Occlusal Analysis of the Subjects with Chewing Side Preference Using the T-Scan II System

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While orofacial pain or various dental factors are generally considered as the primary cause of unilateral chewing tendency, there exist several studies indicating that dental factors did not affect the preferred chewing side. The aim of this study was to examine difference of occlusal scheme between the subjects with and without chewing side preference. The difference between the chewing and non-chewing sides in the unilateral chewing group was investigated as well. Computerized, T-Scan II system was used for occlusal analysis.

20 subjects for the unilateral chewing group (mean age of 25.25±2.84 years) and 20 subjects for the bilateral chewing group (mean age of 27.00±5.07 years) were selected by a questionnaire on presence or absence of chewing side preference and those with occlusal problem or pain and/or dysfunction of jaw were excluded. T-Scan recordings were obtained during maximum intercuspation and excursion movement. The number of contact points, relative occlusal force ratio between right and left sides, tooth sliding area and elapsed time throughout the maximum intercuspation were calculated. Elapsed time for excursion was also investigated.

The results of this study shows that the unilateral chewing group had the smaller average tooth contact areas compared with those of the bilateral group ($p<0.005$). In the unilateral chewing group, the contact areas of non-chewing side are smaller than those of chewing side ($p<0.005$). The contact areas on their preferred sides were not significantly different with those of right or left side of the subjects without chewing side preference. There was no significant difference in the elapsed time during maximum intercuspation and lateral excursion, the sliding areas and relative of right-to-left occlusal force ratio between the two groups.

From the results of this study, it is likely that individuals prefer chewing on the side with more contact areas for efficient chewing.

Key words : Unilateral chewing, Occlusal analysis, T-scan II system

I. INTRODUCTION

Right or left handedness is usually accompanied by a preference for using the eye, ear and foot of the same side, and chewing have a single preferred side.[1,2] But the preferred chewing side appears to be independent of handedness and the other preferences.[3] A preferred chewing side was defined by Christensen and Radue as 'when mastication is performed consistently or predominantly on the right or left side of the dentition.[4]

Unilateral chewing habit increases right and left imbalance of masticatory muscle activity and facial asymmetry.[5,6] It also increases prevalence of temporomandibular joint disorders (TMD) followed by pressure of ipsilateral mandibular condyle and

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perpetuates preexisting TMD.[6] Unilateral chewing habit was reported in many TMD.[7] Hoogmartens and Caubergh report 45% of 128 patients had a consistent preference for left- or right-side chewing.[3] There was a report that ipsilateral chewing tendency was more than contra-lateral in unilateral TMD patients.[8] The pain originated dental structure such as caries, periodontitis and TMD causes unilateral chewing habit.[9,10] Dental parameters that affect unilateral chewing habit include occlusion, cusp form, contacts in lateral movement, lack of posterior teeth and working side interferences.[11-14] A predictable correlation between dental factors and unilateral chewing has been shown in several studies.[12-15] However, Pond et al. claim that crossbite, fixed partial dentures, posterior teeth that do not contact in CO, working interferences, balancing interference, open contacts, tooth mobility, fremitus, sensitivity to air, and sensitivity to percussion do not correlate with chewing side preference.[16] Nissan et al. argued that chewing side preference correlated with other tested hemispherical lateralities.[17] It is postulated that initially, chewing side preference is an innate quality, controlled by the chewing centre in the midbrain and that this is subsequently affected by social and personal learning.[1,2,18] However, in some studies, it is suggested that no association was found between chewing-side preference and other hemispherical literalities. Those authors concluded that a peripheral mechanism might be responsible for chewing-side preference, unlike the proposed cortical system that may account for other items of preference.[3,19]

The aim of this study was to examine difference of occlusal scheme between the subjects with and without chewing side preference, using the T-Scan II system, a computerized occlusal analysis system. Occlusal scheme difference between chewing and non-chewing sides was also investigated in the subjects having a preference for chewing on a particular side.

