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# The Correlations between Temporomandibular Joint Symptoms and Magnetic Resonance Imaging Findings in German Patients

Min-Kyoung Kye[1], Young-Yuhn Choi[2], Kee-Joon Lee[3]

[1]Department of Orthodontics, Graduate School of Yonsei University, Seoul,
[2]Department of Oral Hygiene, Suwon Science College, Hwaseong,
[3]Department of Orthodontics, Yonsei University College of Dentistry, Seoul, Korea

**Purpose:** The purpose of this study was to evaluate the correlation between the clinical symptoms of temporomandibular disorder and findings in the magnetic resonance imaging (MRI).

**Materials and Methods:** Clinical data and MRI images were collected from a total of 240 German patients. Clinical symptoms were briefed as joint clicking, crepitus and pain. MRI findings were further defined according to the condyle position, condyle degeneration, disc positon, disc degeneration and the presence of osteophyte/sclerosis/synovitis. Hypermobility was separately recorded. Correlation analysis between parameters was performed.

**Result:** Joint clicking had a positive correlation with unilateral disc degeneration, osteophyte, sclerosis and synovitis. Crepitus had a significant correlation with bilateral osteophyte. Pain was not correlated with any MRI findings except hypermobility.

**Conclusion:** Selective correlations between the MRI findings and clinical symptoms were elucidated. The results of this study imply that condyle-disc deformities could be advanced without pain, and that joint clicking and crepitus could be clinical symptoms of condyle-disc degeneration.

**Key Words:** German patients; Magnetic resonance imaging; Temporomandibular disorders

## Introduction

Temporomandibular disorder (TMD) is very common both among dental patients and general population, with prevalence of 20%~68%[1)]. One third of the population had at least one clinical symptom of TMD. The prevalence of TMD in orthodontic patients was similar to that of normal

Corresponding Author: **Kee-Joon Lee**
Department of Orthodontics, Yonsei University College of Dentistry, 50-1 Yonsei-ro, Seodaemun-gu, Seoul 120-752, Korea
TEL : +82-2-2228-3015, FAX : +82-2-363-3404, E-mail : orthojn@yuhs.ac

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population[1-4].

Plain radiography, panoramic tomography, magnetic resonance imaging (MRI), computed tomography (CT), and cone-beam CT (CBCT) have been widely in use for diagnosis the TMD. In particular, MRI is regarded as a reliable modality based on which hard and soft tissue pathology of TMD can be assessed[5-7].

MRI is known to be less powerful than CBCT or CT in the quantitative assessment of hard tissue lesions by producing high-resolution bone images. Because of the magnetic field formation and long imaging time, MRIs are contraindicated in patients with cardiac pacemaker, metal vessel clips, claustrophobia and patients uptaking diazepam. In contrast, MRI provides differential images between hard and soft tissue, enabling to find minor inflammations, changes in the disc position and morphology. Considering the complex nature of the TMD encompassing the pathologies in the bone, cartilage and ligaments and joint space, it is crucial to evaluate not only the hard tissue but also the surrounding structure of the condyle. Additionally, one of the major advantages of MRI may be the radiation-free imaging process for the patient safety[8,9].

In terms of relating the diagnostic findings and clinical symptoms, however, contradictory findings have been reported[10-13]. For instance, while the prevalence of internal derangement is as high as 33% in asymptomatic subjects[14], no relation between the patients' discomfort or pain and the degree of TMD was also shown[15].

The objectives of this research was to investigate the prevalence of clinical symptoms and condyle-disc displacement and degeneration, to determine a possible correlation between various TMD pathology found in MRI and clinical symptoms so as to provide clinical guidelines for the assessment of TMD.

## Materials and Methods

### *1. Subjects and Clinical Survey*

The clinical data of a total of 240 German patients (109 males and 131 females), who visited Department of Orthodontics, Frankfurt University (Frankfurt, Germany) between 1997 and 2004, were collected retrospectively for this study. All of the patients exhibited at least one of the TMD symptoms; clicking, crepitus and pain. All patients had clinical exams regarding joint clicking, crepitus and joint pain and had received MRI exams for temporomandibular joint (TMJ) area. Age distribution was from 4 to 70 years old, 53 persons were under 20 years old, and 46 persons were 20s. Seven persons were over 60 years old (Fig. 1).

### *2. MRI Scanning*

Continuous 3-mm para-sagittal, para-coronal and para-transverse slices of the TMJ were taken with a 3.0-T superconductive MR scanner (MAGNETOM Espree; Siemens, Munich, Germany) (Fig. 2). MRI assessment of each subject was performed and studied for condyle degeneration, disc position, disc degeneration, osteophyte, sclerosis, synovitis and hypermobility (Fig. 3, 4, Table 1)[16-18].

