Original article

# Quantitative and multidimensional evaluation of symptoms and correlative factors for temporomandibular disorders in clinical and subclinical subjects

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**Key words**：temporomandibular disorders, clinical index, questionnaire, occlusion, correlative factors

**Abstract**：A set of indexed questionnaire (43 variables) and clinical protocol (42 variables) was developed to investigate multidimensional factors of temporomandibular disorders (TMD) in clinical patients (group C, 33), symptomatic subclinical (group S, 32) and asymptomatic normal (group N, 24) subjects. Results indicated that：1) most variables of self-reported jaw movement and pain experiences were significantly different among groups, whereas most variables of occlusal discomfort, psychosocial stress, oral parafuntion/habits and general health were not significantly different between S and C. 2) palpable pain of TMJ and muscles of jaw, neck and back, reciprocal clicking, abnormal jaw movement were significantly dominant in C than in S, whereas such a difference was not found in most variables of occlusion. 3) most variables of self-reported jaw movement and pain experiences were significantly associated with clinical-examined variables of TMJ, muscle and jaw movement, whereas psychosocial stress were less involved. 4) oral parafunction/habits showed significant association with TMJ sounds and palpable muscle pain in C. 5) some variables of occlusal discomfort were significantly associated with palpable muscle pain positively in C and with abnormal jaw movements negatively in S. 6) the association between clinical occlusal variables and clinical signs were weak. These results suggested that：1) the variables discriminating TMD patients from symptomatic or asymptomatic population mainly exist in TMJ and masticatory-cervical muscles. 2) oral parafunction/habits might be the important correlative factor of TMD, while occlusion seems to be less important.

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**顎関節症の臨床例および症状をもつ非臨床例における症状と関連因子の評価**

顎関節症に関わる因子を評価するため，顎関節症の臨床例33名（C群），症状はあるが治療希望のない非臨床例32名（S群），症状のない正常者24名（N群）の3群について，症状と関連因子を調査した．アンケート43項目，臨床診査42項目を点数化し，3群間で比較し，さらに症状と関連因子の関連を調査した．

1）アンケートによれば，顎運動障害と痛みの既往に関するほとんどの項目に3群間で有意差があった．咬合，社会心理的ストレス，口腔異常機能/習癖および全身の健康はN群と他の2群間に有意差があったが，S群とC群の間に有意差はなかった．2）臨床診査によれば，C群はS群に比べて顎関節，咀嚼筋，および頚背筋の痛み，顎関節雑音，顎運動障害の程度が強かった．3）アンケートによる顎運動障害と痛みの既往に関するほとんどの項目が，臨床診査による顎関節，筋，顎運動に関する項目と正の相関があった．しかしこれらの症状と社会心理的ストレスとの相関は無かった．4）C群では口腔機能異常/習癖に関する項目が，顎関節雑音および筋圧痛と正の相関があった．5）アンケートによる咬合不安定に関する項目は，C群では筋圧痛と正の，S群では顎運動障害と負の相関があった．6）臨床診査による咬合に関する項目と臨床症状には有意の相関はなかった．

以上より顎関節，咀嚼筋，頚背筋の症状の程度がS群とC群を分けていると考えられた．また口腔機能異常/習癖は顎関節症の関連因子として重要であるが，咬合の重要性は低いことが示唆された．

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## Introduction

Temporomandibular disorders (TMD), in the broad sense, are considered as a cluster of joint and muscle disorders in the orofacial region characterized primarily by pain, temporomandibular joint (TMJ) sounds and irregular or deviating jaw movements. Therefore, TMD, as a collective term, embraces a number of clinical problems which involve TMJ itself, the masticatory-cervical muscle complex, or both[1]. A number of studies have evaluated TMD signs and symptoms as well as some of correlative factors in order to approach their relationships with the etiology of TMD[2~6]. Few studies, however, involved the quantitative analysis and multifactorial assessment of TMD signs and symptoms together with oral parafunction and habits, psychosocial stress, self-reported occlusal discomfort and clinical status of occlusion, the interactions and associations existing in different signs, symptoms and correlative factors in relation to TMD pathogenesis remain to be unclear and most conflict.

On the other hand, cross-section epidemiological studies of specific nonpatient populations have shown that approximately 75% of them have at least one sign and approximately 33% have at least one symptom of TMD ; however, only 5〜7% are estimated to be in need of treatment[7]. Furthermore, It is estimated that about 5% of the population reporting signs and symptoms of TMD seeks professional advice and treatment for these[8]. There must be some specific factors which determine the objective estimation and subjective treatment needs. Selecting such factors is very meaningful to identify individual TMD signs and symptoms, and to understand their associations with predispositions or contributors to TMD. Adopting the experimental and the control groups only, as routine clinical study, will not be adequate to satisfy this demand. Recently, De Leeuw, *et al.*[8~12] reported their serial investigations of multidimensional evaluation of TMD symptoms among TMD patients, TMD symptomatic subjects and TMD asymptomatic subjects by questionnaire method. However, the objective clinical items and the occlusal variables were not included in their studies.

The present study was designed to qualify and quantify the TMD signs, symptoms and other correlates (oral parafunction/habits, psychosocial stress, *etc.*) among clinical TMD patients, symptomatic subclinical subjects and asymptomatic normal subjects on both the subjective self-reported questionnaire and the objective clinical examination using an indexed method. The specific aims of this study were : 1) to identify the subjective and objective variables which might discriminate TMD clinical patients from the symptomatic subclinical and/or the asymptomatic normal populations ; 2) to elucidate any possible associations between the subjective and objective variables and between occlusion and TMD signs and/or symptoms, and their contribution to TMD.

## Materials and Methods

### Subjects

The clinical patient group (C) consisted of 33 subjects with 14 males and 19 females (mean age : 27.6±5.54). They were judged as TMD patients at their first visits to the TMJ clinic, according to the clinical presentation advocated by McNeill[7]. However, no differentiation was made for myogenous, arthrogenous, or both components, due to small sample sizes.

The symptomatic subclinical group (S) consisted of 32 university students and young university staffs with 17 males and 15 females (mean age : 26.4±3.21). They had one or more TMD signs and/or symptoms judged by their clinical presentation rather than common and/or unexplained complaints as described in details by McNeill[7], but had no desire or consciousness to seek treatment.

The asymptomatic normal group (N) consisted of 24 students or staffs with 13 males and 11 females (mean age 27.8±4.61). They did not show clinical presentation of TMD signs and/or symptoms, and past history concerning TMD.

All judgments for dividing groups were performed by two experienced dentists. The age range of all subjects were between 22 to 38 years old. There were no significant differences for sex ratio and age among the three groups. The full consent was obtained from all subjects.