Ⅱ. MATERIALS AND METHODS

1. T-Scan Ⅱ System

A computerized occlusal analysis system employed for this study was T-ScanTMII (Tekscan, INC., USA) (Fig. 1). T-Scan II system is a Microsoft Windows (Microsoft Corp.) compliant system that has been integrated into a clinical diagnostic computer workstation. It consists of a piezoelectric foil sensor, sensor support, scanning handle, parallel hardware, and software for recording, analyzing, and viewing the data. The sensor is a 60 micrometer-thick polyester film. The film is covered by a silver thread grid, the

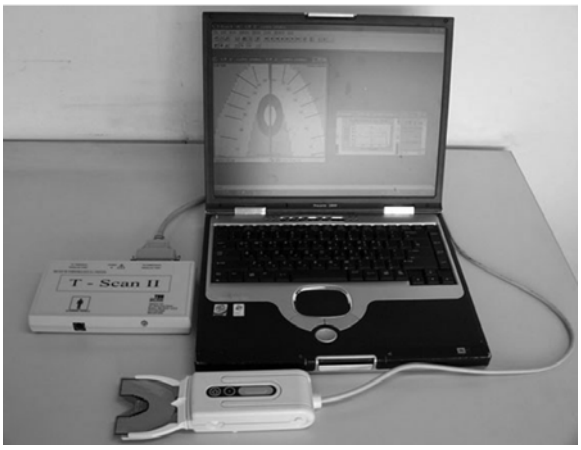

Fig. 1. T-Scan system connected with a computer

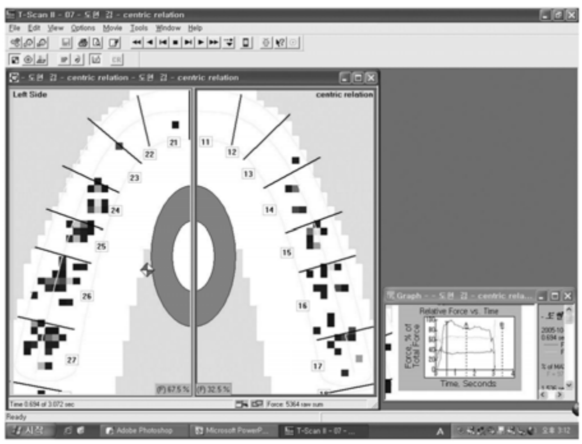

Fig. 2. A model of arches constructed on the screen

intersecting points of which are bathed by conductive ink. When the patient closes firmly on the sensor, the resultant reduction in electric resistance is translated into an image on the screen.[20)]

A 0.01 second real-time occlusal contact recording and 0.01 second incremental playback of the tooth contact timing data can illustrate the order of tooth contacts, as well as their force content (Fig. 2). The combination of contact order, contact duration that precedes the next occlusal contact, contact location within the arch, and magnitude of contact force determines the degree of contact simultaneity and the occlusal balance that is present or absent in a particular occlusal scheme.[21)]

2. Subjects

40 healthy and fully dentate subjects from undergraduate students and workers of Dankook University were voluntarily participated in this study by means of the questionnaire on chewing side preference. 20 subjects (M:F=11:9, unilateral chewing group) had right or left unilateral chewing tendency and the other 20 subjects (M:F=13:7, bilateral chewing group) didn't have preferred side on chewing. While a half of unilateral chewing group had chewing preference on the right side, the other half preferred the left side. Mean age was 25.25 ± 2.84 years for the unilateral chewing group and 27.00 ± 5.07 years for the bilateral group. Informed consent was obtained from the all subjects.

Exclusion criteria for the subjects were as follows;

* Major occlusal abnormalities such as posterior crossbite
* Prior orthodontic treatment or gnatho-surgery
* TMD
* Muscle tenderness to palpation
* Prosthodontics more than single crown
* Missing tooth except for third molars
* Dental caries
* Pathologic periodontal condition
* Current head, neck, and/or facial pain rendering the experimental procedure uncomfortable for the subjects

3. Measurement

During the T-Scan II recordings each subject was kept in a natural sitting position with no head rest according to Frankfort horizontal plane parallel to the floor concerning the feeding position. 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.

1) Habitual intercuspal position

When the sensor was correctly inserted into mouth, each subject was asked to close the mouth in the habitual intercuspal position. The habitual intercuspal position was divided into 3 stages (initial, middle and terminal) according to the time from initial occlusal contact to maximum intercuspation. At each of the 3 stages, the number of contact points of the right and left side was calculated separately and relative ratio of right-to-left occlusal force was also measured. Occlusal force on each stage was obtained by multiplying the number of contact points by intensity of each point. Occlusal force intensity was determined from 1 (the weakest) to 6 (the strongest) according to the legend (Fig. 3).

