

Quantitative analysis of occlusal force balance in intercuspal position using the Dental Prescale system in patients with temporomandibular disorders

Shinsuke Sadamori, DDS, PhD,^a Hiroo Kotani, DDS, PhD,^b Hitoshi Abekura, DDS, PhD,^a and Taizo Hamada, DDS, PhD^a

^aDepartment of Prosthetic Dentistry, Programs for Applied Biomedicine Division of Cervico-Gnathostomatology, Hiroshima University Graduate School of Biomedical Sciences, and

^bKotani Dental Office, Hiroshima, Japan

Purpose: This study evaluated the quantitative analysis of occlusal data (occlusal contact areas, maximum pressure, mean pressure, occlusal force, and occlusal force balance) in intercuspal position in both healthy subjects and patients with temporomandibular disorders (TMD).

Materials and Methods: The occlusal data in intercuspal position were measured using the Dental Prescale system in 15 healthy persons and 16 patients with TMD, i.e., myofascial pain dysfunction syndrome (MPD group; eight patients) and disorders of the temporomandibular joints (TMJ group; eight patients). Force asymmetry index (force AI) was calculated to evaluate the occlusal force balance of the right and left sides.

Results: The value of the force AI of MPD patients was higher than that of healthy subjects. The mean of pressures and force AI of TMJ patients were higher than those of healthy subjects. The values of occlusal contact areas and occlusal force in TMJ patients were lower than those in healthy subjects, while the values of occlusal contact areas and occlusal force in MPD patients were higher than those in TMJ patients.

Conclusion: These data in this study suggest that the force asymmetry index is suitable as the parameter of TMD. (*Int Chin J Dent* 2007; 7: 43-47.)

Key Words: asymmetry index, Dental Prescale system, occlusal force balance, temporomandibular disorders.

Introduction

Improper occlusion is one of the important etiologic factors in temporomandibular disorders (TMD).¹ Unilateral tooth clenching may alter the mechanical relationship of jaw closure; it produces strain a single muscle unlike bilateral tooth clenching and therefore, contributes to more severe damage to the stomatognathic system.² Furthermore one aim of treatment of trauma from occlusion and bruxism is to achieve simultaneous bilateral contact in both the intercuspal (centric occlusion) and the retruded position (centric relation). It is thus necessary for stability of occlusion to achieve balance of right and left side of dental arch.

Occlusal forces and balance in intercuspal position have been examined by various methods.³⁻¹³ A recently developed photo-occlusion technique allows simultaneous quantitative optical recording of occlusal contacts. The Dental Prescale system consists of pressure sensitive sheets and an analyzing computer. The sheet is 0.098 mm thickness and flexible. This system analyses occlusal contact areas, mean pressure, occlusal forces, percentage of areas within a limit of pressure measurement, and occlusal force balance in near inter-cuspal position. Occlusal histories can become a permanent part of the patient's record because this recorded information can be printed or stored in the computer with the software program.

The purpose of this study was to evaluate occlusal contact areas, maximum pressure, mean pressure, occlusal forces, and occlusal force balance were examined in both healthy subjects and patients with TMD, using the Dental Prescale system.

Materials and Methods

Subjects

Healthy subjects consisted of 15 volunteers without clinical evidence of dysfunction of the stomatognathic

system and with class I molar relation with stable occlusions in the intercuspal position (ICP). The patients were divided into the MPD group (eight patients with muscle symptoms of myofascial pain dysfunction syndrome), and the TMJ group (eight patients with disorders of the temporomandibular joints) according to the previous study.¹⁴ The MPD patients had moderate or severe symptoms of MPD syndrome and the TMJ group was composed of patients with disorders of the TMJs, such as TMJ internal derangement with and without reduction and degenerative joint disease. The patients were classified by the history and condition of present illness and radiographs. Table 1 shows the gender distribution of the subjects.

Table 1. Gender distribution of the subjects.

| | Healthy group | MPD group | TMJ group | Total |
|--------|---------------|-----------|-----------|-------|
| Male | 9 | 4 | 1 | 14 |
| Female | 6 | 4 | 7 | 17 |
| Total | 15 | 8 | 8 | 31 |

Recording procedure

Occlusal forces and balance were measured by a Dental Prescale system (Fuji Photo Film, Tokyo, Japan) consists of the pressure sensitive sheets (Dental Prescale, Fuji Photo Film, Tokyo, Japan) and an analyzing computer (Occluzer, GC Corp., Tokyo, Japan). All subjects were asked to sit upright and occlude on the Dental Prescale (50H, type R), in ICP with maximum clenching level for one second. After the Dental Prescale was removed, Occluzer was used to evaluate the occlusally recorded colorations (pattern).