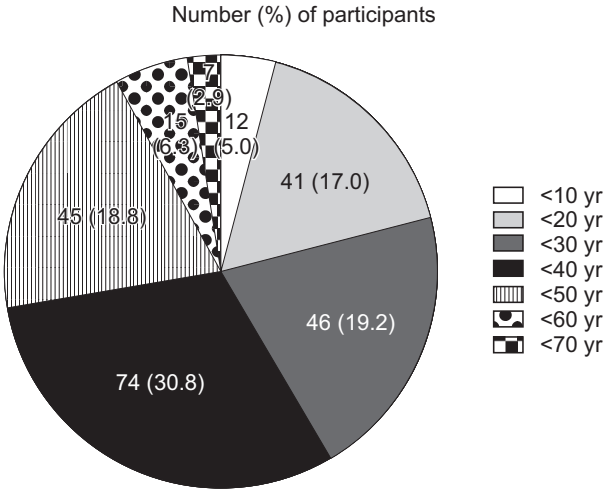


**Fig. 1.** Demographic finding of participants. Age distribution varies from 4 to 70 years old (n=240).

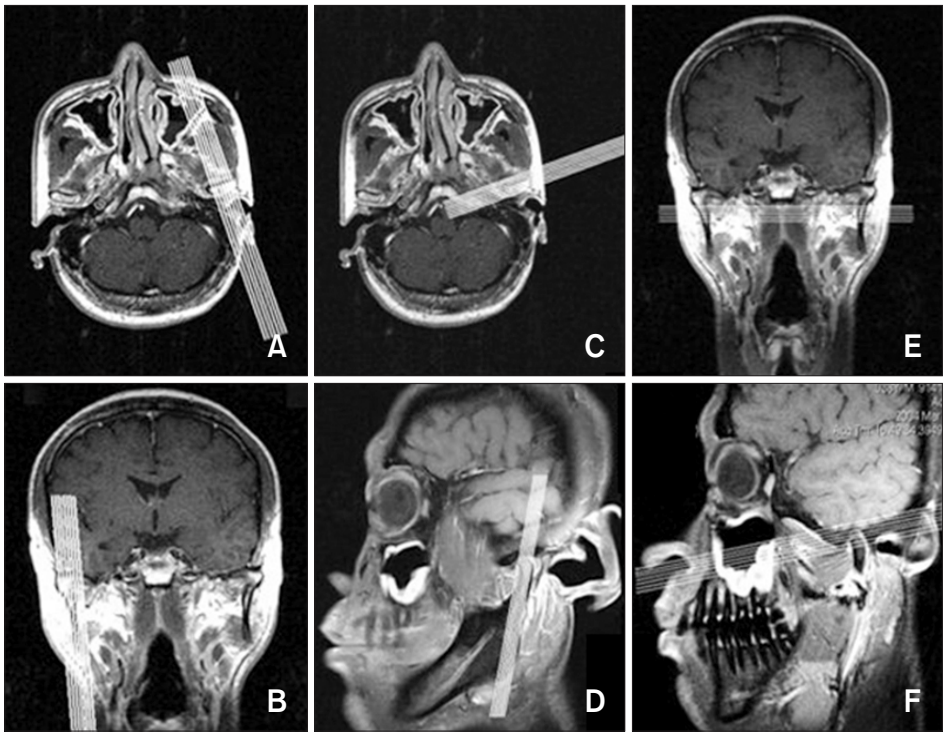


**Fig. 2.** Magnetic resonance imaging (MRI) sections for temporomandibular disorder (TMD). All participants had taken several sections of MRI for TMD evaluation. (A, B) Para-sagittal section. (C, D) Para-coronal section. (E, F) Para-transverse section.

