Study of Disclusion Time during Mandibular Eccentric Movement in Myofascial Pain Syndrome Patients by T-Scan II, Computerized Occlusal Analysis System

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Temporomandibular disorders(TMD) is a collective term which is embracing a number of clinical problems that involve the masticatory musculature, the TMJ and associated structures, or both. Myofascial pain, which is a kind of masticatory muscle disorder of TMD, is the sensory, motor, and autonomic symptoms caused by myofascial trigger points.

There has been some controversies regarding etiologies of TMD and MFP. Especially the issue of occlusal conditions has been a critical issue for long time. Despite much efforts, the results of studies regarding occlusal conditions were contradictory. These controversies might be mostly due to various factors resulting from the complex nature of TMD, however, inaccurate and inappropriate study design, selection criteria, methodologies also play significant roles.

Recently, a computerized occlusal analysis system, T-Scan II which made it possible to reveal quantifiable time data and relative force data for analyzing occlusion, was introduced. Some authorities suggested that the concept of disclusion time and prolonged disclusion time of posterior tooth and MFP are related using T-Scan II. But the previous studies which used T-SCAN II are not reliable for they did not provide accurate diagnostic criteria of MFP. Morever they did not compare with controls, and had many other problems. The purpose of this study was to evaluate the relationship between MFP and prolonged disclusion time of posterior tooth, which is one of the occlusal factors of TMD, by selecting 30 subjects as the study group through strict criteria and comparing them with 38 controls using T-SCAN II, computerized occlusal analysis system. The results, statistically analyzed, are summarized as follows:

1. Cronbach α coefficient of repeated measurements of disclusion time was 0.92.
2. There were no statistically significant differences at repeated measured disclusion time of both side between control and study group.
3. There was no statistically significant diffefence in the disclusion time between right and left side.

From the results above, we can suggest that there was no relationship between MFP and disclusion time, so irreversible treatments leading to the reduction of disclusion time for treating MFP would not be appropriate. However more controlled, large scaled study, which consider various occlusal factors, and quantification of symptoms using Helkimo index would be necessary in the future.

Key words : Computerized occlusal analysis system, Disclusion time, Myofascial pain, T-Scan II

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Ⅰ. INTRODUCTION

Temporomandibular disorders(TMD) is a collective term which is embracing a number of clinical problems that involve the masticatory musculature, the TMJ and associated structures, or both[1]. It is considered to be a subclassification of musculoskeletal disorders[2] and can be greatly divided to two categories, temporomandibular joint articular disorders and masticatory muscle disorders[3]. Myofascial pain, which is a kind of masticatory muscle disorder, is the sensory, motor, and autonomic symptoms caused by myofascial trigger points. Myofascial trigger point is a hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. The spot is painful on compression and can give rise to characteristic referred pain, referred tenderness, motor dysfunction, and autonomic phenomena[4].

There has been some controversies regarding etiologies of TMD and MFP. But recently, four major known etiologies can be pointed out[1]. First, trauma that can be sorted as macrotrauma such as direct blow to face[5,6], and microtrauma such as small repeated force to structure[7], has enough supporting evidences that proves cause of masticatory function disorders[8]. Second is psychosocial factors such as anxiety, depression, emotional stress[9]. Third is pathopysiologic factors which can be divided to systemic factors and local factors. Systemic factors could include degenerative, endocrine, infectious, metabolic, neoplastic, neurologic, rheumatologic, and vascular disorders. Local pathophysiologic factors of TMD, such as a masticatory efficiency, appear to be multifactorial and involve a large span of individual variation as to make norms difficult to establish[10]. Last is occlusal conditions such as working and nonworking posterior contacts[11,12]. and discrepancies between the retruded position(RCP) and intercuspal position(ICP)[13] and so on.

The issue of occlusal conditions has been controversial for long time. In the past, occlusal conditions were convinced as major cause of TMD by many specialists, but nowadays many specialists argue that occlusal conditions nearly contribute to TMD[14,15].

Despite much efforts, the results of studies were contradictory. Even in the studies that agree occlusion as the cause of TMD, results failed to point out one specific occlusal condition[13]. These controversies might be mostly due to various factors resulting from the complex nature of TMD, however, inaccurate and inappropriate study design, selection criteria, methodologies also play significant roles.

