2. Sensor was placed.

C. Measurement

During the T-Scan II recordings the subjects were kept in a natural sitting position with no head rest according to Frankfort horizontal plane parallel to the floor[49-51].

Then the T-Scan II sensor and sensor support assembly were inserted intraorally and positioned correctly. Then force-movie mode was activated manually by pushing the button on the handle. The volunteer was instructed to bite in the habitual intercuspal position which were not guided by the investigator. Several practices were made until a repeatable pattern of tooth contacts was produced on the computer monitor to verify the reliability of the data, and then a representative force movie was printed. Between the records, the volunteer had few minutes of resting time. All these procedures were repeated three times. Relative ratio of right-to-left occlusal force side was measured through the analysis of center and center orbit of force.

Analysis of a balance between Rt, and Lt. occlusal force: Rt. and Lt. side occlusal force on frame which displays MIC(maximum intercuspation) and expressed by percentage.

To measure Occlusion time, patient close completely into their intercuspid position (IP), and hold their teeth together in IP approximately 1 to 2 seconds. Then the Center of Force (COF) icon will stop moving and become static. The patient can then open.

Set OT A-line

Place the black time line at the closest point to where Maximun Force=1%. without going over 1% maximun force. then superimpose the A-line on the black time line in the graph.

Set OT B-line

Estimate where the Red line(right side) and Green line(left side)become static/parallel to each other. This is the point where all the teeth first become into IP.

Place the black time line at the point to where Maximun Force approximately 85%, without going earlier than 80%. then superimpose the B-line on the black time line in the graph.

Tooth sliding area was measured availing of a 'delta' display option in T-Scan. 'Delta' displays an image created by calculating MAX frame, a collection of the highest tooth contact force on all teeth over the whole frames, and then subtracting the intercuspal position frame.

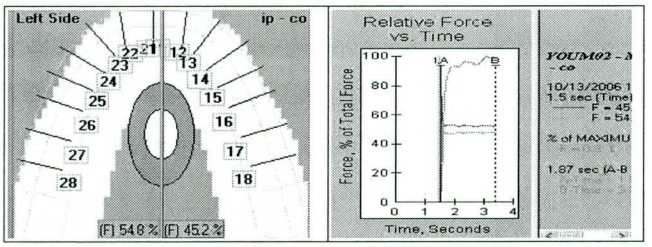

Fig. 3. Measuring occlusal time(set A-line).

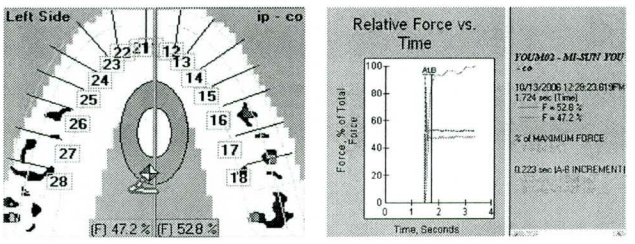

Fig. 4. Measuring occlusal time(set B-line).

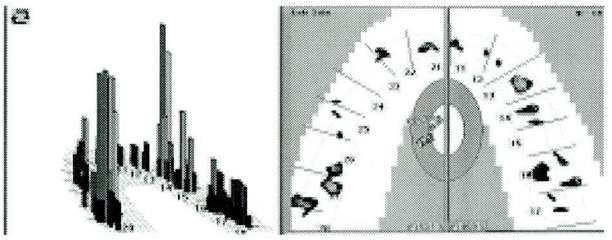

Fig. 5. Measuring occllusal force.

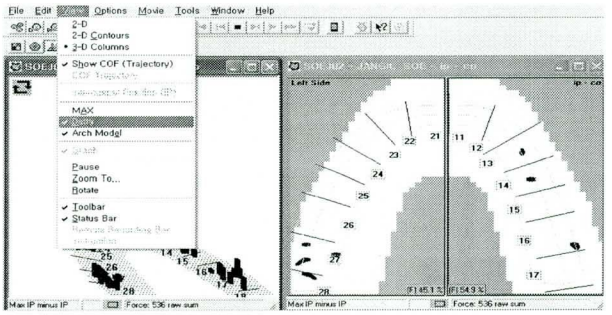

Fig. 6. Measuring sliding area.

D. Statistical analysis

All values of P less than 0.005 were considered to indicate statistical significance(two-tailed). The SPSS package version 10.1 for Windows was used for statistical analysis.

Ⅲ. RESULTS

1. Comparison of relative occlusal force ratio between left and right side

No statistically significant differences were observed between right and left side relative occlusal force ratio of normal, unilateral TMD group and both through paired t-test.

The bilateral symmetrical attribution of occlusal force wasn't accurate both normal and unilateral TMD group.

The mean occlusal force of left TMJ of Unilateral TMD group was less than normal group, but there is no statistically significant differences because P-value was more than 0.005.

Table 2. Comparison of relative occlusal force ratio between left and right side in normal and unilateral TMD group.

Group	Balance Ratio		
	Normal(N=15)	Unilateral TMD(N=15)	P-value
Lt.	48.120	44.433	0.683
Rt.	52.213	55.567	0.568

significance level $p<0.005$

2. Comparison of Occlusion time betweem Normal and Unilateral TMD Group

Occlusion time between normal and unilateral TMD group has no statistically significant differences because P-value was more than 0.05, however, there is a slight differences in the mean value. The occlusion time of normal group is less than unilateral TMD Group.

Table 3. Comparison of Occlusion time betweem Normal and Unilateral TMD Group.

Occlusion time		
Normal(N=15)	Unilateral TMD(N=15)	P-value
0.21078	0.25590	0.244

significance level p<0.005

3. Tooth sliding area during intercuspation in Normal and Unilateral TMD Group

Unilateral Group was less than normal group, but there is no statistically significant differences in P-value.