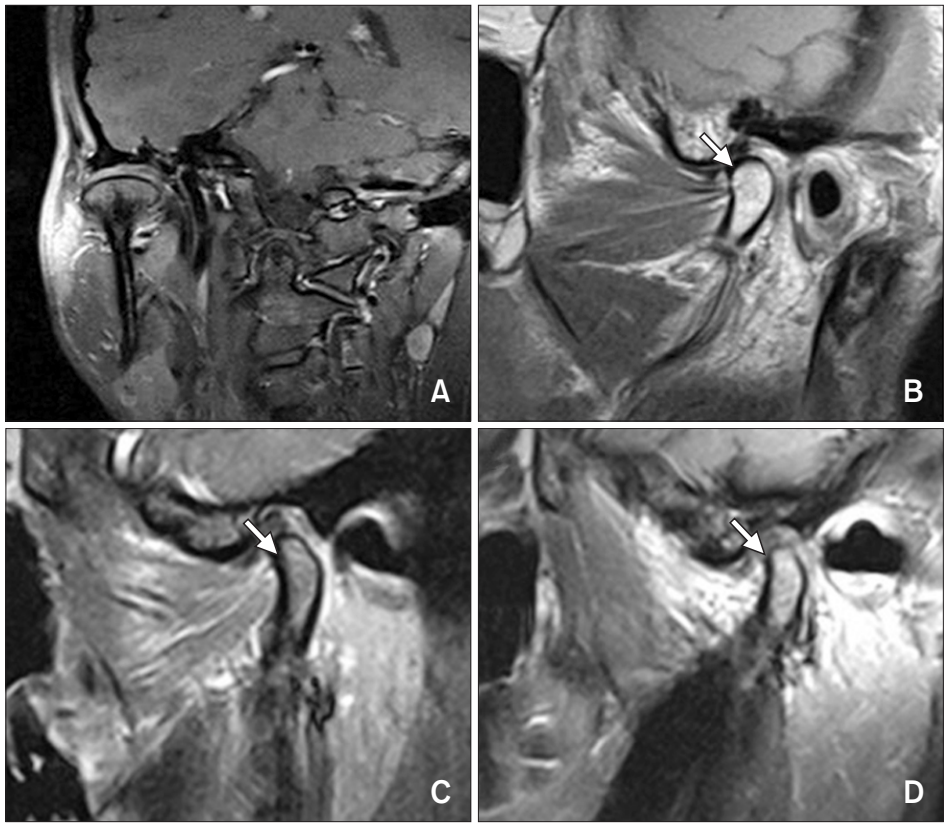


**Fig. 3.** Magnetic resonance imaging (MRI) findings of condyle degeneration. MRI findings show degree of condylar degeneration. (A) Normal relationship between condyle and disc. (B) Degeneration of condyle, beginning (arrow). (C) Degeneration of condyle, intermediate state (arrow). (D) Significant degeneration of condyle and disc (arrow).