### Questionnaire for subjective variables

The questionnaire developed by Hijzen and Slangen[2] was revised and rearranged with supplement of inquiry for occlusal discomfort. In addition, score of each variable was weighted according to its definite or indefinite relation to TMD. The questi-

**Table 1 Anamnestic questionnaire for TMD**

| | Rating scale | Weight | Score | | Rating scale | Weight | Score |
|---|---|---|---|---|---|---|---|
| **1. Jaw movement** | | | | Anxiety/Stress | | | |
| Restricted jaw opening | 0 1 2 3 4 | 1.0 | — | on marriage/love | 0 1 2 3 4 | 0.8 | — |
| Sounds at jaw movement | 0 1 2 3 4 | 1.0 | — | on work/study | 0 1 2 3 4 | 0.8 | — |
| Tired feeling at jaw movement | 0 1 2 3 4 | 0.9 | — | on family/child | 0 1 2 3 4 | 0.8 | — |
| Stiffness at jaw movement | 0 1 2 3 4 | 0.9 | — | on personal relations | 0 1 2 3 4 | 0.7 | — |
| Sum | | | — | Unsatisfaction | 0 1 2 3 4 | 0.5 | — |
| **2. Pain experiences** | | | | Bad sleeping | 0 1 2 3 4 | 0.5 | — |
| TMJ pain | 0 1 2 3 4 | 1.0 | — | Use of sleeping pills | 0 1 2 3 4 | 0.8 | — |
| Jaw muscle's pain | 0 1 2 3 4 | 1.0 | — | Sum | | | — |
| Headache | 0 1 2 3 4 | 0.9 | — | **5. Oral parafunction/habits** | | | |
| Neck pain | 0 1 2 3 4 | 0.9 | — | Grinding during sleeping | 0 1 2 3 4 | 1.0 | — |
| Shoulder pain | 0 1 2 3 4 | 0.8 | — | Impercipient clenching | 0 1 2 3 4 | 1.0 | — |
| Back pain | 0 1 2 3 4 | 0.8 | — | Preference for soft food | 0 1 2 3 4 | 0.8 | — |
| Pain when eating tough food | 0 1 2 3 4 | 0.8 | — | Unilateral chewing | 0 1 2 3 4 | 0.8 | — |
| Stiffness of jaw muscles | 0 1 2 3 4 | 0.9 | — | Intentional TMJ clicking | 0 1 2 3 4 | 1.0 | — |
| Awakening tired at jaw muscles | 0 1 2 3 4 | 0.9 | — | Eating with water or beverages | 0 1 2 3 4 | 0.7 | — |
| Toothache | 0 1 2 3 4 | 0.5 | — | Nail biting | 0 1 2 3 4 | 0.5 | — |
| Sum | | | — | Lip biting | 0 1 2 3 4 | 0.5 | — |
| **3. Occlusal discomfort** | | | | Cheek biting | 0 1 2 3 4 | 0.5 | — |
| Unstable occlusion | 0 1 2 3 4 | 0.8 | — | Tongue biting | 0 1 2 3 4 | 0.5 | — |
| Incomplete occlusal contact | 0 1 2 3 4 | 0.7 | — | Sum | | | — |
| Unsatisfaction for tooth alignment | 0 1 2 3 4 | 0.6 | — | **6. General health** | | | |
| | | | | General health | 0 1 2 3 4 | 0.5 | — |
| Unfitting denture | 0 1 2 3 4 | 0.5 | — | Ear problem | 0 1 2 3 4 | 0.5 | — |
| Uncomfortable at ICP | 0 1 2 3 4 | 0.5 | — | Eye problem | 0 1 2 3 4 | 0.5 | — |
| Sum | | | — | Nose problem | 0 1 2 3 4 | 0.5 | — |
| **4. Psychosocial stress** | | | | Throat problem | 0 1 2 3 4 | 0.5 | — |
| Excitability | 0 1 2 3 4 | 0.8 | — | Sum | | | — |
| Depression | 0 1 2 3 4 | 0.8 | — | **Total** | | | — |

onnaire (Table 1) covered questions in six dimensions with 43 variables. They were jaw movement (4 variables), pain experiences (10 variables), occlusal discomfort (5 variables), psychosocial stress (9 variables), oral parafunction/habits (10 variables) and general health (5 variables). All variables were estimated on a five-point rating scale from absent to the most severe (0-4).

Prior to the clinical examination, each subject was asked to circle one of the scales which rated his self-feeling intensity and/or the frequency of corresponding variables.

**Examination for clinical variables**

Eight experienced dentists participated this procedures in order to avoid a individual bias of assessment. But, each subject was examined twice by two of eight dentists separately. Examiners, who knew well the definition of each clinical variable and its scale-rating criteria, were kept to be blind as to what kind of subject (N, S or C) was evaluated, what kind of answer was given to the questionnaire, and what score was calculated by the other examiner.

The standardized protocol of clinical examination consisted of 42 variables covering the following 4 dimensions each with two sub-dimensions.

**1. TMJ dimension (8 variables)**

1) TMJ tenderness was examined by palpating 4 areas bilaterally; *i.e.*, the external auditory meatus, the preauricular region, the postero-superior margin of mandibular ramus and the mandibular notch. A positive finding was recorded, if the subject felt a difference between the right and the left sides and described the palpable pain. A five-point scale from absent to the most severe (0-4) was rated according to the subjects' response to the palpation. Coefficients were used to multiply the

score if the dynamic pain (×1.2), the referring pain (×1.2), or both (×1.5) was evoked either by the palpation. When the positive findings were detected on both sides, the score was doubled. The same manner was used for the following concerning variables.

2) TMJ sounds (reciprocal clicking, non-reciprocal clicking, grinding and crepitus, 4 variables) were recorded by using a stethoscope. The five-point scale was rated according to the intensity and/or the frequency of the sounds. Coefficients were also used if the sound accompanied with pain (×1.2), jaw jumping (×1.2), or both (×1.5).

**2. Muscle dimension (9 variables)**

1) Muscle tenderness was palpated on the following musculature : the masticatory muscles (masseter, temporal, and lateral and medial pterygoid muscles), the suprahyoid muscles mainly in digastric muscle, the infrahyoid muscle, the neck muscle mainly in sternocleidomatoid muscle, the back muscle mainly in trapezial muscle, and the expression muscles. There were 6 variables. The rating scale and the calculation of scores were the same as those of TMJ tenderness.

2) The muscle quality included 3 variables. The subject was asked to keep his jaw in the intercuspal position (ICP). Muscle asymmetry mainly in masseter was determined if the muscle size was different between the homonymous muscles of both sides. Muscle stiffness or muscle node/fascicle was recorded if the muscle hardness was different between the right and the left sides, or if the muscle node/fascicle was found by palpation, respectively. A five -point scale was rated according to the degrees of asymmetry, stiffness and node/fascicle.

**3. Jaw movement dimension (7 variables)**

1) The menton movement was examined and measured on the clinical inspection. The restricted and/or the deviated excursion of menton was recorded when the subject was asked to open, protrude and move the chin laterally. Zigzag opening path was set as another independent variable. Thus, there were 4 variables. A five-point scale was rated according to the degree of restriction and deviation.

2) The condylar movement was examined by the bilateral palpation on the preauricular region when the subject was asked to open the mouth wide repeatedly. The asymmetric shift, the subluxation/dislocation and the closed lock were detected and rated on a five-point scale as well.

**4. Occlusal dimension (15 variables)**

1) Static occlusion included totally 11 variables in 3 items, *i.e.,* tooth alignment, loss and attrition.

Tooth alignment contained 7 variables. They were the anterior deep overbite and overjet, the crowding, the anterior and posterior cross bite, the anterior open bite and the edge to edge bite. The criteria has been described elsewhere[5,13]. A five-point scale was rated on the degree of each presentation.

Tooth loss was divided into the anterior and the posterior loss. The five-point scale was rated according to the number of teeth lost (except the third molar).

Tooth attrition was also divided into the anterior and the posterior attrition. A five-point scale was rated according to Martin's criteria[14].

2) Functional occlusion included totally 4 variables in 2 items, *i.e.,* occlusal interferences and occlusal premature contact.

