Bite force, occlusal contact area and occlusal pressure of patients with temporomandibular joint internal derangement

연세대학교 대학원

치의학과

김 기 서

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이 논문을 석사 학위논문으로 제출함

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김기서의 석사 학위논문을 인준함

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감사의 글

한 편의 논문을 완성하기까지 주위 여러분의 많은 도움이 없었다면 부족한 저 한 사람의 힘으로는 도저히 불가능한 일이었을 것입니다. 본 연구가 이루어지기까지 때로는 자상한 관심과 조언, 때로는 엄격한 지도를 통해 이끌어 주셨던 최종훈 교수님과 김종열 교수님, . 또한 연구를 진행하는데 있어서 바쁘신 와중에도 세세한 부분까지 열성적인 가르침을 아끼지 않으신 김성택 교수님과 안형준 교수님께도 감사드립니다. 그리고 실험에 참여해주신 연세대학교 치과대학병원 직원 및 치과대학생 여러분과 연구에 차질이 없도록 성실히 도와주신 주식회사 신기사 여러분께도 감사드립니다.

3 ¦간의 의국생활동안 서로 기쁨과 어려움을 함께 나누며 마침내 보람있는 결실을 맺게 된 동기 유지원 선생님에게도 축하와 감사를 함께 전하며, 충실한 연구가 이루어질 수 있도록 헌신적으로 노력해 준 강승철, , 신준한 선생님에게도 큰 감사를 드립니다.

지금까지 한결같은 사랑으로 뒷바라지 해주신 부모님과 힘들때도 지치지 않도록 끝까지 격려해준 누님과 형님에게도 감사의 마음을 전하며 이 기쁨을 함께 나누고자 합니다.

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ABSTRACT

Bite force, occlusal contact area and occlusal pressure of patients with temporomandibular joint internal derangement

Temporomandibular joint (TMJ) internal derangement, especially disc displacement with reduction (DDwR) is the most common TMJ arthropathy and has been thought to do some effects on masticatory performance. Measuring of maximal bite force has been widely used as objective and quantitative method of evaluating masticatory performance, but previous studies showed various results due to various characteristics of subjects and different measuring devices and techniques. In a few studies about the correlation of bite force and temporomandibular disorders (TMD), some authors reported that bite force and masticatory performance would be reduced in patients with TMD because of pain. But the correlation of changes in structure of articular disc and masticatory performance has not been well investigated yet. In this study, to investigate the influences of non-painful disc change on the masticatory performance, we measured the value of maximal bite force, occlusal contact area and occlusal pressure of 39 patients with non-painful DDwR of the TMJ using pressure sensitive film, and compared it with that of 59 controls. the results are summarized as follows:

1. The maximal bite force ($P < 0.01$) and the occlusal contact area ($P < 0.05$) of the DDwR patients were greater than the controls.

2. There was no significant difference in occlusal pressure between the DDwR patients and the controls ($P > 0.05$).

3. The maximal bite force of the male group was greater than that of the female group ($P < 0.05$). However, the occlusal contact area and the occlusal pressure between the male and the female group didn't show significant difference ($P > 0.05$).

From the results above, we can suggest that DDwR could be a factor of changing bite force, but more controlled, large scaled and EMG related further study is needed.

Key Words : bite force, occlusal contact area, occlusal pressure, pressure sensitive film, disc displacement with reduction

Bite force, occlusal contact area and occlusal pressure of patients with temporomandibular joint internal derangement

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Ⅰ. Introduction

Mastication, or chewing, is one of the main functions of the stomatognathic system(Peroz, 2002). Masticatory performance can be influenced by many changes on the stomatognathic system such as orthognathic surgery(Zarrinkelk and Throckmorton, 1995), muscle problems(Liu and Yamagata, 1999), disorders of the temporomandibular joint(Harper and Brown, 2000), loss of occlusal support(van der Bilt, 1994), different types of dentures(Fontijn-Tekamp, 2000), age(Hirai and Ishijima, 1994) and sex(Julien and Buschang, 1996).

Temporomandibular disorders(TMD) are divided into temporomandibular

joint(TMJ) disorders and masticatory muscle disorders. TMJ disorders include internal derangement(or articular disc displacement) and it is the most common TMJ arthropathy and is characterized by several stages of clinical dysfunction that involve the condyle-disc relation. It is subdivided into disc displacement with reduction(DDwR) and disc displacement without reduction(DDw/oR) (Okeson *et al.*, 1996).