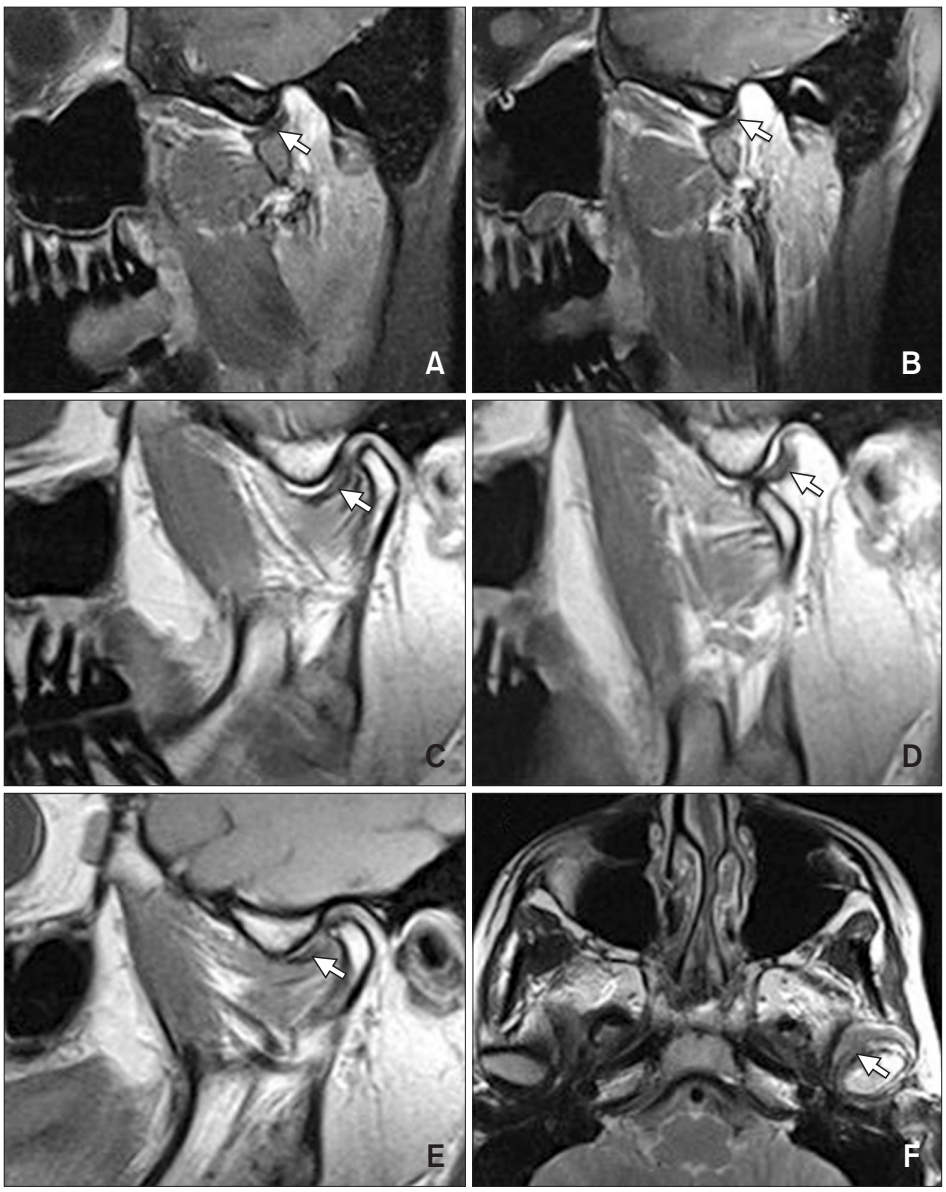


**Fig. 4.** Magnetic resonance imaging (MRI) findings of disc degeneration. MRI findings show degree of disc degeneration and synovitis. (A) Normal elasticity of disc (arrow). (B) Degeneration of disc, loss of elasticity (arrow). (C) Total anterior displacement, acute phase (arrow). (D) Total anterior disc displacement with reduction acute phase (arrow). (E) Total anterior disc displacement, chronic phase (arrow). (F) Synovitis in juvenile temporomandibular joint (arrow).

**Table 1.** Definition of temporomandibular joint disorders

| Disorder | Description |
|---|---|
| Disc displacement with reduction | Alteration, usually abrupt, or the disc-condyle structural relationship during mandibular translation, usually characterized by reciprocal clicking |
| Disc displacement without reduction | Altered disc-condyle structural relationship that is maintained during translation; can be acute or chronic |
| Synovitis | An inflammation in the synovial lining of the temporomandibular joint |
| Hypermobility | Excessive disc or condyle translation usually well beyond the eminence |
| Osteophyte | Small bone projection on condyle, condyle is flattened |
| Sclerosis | An increase in the density of the bone |

### *3. MRI Criteria*

The condyle degeneration was initially described as 5 degrees as no/little/moderate/severe condyle degeneration and beak peak, according to the MRI findings. These 5 degrees were categorized into two states with moderate, severe and peak degrees as condyle degeneration state, and no and little degeneration as no condyle degeneration state.

The disc degeneration was initially divided to 4 degrees as no disc degeneration, flat disc degeneration, perfusion and adhesion, from the MRI findings. Among these 4 degrees, flat, perfusion and adhesion were defined as disc degeneration state.

The condyle position was divided into 5 categories as normal, dorsal, ventral, medial and lateral. For the simplicity in statistical analysis, they were re-categorized as normal, unilateral and bilateral condyle dislocation.

The disc position was interpreted as 11 categories such as normal, dorsal, ventral, medial, lateral, none luxation, partial luxation, total luxation, none reposition, partial reposition and total reposition. These were re-classified into 5 divisions as normal position, unilateral reposition with reduction, bilateral reposition with reduction, unilateral reposition without reduction and bilateral reposition without reduction.

### *4. Statistics*

Correlations between clinical symptoms and MRI findings were analyzed with Pearson's chi-square test using SPSS version 10.0 (SPSS Inc., Chicago, IL, USA). Correlation coefficients were calculated between clinically symptoms and MRI findings. P-value under 0.05 was regarded as being statistically significant.

## Result

### *1. Descriptive Statistics on the Prevalence of Clinical Symptoms and MRI Finding*

Among the total of 240 patients, 117 patients (48.8%) had no clicking, 67 patients (27.9%)