Occlusal interferences contained the protruding interference, the lateral interference and the interference between the retruded contact position (RCP) to ICP. Dual-color articulating papers were used to detect the location and the intensity of interference. The protruding interference was recorded if the posterior teeth contacted when the mandible was guided to protrude. Coefficients were multiplied if the anterior teeth contacted unilaterally (×1.2) or did not contacted (×1.5). The lateral interference was determined if the posterior teeth contacted in the non-working side when the mandible was guided to move laterally. A coefficient was multiplied if there was no contact in the working side (×1.5). As to the interference between RCP -ICP, a positive finding was established if the posterior teeth contacted unilaterally while the mandible was guided from ICP into RCP, or the mandible could not be guided. Then the subject was asked to close the mouth into ICP. A positive finding was recorded if the shifting distance from RCP to ICP was larger than 1.5 mm or an oblique shifting was observed. If the unilateral contact in the posterior teeth accompanied with each or both of shifting descriptions above, a coefficient was multiplied for each (×1.2), or both (×1.5) respectively. A five-point scale was rated according to the degree and the extent of the interference.

The occlusal premature contact was determined if the obvious sliding was observed when the subject was asked to close the mouth slowly from the rest

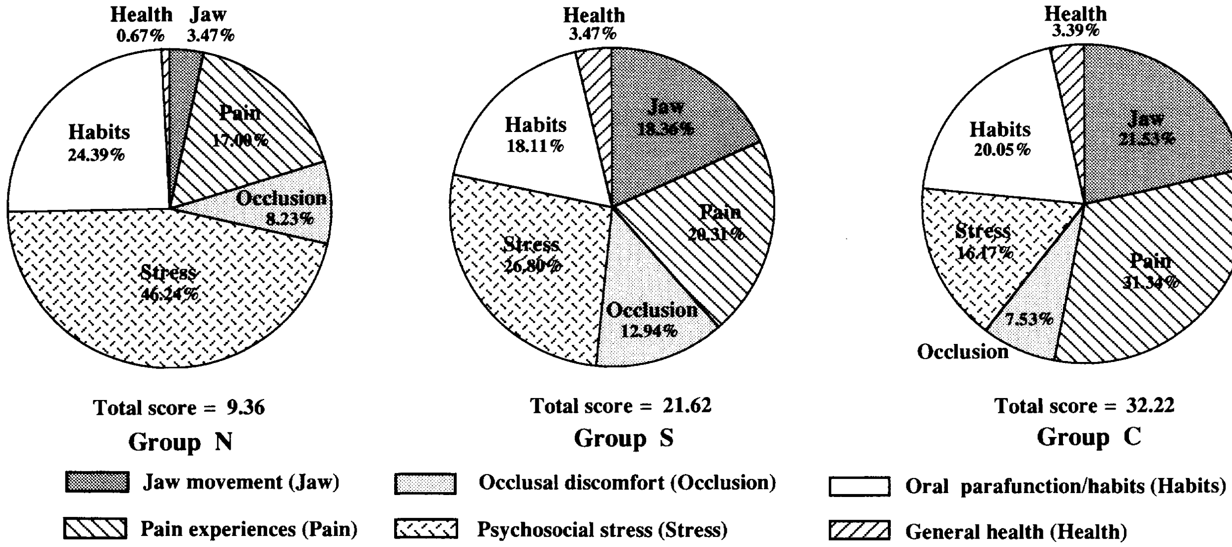


**Fig. 1 Distribution of subjective scores in six dimensions of questionnaire in the three groups**

position till teeth coming to contact, then to close forcefully. The observations were supplemented by questioning the subject whether or which side the teeth contacted first during the above two-stage closure. A five-point scale was rated according to the extent of sliding.

### Statistics

Since the data appeared in the ranking-scale way, the nonparametric statistics were performed by SPSS program (SPSS 6.0, SPSS Inc. USA). Prevalences of the scores were calculated in numerical values, while prevalences of the positive response rates to questionnaire and the positive finding rates during the examination were calculated in percentages. The positive response rates were calculated when the ratings of the subjective variables were positive regardless of the level of rating scales. A Wilcoxon Matched-pairs Signed Rank test was first performed to confirm the inter-individual agreement in the numerical values between two examiners for randomly sampled 10 subjects from the three groups. As there were no significant differences between two examiners for all clinical-examined scores, the mean values of clinical scores were used for the present analysis.

The chi-square test was carried out to detect the difference of prevalence of each variable for the percentages, while Kruskal-Wallis One-way Anova was done for numerical values, among the three groups. Whatever the significance was found, a Mann-Whitney U test was further performed to detect the significance between each two groups. A Spearman Correlation Coefficient was used to find the associations between the subjective and the clinical variables, and between the clinical occlusal variables and other clinical variables. Statistical significance was regarded as significant for $p < 0.05$, highly significant for $p < 0.01$ and most highly significant for $p < 0.001$.

## Results

### Distribution of subjective and clinical scores

Figure 1 gives the distribution of subjective scores in six dimensions of questionnaire. The total scores were progressively increased in the order of N (9.36), S (21.62) and C (32.22). The highest score among six dimensions was found for psychosocial stress in N (46.24%) and S (26.80%), but for pain experiences in C (31.34%). Main parts of score were obtained from psychosocial stress and oral parafunction/habits in N (70.63%), but from psychosocial stress, pain experiences and jaw movement in S (65.47%) and from pain experiences and jaw movement in C (52.87%).

Figure 2 gives the distribution of clinical scores in eight sub-dimensions of the protocol. The total scores were progressively increased from N, S to C (7.15, 17.42 to 27.23, respectively). The largest source of scoring in all three groups came from the occlusal dimension (N : 95.24%, S : 45.05%, C : 38.51%), with distribution of TMJ, muscles and jaw movement scores being increased in S and C.