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

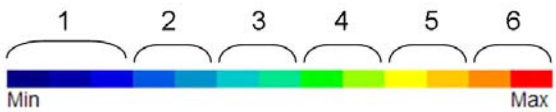

Fig. 3. The legend (color scale) of occlusal force.

the intercuspal position frame. Elapsed time was measured during habitual mouth closing.

2) Excursion movement

From the habitual closure position, the subjects then move their mandible laterally until the cusp of the upper canine was made to coincide with that of the lower canine. The excursive movements were unguided by the dentist but the speed was determined by the subjects. The right and left excursion time were measured irrespectively.

4. Statistical analysis

Repeated measures ANOVA and multiple comparison t-tests were used to determine the significance of difference in the number of contact points and relative occlusal force ratio during habitual mouth closing between the bilateral and unilateral chewing groups. In order to compare the difference of habitual closing time and tooth sliding areas during habitual mouth closing between the two groups, t-test was performed. Repeated measures ANOVA was employed in order to compare the excursion time of the two groups.

Ⅲ. RESULTS

It is shown in Table 1 and Fig. 4 how the numbers of contact points related to mouth closing stage in the unilateral and bilateral chewing groups. There was significant difference among the three stages in the both groups and the number of contact points significantly increased with progress of closing ($p<0.005$). The number of contact points of the bilateral chewing group was significantly more than that of the unilateral group ($p<0.005$).

Table 2 represents the number of contact points on right and left side at each closing stage. In unilateral chewing group, the occlusal contact points of chewing side were significantly more than that of non-chewing side($p<0.005$). Each side, regardless of right or left, in the bilateral group had more contact points as compared with the non-chewing side of the unilateral group ($p<0.005$) while there was no significant difference among right and left sides in bilateral chewing group and chewing side of unilateral chewing group ($p>0.05$).

There was no statistical significance in relative right to left occlusal force ratio difference at each

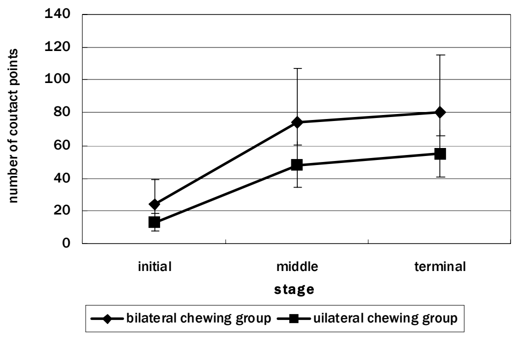

Fig. 4. Graph showing changes of the number of contact points related to mouth closing stages in the bilateral and unilateral chewing groups.

Table 1. Changes of the number of contact points related to mouth closing stages in the bilateral and unilateral chewing groups

	Initial	Middle	Terminal	ANOVA
Bilateral chewing group	24.225 ± 14.668[a,b]	74.275 ± 32.812[a,e]	80.325 ± 35.257[b,f]	$p< 0.005$
Unilateral chewing group	13.200 ± 5.557[c,d]	48.150 ± 13.984[c,e]	54.925 ± 14.219[d,f]	
ANOVA		$p < 0.005$		

Significant difference between the same alphabets, *; $p<0.005$

Table 2. Changes of the contact point numbers on each side in the bilateral and unilateral chewing groups related to mouth closing stage

	Bilateral chewing group		Unilateral chewing group		ANOVA
	Rt. Side(A)	Lt. side(B)	Chewing side	Non-chewing side(C)	
Initial	26.950 ± 17.31	21.500 ± 12.693	16.842 ± 7.953	10.474 ± 4.033	A-C B-C : $p<0.005$
Middle	74.250 ± 32.614[a]	74.300 ± 33.783[b]	55.700 ± 15.138	40.6 ± 15.223[ab]	
Terminal	80.4 ± 34.986[c]	80.250 ± 36.528[d]	63.8 ± 16.433	46.050 ±15.415[cd]	
ANOVA	NS		$p<0.005$		

Significant difference between the same alphabets, *; p<0.005

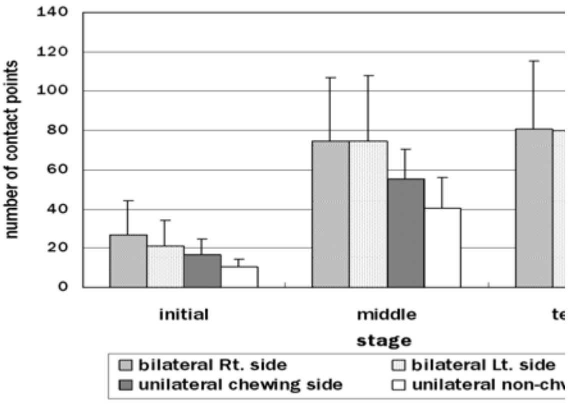

Fig. 5. Graph showing the contact point numbers on each side in the bilateral and unilateral chewing groups related to mouth closing stages.