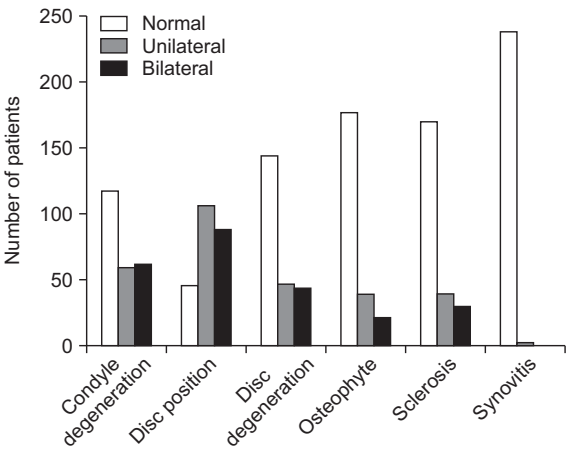


**Fig. 6.** Prevalence of respective pathologic findings in magnetic resonance imaging.

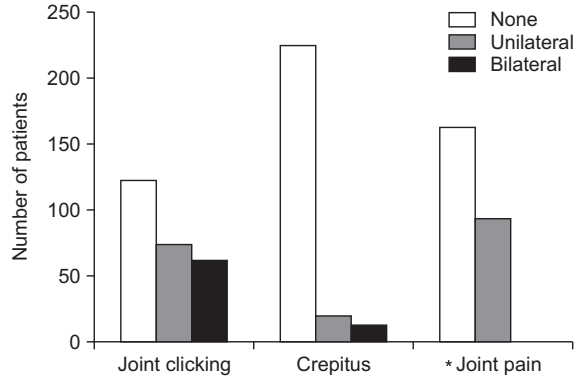


**Fig. 5.** Prevalence of clinical symptoms-joint clicking, crepitus and joint pain. *Joint pain was not divided into unilateral or bilateral.

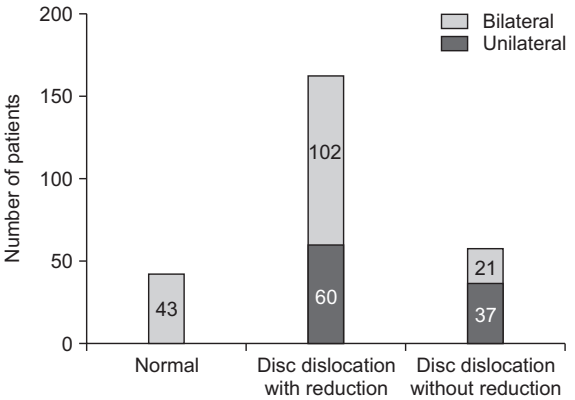


**Fig. 7.** Prevalence of disc dislocation with or without reduction in magnetic resonance imaging.

**Table 2.** Correlation between clinical symptoms and condyle position

| Symptom | Condyle position | | | | | |
|---|---|---|---|---|---|---|
| | Normal | | Unilateral dislocation | | Bilateral dislocation | |
| | R | P-value | R | P-value | R | P-value |
| Joint clicking | | | | | | |
| None | 0.031 | 0.631 | –0.076 | 0.240 | 0.041 | 0.528 |
| Unilateral | 0.032 | 0.619 | 0.053 | 0.410 | –0.075 | 0.248 |
| Bilateral | –0.071 | 0.276 | 0.033 | 0.610 | 0.031 | 0.635 |
| Crepitus | | | | | | |
| None | 0.112 | 0.082 | –0.026 | 0.688 | –0.068 | 0.291 |
| Unilateral | –0.019 | 0.770 | 0.006 | 0.923 | 0.017 | 0.792 |
| Bilateral | –0.136 | 0.035* | 0.071 | 0.274 | 0.086 | 0.186 |
| Pain | –0.021 | 0.746 | –0.025 | 0.701 | 0.050 | 0.437 |

R: Pearson correlation coefficients.

*P<0.05.

**Table 3.** Correlation between clinical symptoms and condyle degeneration

| Symptom | Condyle degeneration | | | | | |
|---|---|---|---|---|---|---|
| | None | | Unilateral | | Bilateral | |
| | R | P-value | R | P-value | R | P-value |
| Joint clicking | | | | | | |
| None | 0.016 | 0.804 | –0.009 | 0.887 | 0.010 | 0.872 |
| Unilateral | 0.038 | 0.555 | 0.021 | 0.750 | –0.076 | 0.242 |
| Bilateral | –0.059 | 0.361 | –0.011 | 0.866 | 0.068 | 0.297 |
| Crepitus | | | | | | |
| None | 0.039 | 0.547 | –0.022 | 0.729 | –0.068 | 0.291 |
| Unilateral | 0.075 | 0.245 | –0.023 | 0.725 | 0.017 | 0.792 |
| Bilateral | –0.143 | 0.026* | –0.018 | 0.780 | 0.086 | 0.186 |
| Pain | –0.093 | 0.153 | 0.033 | 0.610 | 0.050 | 0.437 |

R: Pearson correlation coefficients.

*P<0.05.

unilateral clicking and 56 patients (23.3%) bilateral clicking. Two hundred nineteen patients (91.3%) had no crepitus, 14 patients (5.8%) had unilateral and 7 patients (2.9%) had bilateral crepitus. Eighty-four patients (35.0%) had unilateral or bilateral pain (Fig. 5).