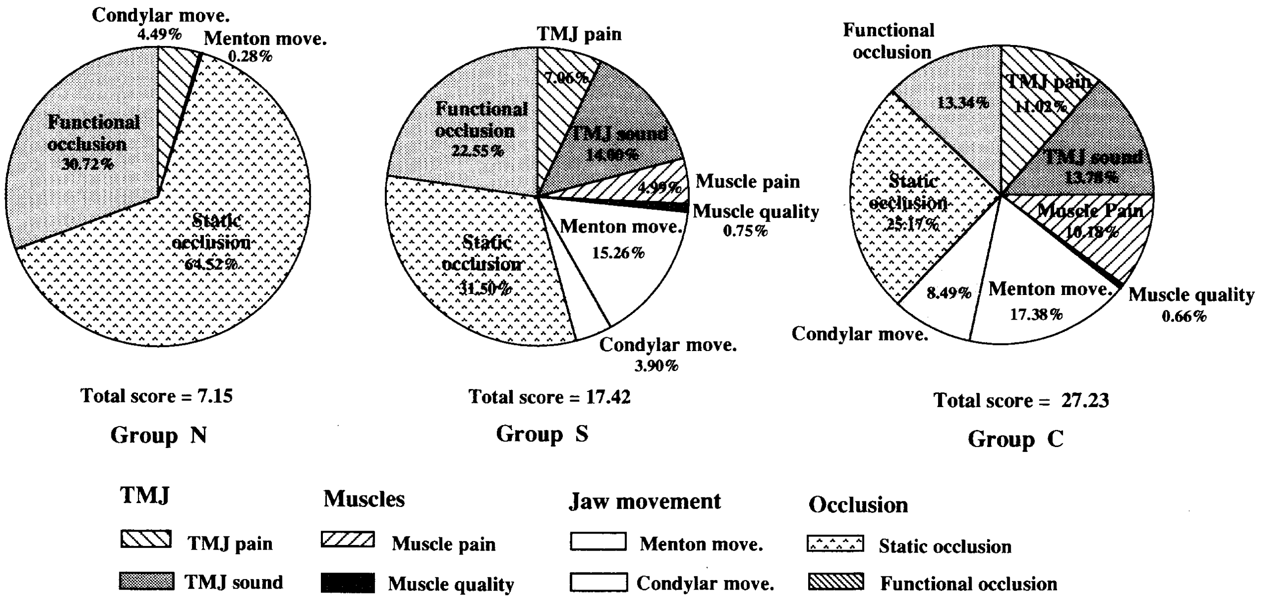


**Fig. 2** Distribution of clinical scores in eight sub-dimensions of the protocol in the three groups

Furthermore, the distributions of scores of TMJ pain, muscle pain and condylar movement were larger in C than in S. The distribution of score of TMJ sounds were almost the same in S and C. However, the distribution of functional occlusion score was nearly twice in S (22.55%) as much as in C (13.34%).

### Comparison of the subjective variables

Table 2 shows the comparison of mean scores and positive response rates of subjective variables between each two groups, in which the variables with no statistical significance by Kruskal-Wallis One-way Anova test were omitted. The statistical differences of the scores were roughly in accordance with those of the rates.

All 4 variables of the jaw movement showed significantly higher values in both S and C. The higher prevalences were found in restricted jaw opening for both the score and the rate, but for stiffness of jaw movement only the score was higher in C than in S. As the rate was calculated whatever the rating was positive, this difference indicates that the subjects of C circled a higher rating of stiffness of jaw movement than the subjects of S did. There were no significant difference for complaints of TMJ sounds and tired feeling at jaw movement between S and C.

As for 10 variables of the pain experiences, data in the neck, shoulder and back pain and headache were omitted because of no differences among the three groups. The remaining 6 variables showed generally higher values in both S and C. The scores and the rates of awakening tired at jaw muscles and the toothache showed no differences between N and S. However, all of listed scores and rates were higher in C than in S.

Of 5 variables of the occlusal discomfort, both S and C represented the higher scores in the variables concerning the occlusal sensation, while differences of complaint of unsatisfaction for tooth alignment among the three groups were relatively weak. No difference was found between S and C for the sum of this dimension.

Of 9 variables of the psychosocial stress, only depression showed the higher scores in both S and C than in N, without difference between each other. A significant higher score of anxiety/stress on work/study was shown in both N and S than in C. However, there were no difference among the three groups for the sum of this dimension.

Of 10 variables of the oral parafunction/habits, intentional TMJ clicking was most frequent in C. Both S and C showed more positive and severer responses to preference for soft food and unilateral chewing than N did. The habit of eating with water or beverage was more frequently found in C than in both S and N.

For the dimension of general health, there were no differences for the complaints of eye, nose and throat problems. C and S, even without difference between each other, had a tendency of higher score

**Table 2 Comparison of mean scores and positive response rates of subjective variables between each two groups**

| Variables | Mean scores | | | | | | Positive response rates (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | S | C | N-S | N-C | S-C | N | S | C | N-S | N-C | S-C |
| Restricted jaw opening | 0 | 0.50 | 1.73 | ** | *** | *** | 0 | 34.38 | 75.76 | ** | *** | ** |
| Sounds at jaw movement | 0 | 1.81 | 2.27 | *** | *** | ns | 0 | 96.88 | 87.88 | *** | *** | ns |
| Tired feeling at jaw movement | 0.08 | 0.82 | 1.16 | *** | *** | ns | 8.33 | 65.63 | 66.67 | ** | ** | ns |
| Stiffness at jaw movement | 0 | 0.84 | 1.77 | *** | *** | *** | 0 | 65.63 | 81.82 | ** | ** | ns |
| **Sum (jaw movement)** | **0.08** | **3.97** | **6.94** | ******* | ******* | ******* | | | | | | |
| TMJ Pain | 0 | 0.34 | 1.73 | ** | *** | *** | 0 | 25.00 | 78.79 | ** | *** | *** |
| Jaw muscles' pain | 0 | 0.34 | 1.30 | * | *** | ** | 0 | 21.88 | 60.61 | ** | ** | ** |
| Pain when eating tough food | 0.03 | 0.55 | 1.45 | *** | *** | ** | 4.71 | 43.75 | 60.61 | ** | ** | * |
| Stiffness of jaw muscles | 0 | 0.31 | 1.15 | ** | *** | ** | 0 | 25.00 | 60.61 | * | ** | ** |
| Awakening tired at jaw muscles | 0 | 0.23 | 0.71 | ns | *** | * | 0 | 12.50 | 39.39 | ns | * | * |
| Toothache | 0.04 | 0.01 | 0.45 | ns | * | * | 8.33 | 9.38 | 30.30 | ns | ** | * |
| **Sum (pain experiences)** | **1.59** | **4.39** | **10.10** | ***** | ******* | ****** | | | | | | |
| Unstable occlusion | 0.07 | 0.66 | 0.88 | ** | *** | ns | 8.33 | 37.50 | 57.58 | ** | *** | ns |
| Incomplete occlusal contact | 0.12 | 0.61 | 0.47 | * | * | ns | 12.50 | 40.63 | 42.42 | ns | ns | ns |
| Unsatisfaction for tooth alignment | 0.53 | 0.92 | 0.53 | ns | ns | * | 41.67 | 71.88 | 39.39 | * | ns | * |
| Uncomfortable at ICP | 0.06 | 0.55 | 0.52 | ** | ** | ns | 12.50 | 46.88 | 45.45 | ** | ** | ns |
| **Sum (occlusal discomfort)** | **0.77** | **2.80** | **2.42** | ****** | ****** | **ns** | | | | | | |
| Depression | 0.43 | 0.88 | 1.02 | ns | * | ns | 37.50 | 59.38 | 60.61 | ns | ns | ns |
| Anxiety/stress on work/study | 1.14 | 1.08 | 0.87 | ns | * | * | 91.67 | 94.38 | 57.58 | ns | ns | ns |
| **Sum (psychosocial stress)** | **4.33** | **5.79** | **5.21** | **ns** | **ns** | **ns** | | | | | | |
| Preference for soft food | 0.23 | 0.70 | 0.75 | * | * | ns | 20.83 | 50.00 | 48.48 | * | * | ns |
| Unilateral chewing | 0.43 | 1.00 | 1.50 | * | *** | * | 33.30 | 62.50 | 58.79 | * | *** | ns |
| Eating with water or beverages | 0.55 | 0.81 | 1.14 | ns | ** | ** | 45.83 | 56.25 | 72.73 | ns | * | ns |
| Intentional TMJ clicking | 0 | 0.13 | 0.76 | ns | * | * | 0 | 6.25 | 33.33 | ns | ** | ** |
| **Sum (oral parafunction/habits)** | **2.28** | **3.92** | **6.46** | ***** | ******* | ****** | | | | | | |
| General health | 0.04 | 0.30 | 0.35 | * | ** | ns | 8.33 | 34.38 | 39.39 | * | ** | ns |
| Ear problem | 0 | 0.08 | 0.20 | ns | * | ns | 0 | 6.25 | 18.18 | ns | ns | ns |
| **Sum (general health)** | **0.06** | **0.75** | **1.09** | ****** | ****** | **ns** | | | | | | |
| **Total Score** | **9.36** | **21.62** | **32.22** | ******* | ******* | ****** | | | | | | |

The variables were omitted if the statistical difference was not found by Kruskal-Wallis One-way Anova test
* : $p<0.05$, ** : $p<0.01$, *** : $p<0.001$, ns : not significant.

for remaining 2 variables than N did, especially for ear problem.