Dental Prescale consists of color-developing materials and various sizes of microcapsules containing color-producing materials which are coated on the polyethylene-terephthalate (PET) resin film, and wrapped with PET films on both sides. The foil shows coloration depending on pressure. According to the level of the pressure applied (occlusal pressure and force), color formation occurs in different densities. Formed colors on the sheets are read out by an Occluzer-contained color image scanner, the identified color density and area data can be used to estimate the magnitude of the occlusal pressure and force.¹⁵ To evaluate the occlusal force balance of the right and left sides, the asymmetry index (AI), advocated by Naeije et al.¹⁶ was modified for this study as follows:

$$\text{force Asymmetry Index (AI)} = \frac{|\text{Occlusal force (Right)} - \text{Occlusal force (Left)}|}{|\text{Occlusal force (Right)} + \text{Occlusal force (Left)}|} \times 100 \quad (\%)$$

Statistical evaluation was based on Mann-Whitney U-test. The results were analyzed by the StatView Version 4.0 software (Abacus Concepts, Inc., Berkeley, CA, USA).

Results

Table 2 shows data of occlusal contact areas, maximum pressure, mean pressure, occlusal forces, and occlusal force balances (force AI) of healthy subjects and p values analyzed by Mann-Whitney U-test. There is no significant difference ($p > 0.05$) between the occlusal data of male and female. However the values of occlusal contact areas and occlusal forces in males tended to be greater than those in females.

Table 3 shows data of healthy subjects and MPD patients. MPD patients demonstrate difference from the healthy subjects in the force asymmetry index (force AI). The value of the force AI of MPD patients is higher

than that of healthy subjects ($p=0.0141$).

Table 2. Means and SDs of occlusal data in healthy subjects.

| Subject | Occlusal contact areas (mm ²) | | Maximum pressure (MPa) | | Mean pressure (MPa) | | Occlusal force (N) | | force AI (%) | |
|---------|--|-----|---------------------------|-----|------------------------|-----|-----------------------|-------|-----------------|-----|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Male | 21.5 | 5.2 | 112.6 | 8.4 | 40.0 | 3.6 | 861.5 | 219.5 | 3.4 | 4.1 |
| Female | 16.7 | 5.5 | 113.2 | 7.3 | 41.4 | 3.0 | 687.0 | 213.4 | 7.0 | 4.2 |
| p-value | 0.1255 | | 0.8570 | | 0.3458 | | 0.1949 | | 0.0582 | |

Subject number: Male=9, Female=6. The p-values were analyzed by Mann-Whitney U-test.

Table 3. Means and SDs of occlusal data in MPD patients and healthy subjects.

| Subject | Occlusal contact areas (mm ²) | | Maximum pressure (MPa) | | Mean pressure (MPa) | | Occlusal force (N) | | force AI (%) | |
|---------------|--|-----|---------------------------|-----|------------------------|-----|-----------------------|-------|-----------------|------|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| MPD group | 21.7 | 7.8 | 116.3 | 7.3 | 42.9 | 6.9 | 896.9 | 274.1 | 18.5 | 18.5 |
| Healthy group | 19.6 | 5.7 | 112.8 | 7.7 | 40.6 | 3.3 | 791.7 | 227.2 | 4.9 | 4.4 |
| p-value | 0.4577 | | 0.1509 | | 0.4578 | | 0.3662 | | 0.0141 | |

Subject number: MPD group=8, Healthy group=15. The p-values were analyzed by Mann-Whitney U-test.

TMJ patients demonstrated differences from healthy subjects in occlusal contact areas, mean pressure, occlusal forces, and the force AI (Table 4). There are significant differences ($p=0.0108$, 0.0453 , 0.0332 , and 0.0012) in occlusal contact areas, mean pressure, occlusal forces, and force AI, respectively.

Table 4. Means and SDs of occlusal data in TMJ patients and healthy subjects.

| Subject | Occlusal contact areas (mm ²) | | Maximum pressure (MPa) | | Mean pressure (MPa) | | Occlusal force (N) | | force AI (%) | |
|---------------|--|-----|---------------------------|-----|------------------------|-----|-----------------------|-------|-----------------|------|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| TMJ group | 12.5 | 5.1 | 117.7 | 6.3 | 43.5 | 1.7 | 538.3 | 204.3 | 27.9 | 16.5 |
| Healthy group | 19.6 | 5.7 | 112.8 | 7.7 | 40.6 | 3.3 | 791.7 | 227.2 | 4.9 | 4.4 |
| p-value | 0.0108 | | 0.0648 | | 0.0453 | | 0.0332 | | 0.0012 | |

Subject number: TMJ group=8, Healthy group=15. The p-values were analyzed by Mann-Whitney U-test.

