

ORIGINAL ARTICLE

Temporomandibular Joint Disorders in Patients with Rheumatoid Arthritis

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Background: Temporomandibular joint disorders (TMD) are not uncommon in patients with rheumatoid arthritis (RA). However, the extent of involvement and its clinical relevance have not been well characterized. This study evaluated the correlation between the severity of RA-related TMD and RA, as well as determined the potential predictors for early identification and management of TMD in RA patients.

Methods: We sequentially recruited 56 adult RA patients from our Arthritis Clinic. TMD and RA were surveyed, clinically by questionnaires and physical examinations, and radiologically by tomography in TMD and conventional radiography in RA. The patients were stratified into no, mild and severe TMD groups according to the physical and tomographic examinations. The correlation of the severity of TMD and RA were evaluated. The relative importance of relevant predictors of severe TMD was analyzed by a logistic regression model.

Results: Physical and radiologic temporomandibular joint abnormalities were found to be highly prevalent (85.7% and 74.5%) in these patients, and the occurrence increased to as much as 92.9% when the 2 data sets were combined. More than half of the patients had severe TMD presenting with debilitating symptoms or with a significant degree of bony destruction. The severity of TMD was variably correlated with RA severity. The score of hand-joint space narrowing was found to be the most influential predictor of severe TMD by logistic regression analysis.

Conclusion: There was a high prevalence of TMD in RA patients. The severity of TMD variably correlated with RA severity. Clinically, a high score of hand-joint space narrowing may serve as an early indicator of RA patients at risk of severe TMD. This may facilitate early management and prevent the functional impairment of the temporomandibular joint. [*J Chin Med Assoc* 2007;70(12):527–534]

Key Words: rheumatoid arthritis, temporomandibular joint disorders, tomography

Introduction

Rheumatoid arthritis (RA) is a systemic disorder, which may involve many of the diarthrodial joints in the body. Temporomandibular joints (TMJ) afflicted with RA may produce pain, joint stiffness, difficulties in opening the mouth, and open bite.^{1–3} In severe cases of temporomandibular joint disorders (TMD), masticatory movement may be hampered.

The reported prevalence of TMJ involvement by RA varies widely from 4.7% to 88%.^{4–9} Inconsistencies in patient selection, diagnostic criteria and techniques

for TMD may result in this disparity. In addition, TMD in RA patients is frequently overlooked by rheumatologists or by the patients themselves, especially when treatment is focused on other joints for upper extremity function or weight-bearing. Because severe TMD may lead to severe sequelae and disabilities, early diagnosis, as well as timely and appropriate management, is warranted.

The magnitude of TMJ involvement seems to be correlated with the severity of RA. The level of rheumatoid factor (RF), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), thrombocyte

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count, and plasma tumor necrosis factor- α have all been noted to correlate with the severity of TMD.^{2,6,10-14} Akerman et al found that the severity of radiologic changes in the TMJ were comparable to those of the metacarpophalangeal (MCP) and metatarsophalangeal (MTP) joints of the hands and feet when evaluated by the Larsen method.¹⁵ Redlund-Johnell noted that severe destruction of the TMJ due to RA occurred significantly more often in patients with severe cervical arthritis than in those without when evaluated by cervical radiography.¹⁶ In the reports of Yoshida et al⁶ and Yamakawa et al,⁷ TMD severity corresponded to Steinbrocker's staging of the joints of RA patients. In clinical practice, we may identify severe TMD by assessing RA activity. If we can determine what the most important predictive factors are, then improved clinical practice may be facilitated.

On the other hand, controversies remain regarding the relationship between the duration of RA and TMD. In an early report by Mayne and Hatch, TMJ pain positively correlated with RA duration.¹⁷ Moreover, Ogun noted TMJ involvement more frequently in patients with ≥ 5 years' duration of RA.⁴ However, a recent study by Goupille et al negated this correlation.² Further studies are required to resolve this issue.

The purpose of this study was to evaluate the correlation between the severity of RA-related TMD and RA, as well as determine the potential predictors for early identification and management of TMD in RA patients.