**Comparison of clinical variables**

Table 3 shows the comparison of mean scores and the positive finding rates of clinical variables between each two groups, with the omitted variables same as Table 2. Similarly, differences of the scores were grossly consistent with those of the rates.

For the TMJ pain, the scores and the rates of 4 variables were all higher in C than in S, whereas only palpable pain at the external meatus and the preauricular region showed significant. Thus, the palpable pain in these two regions might be one of features in C. For the TMJ sounds, the score and the rate of reciprocal clicking increased significantly in C as compared with S, while crepitus showed no differences in both the scores and the rates between S and C. It is noted that a higher score of non-reciprocal clicking and crepitus were found in S instead of C.

For the muscle pain, palpation in the regions of supra and infra hyoid muscles and expression muscles did not show any significant difference among the three groups. The most discriminating variable of muscle pain between groups was the palpable pain in the masticatory muscles, whose score and rate increased significantly from S to C. However, only C showed higher scores in neck and back muscles compared with other two groups. In addition, the score and the rate were significantly higher in both C and S without difference between each other for stiffness at palpation which were account-

**Table 3 Comparison of mean scores and positive finding rates of clinical variables between each two groups**

| Variables | Mean scores | | | | | | Positive finding rates (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | S | C | N-S | N-C | S-C | N | S | C | N-S | N-C | S-C |
| Ext. auditory meatus | 0 | 0.08 | 0.79 | ns | *** | *** | 0 | 9.38 | 48.48 | ns | *** | ** |
| Preauricular region | 0 | 0.38 | 0.95 | ** | *** | ** | 0 | 31.25 | 81.82 | ** | *** | *** |
| Post-super. margin of ramus | 0 | 0.51 | 0.88 | *** | *** | ns | 0 | 43.75 | 57.58 | ** | ** | ns |
| Mandibular notch | 0 | 0.26 | 0.39 | * | ** | ns | 0 | 18.75 | 27.27 | * | ** | ns |
| Clicking (reciprocal) | 0 | 0.80 | 2.86 | ** | *** | ** | 0 | 31.25 | 57.38 | ** | *** | * |
| Clicking (non-reciprocal) | 0 | 0.45 | 0.08 | ** | ns | * | 0 | 25.00 | 16.25 | ** | ** | ns |
| Crepitus | 0 | 0.64 | 0.33 | ** | ns | ns | 0 | 12.50 | 9.09 | * | * | ns |
| **Sum (TMJ)** | **0** | **3.67** | **6.76** | *** | *** | *** | | | | | | |
| Masticatory muscles | 0 | 0.61 | 1.43 | *** | *** | * | 0 | 37.50 | 63.64 | ** | *** | * |
| Neck muscles | 0 | 0.14 | 0.61 | ns | *** | ** | 0 | 12.50 | 39.39 | * | ** | * |
| Back muscles | 0 | 0.08 | 0.52 | ns | ** | * | 0 | 12.50 | 45.83 | * | *** | * |
| Stiffness at palpation | 0 | 0.08 | 0.01 | * | ** | ns | 0 | 18.75 | 17.27 | * | ** | ns |
| **Sum (muscles)** | **0** | **1.00** | **2.95** | ** | *** | *** | | | | | | |
| Opening. deviated/restricted | 0.07 | 0.70 | 1.73 | *** | *** | *** | 8.33 | 56.25 | 93.94 | ** | *** | ** |
| Protruding. deviated/restricted | 0.18 | 1.14 | 1.54 | *** | *** | * | 20.83 | 87.50 | 96.97 | ** | ** | ns |
| Lateral move. deviated/restricted | 0.02 | 0.37 | 0.67 | *** | *** | * | 4.17 | 43.75 | 75.76 | ** | *** | ** |
| Zigzag opening path | 0 | 0.45 | 0.79 | ** | *** | ns | 0 | 43.75 | 54.55 | ** | *** | ns |
| Asymmetric condylar movement | 0.02 | 0.45 | 0.73 | *** | *** | * | 4.17 | 46.88 | 81.82 | ** | *** | ** |
| Subluxation/Dislocation | 0 | 0.10 | 0.18 | ns | * | ns | 0 | 12.50 | 24.24 | ns | ** | ns |
| Closed lock | 0 | 0.13 | 1.30 | ns | *** | *** | 0 | 6.25 | 45.45 | ns | *** | *** |
| **Sum (jaw movement)** | **0.33** | **3.24** | **7.03** | *** | *** | *** | | | | | | |
| Deep overbite | 0.46 | 0.59 | 1.00 | ns | * | * | 33.33 | 31.25 | 66.67 | ns | ** | ** |
| Deep overjet | 0.29 | 0.30 | 0.85 | ns | *** | *** | 41.67 | 28.13 | 78.79 | ns | ** | *** |
| Attrition ante. teeth | 0.98 | 0.99 | 1.34 | ns | ** | ** | 95.83 | 96.88 | 96.97 | ns | ns | ns |
| RCP-ICP interference | 0.49 | 1.18 | 1.34 | * | *** | ns | 33.33 | 65.63 | 78.79 | ** | ns | ns |
| **Sum (occlusion)** | **6.80** | **9.42** | **10.49** | * | *** | **ns** | | | | | | |
| **Total score** | **7.15** | **17.42** | **27.23** | *** | *** | *** | | | | | | |

The variables were omitted if the statistical difference was not found by Kruskal-Wallis One-way Anova test
* : $p<0.05$, ** : $p<0.01$, *** : $p<0.001$, ns : not significant.

ed into one variable of the sub-dimension of muscle quality.

Identical to the dimension of TMJ, all 4 variables in the menton movement manifested the strikingly higher scores and rates in both S and C. Comparing with S, the scores of these variables were all significantly higher in C except for zigzag opening path. On the other hand, asymmetric condylar movement in both sides and closed lock were more dominant in C than in S, especially for closed lock. There were no significant differences of subluxation/dislocation and closed lock between N and S for both their scores and rates.

Of 15 variables of the occlusal dimension, however, the differences appeared merely in 4 of them among the three groups. Only RCP-ICP interference had the significantly higher score and rate in both S and C. The scores of remaining 3 variables were significantly higher in C only. There was almost the same rate of attrition of anterior teeth among the three groups, whereas its score was higher in C than in other two groups. This fact indicated that more severe attrition occurred in C. The variables of deep overbite and overjet were more frequent in C than in other two groups. However, the sum of scores for this dimension did not display the significant difference between S and C.