Table 4. Comparison of Sliding area between Normal and Unilateral Group.

Sliding area		
Normal(N=15)	Unilateral TMD(N=15)	P-value
749.07	684.4	0.650

significance level p<0.005

Ⅳ. DISCUSSION

There has been a long debate regarding etiologies of TMD. Due to the specific anatomical structures of TMJ and complex nature of TMD, numerous etiologies were proposed.

Among the etiologies, especially, occlusal factor has been a critical issue, after James Costen (1934)[52] claimed that change of occlusion and various ear symptom were related to each other based on eleven clinical cases.

In contrast, some authorities announced doubtful opinions about the occlusion as the etiologic factor of TMD.

Conventional registration materials (including inked marking strips[53], waxes[54], ribbons and silicone[55]) and other impression materials such as plaster presently are used to analysis the occlusion. These materials are preferred primarily because of their low cost and easy application. None of these, however, has proved to be ideal. They are affected by the presence of saliva[56] and show low reproducibility and high variability[57]. Photo-occlusion presents quantitative measures for determining occlusal relationship but it is reported to be "difficult to apply" and "little reproducible"[58),59]. Moreover all of these materials demonstrate only the static condition. The T-Scan system registers and depicts a measure of the dynamics of occlusion[60),61]. The sensitivity of this system is not changed whether the saliva is present or not[56]. In a few study about comparing the T-Scan system with another registration material in vivo and in vitro, this system showed high accuracy and validity[62),63]. In our study, we selected the T-Scan system for occlusal analysis.

In this regard, Wilding et al[64] selected the wax as an occlusal contact registration material and the wax thickness after holding between the teeth was regarded as a criterion of contact area.

But the wax has a limitation of lack of stability and accuracy[65),66]. Since wax might have a dimensional change and distortion, there was a probability of

missing a fine part of contact area.

Although the T-Scan system does not accurately measure absolute bite force, the device can provide a constant expression in relation to a sustained force[67),68)]. In past studies, the bite force was measured with a thick transducer, and it was thus impossible to evaluate both the bite force and occlusal contacts simultaneously. The T-Scan sensor is very thin, permitting simultaneous measurement of both parameters. The relationship of force distribution can be computed not only in the mediolateral plane but also in the anteroposterior plane, which adds another important dimension to the analysis of occlusal force distribution.

Another software enhancement for analyzing occlusion is the center of force trajectory, which analyzes the force effect of the tooth contacts over the course of closure.

By recording the occlusal contacts as they progress from first contact to MIP, their effects can be measured. The results of the occlusal force are analyzed by following the trajectory during the playback of the closure.

This investigation examined the possible association between unilateral TMD and a lack of bilateral symmetry in the occlusion in a sample of young adults with complete natural dentitions and normal occlusion. Although the reference population was clearly identified, the possibility of biased selection of unilateral subjects with TMD cannot be excluded given the unusual correspondence of unilateral clinical findings and symptoms. From an epidemiologic perspective, such bias would be a limitation of this study.

In unilateral TMD subjects, no difference was found between sides with and without signs and symptoms of TMD.

These results agree with some previous studies[7),11),12)] but differ from others[9),10),13),16),18)]. Once again, it should be recognized that some of these studies cannot be compared because of different study designs, methods of data collection, and assessments of occlusal conditions.

The within-subject analysis disclosed a weak association between unilateral TMD and asymmetry of occlusion. Absence of perfect bilateral symmetry was common both in subjects with TMD (100%) and control subjects (86.7%) and did not differ significantly between groups. In other studies, the prevalence of perfect symmetry in healthy subjects ranged from approximately 5%[33] to 21%[23]. These results support the conclusion that asymmetry of occlusion seems to be the rule rather than the exception, both in subjects with TMD and healthy subjects. Nevertheless, in this study, subjects with unilateral TMD exhibited greater asymmetry than control subjects. This result suggests that, although significant asymmetry may be relatively rare in healthy subjects (as also found by McDevitt and Warreth[23] and Korioth[33]), it is quite common in unilateral subjects with TMD.

Several studies have evaluated asymmetries in patients with TMD, with special focus on electromyographic muscle activity and facial morphologic characteristics[5,14,15,17,19,21,22]. The results are controversial. In particular, it has been suggested that in subjects with TMD, asymmetry in occlusal relations may be related primarily to skeletal asymmetry[22].

On the basis of the results, an independent association between unilateral TMD and asymmetry of occlusal contacts may be inferred. This conclusion is in agreement with Watanabe et al[17], they were drawn from a clinical population of patients that may have had bilateral TMD. Moreover, Watanabe et al[17] evaluated occlusion during lateral excursion, although this study evaluated occlusion in the intercuspal position. These diverse occlusal positions may have led to different estimated of the prevalence of contacts.

Large, longitudinal studies are necessary to confirm the results of this study and to clarify the nature of the relationship between TMD and occlusion.

V. CONCLUSIONS

Within the limitations of this study, a weak association between unilateral TMD and asymmetry of occlusal force was found in young adults with complete natural dentitions and normal occlusion. Absence of bilateral symmetry of contacts seemed to be the rule rather than the exception, both in subjects with TMD and healthy subjects, but subjects with unilateral TMD exhibited relatively greater asymmetry.

1. There was no exact bilateral symmetrical distribution of occlusion both in normal and unilateral TMD group($p>0.005$).
2. Occlusal time of normal group was less than that of unilateral TMD group($p>0.05$).
3. There was no significant differences in sliding area of normal and unilateral TMD group($p>0.05$).

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