In the previous studies, electromyography had been used to prove occlusal disharmony as the cause of muscular component of TMD[16]. However, electromyography is one of the insufficient methods used for diagnosis of TMD. Wide variation of surface EMG can hardly distinguish normalness from abnormalness. Increased EMG activity is not an indication of masticatory muscle pain[17]. The conventional methods of occlusal analysis such as marking paper, wax, paste[18], articulating paper, foil, and silk strip only can establish the location and number of tooth contact and have a great deal of errors especially on the wet condition[19]. In a vitro study, reproducibility of marking paper has inordinate variation[20]. More importantly, the conventional methods of occlusal analysis can't represent time and force. However, a computerized occlusal analysis system has the capacity to reveal quantifiable time data and relative force data to challenge the conventional methods for their perceived descriptive capacity[21]. An accuracy of time record, force record and stability of force recording of T-SCAN II, a computerized occlusal analysis system, was proved[22].

From old times, many authorities[23,24] suggested that TMD/MFP and occlusal interferences are related because masticatory musculature was constantly contracting in all functional movement without diminishing rest period for muscle recovery. Recently some authorities[25] suggested that the concept of disclusion time which is defined as a

time, in seconds, required to disclude the working and nonworking molar interferences and non-working premolar interferences from the habitual centric closure position to the completion of a mandibular excursion, and prolonged disclusion time of posterior tooth and TMD are related. A computerized occlusal analysis system, T-SCAN II(Tekscan Inc, Boston, MA, U.S.A.) can make it possible by quantification of time during mandible excursion.

They also reported that "Immediate Complete Anterior Guidance Development (ICAGD)", a procedure of occlusal adjustment for eliminating working and nonworking molar interferences and non-working premolar interferences, which would reduce activities of masseter and temporal muscles[26], was a successful method of reducing the chronic symptroms of myofascial pain dysfuction syndrome(MPDS)[27,28].

Although T-SCAN II is a useful method for analysing occlusion [21,29], the results of the previous studies which used T-SCAN II are not reliable for they did not provide accurate diagnostic criteria of MFP[27], did not compare with control[21], and had many other problems[30].

The purpose of this study was to evaluate the relationship between MFP and prolonged disclusion time of posterior tooth, which is one of the occlusal factors of TMD, by selecting study group through strict criteria and comparing them with control group using T-SCAN II, computerized occlusal analysis system.

Ⅱ. SUBJECTS & METHODS

1. Subjects

94 volunteers(50 males, 44 females) comprised of dental students and staffs at the College of Dentistry, Yonsei University and patients who came to 'Dept. of Oral Medicine', and 'TMJ and Orofacial Pain Clinic' of Dental Hospital in Yonsei University complaining symptoms of TMD, participated in this study. Their ages ranged from 21 to 36 years, with average of 25.3 years. They were fully informed of purpose and procedures of this study, and a signed written informed consent was obtained from all the volunteers. Through clinical dental, occlusal examination, TMJ and Orofacial Pain evaluation examination, 30 volunteers(15 males, 15 females) diagnosed as myofascial pain syndrome with normal occlusion served as the study group. Their ages ranged from 21 to 36, with average of 25.6 years.

Those were asymptomatic or had only non-painful disc displacement with reduction were assigned as control group. 38 volunteers(23 males, 15 females) were selected as controls. Their ages ranged from 21 to 36, with average of 25.0 years. Through examinations, 26 volunteers were excluded from this study.

2. Method

1) Clinical occlusal examination

Centric stops and lateral guidance during eccentric movement were recorded using shim-stock. Overjet, overbite, number of contact tooth during maximum clenching, missing tooth, midline deviation, and attrition were also recorded. Subjects who had normal occlusal conditions were included in the study. However, subjects who had abnormal occlusal conditions such as severe Angle's Class II or III occlusal relations, anterior open bite, missing tooth, deep bite(more than 5 mm), RCP-ICP discrepancy(more than 2 mm), severe ectopic eruption, crowding, and spacing which could affect the normal occlusion were excluded.