### Correlation between subjective and clinical variables

Table 4 gives the correlation coefficients between the subjective variables and the clinical sub-dimensions. The correlation between the subjective variables and the clinical variables of TMJ, muscles and jaw movement could not be established in N due to few positive values of these variables. Only the clinical occlusal scores, both in the static and the functional occlusion, were pooled to the subjective

**Table 4 Correlation coefficients between subjective variables and clinical sub-dimensions in the three groups**

| Clinical sub-dimensions / Subjective variables | TMJ | | | | Muscles | | | | Jaw Movement | | | | Occlusion | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pain | | Sound | | Pain | | Quality | | Menton | | Condyle | | Static | | | Functional | | |
| | S | C | S | C | S | C | S | C | S | C | S | C | N | S | C | N | S | C |
| Restricted jaw opening | 0.445* | 0.566** | | | 0.483** | 0.407* | | | | | | 0.359* | | | 0.376* | | | |
| Sounds at jaw movement | | | 0.516** | 0.515** | | 0.359* | | | | | | | | | | | | |
| Tired feeling at jaw movement | 0.397* | 0.381* | | | 0.490** | | | | 0.344* | | 0.424* | | | | | | | |
| Stiffness at jaw movement | | 0.552** | 0.542** | | | 0.460** | | | 0.450* | | | | | | | | 0.356* | |
| **Sum (Jaw movement)** | **0.363*** | **0.450**** | **0.503**** | | **0.448**** | **0.495**** | | | **0.358*** | | | | | | | | | |
| TMJ pain | 0.353* | 0.467** | | | 0.486** | | 0.454** | | 0.424* | | 0.369* | 0.393* | | | | | | |
| Jaw muscles' pain | 0.357* | 0.524** | | | 0.500** | | 0.381* | | 0.384* | | | 0.337* | | | 0.451** | | 0.477** | |
| Headache | | 0.379* | | | | | | | | | | | | | | 0.542** | | |
| Neck pain | | | | | | 0.354* | | | | | | | | | | | | |
| Shoulder pain | 0.381* | | | | | | | | | | | | | | | | | |
| Back pain | | 0.354* | | | | | | | | | | | | | | | | |
| Pain when eating tough food | | 0.426* | | | | 0.407* | | | | | | | | | | | | |
| Stiffness of jaw muscles | | 0.520** | | | | 0.447** | | | | | | | | | 0.399* | | 0.489** | |
| Awakening tired at jaw muscles | | 0.556** | | | | | | | | | | | | | | | | |
| Toothache | | 0.586** | | | | | | | | | | | | | | | | |
| **Sum (Pain experiences)** | **0.586**** | **0.624**** | | | **0.662**** | **0.563**** | **0.619**** | | | | | | | | **0.363*** | | | |
| Incomplete occlusal contact | | | | | | 0.376* | | | | | | | | 0.418* | | | | |
| Unsatisfaction for tooth alignment | | | | | | | | | | | −0.445* | | | 0.481** | 0.458** | | | |
| Uncomfortable at ICP | | | | | | 0.389* | | | −0.434* | | −0.392* | | | | | | | |
| **Sum (Occlusal discomfort)** | | | | | | **0.433*** | | | **−0.312*** | | **−0.398*** | | | **0.453**** | | | **0.378*** | |
| Depression | | | | | | | | | | | | | | | 0.489** | | | |
| Stress on personal relations | | 0.364* | | | | 0.523** | | | | −0.378* | | | | | 0.424* | | | |
| Unsatisfaction | | | | | 0.254* | | | | | | | | | | | | | |
| Bad sleeping | | | | | | 0.345* | | | | | | | | | | | | |
| **Sum (Psychosocial stress)** | | | | | | | | | | | | | | | | | | |
| Grinding during sleeping | | | | 0.502** | | | | | | 0.390* | | | | | | | 0.361* | |
| Impercipient clenching | 0.581** | | | 0.365* | | | | | | | | | | | | | | |
| Preference for soft food | | | | | | 0.470** | | | | | | | | | | | | |
| Unilateral chewing | | | | 0.461** | | | | | | | | | | | | | | |
| Intentional TMJ clicking | | | | 0.507** | | | | | | | | | | | | | | |
| Lip biting | | | | | | 0.368* | | | | | −0.380* | 0.368* | | | | | | |
| **Sum (Parafunction/ habits)** | | | | **0.448**** | | **0.345*** | | | | | | | | | | | | |

The variables or coefficients were omitted if statistical significance was not found by Spearmen Correlation Analysis

* : p<0.05, ** : P<0.01

variables for detecting possible associations.

For N, a positive association was only found between the functional occlusion and the complaint of jaw muscles' pain ($r=0.542$, $p<0.01$).

For S, the clinical TMJ pain and muscles' pain showed identical positive associations with the complaints of restricted jaw opening, tired feeling at jaw movement, TMJ and jaw muscles' pain, while TMJ sounds had no association with most of subjective variables apart from the complaints of sounds ($r=0.516$, $p<0.01$) and stiffness at jaw movement ($r=0.542$, $p<0.01$). Similarly, muscle quality had only positive association with the complaints of pain in TMJ ($r=0.454$, $p<0.01$) and jaw ($r=0.381$, $p<0.05$) muscles. The menton and the condylar movement showed positive association with the complaints of jaw movements and pain in TMJ and jaw muscles. It is noted that this clinical dimension had a negative association with the complaints of occlusal discomfort. The functional occlusion was positively correlated with a few subjective variables of stiffness at jaw movement ($r=0.356$, $p<0.05$), TMJ pain ($r=0.477$, $p<0.01$), stiffness of jaw muscles ($r=0.489$, $p<0.01$), sum of occlusal discomfort ($r=0.378$, $p<0.05$) and impercipient clenching ($r=0.361$, $p<0.05$). However, the static occlusion only showed a positive association with the complaints of occlusal discomfort ($r=0.453$, $p<0.01$). Clinical variables rarely associated with the psychosocial stress, while a strong positive association was found between the TMJ pain and the impercipient clenching ($r=0.581$, $p<0.01$). A significant association was not found between clinical variables and the complaints of general health.

Different from S, the positive associations with clinical TMJ pain and muscles' pain were detected in most subjective variables of jaw movement and pain experiences in C. Furthermore, muscle pain positively correlated with the complaints of occlusal discomfort ($r=0.433$, $p<0.05$). It is interesting that menton movement did not show significant association with the complaints of jaw movement and the pain experiences, and condylar movements showed fewer associations with them in C than in S, where only the complaints of restricted jaw opening ($r=0.359$, $p<0.05$), pain in TMJ ($r=0.393$, $p<0.05$) and jaw muscles ($r=0.337$, $p<0.05$) were related with condylar movement. Opposite to the findings in S, there were more positive associations between the static occlusion and subjective variables, and less positive associations between the functional occlusion and subjective variables. It is noted that in C, the oral parafunction/habits was strongly correlated with TMJ sounds ($r=0.448$, $P<0.01$) and muscle pain ($r=0.345$, $p<0.05$), which were attributed to grinding during sleeping ($r=0.502$, $p<0.01$), impercipient clenching ($r=0.365$, $p<0.05$), preference for soft food ($r=0.470$, $p<0.01$), unilateral chewing ($r=0.461$, $p<0.01$), intentional TMJ clicking ($r=0.507$, $p<0.01$) and lip biting ($r=0.368$, $p<0.05$).

**Correlation between occlusal findings and clinical signs**

Fifteen variables in the occlusal dimension were used in conjunction with clinical sub-dimensions to test their associations. Due to the same reason as mentioned above, the correlation was not established in N.

As shown in Table 5, all associations were weak. In S, a significant association was established in the following : attrition of anterior teeth with TMJ pain ($r=-0.390$, $p<0.05$) ; loss of anterior teeth and lateral interference with muscle quality ($r=0.414$ and $0.402$, $p<0.05$) ; and edge to edge bite with condylar movement ($r=0.452$, $p<0.01$). However, the sums of static and functional occlusion showed no significant association with all clinical sub-dimensions.