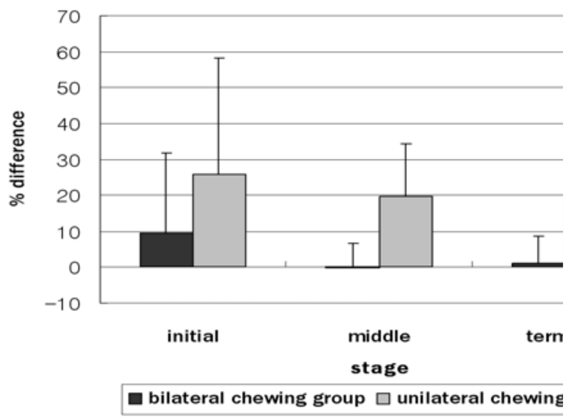

Fig. 6. Graph showing the relative occlusal force ratio difference between left and right sides in the bilateral and unilateral chewing groups.

stage of mouth closing both in the bilateral and unilateral chewing groups (Table 3, Fig. 6). In addition, the tooth sliding area and the elapsed time from initial contact to maximum intercuspation didn't show any significant difference between the two groups (Table 4, Fig. 7 and 8).

Table 3. Comparison of relative right-to-left occlusal force ratio difference between the bilateral and unilateral chewing groups.

	Bilateral chewing group	Unilateral chewing group	ANOVA
Initial	9.680 ± 22.243	25.970 ± 35.167	
Middle	-0.11 ± 6.913	19.59 ± 14.880	NS
Terminal	0.95 ± 7.790	19.97 ± 14.085	
ANOVA	NS		

Table 4. Comparison of the elapsed time and slide during maximum intercuspation (MI) between bilateral and unilateral chewing group.

	Bilateral chewing group	Unilateral chewing group	t-test
Sliding counts	29.000 ± 20.941	32.050 ± 16.097	NS
MI time	0.803 ± 0.309	0.939 ± 0.611	NS

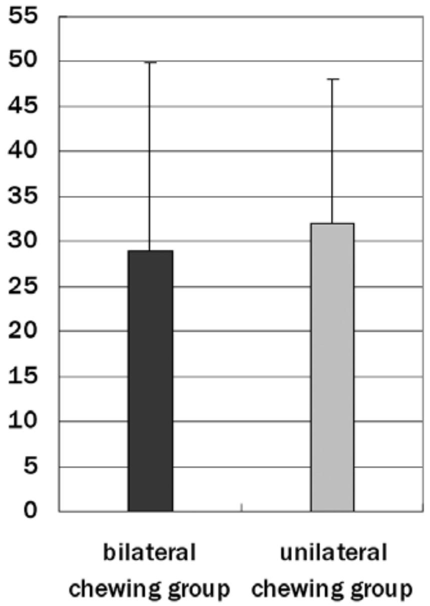

Fig. 7. Graph showing the tooth sliding area during habitual intercuspation in the bilateral and unilateral chewing groups.

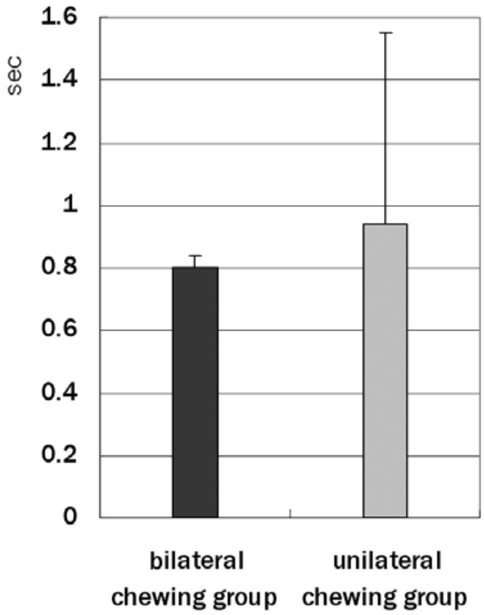

Fig. 8. Graph showing the elapsed time during maximum intercuspation (MI) in the bilateral and unilateral chewing groups.