2) Orofacial Pain Evaluation

Through Clinical Orofaical Pain Evaluation Examination Form(Appendix 1), we investigated chief complaint, history of C.C., general conditions, mandibular vertical & excursive range of motion, opening pattern, TMJ noise dysfunction, palpation on extraoral, and TMJ, provocation test. All of examing and diagnostic procedures were carried out by base on the principles of RDC for TMD(Reaserch Diagnostic Criteria for Temporomandibular Disorders)[31].

Table 1. Classification of subject group

	Subjects	
	Control group	Study group
n	38	30
Male/Female	28/10	15/15
Age	25.0 ± 3.3(21～36)	25.6 ± 4.0(21～36)

Those who were diagnosed to have MFP were selected as study group. Volunteers who had inflammatory joint disorders such as, retrodiscitis, synovitis, and capsulitis; derangement of the condyle-disc complex; local muscle soreness; and chronic mandibular hypermobility were excluded from this study. Those who were diagnosed to have arthritides from the radiographic examination were also excluded.

Volunteers who were asymptomatic or had only non-painful disc displacement with reduction were assigned as control group.

3) T-SCAN II

T-Scan II(Tekscan Inc, Boston, MA, U.S.A.) allows quantification of occlusal contact data. The system consists of a sensor, a sensor support, the recording handle, the parallel interface module(Fig 1), the processing unit(computer), and software. T-Scan II is a Microsoft Windows(Microsoft Corp.) compliant system that has been integrated into a clinical diagnostic computer workstation[25].

Fig. 1. T-Scan II (Tekscan, Boston, MA, U.S.A) parallel interface module and handle assembly

A one/hundred (0.01) second real-time occlusal contact recording and 0.01 second incremental playback of the tooth contact timing data can display the exact order of tooth contacts, as well as their force content. The combination of contact force content all determines the degree of contact simultaneity and the occlusal force balance that is present or absent in a particular occlusal scheme. The sensor consists of two layer of mylar(reinforced polyester film) laminated pressure sensitive ink grid. The film is covered by a silver thread grid, the intersectioning points of which are bathed by conductive ink. When a patient closes firmly on the sensor, the resultant reduction on electric resistance will be converted to an 8-bit digital values and translated into an image on the screen[32].

The volunteer sat upright position, because position of sagittal plane head-neck posture can alter contact position[33]. The T-SCAN II sensor and sensor support assembly were inserted intraorally and positioned correctly(Fig. 2). Then T-Scan force-movie mode is activated manually by pushing the button on the handle. The volunteer was instructed to bite in the habitual intercuspal position, and then made excursive movements which were not guided by the investigator. The right and left excursions were recorded separately. Between the

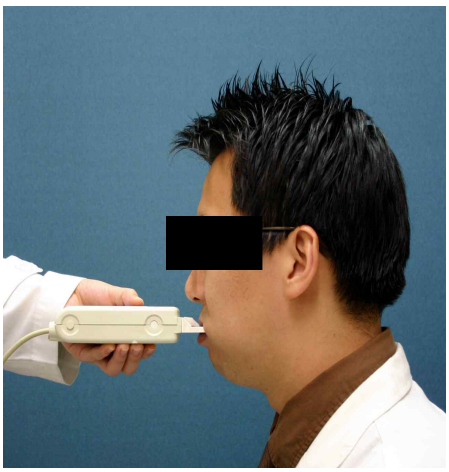

Fig. 2. T-Scan II sensor in the recording handle assembly placed intraorally.

records, patient had few minutes of resting time. All these procedures were repeated three times.

Disclusion time is defined as a time, in seconds, required to disclude the working and nonworking molar interferences and non-working premolar interferences from the habitual centric closure position to the completion of a mandibular excursion[25]. Disclusion time was calculated through three frames of data. Each frame assigned a time value in hundredths of seconds. The frames were identified as follows.