Methods

Subjects

During the period from July 2002 to June 2003, we sequentially enrolled 56 RA patients (15 males, 41 females; mean age, 56.3 ± 14.6 years) who visited the Arthritis Clinic of Taipei Veterans General Hospital. All of the patients fulfilled the criteria laid down by the American College of Rheumatology for the classification of RA.¹⁸ Inclusion criteria were: age > 18 years and onset of RA later than 16 years of age, thereby excluding juvenile RA. The mean duration of disease prior to inclusion was 6.9 ± 6.5 years. All of the patients received appropriate treatment, including combinations of nonsteroidal anti-inflammatory drugs and disease-modifying anti-rheumatic drugs by an experienced rheumatologist during the study period. Written informed consent was obtained from all of the study participants, and the performance of this study was approved by the research ethics committee of the hospital.

Questionnaire

A comprehensive questionnaire was used to assess the clinical characteristics of RA and temporomandibular problems in every recruited subject. The questionnaire had 2 portions that covered RA- and TMJ-related problems. The RA portion included 8 questions, while the portion for TMJ-related problems included 13 questions (8 for jaw pain, 5 for jaw function).¹⁹ Every question was scored between 0 and 4 according to severity. A patient's subjective TMD score was defined as the sum of the score of the 13 questions, which ranged from 0 to 52. A patient was considered to have clinical TMD if their score was ≥ 6 , according to Gerstner et al.¹⁹

Physical examinations

All subjects underwent detailed examination of the stomatognathic system by an experienced expert in TMD. The examinations consisted of palpation for tenderness of the TMJ and masticatory muscles, and auscultation with a stethoscope to detect the click and crepitus sound of TMJ during mandibular opening and closing movements. The active and passive ranges of motion of the TMJ were also evaluated by the maximal inter-incisor distance plus overbite on mouth opening. The presence of anterior open bite was also recorded. The diagnosis was further aided by the compression test and the Widerstand test for retrodiscal tissue and lateral pterygoid muscle tenderness. Functional disability of the TMJ was defined as the presence of either limited mandibular opening (maximal inter-incisor distance < 40 mm) or mandibular deviation from the midline on mandibular opening.

Regarding the examinations for RA activity, several practical clinical measures were employed.^{20,21} Patients underwent examinations of their 50 diarthrodial joints to evaluate the extent of swelling and tenderness, which were graded between 0 to 3 according to severity. A weighted score of joint swelling or tenderness was obtained by the sum of the products of the number of involved joints and its grade. In addition, a Physician's Global Assessment (PGA) score was recorded, which employed a 10 cm visual analog scale on which 0 represented no arthritic activity and 100 represented extremely active arthritis. The PGA score was evaluated by a single rheumatologist during the entire study period.

Laboratory tests

ESR, serum CRP and RF were measured as indicators of RA disease activity. They were measured on the patients' enrolment into the study (present value). We also retrospectively collected the values of the

3 indicators as recorded on subjects' medical charts when the diagnosis of RA was initially established (initial value), and the highest value during the entire clinical course (peak value).

Diagnostic images

Dorsovolar radiographs of bilateral hands and wrists were performed to evaluate joint involvement in the RA patients. Two experienced rheumatologists evaluated the joints most frequently involved in RA by Sharp's scoring method.²² The degree of bone erosion was graded from 0 to 5 for 12 joint areas, including bilateral third and fourth proximal interphalangeal (PIP) joints, second and third MCP joints, and naviculars and lunates. The degree of joint space narrowing was quantified as scores from 0 to 4 for the 12 joints, which included bilateral third and fourth PIP joints, second and third MCP joints, capitate-navicular-lunate joints, and radiocarpal joints. The total scores for bone erosion and joint space narrowing were calculated separately. Furthermore, the sum of both scores was considered as the total hand-joint destruction score, which indicated the total extent of hand-joint abnormalities.

Tomography (Scanora[®]; Soredex, Orion Corp., Helsinki, Finland) of bilateral TMJ at 4 angles (15°, 20°, 25° and 30° deviation from the sagittal plane) was performed within 1 week of the patient's enrolment. A modified grading system for the evaluation of TMJ abnormalities was employed, based on the degree of bony destruction of the mandibular condyle, as detailed below.^{23,24}

- Grade 0 (normal): well-defined cortical outline of the condyle
- Grade I (mild): presence of cortical destruction and irregular margin of the condyle
- Grade II (moderate): bony destruction or erosion of the condyle or evident flattening, with deviation from normal joint morphology
- Grade III (severe): complete or almost complete destruction of the condyle

Tomographs were read independently by 2 experienced radiologists, with a high degree of interobserver and intraobserver agreement (kappa values 0.72 and 0.697, respectively).