Masticatory function has been evaluated using both subjective and objective methods. Bite force is generally evaluated as objective method. Some investigators have reported the comparison of bite force between denture wearers and normal dentate subjects in the dental clinics(Atkinson & Ralph, 1973; Haraldson *et al.*, 1979). But, until now, the effects of temporomandibular disorders(TMD) on masticatory performance have not frequently been investigated. A few studies have assessed bite force of patients with TMD(Helkimo, 1975; Rudy, 2000).

Although Helkimo(1975) found an increasing bite force correlated with decreasing TMD symptoms , this observation could not be confirmed in a more recent study(Rudy, 2000). Patients with DDw/oR had decreased bite force endurance in static chewing, caused by increasing pain in the joints(Stegenga, 1992). Electromyographic studies of patients with DDw/oR(Sato *et al.*, 1998) revealed a significant reduction in bite force when patients were compared with controls. In addition to their studies of bite force and occlusal contact area, the same authors also evaluated the masticatory function of patients with DDw/oR using photometric devices(Sato *et al.*, 1999).

All parameters were reduced in patients compared with controls and reductions in occlusal contact area and/or impaired chewing were discussed as sources of reduced masticatory function.

Many studies describe reduced chewing ability caused by pain among patients with TMD, especially DDw/oR(Helkimo, 1975; Stegenta, 1992), but influence of structural change of disc-condyle relation such as non-painful DDwR to masticatory function has not been well described.

A number of appliances for bite force measurement have been reported including strain gauge transducer(Garner & Kotwal, 1973; Proffit, Fields & Nixon, 1983; Fields *et al.*, 1986; Waltimo, Nyström & Könönen, 1994; Braun *et al.*, 1995; Kikuchi *et al.*, 1997; Raadsheer *et al.*, 1999; Throckmorton, Ellis & Buschang, 2000), biting fork(Helkimo *et al.*, 1977; Kiliaridis *et al.*, 1993; Fogle & Glaros, 1995) and bite force dynamometers(Linderholm & Wennstörm, 1970; Ringqvist, 1973). But these methods were time consuming and unstable because of various level of vertical occlusal height.

Recently, an occlusal diagnostic system called the Dental Prescale System(Fuji Film Co., Tokyo, Japan.) was developed. As compared with the appliances described above, the latter system is more flexible, permits natural occlusion and prevents mandibular displacement during clenching(Suzuki *et al.*, 1997). The reproducibility of this system has been confirmed for use in complete dentitions(Watanabe *et al.*, 1995; Kumagai *et al.*, 1999) and complete denture patients(Suzuki *et al.*, 1997) as well as in implant supported fixed cantilever prostheses(Suzuki *et al.*, 1999) and hemi-maxillectomy patients(Matsui *et al.*, 1996).

The aim of this study is to investigate the influences of non-painful disc change on the masticatory performance by means of comparing the maximal bite force, the occlusal contact area and the biting pressure.

Ⅱ. Material and Methods

1. Subjects

39 patients(18 males, 21 females) diagnosed with DDwR of the TMJ served as the experimental group. Their ages ranged from 21 to 38 years, with an average of 25.9 years. They were fully informed of the nature of the study and agreed to participate. Reciprocal clicking was a clinical sign of DDwR. The clicking can occur at various stages during opening and closing. Patients who have pain on mandibular movement were ruled out. Bony change on the condylar head area of the TMJ was evaluated by radiographic examination to rule out osteoarthritis and osteoarthrosis.

59 individuals were selected as controls(30 males, 29 females). The controls had no past history or present symptoms related to the TMD, joint sounds or pain, muscle pain, deviation on opening or limited mouth opening. Their ages ranged from 19 to 34 years, with an average of 25.6 years. In both the patients with DDwR and the controls, the upper and lower dentition was complete. They had neither malocclusion nor dento-facial deformity. Third molars were either absent or unerupted, uncontacted(Table 1).

Table 1. Classification of subject group

	Subjects	
	Control group	Experimental group
n	59	39
Male/Female	30/29	18/21
Age	25.9±3.1(21~38)	25.6±3.5(19~34)

2. Methods

A. Measurement of maximal bite force, occlusal contact area, occlusal pressure

Maximal bite force, occlusal contact area, occlusal pressure was measured by a Dental Prescale System (Fuji Film Co.), consisting of pressure sensitive sheets (Dental Prescale®, Fuji Film Co., Figure 1) and an analyzing computer (Occluzer®; GC company Co., Figure 2).