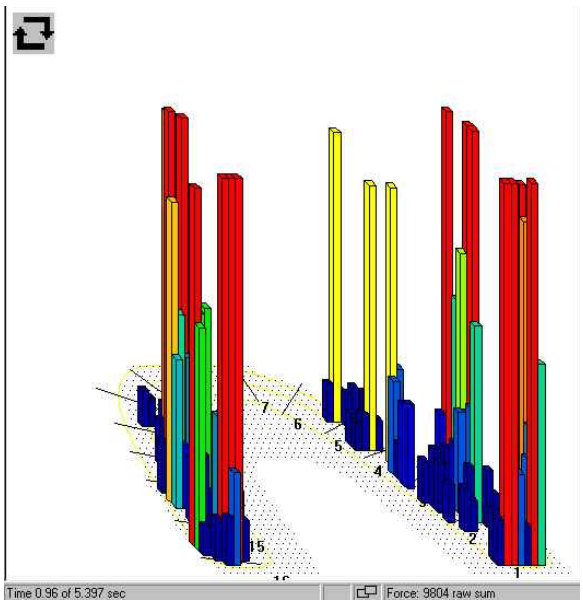

Fig. 3. Frame 1 - Maximum intercuspation: the last frame prior to the excursion

Frame 1 - Maximum intercuspation the last frame prior to the excursion(Fig 3)
Frame 2 - Late excursion with all remaining interferences(Fig 4)
Frame 3 - Total disclusion of posterior tooth or last remaining interferences(Fig 5)

The disclusion time =
time value of frame 2 or 3 - time value of frame 1

4) Statistical analysis

Statistical analyses were perfomed to confirm the consistency of three repeated measured disclusion time by getting Cronbach α coefficient. Then, differences in disclusion time between MFP patients and the controls were evaluated using (a paired t-test and) repeated measure ANOVA. SAS Version 8.1 Windows Statistics Program(SAS Institute, USA) was used for statistical analyses. A P value of $\leq$ 0.05 was considered statistically significant.