Integrated severity classification of TMD

To develop and validate a model for the prediction of clinically significant TMD, we further stratified the patients and established an integrated TMD severity score, based on the presence of the following physical or radiographic abnormalities: tenderness of masticatory muscles; TMJ sounds (click or crepitus);

functional disturbance (maximal inter-incisor distance <40 mm or mandibular deviation from the midline on mouth opening); and moderate or severe TMJ abnormalities on tomography. A score of 1 was given when any 1 of the criteria was fulfilled. Patients were stratified into 3 categories according to their TMD severity score, which was assigned as follows: no TMD—score of 0; mild TMD—score of 1–2; severe TMD—score of 3–4.

Statistical analysis

All data are expressed as mean \pm standard deviation. Differences between the mild and severe TMD groups were assessed by the χ^2 test or the Mann–Whitney test for significance. Correlations were evaluated for statistical significance with Pearson's product moment or Kendall's *tau* correlation coefficient. Stepwise logistic regression model analysis was used to analyze the relative importance of significant predictors of severe TMD. A *p* value <0.05 was considered to be statistically significant.

Results

RA severity

The disease severity of RA in the 56 subjects, as assessed by physical examinations, radiographs, and laboratory tests, are shown in Table 1.

Frequency and presentations of TMD

Based on the questionnaire, 29 (51.8%) of the 56 RA patients recalled subjective problems in their TMJ, bilaterally in 16 (28.6%) patients and unilaterally in 13 (23.2%). Among these RA-related cases of TMD, 29.6% had developed within 1 year after the general joint symptoms, and another 18.5% noted TMJ symptoms before the generalized symptoms. In contrast, a subset (22.2%) of patients did not experience TMJ discomforts until ≥ 5 years after the onset of RA. Quantitatively, only 8.9% of our patients had a subjective TMD score of ≥ 6 .

Physical examinations revealed abnormalities over the TMJ in 48 (85.7%) RA patients, including sounds over the TMJ (click or crepitus), tenderness of the TMJ or masticatory muscle, limited TMJ range of motion, and mandibular deviation on mouth opening (Table 2). Open bite, a finding of severe TMD, was seen in 3 patients. The clinical and radiographic findings of 1 patient with open bite are shown in Figures 1 and 2.

Radiologically, 41 (74.5%) patients had abnormal tomographic findings such as mandibular condyle

Table 1. Clinical, radiologic and laboratory evaluations of rheumatoid arthritis

	Mean \pm SD	Range
Age (yr)	56.3 \pm 14.6	23.2–79.6
Duration of RA (yr)	6.9 \pm 6.5	0.4–30
Number of tender joints	5.8 \pm 0.9	0–30
Weighted score of tender joints	8.4 \pm 1.9	0–90
Number of swollen joints	2.4 \pm 0.58	0–28
Weighted score of swollen joints	3.4 \pm 0.67	0–28
PGA score	54.8 \pm 1.7	13.3–80.7
Score of hand bone erosion	11.5 \pm 1.2	0–34
Score of hand-joint space narrowing	19.0 \pm 1.7	0–48
Total hand-joint destruction score	30.4 \pm 2.8	0–82
Peak RF* (IU/mL)	564.9 \pm 112.5	10.4–3,900
Peak ESR* (mm/hr)	75.9 \pm 6.4	9–159
Peak CRP* (mg/dL)	5.0 \pm 0.6	0.3–18.5

*Normal values are RF < 40 IU/mL, ESR < 20 mm/hr in females and < 15 mm/hr in males, and CRP < 0.8 mg/dL. SD = standard deviation; RA = rheumatoid arthritis; PGA = Physician's Global Assessment; RF = rheumatoid factor; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein.