Table 5. Means and SDs of occlusal data in MPD and TMJ patients.

| Subject | Occlusal contact areas (mm ²) | | Maximum pressure (MPa) | | Mean pressure (MPa) | | Occlusal force (N) | | force AI (%) | |
|-----------|--|-----|---------------------------|-----|------------------------|-----|-----------------------|-------|-----------------|------|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| MPD group | 21.7 | 7.8 | 116.3 | 7.3 | 42.9 | 6.9 | 896.9 | 274.1 | 18.5 | 18.5 |
| TMJ group | 12.5 | 5.1 | 117.7 | 6.3 | 43.5 | 1.7 | 538.3 | 204.3 | 27.9 | 16.5 |
| p-value | 0.0208 | | 0.8903 | | 0.3442 | | 0.0117 | | 0.2936 | |

Subject number: MPD group=8, TMJ group=8. The p-values were analyzed by Mann-Whitney U-test.

The data of MPD and TMJ patients was shown in Table 5. There are significant differences ($p=0.0208$, and $p=0.0117$) in occlusal contact areas and occlusal force, respectively.

Discussion

Several methods have been employed for the evaluation of occlusal data. New diagnostic devices such as Photocclusion⁸ and T-scan system (Tekscan, Boston, MA, USA)⁹ have been developed. The Photocclusion system is difficult to measure the acting occlusal force precisely because of using a rather rigid material for occlusal examination.¹⁵ Patyk et al.⁹ stated that the T-Scan-sensor-foil was too thick and too inflexible and therefore created an uncontrollable shift of the mandible when biting. It may misreading the qualitative analysis of the occlusion. The thickness of the Dental Prescale sensor (0.098 mm) is similar to that of the T-Scan system sensor (0.1 mm). However, the Dental Prescale sensor is more flexible than the T-Scan system sensor. It is easier to control the shift of the mandible when closing the bite and may achieve improvement in quantifying and simplifying the analysis of occlusion. Another advantage is that occlusal data are recorded easily, with resulting comparing with other data.

There were not significant differences of occlusal data between male and female, although the values of occlusal contact areas and occlusal forces in males tended to be greater than those in females. This is in agreement with the previous report that studies of static closing force report no correlation between force and sex, weight, height, or body build of the subjects.¹⁷ The force AI in both of male and female indicated low values. It is not surprising that there is no significant difference between the force AIs in male and female. There is general agreement concerning this.

TMD is a frequent clinical problem and its pathophysiologic characteristics are complicated, but can be separated into masticatory muscle disorders and disorders of the temporomandibular joints.¹⁸⁻²⁰ TMD in this study was separated into MPD and TMJ groups, and evaluated. The force AI of TMD patients was higher than that of healthy subjects (Tables 3 and 4). The absolute asymmetry index (aAI) of the masseter muscles during intercuspals maximal clenching was higher in TMD patients than the healthy subjects.¹⁴ This is in agreement with the results in this study. This result might indicate that the greater occlusal imbalance, namely the high value of the force AI, relate to TMD. However it cannot be denied that the increase of the force AI was the result that the symptoms such as pain in TMD are commonly unilateral. However, determination of occlusal force balance (force AI) is a reliable index of TMD.

MPD syndrome is believed to be a stress-related disorder²¹⁻²³ and starts as a functional disorder. It is hypothesized that centrally induced increases in muscle tension, frequently combined with the presence of parafunctional habits such as clenching or grinding of the teeth, result in muscle fatigue and spasm that produce the pain and dysfunction. There were no significant differences between the values of occlusal contacts area and occlusal force in MPD patients and in healthy subjects (Table 3). This result is in agreement with the fact that the occlusions in some cases of MPD patients are stable.

The occlusal data in TMJ patients were different from those in healthy subjects, except for the data of maximum pressure. TMJ patients had the high value of force AI and mean pressure, and low value of contact areas comparing with the values in MPD patients (Table 4). These data in TMJ patients might indicate that there were not only imbalance between left and right of occlusion but also unstable occlusion due to the interfering occlusal contacts.

The Dental Prescale system has potential as a clinical device to diagnose and treat occlusion because it offers a greater variety and accuracy of occlusal data and because it uses time as the diagnostic variable.

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Correspondence to:

Dr. Shinsuke Sadamori

Department of Prosthetic Dentistry, Programs for Applied Biomedicine Division of Cervico-Gnathostomatology, Hiroshima University Graduate School of Biomedical Sciences
1-2-3 Kasumi, Minami-ku, Hiroshima 734-8553, Japan
Fax: +81-82-257-5684 E-mail: tsada@hiroshima-u.ac.jp

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