The Dental Prescale® consists of two papersheets and numerous microcapsules containing a red dye between them. When the teeth are brought into occlusion, these microcapsules rupture and discharge the dye, staining one of the papers red. The density of the color is in proportion to the degree of pressure applied. The occlusal contact area was measured, and the occlusal pressure and the bite force calculated for each subject. All measurements were made with the subject seated with the head upright, looking forward, and in an unsupported natural head position. The subject was instructed to bite as forcefully as possible. Tooth

contact area and the density of the color for the occlusal pressure recorded on the Dental Prescale® were measured by an Occluzer® computer(FPD707) and the bite force was also calculated using this apparatus. In this study, the value of the occlusal contact area and the value of the bite force were explained, respectively, as the total contact areas and the total force calculated on contact area between the upper and lower teeth in occlusion for each subject. The value of the occlusal pressure was represented by the mean value of pressures measured on the contact area between the upper and lower teeth in occlusion for each subject.

Figure 1. Dental Prescale® film (50H type-R, large size)

Before recording, each subject was seated at the upright position, in parallel with the Frankfort plane and instructed to bite so as to exert and produce maximal clenching. Dental Prescale® sheet(50H, type R) was placed between the upper and lower dentitions and the subjects were instructed to bite at the intercuspal position for 2~3 seconds. On occlusion, the midline of the Dental Prescale® was matched with that of the subject's dental arch. After testing, the

sheets were stored in a lightproof box for at least 3 hours to stabilize the intensity of color.

Figure 2. Occluzer®(GC company Co.)

B. Statistical analysis

Differences in maximal bite force, occlusal contact area, occlusal pressure between patients with DDwR and the controls, and between male and female group were evaluated with paired *t*-test.

Ⅲ. Results

1. Maximal bite force

The maximal bite force of experimental group(patients with DDwR) were greater than that of control group in both of male(989.0±309.7 versus 818.6±227.50 N) and female group(813.8±186.3 versus 700.2±178.2 N). Standard deviation were relative small in female group in both of control and experimental group. The mean and standard deviation(S.D.) of maximal bite force of each subject groups are listed below(Table 2.)

Table 2. Maximal bite force(Mean±S.D.)

Group	Maximal bite force (N)		
	Control group	Experimental group	*P* value
Male	818.6±227.50	989.0±309.7	0.0336*
Female	700.2±178.2	813.8±186.3	0.0339*
Total	760.4±211.6	894.2±262.7	0.0064**

* : $P < 0.05$ ** : $P < 0.01$

The value of bite force measured in patients with DDwR was significantly greater than that in the controls ($P < 0.01$).

2. Occlusal contact area

The occlusal contact area of experimental group(26.8±9.6 mm^2) (patients with DDwR) were greater than the controls (23.1±7.7 mm^2). The mean and standard deviation(S.D.) of occlusal contact area of each subject groups are listed below(Table 3).

Table 3. Occlusal contact area(Mean±S.D.)

Group	Occlusal contact area(mm^2)		
	Control group	Experiment group	*P* value
Male	23.5±7.5	29.3±11.6	0.0713
Female	22.8±6.0	24.6±7.1	0.3950
Total	23.1±7.7	26.8±9.6	0.0408*

* : $P < 0.05$ ** : $P < 0.01$

The value of occlusal contact area measured in patients with DDwR was greater than that in the controls($P < 0.05$).

3. Occlusal pressure

There was no significant difference in occlusal pressure between the DDwR patients(34.0±4.7 Mpa) and the controls(33.9±5.8 Mpa). The mean and standard deviation(S.D.) of occlusal pressure of each subject groups are listed below(Table 4).

Table 4. Occlusal pressure(Mean±S.D.)

Group	Occlusal pressure(Mpa)		
	Control group	**Experimental group**	***P* value**
Male	35.4±5.1	34.5±4.7	0.5700
Female	32.4±6.2	33.5±4.8	0.5066
Total	33.9±5.8	34.0±4.7	0.9615

* : $P < 0.05$ ** : $P < 0.01$

4. Comparison of male and female group

In both of control and experiment group, only the value of the bite force measured in males was significantly greater than that in females($P < 0.05$).

The maximal bite force of the male group(818.6±227.50 N in control, 989.0±309.7 N in experimental group) was greater than that of the female group(700.2±178.2 N in control, 813.8±186.3 N in experimental group) in both of control and experimental group($P < 0.05$). However, the occlusal contact area and the occlusal pressure between the male and the female group didn't show significant difference($P > 0.05$). The mean and standard deviation(S.D.) of each evaluated values of control and experiment group are listed below(Table 5, 6).