Table 2. Frequency and presentation of temporomandibular joint abnormalities

Physical findings	n (%) or mean \pm SD	Incidence in normal population (%)*
Sound over TMJ	48 (85.7)	23–62
Click	8 (14.3)	17–62
Crepitus	39 (69.6)	2–29
Both	1 (1.8)	
Tenderness over TMJ	20 (35.7)	2–48
Tenderness over masticatory muscle	15 (26.8)	6–64
Active ROM (mm)	42.2 \pm 0.8	
Passive ROM (mm)	44.2 \pm 0.8	
Maximal mouth opening < 40 mm	13 (23.2)	1–15
Deviation of mandible	22 (39.3)	
Functional disability [†]	33 (58.9)	
Open bite	3 (5.4)	
Abnormal physical examinations	48 (85.7)	
Abnormal tomographic findings	41 (74.5)	
Combined abnormal physical examination and tomographic findings	52 (92.9)	

*Adapted from Reference 30; [†]functional disability means limited ROM of the TMJ or mandibular deviation on mouth opening. SD = standard deviation; TMJ = temporomandibular joint; ROM = range of motion.

destruction and deformity or loss of integrity. Twenty-three (41.8%) patients had Grade II (moderate) or Grade III (severe) changes, and 31 (56.4%) patients had bilateral lesions.

Combining the physical and tomographic findings, 52 (92.9%) RA patients had TMJ abnormalities.

Comparisons between mild and severe RA-related TMD

According to our integrated severity classification of RA-related TMD, 28 (53.8%) of the 52 patients with

TMD fulfilled the definition of severe TMD, while 24 (46.2%) were categorized as mild TMD. The comparison between mild and severe TMD subjects is shown in Table 3. The differences in age, sex distribution, duration of RA, number and weighted score of swollen joints, subjective TMD score, the 3 indicators of RA disease activity (peak values of RF, CRP, ESR) and the score of hand bone erosion were all statistically insignificant between the mild and severe TMD groups. Nonetheless, compared with patients with mild TMD, patients with severe TMD exhibited more



Figure 1. Open bite in a rheumatoid arthritis patient with severe temporomandibular joint disorder.



Figure 2. X-ray of the same rheumatoid arthritis patient shows severe condyle erosion.

Table 3. Comparison between patients with mild and severe temporomandibular disorders

	Mild (n=24)	Severe (n=28)	p*
Age (yr)	59.4±2.4	54.6±3.2	
Sex (male/female)	9/15	5/23	
Duration of RA (yr)	5.9±1.0	7.9±1.4	
Peak RF (IU/mL)	476.1±160.7	718.0±173.3	
Peak CRP (mg/dL)	4.3±0.9	5.6±1.0	
Peak ESR (mm/hr)	68.5±9.3	84.1±9.7	
Number of tender joints	4.7±1.3	7.4±1.3	<0.05
Weighted score of tender joints	6.7±2.2	10.8±3.1	<0.05
Number of swollen joints	2.4±0.6	2.7±1.0	
Weighted score of swollen joints	3.7±1.0	3.5±1.0	
PGA score	52.6±1.7	58.5±1.9	<0.05
Score of hand bone erosion	9.7±1.4	14.0±1.9	
Score of hand-joint space narrowing	15.0±2.2	23.1±2.6	<0.05
Total hand-joint destruction score	24.7±3.4	37.1±4.3	<0.05
Subjective TMD score	2.3±0.4	3.5±0.6	
Limitation of maximal mouth opening	1 (4.2%)	11 (39.3%)	<0.01
Disabilities of TMJ	7 (29.2%)	25 (89.3%)	<0.001
TMJ sound			
Click	3 (12.5%)	5 (17.9%)	
Crepitus	17 (70.8%)	22 (78.6%)	
TMJ tenderness	4 (16.7%)	16 (57.1%)	<0.01
Masticatory muscle tenderness	3 (6.3%)	12 (42.9%)	<0.05
Abnormal tomographic finding	15 (62.5%)	26 (96.3%)	<0.01
Grade of tomographic abnormalities	0.79±0.17	2.15±0.17	<0.001

*Comparison between 2 groups with Mann-Whitney test or χ^2 test. RA = rheumatoid arthritis; RF = rheumatoid factor; CRP = C-reactive protein; ESR = erythrocyte sedimentation rate; PGA = Physician's Global Assessment; TMD = temporomandibular joint disorder; TMJ = temporomandibular joint.

prominent hand-joint tenderness, higher PGA scores, and greater degrees of hand-joint space narrowing.