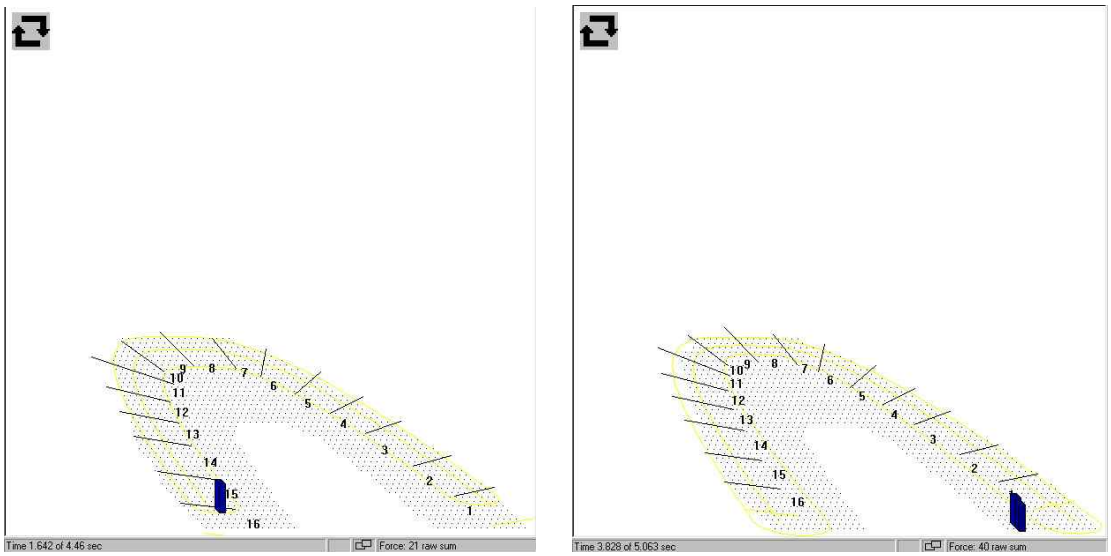

Fig. 4. Frame 2 - Late excursion with all remaining interferences

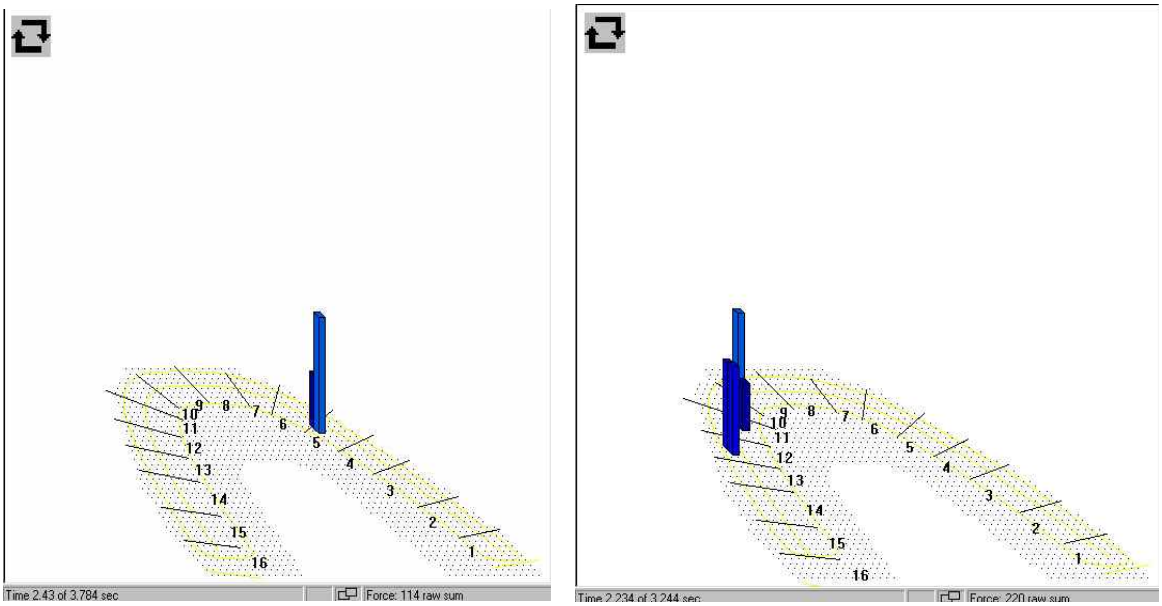

Fig. 5. Frame 3 - Total disclusion of posterior tooth or last remaining interferences

Table 2. Consistency of repreated measure Disclusion Time.

	Cronbach α coefficient	
Rt 1	0.918	0.920
Rt 2	0.902	
Rt 3	0.894	
Lt 1	0.904	
Lt 2	0.914	
Lt 3	0.899	

Ⅲ. RESULT

1. Consistency of repreated measure disclusion time

Consistency of repeated measure disclusion time was examined. Cronbach α coefficients obtained were listed below(Table 2). Average Cronbach α coefficient was 0.92. It means that repeated measured disclusion time had very high consistency.

Table 3. Comparison of right side disclusion time between control and study group.

Right	Disclusion Time (sec)		
	Control	Study	p-value
1	1.24 ± 0.62	1.28 ± 0.59	0.7806
2	1.17 ± 0.67	1.14 ± 0.47	
3	1.18 ± 0.64	1.12 ± 0.48	

Table 4. Comparison of left side disclusion time between control and study group.

Left	Disclusion Time (sec)		
	Control	Study	p-value
1	1.16 ± 0.66	1.28 ± 0.58	
2	1.25 ± 0.59	1.23 ± 0.48	0.7636
3	1.25 ± 0.72	1.23 ± 0.50	

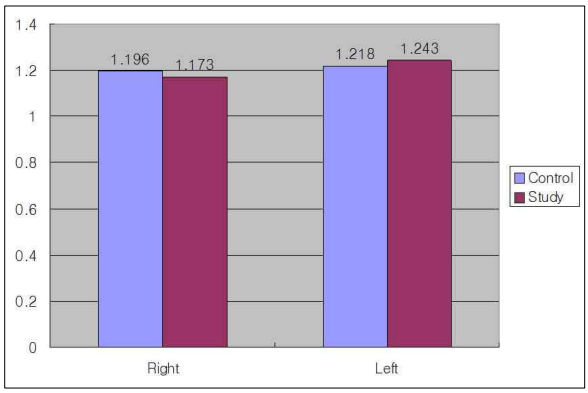

Fig. 6. Comparison of left side disclusion time between control and study group

Fig. 7. Comparison of disclusion time between right and left side

2. Comparison of disclusion time between control and study group.

No statistically significant differences were observed at repeated measure disclusion time of right side between control and study group(Table 3, Fig 6). Also, no statistically significant differences were observed at repeated measure disclusion time of left side between control and study group(Table 4, Fig 6).

Table 5. Comparison of disclusion time between right and left side.