Table 5. Comparison between male and female control group

Group	Control group		
	Male	**Female**	***P* value**
Maximal bite force(N)	818.6±227.50	700.2±178.2	0.0303*
Occlusal contact area(mm^2)	23.5±7.5	22.8±6.0	0.7084
Occlusal pressure (Mpa)	35.4±5.1	32.4±6.2	0.0504

* : $P < 0.05$ ** : $P < 0.01$

Table 6. Comparison between male and female experiment group

Group	Experimental group(DDwR)		
	Male	Female	*P* value
Maximal bite force (N)	989.0±309.7	813.8±186.3	0.0455*
Occlusal contact area (mm^2)	29.3±11.6	24.6±7.1	0.1513
Occlusal pressure (Mpa)	34.5±4.7	33.5±4.8	0.5023

* : $P < 0.05$ ** : $P < 0.01$

Ⅳ. Discussion

Most of previous studies provided variable results on maximal bite force, and it maybe due to a lack in the control of such variables to affect bite force measurements as age(Garner & Kotwal, 1973; Helkimo *et al.*, 1977; Fogle & Glaros, 1995; Miyaura *et al.*, 1999), sex(Garner & Kotwal, 1973; Fields *et al.*, 1986; Braun *et al.*, 1995; Miyaura *et al.*, 1999), physical characteristics of subjects including height and weight(Fields *et al.*, 1986; Kiliaridis *et al.*, 1993; Braun *et al.*, 1995), the number of teeth present(Hidaka *et al.*, 1999; Miyaura *et al.*, 1999), diverse population and different measuring devices and techniques(Linderholm & Wennstörm, 1970; Ringqvist, 1973; Tortopidis *et al.*, 1998).

In the present study, age, sex, the number of tooth present and measuring device were considered except physical characteristics including body height and weight. Several authors found positive correlation between bite force and growth variables such as age and body height and weight. It is assumed that persons with larger body build, size and/or weight may exhibit a greater bite force. Kiliaridis *et al.*(1993) noticed a correlation between body height and the mean amplitude of the maximal bite force. Ringqvist(1973) found significant correlation between body height and maximal molar bite force in female, whereas Linderholm and Wennstörm(1970) and Braun *et al.*(1995) did not. In this study, the standard deviation of maximal bite force ranged from 178.2 to 309.2, and it is consistent to that of the previous studies(Miyaura *et al.*, 1999; Sato *et al.*, 1999; Sondang *et al.*, 2003). Threrfore, a group of similar body height and weight could be an important factor in future studies.

In the previous studies, maximal bite force was measured using a metal material such as transducer, biting fork or bite force dynamometer of various sizes and thicknesses. The thickness(4~16 mm) is one of the reasons for unstable positions. Moreover, subjects might be reluctant to bite maximally because of fear of tooth damage or pain. In this study, maximal bite force was measured using the Dental Prescale System, which consists of pressure sensitive sheet(Dental Prescale®, Fuji Film Co., Tokyo, Japan) and a computer for analysis(Occluzer®, GC company Co., Japan). Suzuki *et al.*(1997) reported that Dental Prescale System has some advantages as follows: (i) the thin material induces only a small change in the occlusal vertical dimension(98 ㎛ thickness), and makes it available to measure at a position near the intercuspal position, (ii) it is not necessary to prepare special measurement equipment, (iii) many patients may be examined for a short time, (iv) recording storage, even for an extended period, is simplified and (v) it is easy to explain the treatment to patients by using dental images. In addition, the clinical usefulness of this system was documented in terms of quantitative evaluation for occlusal load distribution(Matsui *et al.*, 1996; Suzuki *et al.*, 1997).

In the present study, the mean value of maximal bite force was greater than that obtained by previous studies. Bakke *et al.*(1990) examined a large sample of subjects(63 females and 59 males), and found a mean bite force of 522 N in males and 441 N in females. Dean *et al.*(1992) found the mean values at the molar region to be 490 N in males and 402 N in females. Braun *et al.*(1995) reported a mean value of 814 N for males and 615 N for females. This variability might be due to the differences of measuring point and appliances used.