Correlations between disease severity of RA and TMD

The bivariate correlation between the severity markers of RA and TMD is summarized in Table 4. PGA score,

peak RF and ESR values, number and weighted score of tender joints, score of hand bone erosion, score of hand-joint space narrowing, and total hand-joint destruction score were significantly correlated with TMD severity. The correlation between TMD severity and duration of RA, number and weighted score of swollen joints, and peak CRP values were not statistically

Table 4. Correlation between severity of rheumatoid arthritis and temporomandibular disorders*

	Subjective TMD score	Tomographic grading	Integrated TMD severity classification
Duration of RA	0.255	0.303 [†]	0.160
Number of tender joints	0.479 [†]	0.232	0.308 [§]
Weighted score of tender joints	0.345 [§]	0.213 [†]	0.311 [§]
Number of swollen joints	0.130	0.116	0.071
Weighted score of swollen joints	0.150	0.112	0.035
PGA score	0.529 [†]	0.357 [§]	0.311 [§]
Peak RF	0.263	0.271	0.245 [†]
Peak ESR	0.275	0.292	0.264 [†]
Peak CRP	0.140	0.232	0.116
Score of hand bone erosion	0.448 [†]	0.508 [†]	0.315 [§]
Score of hand-joint space narrowing	0.339 [†]	0.496 [†]	0.293 [§]
Total hand-joint destruction score	0.402 [§]	0.524 [†]	0.327 [§]

*Data are presented as Pearson's product moment or Kendall's tau correlation coefficients; [†] $p < 0.05$; [‡] $p < 0.001$; [§] $p < 0.01$. TMD=temporomandibular joint disorder; RA=rheumatoid arthritis; PGA=Physician's Global Assessment; RF=rheumatoid factor; ESR=erythrocyte sedimentation rate; CRP=C-reactive protein.

significant. Individual variables that showed significant correlation with the severity indices of TMD were analyzed together in a multiple logistic regression model, where the dependent variable was the probability of no or mild TMD (0) or severe TMD (1). Variables were selected using a stepwise backward elimination and the score of hand-joint space narrowing was found to be the most influential determinant factor of severe TMD ($p < 0.05$). The model of a predictive index for severe TMD may be expressed as follows: $Y = -1.0639 + 0.0580X$, where X = score of hand-joint space narrowing, and $Y = \log_e[P/(1-P)]$, where P is the probability of severe TMD.

Discussion

When the findings of physical and radiographic examinations in the present study were combined, RA patients were found to have a very high prevalence of TMD (92.9%). This rather high prevalence, exceeding those of previous studies (4.7–88%),^{4–9} might be attributed to our hospital being a tertiary medical center. Hence, most of the referred patients were much more complicated. Nevertheless, only 51.8% of them had experienced TMJ-related problems, while the others had remained clinically silent. Moreover, most of our patients (91.1%) had subjective TMD score < 6 .

There are several possible explanations for this discrepancy. First, subjective TMJ discomfort or complaints are likely to be overshadowed by joint problems elsewhere in the body.^{5,25} Compared with other joints like the hands and knees where frequent motion or weight-bearing is unavoidable in daily life, the joints

of the stomatognathic system are less of a problem for RA patients. They can subjectively reduce its motion by talking less or by avoiding ingestion of hard food.²⁶ Second, the TMJ is structurally different from other joints. It has special retrodiscal tissue that is rich in blood vessels, which may act as a highly efficient drainage system for joint exudates. In this manner, joint swelling and pain may be alleviated or even prevented.²⁷ Third, consistent with previous studies,^{2–4,10,25} we found that mandibular function was not significantly restricted—only 13 (23.2%) patients had maximal mouth opening < 40 mm, despite severe TMJ destruction. This might be due to the presence of a specialized articular disc structure, which divides the TMJ into 2 distinct cavities,²⁸ the upper and lower one. This may also constitute an important cause for reduced self-awareness of TMJ problems among RA patients. Furthermore, although 92.9% of our RA patients had TMD, we still cannot ascertain that all of the TMDs were due to the underlying RA. Previously, Marbach stated that the most common disease of the TMJ is osteoarthritis (OA).²⁶ Similarly, Gynther et al reported that there is no radiographic criterion that is pathognomonic for generalized OA or RA,²⁹ although condyle erosion is more common in RA. In a later study by Gynther et al, arthroscopic, histologic and immunohistochemical studies revealed that TMD related to generalized OA was similar to those related to RA.⁸ On the other hand, as shown in Table 2, data from McNeill showed that a large percentage of the normal population had abnormal findings in the clinical examination of TMJ.³⁰ Therefore, in some patients with TMD but with normal or mild tomographic findings, their TMD might not be due to RA *per se*. Further

studies with computed tomography or magnetic resonance imaging may help in differential diagnosis.