Disclusion Time (sec)		
Right	Left	p-value
1.186±0.584	1.229±0.596	0.4575

3. Comparison between right and left side disclusion time

No statistically significant diffefences were observed between right and left side disclusion time through repeated measure ANOVA(Table 5, Fig 7).

Ⅳ. DISCUSSION

There has been long debate regarding etiologies of TMD and MFP. Due to the specific anatomical structures of temporomandibular joint and complex nature of TMD, numerous etiologies were proposed, but none of the etiologies have been proved scientifically. Only the fact that multiple factors were involved in the TMD became known[34]. Among the etiologies, especially, occlusal factor has been a critical issue, after James Costen claimed that change of occlusion and various ear symptom were related to each other based on eleven clinical

cases[35].

In 1937, Seaver suggested a relationship between muscles and occlusion[36]. Jarabak and Perry reported that TMD patients had increased masticatory muscle disorder, and Moyer pointed out occlusal disharmony as a cause of TMD in the study of certain muscles involved in temporomandibular movement by EMG. Riise and Scheikholeslam revealed that high interim amalgam restoration immediately increased EMG activity, and induced muscle fatigue[37]. Ingervall and Carlson reported that muscle activity duration and force increased in presence of occlusal interference by measuring muscle activity before and after elimination of balancing interferences[38]. Roth also reported that balancing interferences during mandibular excursive movement had a close relationship with TMD[39].

In contrast, some authorities announced doubtful opinions about the occlusion as the etiologic factor of TMD. Williams and Simmon who studied 53 orthodontic patients, and Cacchiotti, who compared totally 81 TMD patients and controls aged 19 to 40, failed to prove the association between occlusal factor and TMD[40,41]. In research on 3428 Swedish students, the relationship between occlusal factor and TMD was not established[42]. Like above, there has been constant controvercy concering the hypothesis that occlusal factors are part of a causal complex of TMD[43].

After Maness[44] developed T-SCAN, computerized occlusal analysis system, the concpet of time for analysing occlusion was introduced. Kerstein and his colleagues suggested that prolonged disclusion time of molars and nonworking premolars during mandible excursion was the cause of MPDS(Myofascial Pain Dysfunction Syndrome). This theory was on extension of the occlusion concept, "Mutually protected occlusion", emphasizing canine guidance. Prolonged posterior tooth contact during excursion was thought to activate the elevator muscles and cause muscle pain. They suggested that shortening of disclusion time(less than 0.5sec) by achieving ICAGD(Immedicate Complete Anterior Guidance Development) was an effective treatment for TMD[28].

The results of the previous studies which used T-SCAN II are not reliable for they did not provide accurate diagnostic criteria of MFP[27], did not compare with controls[25], and had many other problems[30]. This study compared the disclusion time of the study group comprised of myofascial pain patients diagnosed according to RDC-TMD to that of the control group.

Cronbach α coefficient was 0.92. This implies that repeated measure disclusion time showed very high consistency, and also indirectly suggests that T-SCAN II had a high reproducibility. This result corresponds to the previous studies[45,46].

Contrary to the previous study by Kerstein in 1994, our result showed no significant difference between the control and the study group at both sides. Disclusion time of right side was 1.173 sec, and that of left side was 1.243sec in the study group. These values were smaller than those of the previous study[47] in which disclusion time of right side of the study group was 1.314~1.608sec while that of left side was 1.546~1.585sec. Disclusion time of right side was 1.196 sec, and left side was 1.218sec in the control group. This result was almost the same with the previos study[47] in which disclusion time in control group was 1.033~1.227sec. The statistical discrepancy between our study and the previous study might be due to the difference in the result observed in the study groups. In Kerstein's study, the subjects had not only myofascial pain but also other symptoms including TMJ derangements. Moreover, the subjects who were diagnosed as MPDS without any objective examination but the subject's own words. This study tried to avoid the same error Kerstein committed by establishing proper diagnosis of MFP according to RDC-TMD(AXIS I), and controlling the abnormal occlusal factors.

There was no significant difference in disclusion time between right and left sides. This result was coincident with the previous study[47]. This might have resulted from controlling of abnormal occlusal

factors by excluding malocclusions.