There are few studies which have examined occlusal pressure, contact area and bite force in patients with TMD or anterior disc displacement of TMJ. Takenoshita *et al.*(1991) observed no difference in occlusal contact area between the patients with TMJ dysfunction and the controls without TMJ dysfunction. Our results show that the value of the occlusal contact area measured in patients with DDwR of the TMJ was slightly greater than that in the controls($P < 0.05$), and are thus not consistent with the results of Sato *et al.*(1999), who reported smaller occlusal contact area in patients with anterior disc displacement of the TMJ. It remains obscure why the value of occlusal contact area measured in patients with DDwR was greater than that in the controls. But we can guess increased masticatory muscle activity, as in bruxism patients, could make increased tooth wear, thus occlusal contact area could be increased. Further EMG related studies could be valuable. Our results also show that the bite force in patients with DDwR of the TMJ was greater than that in the controls, although there was no difference in the occlusal pressure. From these results we can think that occlusal contact area should have more important role in masticatory performance than occlusal pressure. In previous studies, the bite force and occlusal contact area in patients with DDwR of the TMJ was smaller than that in the controls and it was thought because the patients' symptoms - such as TMJ pain or masticatory muscle pain, fear to TMJ noise etc. - could disturb a stronger bite force. Sinn, de Assis & Throckmorton(1996) examined the bite force in patients with TMJ dysfunction. They also found that the maximal bite force in patients was smaller than that in the controls without TMJ dysfunction. However, most of previous studies included various types of TMJ dysfunction, including myofascial pain, internal derangement of the TMJ(DD with or without

reduction), osteoarthritis etc. In our study, we examined only in patients with non-painful DDwR of the TMJ, therefore, influence of disc displacement could be reflected more critically. In other words, increased bite force and occlusal contact area could be a cause of disc displacement.

Both of the control and the DDwR group, maximal bite force of male group was greater than that of female group. This result is consistent with the results of previous studies(Julien and Buschang, 1996; Bakke *et al.*, 1990; Miyaura 1999).

In conclusion, we can suggest that DDwR could be a factor of changing bite force regardless of pain, but more controlled, large scaled and EMG related further study is needed.

Ⅴ. Conclusion

To investigate the influences of non-painful disc change on the masticatory performance, we measured the value of maximal bite force, occlusal contact area and occlusal pressure of 39 patients with non-painful DDwR of the TMJ using pressure sensitive film, and compared it with that of 59 controls. the results are summarized as follows:

1. The maximal bite force ($P < 0.01$) and the occlusal contact area ($P < 0.05$) of the DDwR patients were greater than those of the controls.

2. There was no significant difference in the occlusal pressure between the DDwR patients and the controls ($P > 0.05$).

3. The maximal bite force of the male group was greater than that of the female group ($P < 0.05$). However, there was no significant difference in the occlusal contact area and the occlusal pressure between the male and the female group ($P > 0.05$).

From the results above, we can suggest that DDwR could be a factor of changing bite force, but more controlled, large scaled and EMG related further study is needed.

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국 문 요 약

측두하악관절 내장증 환자의 교합력, 교합 접촉 면적 및 교합압

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측두하악관절 내장증, (Disc displacement with reduction; DDwR) , 저작 능력에 다양한 영향을 미칠 것으로 생각되어져 왔다. 저작 능력을 평가하는 객관적이고 가시적인 수단으로 최대 교합력의 측정이 널리 통용되어져 왔는데, 과거 많은 연구자들이 측두하악장애(TMD) , 피험자의 개인적 특성이나 측정 방법의 차이 등으로 인하여 통일성 있는 결과를 얻지 못하고 있으며, 측두하악장애로 인한 통증이 교합력 및 저작능력을 감소시킨다고 보고된 바 있으나 측두하악관절의 구조적 변화와 저작능력의 관계에 대한 연구는 아직 충분히 이루어져 있지 않다. 본 연구에서는 측두하악관절의 구조적 변화와 저작 능력의 관계를 파악해 보고자 개구시 무통성의 관절음을 보이는 환자 39 59 }을 대상으로 최대 교합력, (pressure sensitivie film) , .

1. (P < 0.01) 및 넓은 교합 접촉 면적(P < 0.05) .

2. 단위 면적당 평균 교합압은 대조군과 정복성 관절원판 변위 환자군 간에 있어서 유의성있는 차이를 보이지 않았다($P > 0.05$).

3. , 정복성 관절원판 환자군과 대조군 모두에서 남성이 여성보다 높은 교합압을 나타내었으나($P < 0.05$), 평균 교합압과 교합 접촉 면적은 유의성있는 차이를 보이지 않았다($P > 0.05$).

이상의 결과로부터 얻을 수 있는 결론은 측두하악관절의 정복성 관절원판 변위가 교합 기능을 변화시키는 한 요소로서 작용할 수 있다는 점이다. 향후의 연구에 있어서 근전도 등을 이용한 저작근 활성도 측정을 병행함이 유용할 것으로 사료되며, 교합력에 영향을 미치는 다른 요소가 통제된 보다 대규모 환자집단에 대한 연구가 필요할 것으로 사료된다.

핵심되는 말 : , , , , 정복성 관절원판 변위