Consistent with previous findings,³¹ the majority of RA patients (29.6%) in the present study developed TMJ symptoms shortly (within 1 year) after the onset of the generalized disease. Aside from this, 18.5% noted TMJ symptoms before the generalized disease. The early onset of TMD in RA patients implies that early diagnosis and prompt treatment may be beneficial. On the other hand, a large proportion of these patients (51.8%) developed TMJ symptoms more than 1 year after the onset of RA, with up to 22.2% of cases developing their symptoms after 5 years or more. Therefore, continuous and close monitoring of the TMJ during the course of RA is necessary.

In the present study, although a very high prevalence of RA-related TMD existed, the severity varied. We integrated the findings of physical examinations and tomography to establish a clinical-oriented severity score of TMD. Severe TMD was defined as the presence of at least 3 of 4 items (TMJ tenderness, TMJ sounds, functional disturbance, evidence of moderate or severe TMJ abnormalities on tomography). Half of our RA patients belonged to the severe TMD group. They had more debilitating symptoms and functional disabilities, and thus need to be referred to TMJ clinics promptly and managed more actively.

Because most of the RA patients received treatment from rheumatologists rather than dentists, we attempted to analyze the link between markers of RA severity and TMD in order to provide a useful guide for rheumatologists in predicting the probability of severe TMJ involvement in their patients. Previous studies have revealed inconsistent relationships between RA severity and TMJ involvement.^{2,4,6,7,10-13,15,31} Bivariate correlation analysis in this study also showed significant correlations between TMD severity and joint destruction, PGA score, and peak ESR and RF values. After further analysis by stepwise logistic regression, the score of hand-joint space narrowing proved to be the single most relevant factor in the prediction of severe TMD. A plausible explanation is that, unlike other factors such as joint tenderness or erosion that represent initial or transient phenomenon of the disease, joint space narrowing usually appears later in the course of RA, at a stage when the involvement of the TMJ is likely to be more prominent.

As for the 3 laboratory markers in our study, peak RF and ESR values correlated with integrated TMD severity ($p < 0.05$), but CRP did not. The finding for peak RF corresponds to those of previous studies.^{2,5,11} But contrary to previous reports,^{2,6,11,12} peak CRP was not correlated with TMD severity in

our study. One possible explanation is that ESR tends to be an indicator of chronic persistent inflammation while CRP is an acute phase protein that usually elevates in less than 24 hours during an episode of acute inflammation and declines rapidly after the inflammation is controlled. The peak CRP value only points out the transient activity of joint inflammatory processes, which cannot signify the extent of joint destruction. However, statistical analysis of an average of repetitive laboratory marker values will lead to different results, and further studies are necessary to clarify this.

The duration of RA was noted to correspond to TMD severity in the aforementioned series.^{4,11,17} However, it was not comparable to the integrated TMD severity in the present study. We speculate that the articular damage in RA, including TMD, is proportional to the duration of active inflammation rather than the total duration of arthritis.³²

In addition, there were 6 cases of cervical spine involvement by RA in our patients (data not shown). The severe TMD group did not have significantly more cervical spine involvement than the mild group ($p > 0.05$). While cervical RA, like severe RA-related TMD, was noted to relate to severe joint involvement in previous studies, there has been only 1 report of direct correlation between cervical arthritis and TMD in adult RA.¹⁶ Another report stated the coincidence of cervical and TMJ arthritis in juvenile RA.³³

Within the limitations of this study, we conclude that TMD is a frequent manifestation of RA. Approximately half of the cases of TMJ involvement in RA developed profound symptoms or joint abnormalities, demanding aggressive management. The severe type of RA-related TMD can be predicted by examining radiographic manifestations of hand-joint abnormalities, especially the degree of joint space narrowing, a convenient and useful clinical index. Application of this finding by rheumatologists in their clinical practice may lead to earlier identification and prompt management of TMD. Further large-scale investigations are needed to verify its clinical value.

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