Condyle degeneration, disc position, disc degeneration, osteophyte, sclerosis and synovitis were defined and classified as normal, unilateral and bilateral findings (Fig. 6).

Forty-three patients (17.9%) of the patients showed normal disc position, 162 patients (67.5%) had disc reposition with reduction state, and 58 patients (24.2%) had disc reposition without reduction state (Fig. 7).

### *2. Correlation between Clinical Symptoms and MRI Findings*

In view of the relation between the clinical symptoms and MRI finding of condyle, a negative correlation (R=–0.136) between normal condyle position and bilateral crepitus (Table 2) was found.

**Table 4.** Correlation between clinical symptoms and disc position

| Symptom | Disc position | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Normal | | Unilateral dislocation | | | | Bilateral dislocation | | | |
| | | | With reduction | | Without reduction | | With reduction | | Without reduction | |
| | R | P-value | R | P-value | R | P-value | R | P-value | R | P-value |
| Joint clicking | | | | | | | | | | |
| None | –0.017 | 0.793 | –0.077 | 0.235 | –0.113 | 0.081 | 0.079 | 0.221 | –0.034 | 0.601 |
| Unilateral | 0.024 | 0.710 | 0.027 | 0.679 | 0.043 | 0.508 | –0.028 | 0.669 | –0.028 | 0.662 |
| Bilateral | –0.005 | 0.933 | 0.062 | 0.337 | 0.087 | 0.179 | –0.064 | 0.324 | 0.070 | 0.282 |
| Crepitus | | | | | | | | | | |
| None | 0.029 | 0.651 | –0.026 | 0.694 | –0.072 | 0.267 | 0.057 | 0.376 | 0.078 | 0.458 |
| Unilateral | 0.023 | 0.725 | 0.062 | 0.342 | 0.091 | 0.161 | –0.070 | 0.279 | –0.014 | 0.827 |
| Bilateral | –0.068 | 0.293 | –0.084 | 0.194 | 0.019 | 0.775 | 0.052 | 0.426 | 0.058 | 0.370 |
| Pain | –0.001 | 0.986 | 0 | 1 | 0.074 | 0.255 | 0.005 | 0.935 | –0.011 | 0.868 |

R: Pearson correlation coefficients.

**Table 5.** Correlation between clinical symptoms and disc degeneration

| Symptom | Disc degeneration | | | | | |
|---|---|---|---|---|---|---|
| | Normal | | Unilateral | | Bilateral | |
| | R | P-value | R | P-value | R | P-value |
| Joint clicking | | | | | | |
| None | 0.143 | 0.027* | –0.171 | 0.008** | 0.006 | 0.927 |
| Unilateral | –0.099 | 0.128 | 0.037 | 0.567 | 0.067 | 0.298 |
| Bilateral | –0.064 | 0.324 | 0.162 | 0.014* | –0.078 | 0.228 |
| Crepitus | | | | | | |
| None | 0.048 | 0.458 | 0.044 | 0.495 | –0.107 | 0.097 |
| Unilateral | –0.087 | 0.179 | 0.009 | 0.891 | 0.101 | 0.118 |
| Bilateral | 0.060 | 0.358 | –0.073 | 0.260 | 0.002 | 0.981 |
| Pain | –0.061 | 0.350 | 0.023 | 0.686 | 0.056 | 0.387 |

R: Pearson correlation coefficients.

*P<0.05. **P<0.01.

There was also a negative correlation (R=–0.143) between no condyle degeneration and bilateral crepitus (Table 3).

In terms of association between the clinical symptoms and disc positions, there was no significant correlation between disc position and joint clicking, crepitus or pain (Table 4). There was negative correlation (R=–0.171) between unilateral disc degeneration and no joint clicking. There was positive correlation (R=0.162) between unilateral disc degeneration and bilateral joint clicking (Table 5), indicating some effect of clicking on the pathology of disc.

Other morphological abnormalities including osteophyte or sclerosis were associated with clinical symptoms. There was positive correlation (R=0.154) between unilateral osteophyte, unilateral sclerosis and unilateral joint clicking (Tables 6, 7). There was also a strong correlation (R=0.257) between bilateral osteophyte and bilateral crepitus (Table 6).