There was no significant difference in the excursion time elapsed between the bilateral and unilateral chewing groups (Table 5, Fig. 9).

Ⅳ. DISCUSSION

Conventional registration materials (including inked marking strips,[22] waxes,[23] ribbons and silicone[24]) 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[25] and show low reproducibility and high variability.[26] Photo-occlusion presents quantitative measures for determining occlusal relationship but it is reported to be “difficult to apply” and “little reproducible”.[27,28] Moreover all of these materials demonstrate only the static condition. The T-Scan system registers and depicts a measure of the dynamics of occlusion[20,21] and its sensitivity is not changed whether the saliva is present or not.[25] 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.[29,30] These merits made the T-Scan system to be selected for occlusal

Table 5. Comparison of the excursion time between the bilateral and unilateral chewing groups.

Bilateral chewing group		Unilateral chewing group		ANOVA
Rt. side	Lt. side	Chewing side	Non-chewing side	
0.841 ± 0.319	0.892 ± 0.435	0.715 ± 0.365	0.684 ± 0.353	NS

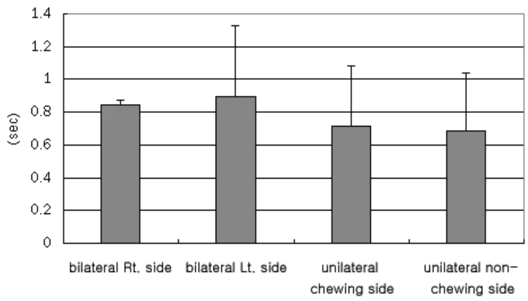

Fig. 9. Graph showing the excursion time in the bilateral and unilateral chewing groups

analysis in this study.

Several methods have been suggested to determine the existence of a preferred chewing side. Electromyogram was used by Moller[31] and a jaw-tracking device, sirognathograph was selected by Wilding and Lewing.[19] Wictorin et al. employed cineradiography[32] and Gillings applied videotape recordings.[33] Neill made use of kinesiography, a technique which allows movement of jaws to be observed without impeding normal function.[34] Christensen and Radue proposed the visual spot-checking method which consisted of a series of three visual inspections following chewing on chewing gum for three consecutive periods of 15, 20 and 25s.[4] They concluded that adult subjects predicted fairly reliably their chewing side preference i.e. their stated and observed preferred chewing side tended to be coincident. Nissan also reported the same results.[17] Thus a questionnaire was used to determine an individual' s preferred chewing side in this study.

In assessing the chewing potential of a dentition it would be necessary to measure not only the areas of actual tooth contact, but in addition, to include the surrounding areas where the opposing teeth are in close proximity.[14] Yurkstas et al. stated: "…it is probably the contact and near contact areas which constitute the actual food platform".[35] We admitted the 60 micrometers thickness of T-Scan sensor to be correspond with a space of near contact between opposing teeth.

The occlusal contact area does not take into account any contacts that may occur between the teeth during lateral jaw movements and may not represent the tooth surface areas used during chewing. But Pameijer et al. emphasized the importance of the intercuspal position during chewing.[36] Studies on the bite forces generated during chewing have established that the highest are towards the end of the chewing cycle when the teeth are in a central area.[37] This finding indicates that tooth contacts in centric occlusion are involved in some critical stages of chewing. It is likely that the choice of a favored chewing side would also be influenced by the quality and quantity of occlusal contacts on that side. In this regard, Wilding et al. investigated association between a preferred chewing side and its area of functional occlusal contact.[14] In that study, they 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. They concluded that no correlation was found between the area of occlusal contact on one side and the preference for chewing on that side. On the contrary, the results from this study exhibited the larger contact area on the preferred side. The wax used in the of Pameijer' s study has a limitation of lack of stability and accuracy.[38-40] As the wax might have a dimensional change and distortion, there was a probability of missing a fine part of contact area. The difference in a near contact space between their study and ours (45 and 60 micrometer thickness, irrespectively) might be another explanation.