The significant association was found in fewer occlusal variables in C than in S, which derived from deep overbite with condylar movement ($r=0.371$, $p<0.05$) and attrition of anterior teeth with the muscle quality ($r=0.447$, $p<0.01$). All variables in the functional occlusion did not show any significant association with clinical sub-dimensions.

## Discussion

**Indexed questionnaire and clinical protocol**

Several index systems have been established for screening and examining TMD subjects, and evaluating the self-reported and clinical-examined variables quantitatively[2,3,15~17]. The present study brought multidimensional variables pertaining to TMD together into a set of questionnaire and clinical protocol, and adopted a five-point rating scales to calculate the indices of all variables. In addition, a weighted method was used in the questionnaire for avoiding a misloading or overloading effect by indeterminate variables, such as toothache. It must be noted that direct comparison of the present detailed indices (scores) with those of other investigations may be misleading because of the difference in index calculation and variables selected. However, the results of the present study are comparable in a broad sense with those of other studies.

The screening practice demonstrated that the present questionnaire was easy to understand for subjects and time saving. Although the palpation technique used in the clinical examination was not standardized by use of a pressure algometer, as suggested by Schiffman, *et al.*[18], all examiners were

**Table 5 Correlation coefficients between occlusal variables and clinical sub-dimensions in groups S and C**

| Occlusal variables \ Clinical sub-dimensions | TMJ | | | | Muscles | | | | Jaw movement | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pain | | Sound | | Pain | | Quality | | Menton | | Condyle | |
| | S | C | S | C | S | C | S | C | S | C | S | C |
| Deep overbite | −0.214 | 0.286 | 0.005 | 0.064 | −0.147 | 0.295 | −0.125 | −0.072 | 0.059 | 0.187 | −0.073 | 0.371* |
| Deep overjet | −0.161 | 0.205 | 0.246 | −0.226 | 0.037 | 0.012 | 0.087 | 0.093 | 0.019 | 0.118 | −0.158 | 0.304 |
| Crowding | −0.159 | 0.244 | 0.143 | 0.030 | 0.188 | 0.280 | 0.311 | 0.089 | 0.109 | 0.253 | −0.226 | 0.217 |
| Anterior cross bite | 0.145 | −0.136 | 0.078 | −0.092 | 0.311 | −0.119 | 0.289 | 0.186 | 0.232 | 0.038 | 0.068 | −0.048 |
| Posterior cross bite | 0.142 | — | −0.019 | — | −0.031 | — | −0.063 | — | −0.250 | — | 0.054 | — |
| Open bite | 0.156 | 0.119 | −0.247 | −0.048 | 0.067 | 0.277 | 0.083 | −0.272 | −0.258 | 0.004 | 0.157 | −0.102 |
| Edge to edge bite | 0.194 | −0.145 | −0.113 | −0.266 | 0.325 | −0.099 | −0.058 | 0.117 | 0.165 | −0.303 | 0.452** | −0.096 |
| Loss ante. Ieth | 0.016 | 0.057 | −0.187 | 0.088 | 0.334 | 0.054 | 0.414* | 0.129 | 0.026 | 0.245 | −0.213 | 0.024 |
| Loss post. teeth | 0.020 | 0.175 | −0.013 | 0.138 | 0.038 | 0.119 | 0.004 | 0.010 | −0.286 | 0.082 | −0.177 | 0.217 |
| Attrition ante. teeth | −0.390* | −0.034 | 0.072 | −0.011 | −0.308 | 0.093 | −0.161 | 0.447** | 0.144 | −0.175 | −0.002 | 0.106 |
| Attrition post. teeth | −0.263 | −0.029 | −0.328 | 0.140 | −0.205 | 0.023 | −0.159 | 0.204 | −0.045 | 0.116 | −0.029 | 0.240 |
| **Sum (static)** | **−0.137** | **0.309** | **0.064** | **0.048** | **0.191** | **0.310** | **0.174** | **0.145** | **0.043** | **0.251** | **0.008** | **0.266** |
| Protruding interference | 0.269 | −0.072 | 0.028 | 0.011 | 0.286 | 0.144 | 0.244 | −0.210 | −0.016 | −0.071 | 0.190 | −0.063 |
| Lateral interference | 0.299 | −0.181 | −0.102 | 0.163 | 0.341 | −0.010 | 0.402* | −0.185 | −0.303 | −0.012 | −0.186 | −0.363 |
| RCP-ICP interference | 0.078 | 0.112 | 0.193 | −0.081 | −0.022 | 0.242 | −0.028 | −0.073 | −0.074 | −0.005 | −0.212 | 0.069 |
| Occlusal premature | −0.037 | 0.209 | 0.061 | 0.121 | 0.044 | 0.131 | 0.346 | −0.021 | 0.208 | 0.103 | −0.023 | 0.031 |
| **Sum (functional)** | **0.228** | **−0.055** | **0.041** | **0.259** | **0.275** | **0.245** | **0.308** | **−0.093** | **−0.060** | **0.171** | **−0.029** | **−0.243** |

*: $p<0.05$, **: $p<0.01$, −: A coefificient could not be computed

well trained and the inter-examiners agreements were confirmed by Wilcoxon Matched-paired Signed Rank test in all 42 variables of the clinical protocol. The total time to complete the questionnaire and the clinical examination was from 20 to 30 minutes, which is suitable for the routine clinical schedule if its reliability and validity would be further tested.

**Subjective and clinical discrimination among clinical TMD patients, symptomatic subclinical and asymptomatic normal subjects**

1. Jaw movement and TMJ sounds

The abnormal jaw movement and TMJ sounds have been defined as two major clinical presentations of TMD[7], although the interpretation of TMJ sounds in subjects without significant signs/symptoms of TMD is still in controversy[19]. The present results revealed that N responded negatively to the questions concerning the jaw movement and TMJ sounds, while the clinical examination found the slightly deviated jaw protruding movement in 20.83% of the subjects (Table 3). The differences between S and C were found in restricted jaw opening and stiffness of jaw movement by the questionnaire, and in reciprocal clicking, deviated/restricted menton movement, asymmetric movement and closed lock of condyle by the clinical examination. Therefore, it can be concluded that clinical TMD patients have worse dysfunction of jaw movement, mainly characterized by the restricted motion of jaw and the reciprocal clicking of TMJ compared with symptomatic subclinical subjects, while asymptomatic normal subjects have no such dysfunctional features and TMJ sounds at all.

2. Pain assessments

Orofacial pain is another major clinical presentation of TMD and has been considered as a critical reason for subjective treatment need[10,20]. The present results indicated that the subjects of N did not complaint any pain at TMJ and jaw muscles, apart from occasional headache and pain in shoulder, neck and back muscles similar to the subjects of S and C. The principal pain reported by C were located in TMJ and jaw muscles, followed by pain when eating tough food, stiffness of jaw muscles, awakening tired at jaw muscles and toothache, which all reached a higher degree than those in S (Table 2). The clinical examination revealed that the palpable pain in C dominated at external auditory meatus, preauricular regions and masticatory, neck and back muscles (Table 3). The palpable pain at supra and infra hyoid and expression muscles were not different between S and C.

Therefore, the subjective pain, which has been proved to be more severe in clinical patients than in subclinical subjects[21], are generally localized at TMJ and jaw muscles, rather than other regions such as head, neck, shoulder, *etc*. Moreover, compared with symptomatic subclinical subjects, clinical patients are more sensitive to palpation at TMJ and masticatory muscles as well as at neck and back muscles. Asymptomatic normal subjects sometimes have the subjective pain, but it does not involve TMJ and jaw muscles, nor does the positive finding by the palpation.