Kerstein argued that adjustment of disclusion time below 0.5sec would treat symptoms of myofascial pain[48]. However, we found only 1 subject showing disclusion time below 0.5sec among the total 68 subjects including the controls, which implies that achievement of such disclusion time might be unrealistic and a mere clinical assumption. In addition, the prevalence of TMD does not increase with aging, which accompanies increased posterior occlusal interference during excursion due to progressive tooth attrition[49].

Therefore, irreversible treatments, such as occlusal adjustment, prosthodontic treatment, resin build up on anterior tooth, leading to the reduction of disclusion time of posterior tooth would not be the appropriate treatment for MFP. However more controlled, large scaled study, which consider various occlusal factors, and quantification of symptoms using Helkimo index would be necessary in the future.

V. CONCLUSION

In order to evaluate the relationship between MFP and prolonged disclusion time of posterior tooth, which is one of the occlusal factors of TMD, by selecting 30 subjects as the study group through strict criteria and comparing them with 38 controls using T-SCAN II, computerized occlusal analysis system. The results are summarized as follows:

1. Cronbach α coefficient of repeated measurements of disclusion time was 0.92.
2. There were no statistically significant differences at repeated measured disclusion time of both side between control and study group.
3. There was no statistically significant diffefence in the disclusion time between right and left side.

From the results above, we can suggest that there was no relationship between MFP and disclusion time, so irreversible treatments leading to the reduction of disclusion time for treating MFP would not be appropriate. However more controlled, large scaled study, which consider various occlusal factors, and quantification of symptoms using Helkimo index would be necessary in the future.

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국문초록

컴퓨터 교학분석기인 T-Scan II를 이용한 측방운동시 구치부 이개시간에 관한 연구

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측두하악관절장애는 저작근, 측두하악관절, 주변 구조물 또는 모두를 포함하는 다수의 임상문제를 포함하는 용어이다. 근막동통은 측두하악관절장애 중 저작근 장애의 한 종류로, 근막 발통점에 의해 발생하는 감각, 운동, 자율신경 증상이다.

측두하악관절장애와 근막동통의 원인에 대한 논쟁이 지속되어왔다. 특히 교합 원인은 오랫동안 논쟁의 핵심이었으며, 많은 노력에도 불구하고 교합원인에 대한 연구는 상반된 결과를 보였다. 이런 논쟁은 대부분이 측두하악관절장애 본연의 복잡성에서 기인하지만, 부적절하고 부적당한 연구설계, 선정기준, 연구방법 또한 중요한 역할을 한다.

최근에 교합분석시 시간과 상대적 힘이 측정가능한 컴퓨터 교합분석 기기인 T-Scan II가 소개되었다. 일부 저자들은 T-Scan II를 이용하여 이개시간 개념 및 연장된 구치부 이개시간과 근막통증의 연관성에 대하여 제안하였다. 그러나 T-Scan II를 이용한 기존의 연구들은 근막통증에 대한 정확한 진단 기준을 제시하지 못하였으며, 대조군과의 비교 부재 및 다른 많은 문제점을 가지고 있었기 때문에 신뢰할 만하지 못하다. 이번 연구의 목적은 컴퓨터 교합분석 기기인 T-Scan II을 이용하여 30명의 실험군을 선택하고 이를 38명의 대조군과 비교함으로써, 근막통증과 구치부 이개시간과의 연관성을 평가하는 것이다. 통계적으로 분석된 결과는 다음과 같다:

1. 반복 측정한 이개시간의 Cronbach α 계수는 0.92 였다.
2. 반복 측정한 이개시간 평가시 양측에서 실험군과 대조군 사이 유의성 있는 차이를 보이지 않았다.
3. 이개시간 평가시 좌측 우측 사이에 유의성 있는 차이를 보이지 않았다.

이상의 결과로부터 근막통증과 이개시간 사이에는 관련성이 없는 것으로 판단된다. 따라서 근막통증을 치료하기 위하여 이개시간을 줄이는 비가역적인 치료는 적절치 않다. 향후의 연구에 있어서, 여러 교합요소와 헬키모 지수 등을 이용하여 증상의 정량화를 고려한 보다 통제된 대규모 환자 집단에 대한 연구가 필요할 것으로 사료된다.

주제어 : 근막통증, 이개시간, T-SCAN II, 컴퓨터 교합분석기