Pathologic changes such as unilateral synovitis showed significant correlation with unilateral joint

**Table 6.** Correlation between clinical symptoms and osteophyte

| Symptom | Osteophyte | | | | | |
|---|---|---|---|---|---|---|
| | None | | Unilateral | | Bilateral | |
| | R | P-value | R | P-value | R | P-value |
| Joint clicking | | | | | | |
| None | 0.086 | 0.185 | –0.110 | 0.090 | 0.011 | 0.870 |
| Unilateral | –0.085 | 0.191 | 0.154 | 0.017* | –0.069 | 0.287 |
| Bilateral | –0.012 | 0.859 | –0.034 | 0.605 | 0.060 | 0.353 |
| Crepitus | | | | | | |
| None | –0.011 | 0.860 | 0.096 | 0.136 | –0.106 | 0.101 |
| Unilateral | 0.064 | 0.326 | –0.061 | 0.343 | –0.017 | 0.788 |
| Bilateral | –0.116 | 0.073 | –0.064 | 0.322 | 0.257 | 0.000** |
| Pain | –0.033 | 0.610 | 0.008 | 0.898 | 0.039 | 0.544 |

R: Pearson correlation coefficients.

*P<0.05. **P<0.01.

**Table 7.** Correlation between clinical symptoms and sclerosis

| Symptom | Sclerosis | | | | | |
|---|---|---|---|---|---|---|
| | None | | Unilateral | | Bilateral | |
| | R | P-value | R | P-value | R | P-value |
| Joint clicking | | | | | | |
| None | 0.086 | 0.185 | –0.110 | 0.090 | 0.011 | 0.870 |
| Unilateral | –0.085 | 0.191 | 0.154 | 0.017* | –0.069 | 0.287 |
| Bilateral | –0.012 | 0.859 | –0.034 | 0.605 | 0.060 | 0.353 |
| Crepitus | | | | | | |
| None | 0.044 | 0.502 | –0.027 | 0.674 | –0.025 | 0.697 |
| Unilateral | –0.008 | 0.898 | –0.011 | 0.871 | 0.020 | 0.754 |
| Bilateral | –0.041 | 0.513 | 0.017 | 0.797 | 0.038 | 0.559 |
| Pain | –0.064 | 0.324 | 0.017 | 0.796 | 0.087 | 0.179 |

Positive correlation (R=0.154) between unilateral sclerosis and unilateral joint clicking was noted.

R: Pearson correlation coefficients.

*P<0.05.

clicking (Table 8). Additionally, pain was correlated with hypermobility, dorsal disc position and moderate disc degeneration (Table 9).

## Discussion

In order to make a proper diagnosis of the TMD, clinicians conduct clinical examinations and take various images. Clinical examinations consist of range of mouth opening, pain, joint clicking, crepitus and muscle tenderness on palpation. In TMD patients, displacement of the articular disc occurs frequently and the disc displacement has been claimed as a common cause of TMJ clicking and crepitus[19]. TMJ pain is another major clinical symptom of TMD[20].

Due to the diversity in the treatment plans and modalities in TMD, the fundamental question has been whether sophisticated imaging devices such as MRI may help finding the cause of TMD symptoms[21]. MRI defines hard and soft tissue and is often applied to examine the soft tissue pathology

**Table 8.** Correlation between clinical symptoms and synovitis

| Symptom | Synovitis | | | | | |
|---|---|---|---|---|---|---|
| | None | | Unilateral | | Bilateral | |
| | R | P-value | R | P-value | R | P-value |
| Joint clicking | | | | | | |
| None | 0.109 | 0.093 | –0.089 | 0.171 | –0.063 | 0.334 |
| Unilateral | –0.097 | 0.133 | 0.147 | 0.022* | –0.040 | 0.535 |
| Bilateral | –0.025 | 0.696 | –0.051 | 0.430 | 0.116 | 0.073 |
| Crepitus | | | | | | |
| None | –0.035 | 0.591 | 0.028 | 0.662 | 0.020 | 0.758 |
| Unilateral | 0.028 | 0.666 | –0.023 | 0.725 | –0.016 | 0.804 |
| Bilateral | 0.016 | 0.800 | –0.013 | 0.837 | –0.009 | 0.884 |
| Pain | 0.004 | 0.952 | 0.029 | 0.657 | –0.047 | 0.464 |

There was positive correlation (R=0.147) between unilateral synovitis and unilateral joint clicking.

R: Pearson correlation coefficients.

*P<0.05.

**Table 9.** Correlation between clinical symptoms and hypermobility

| Symptom | Hypermobility | |
|---|---|---|
| | R | P-value |
| Joint clicking | | |
| None | 0.026 | 0.690 |
| Unilateral | 0.031 | 0.631 |
| Bilateral | –0.063 | 0.330 |
| Crepitus | | |
| None | 0.019 | 0.769 |
| Unilateral | 0.009 | 0.887 |
| Bilateral | –0.038 | 0.561 |
| Pain | 0.135 | 0.036* |

Positive correlation (R=0.135) between hypermobility and pain was found.