3. Occlusion

Most of TMD questionnaires have not contained questions on the occlusal discomfort[2,8,15~17,22]. The present study revealed that every group responded frequently to the question of unsatisfaction for tooth alignment. Subjects of S and C reported the discomfort feeling of occlusal contact more frequently and severely than those of N did (Table 2). However, clinical examination indicated that S and N showed a similar static occlusion, while C represented higher scores and positive rates for the static occlusal variables, especially in deep overjet and attrition of anterior teeth. As for functional occlusal variables, only RCP-ICP interference exhibited more severe and frequent in both S and C than in N (Table 3).

These results suggested that clinical patients may be distinguishable from symptomatic subclinical and asymptomatic normal subjects by several variables of the static occlusion, but the later groups show little difference. Deep overjet and severe attrition of anterior teeth might be considered as two characteristics of static occlusion in clinical patients. On the other hand, RCP-ICP interference might be considered as the dominant variable of functional occlusion for both clinical patients and symptomatic subclinical subjects, with which, however, clinical patients are not distinguishable from symptomatic subclinical subjects.

4. Oral parafunction and habits

De Leeuw, *et al.*[8] reported that symptoms of jaw movement, joint sounds and oral parafunctions are three variables discriminating best between clinical patients and symptomatic subjects. However, no particular variables of oral parafunctions were indicated in their investigation. The present results indicated that the variables in the oral parafunction/habits dimension, as a whole, are distinguishable among the three groups. However, the involved particular variables should be accounted into the habits rather than the parafunction, except for intentional TMJ clicking which may discriminate C from other two groups. As investigated previously[4], these habits concern preference for soft foods, unilateral chewing and eating with water or beverage (Table 2). Nevertheless, it is not clear whether the higher prevalence of such oral habits in C and S are originally self-holding or resulted from pain and/or dysfunction of jaw movement.

5. Psychosocial stress and general health

The psychosocial stress is difficult to evaluate, since it is a multidimensional variable[3]. Except depression and anxiety/stress on work/study, all variables of this dimension did not show any noticeable differences among the three groups. The reason why higher scores and rates of anxiety/stress on work/study were found in N and S rather than in C must attribute to the former two groups being mainly composed of university students. Then the stress might not be an important variable to discriminate clinical patients from symptomatic subclinical and asymptomatic normal subjects. This is consistent with the previous reports that TMD patients are not characterized by a specific premorbid personality[23] and that patients with myofascial pain dysfunction (MPD) are not experienced more job stress and interpersonal conflicts than control subjects[2].

Clinical patients seemed to report more problems of ear and general health than asymptomatic normal subjects with symptomatic subclinical subjects lying in between. However, the difference between clinical patients and symptomatic subclinical subjects was not significant.

**Association between subjective and clinical features**

The present study demonstrated that subjective variables on jaw movement and pain experiences were positively associated with palpable TMJ and muscle pain in both S and C , which was more dominant in C (Table 4). The subjective TMJ and jaw muscles' pain were positively correlated with the clinical TMJ and muscle pain in S, but only with the clinical TMJ pain in C. Similarly, subjective variables on jaw movement and pain experiences showed more associations with the clinical findings of jaw movement in S than in C, where only the abnormal condylar excursion correlated with subjective restricted jaw movement and pain in TMJ and jaw muscles for C (Table 4). As C showed severer closed lock of condyle and palpable TMJ pain (Table 3), clinical patients may have their signs and symptoms more limited in the TMJ region. A strong correlation between the reported toothache and the clinical TMJ pain ($r=0.586$, $p<0.01$) for C suggested that complaint of toothache can be one of the TMD correlates and must be differentiated carefully.

On the other hand, the subjective variables on jaw movement and pain experiences showed several significantly positive associations with the static occlusion in C and with the functional occlusion in S. This finding indicates that occlusion may not have a consistent relationship with subjective TMD symptoms. Furthermore, the subjective occlusal discomfort was positively associated with the clinical muscle pain in C and negatively with jaw movement in S, while less associated with clinical occlusal findings as expected, especially for functional occlusion (Table 4). This feature implies that the subjective unsuitable or unstable occlusal sensation might be one of the reflects from TMD symptoms and/or signs on the orofacial perception but not be in relation to the relevant occlusal status necessarily, since clinical patients and symptomatic subclinical subjects reported more occlusal discomfort than asymptomatic normal subjects did (Table 2). Moreover, the negative association between occlusal discomfort and jaw movement in S suggest that, contrary to above relationships, mild abnormal jaw movement may alleviate occlusal discomfort in some degree, due to this association only existing in symptomatic subclinical subjects who showed quite slight jaw movement dysfunction comparing with clinical TMD patients, especially for opening deviation/restriction and closed lock (Table 3).

The psychophysiological model proposes that TMD patient, except for the obvious degenerative condition and problems induced by external trauma, has the stress as a primary cause[24]. The present results revealed that association between the psychosocial stress and the clinical signs of TMD was quite weak (Table 4). These negligible relationships existed only in the pain of TMJ/muscles and the static occlusion in C and muscle pain in S, and the involved variables of the stress were few.

Therefore, psychosocial stress etiology of TMD can not be directly supported by the present study.

Oral parafunctions are also mentioned as important co-factors in the etiology of TMD[1]. The present study revealed that the most correlative variables of oral parafunction and habits attributed to nocturnal bruxism and clenching, followed by preference for soft foods, unilateral chewing, intentional TMJ clicking and lip biting (Table 4). The most correlative clinical presentations were TMJ sounds and muscle pain. These results are more or less in accordance with other studies[3,4,6,25,26]. Then the parafunctional activity (bruxism and clenching) and the oral habits with insufficient or worse masticatory behaviors might be the predispositions or contributors to TMD, so that the relevant counseling therapy should be introduced for treatment and prevention of TMD[27,28].

**Occlusal factors contributing to TMD**

It has been pointed that occlusion cannot be considered as an unique or dominant factor in defining TMD populations[29]. Many other studies have also proved that there are no significant association between the definite signs/symptoms of TMD and morphologic or functional malocclusion[13,30,31]. However, considerable studies still showed a positive relationship between occlusal factors and TMD[23,33].

In the present study, associations between the clinical occlusal variables and other clinical signs were weak. No significant associations were found between the static/functional occlusion and the clinical signs in both S and C, although the scores of several variables and the sum of occlusal dimension were higher in these two groups (Table 3). It is interesting that the functional occlusion was not significantly involved for C at all, and TMJ sounds, muscle pain and abnormal menton movement, as most frequent TMD presentation, showed no relation to occlusal variables at all (Table 5). Therefore, the role of occlusion both in the static and the functional aspects may not be so important in explaining the etiology or the definite signs/symptoms of TMD.

On the other hand, edge to edge bite showed significant correlation with abnormal jaw movement, while the positive finding rates of this occlusal variables was found less than 20% for each group. Although lateral interference, loss and attrition of anterior teeth showed a significant association with the muscle quality, the positive finding rates of muscle quality for each group were also less than 20%. As a result, these associations might result from the occasion or statistical noise and could not be considered to be specific or clinically significant. The remaining two significant associations, i.e., deep overbite with abnormal condyle movement for C and attrition of anterior teeth with TMJ pain for S might be considered to be clinically meaningful. In a word, except for a few defined occlusal status, occlusion may not relate to TMD closely and directly.

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