Efficient chewing may be defined as the breakdown of food with the minimum effort and maximum rate of particle-size reduction. There is general agreement that chewing efficiency is related to the state of the dentition. Some evaluated the dentition by counting posterior teeth in contact[41] and others measured the area of occlusal table.[42] In a study by Yurkstas, it was found that the number of tooth contacts was not related to chewing efficiency, but the area of contact was.[43] The result of this study demonstrated that subjects with habitual unilateral chewing tendency had smaller average tooth contact area than who had bilateral chewing tendency. In unilateral chewing subjects, the contact areas of chewing side are larger than that of non-chewing side. Further, there was no significant difference among the contact areas of the preferred chewing side in the unilateral chewing subjects, right and left sides in the bilateral chewing subjects. That is to say, this study shows that people have a tendency of chewing with larger contact area of left or right side. It might be improved chewing efficiency on the preferred chewing side. Wilding et al. reported the tendency that particle size after chewing was smaller on the preferred side.[44] Yurkstas concluded that the unilateral chewing tended to be the most efficient side. If both sides are equally efficient, then chewing occurs on both sides although their study was performed with uncontrolled subjects.[43,45] It should also be concerned a possibility that the larger contact area on the preferred side might be somewhat a result of unilateral chewing habit.

According to the results from this study, there exists no significant difference in the elapsed time during maximum intercuspation and lateral excursion and the sliding area between the subjects with and without unilateral chewing preference. These results, to a certain extent, give support to some studies indicating that occlusal interference does not correlate with chewing side preference. Relative occlusal force ratio between chewing and non-chewing sides in unilateral chewing subjects was not significantly different, but the chewing side tended to have a large contact force compared to the non-chewing side. It might mean that there are some more variables in chewing. A preference for chewing on one side was found to be associated with certain types of jaw movement.[19] Further studies are needed about the variables of preferred chewing habit.

V. CONCLUSIONS

The subjects with preferred chewing side had smaller tooth contact area than those with bilateral chewing tendency. There was no significant difference among the chewing side contact area of unilateral chewing subjects, right and left side contact area of bilateral chewing subjects. However, the contact areas of non-chewing side are significantly smaller than that of chewing side. The results of our study shows that people have a tendency of chewing with larger contact area between left and right side in order to avoid low chewing efficiency.

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국문요약

T-Scan II 시스템을 이용한 습관적 편측저작자들의 교합 분석

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구강안면 영역의 통증이나 치아결손, 부정교합 같은 치아적 요소가 편측저작습관의 주요요인으로 여겨지나, 치아적 요소가 선호하는 저작측에 영향을 주지 않는다는 연구들도 있다. 본 연구에서는 컴퓨터화된 교합분석 시스템인 T-Scan II 시스템을 사용하여 편측으로 저작하는 대상자와 양측으로 저작하는 대상자 사이에 교합양상의 특이점이 있는지 조사하고 편측 저작자의 주저작측과 비저작측 사이의 차이를 함께 평가하고자 하였다.

편측저작습관에 대한 설문을 통하여 20명의 편측 저작자(평균 25.25±2.84세)와 20명의 양측 저작자(평균 27.00±5.07세)를 선정하였으며 치아적 문제나 악골의 통증이나 기능이상 같은 문제가 있는 경우는 모두 제외하였다. 습관적 폐구와 측방운동시의 교합양상은 T-Scan II 시스템을 이용하여 측정하였다. 습관적 폐구는 시간에 따라 초기, 중기, 말기로 나누었다. 각 세 단계에서의 접촉점의 수와 교합력의 비율을 좌우 양측으로 나누어 조사하였다. 습관적 폐구 동안의 경과시간 및 치아 활주면적, 좌우측 각각의 측방운동시간이 측정되었다.

편측 저작 습관을 가진 사람들의 경우 양측 저작을 하는 사람에 비해서 치아의 평균 교합 면적이 작았다 ($p<0.005$). 습관적 편측저작자에서 저작측과 비저작측을 비교해보았을 때 비저작측의 교합면적은 저작측에 비해 작았으나 ($p<0.005$), 편측저작자의 저작측과 양측저작군의 어느 한쪽의 교합면적 사이에는 유의한 차이가 없었다. 최초접촉부터 최대교두감합위까지의 경과 시간 및 측방운동 시간, 치아의 활주 면적 및 교합력의 좌우 비율도 양측저작군과 편측저작군 사이에 유의한 차이가 없었다. 이러한 결과는 저작시 좌우측 중 교합면적이 작은 측을 피하여 교합효율이 높은 방향으로 저작을 한다는 것을 의미한다.

주제어 : 편측저작, 교합분석, T-scan II 시스템