R: Pearson correlation coefficients.

*P<0.05.

of the TMJ. Studies that compared MRI findings with surgical and autopsy specimens reported an accuracy of around 90%~95% for detecting disc position abnormalities when both coronal and sagittal images were evaluated[17].

The purpose of this study was to investigate whether clinical symptoms such as clicking, crepitus and pain have correlations with MRI findings of condyle-disc pathology. The prevalence of clinical symptoms and condyle-disc displacement and degeneration was investigated and the association between MRI findings on the condyle-disc pathology and clinical symptoms was studied.

The results of correlation test showed that the joint clicking had a positive correlation with unilateral disc degeneration, osteophyte, sclerosis and synovitis. Crepitus had a significant correlation with bilateral osteophyte. However, pain was not significantly correlated with any MRI findings except hypermobility. In contrast, the crepitus was negatively correlated with condyle position, condyle degeneration, indicating the presence of the symptom(s) even without obvious MRI findings.

Overall, the results implicate relatively low correlation between the MRI findings and joints noises-clicking and crepitus. Although joint clicking had positive correlation with some MRI findings, the cause-and-effect relationship is not easily defined. In particular, the disc dislocation was not associated with joint noises, which is in contrast to the common understanding that the disc displacement causes the joint clicking. Unlike the major displacement of the disc beyond the joint

space, minor dislocation detected from the MRIs may not be directly related to the clinical symptoms. However, since this was a cross-sectional study, a long-term follow up may be needed to find whether minor positional changes would eventually lead to clinical symptoms.

None of the MRI findings was directly related to pain. Since pain is caused by multifactorial factors, the etiology of pain has to be found via assessment of comprehensive clinical information, not necessarily by MRI findings. Moreover, pain as a clinical symptom of the TMD may be classified as myofascial pain, TMJ pain and referred pain etc. In this study the origin of pain was not clarified and the scale of the severity of pain was not specified. Range of mouth opening is the one of the clinical sign of TMD. Mouth opening limitation is a clinically important symptom to diagnose the TMD however in this study mouth opening limitation was not investigated in this study[22].

Oseteoarthritis/osteoarthrosis is recognized if erosion, concavity, flattening, osteophyte formation, osteosclerosis, subchondral cyst, and/or deformity were found at the articular surface of the condyle[13,23]. In a previous study, a higher prevalence of joint pain was observed in joints with osteoarthritis/arthrosis[13]. However, several authors have reported a high prevalence of signs of osteoarthritis without radiographic findings[20,24]. The correlation has been contradictory according to the studies. In the previous studies using conventional radiography or CT, joint clicking and crepitus had correlations with radiographic abnormalities[5]. In contrast, others have stated that this relationship is not present in all cases[25].

Taken together, it can be claimed that condyle and disc degeneration may progress without pain or other clinical symptoms[26,27], supporting the results of the present study.

Since all clinical and MRI data were re-constructed to unilateral and bilateral findings in this study, there is some limitation in the study design. Namely, if a patient had disc displacement with reduction at the right TMJ and disc displacement without reduction at the left TMJ, MRI findings of the same patient were categorized as unilateral disc displacement with reduction and unilateral disc displacement without reduction. If a patient had a disc displacement with reduction on both TMJ, this patient was categorized as bilateral disc displacement with reduction. When analyzing correlations between clinical symptoms and MRI findings on condyle-disc pathology, MRI findings of each TMJ would be categorized into 3 types as unilateral, bilateral and normal state, which may not be conjugated to respective clinical finding. Considering the diversity of the MRI interpretation, sophisticated statistics using various significance levels (*i.e.*, 0.01) may produce more specified results.

To make more reliable diagnosis and to understand better the pathology of each TMD case, additional information should be considered such as range of mouth opening, Angle's classification, origin of pain and tenderness of muscle palpation.

The results of this study are that joint clicking and crepitus were correlated with MRI findings of condyle-disc pathology and without pain condyle-disc degeneration could be advanced. It is speculated that MR images may not provide sufficient information on the etiology of the clinical symptoms of TMD. A comprehensive clinical evaluation should precede the diagnosis of TMJ problems.

## Conclusion

The hypothesis of this study that the clinical symptoms have the correlation with MRI findings was partly accepted. In particular, joint clicking and crepitus had significant correlations with condyle-disc degeneration or sclerosis. In contrast, pain was not correlated with any MRI findings significantly except for clinical hypermobility. The results of this study imply that condyle-disc deformities could be

advanced without pain, and that joint clicking and crepitus could be clinical symptoms of condyle-disc degeneration.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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