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# Comparison of the Usefulness of CBCT and MRI in TMD Patients According to Clinical Symptoms and Age

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**Abstract:** Recently, the number of patients who visit the hospital with symptoms of temporomandibular joint disorders (TMD) has been gradually increasing, and the need for special imaging such as cone-beam computed tomography (CBCT) and magnetic resonance imaging (MRI) is increasing for accurate diagnosis and treatment. The purpose of this study was to help the image guideline by comparing the usefulness of CBCT and MRI according to the clinical symptoms of TMD patients and further examining whether the usefulness varies with age. A total of 473 temporomandibular joints (TMJs) with clinical symptoms of TMD who underwent both CBCT and MRI examinations were retrospectively reviewed. Clinical symptoms included pain, sound and limited mouth opening. The CBCT findings included sclerosis, flattening, erosion and osteophyte, while the MRI findings were defined as disc deformity, disc derangement or joint effusion. Joints were divided according to the presence of CBCT and MRI findings as follows: type I (neither CBCT nor MRI findings), type II (only CBCT findings), type III (only MRI findings) and type IV (both CBCT and MRI findings). We assessed the usefulness of the two imaging modalities by comparing the frequency of those four groups according to clinical symptoms and age. In TMD patients with the clinical symptoms, MRI and CBCT are complementary, but if it is difficult to choose the first of these two modalities, MRI is more recommended, and the younger the patient, the more the MRI is recommended.

**Keywords:** cone-beam computed tomography; magnetic resonance imaging; temporomandibular joint; temporomandibular joint disorders

## 1. Introduction

The temporomandibular joint (TMJ) consists of the articular bony components of the temporal bone and mandibular condyle, as well as of soft tissue components such as masticatory muscles and ligaments attached to the bony parts of the TMJ [1]. For many reasons, such as changes in eating habits and increased social stress, temporomandibular joint disorders (TMD) have rapidly become more common in recent years, and the incidence of TMD in younger individuals is also increasing.

The clinical diagnosis of TMD is challenging due to its complex etiologic factors and various symptoms and an imaging evaluation may play important roles in diagnosis. Diagnostic imaging includes panoramic radiography, transcranial radiography, cone-beam computed tomography (CBCT), computed tomography (CT) and magnetic resonance imaging (MRI) [2]. In the past, conservative treatment was performed on the basis of conventional radiography findings, but it has become more common to pursue a specific diagnosis more accurately using specialized imaging modalities such as CBCT, CT and MRI. These imaging modalities can lead to a more accurate diagnosis and appropriate treatment. However, these modalities may not always be suitable in light of factors such as cost, time, and radiation dose, so it may be useful to have imaging guidelines. CBCT or CT is suitable for evaluating bony changes of the TMJ [3–5] while the MRI is useful for evaluating soft tissue changes and internal disc derangement [6]. Because of the low dose radiation and isotropic resolution of CBCT, CBCT is more recommended than CT for hard tissue evaluation of TMJ [4]. If a detailed clinical examination of TMD patients can distinguish between hard and soft tissue problems, in theory, an informed decision can be made to conduct an imaging work-up using CBCT (CT) or MRI. However, in reality, no matter how detailed the clinical examination, it is difficult to distinguish between hard tissue problems and soft tissue problems. It is not easy to determine which CBCT or MRI is better suited for diagnosis.

Numerous studies have investigated the relationships between CBCT findings and clinical symptoms [7] and between MRI findings and clinical symptoms [8–13]. However, there is a lack of imaging guidelines according to clinical symptoms, and few studies have reported age-based imaging guidelines.

The purpose of this study was to evaluate CBCT and MRI findings in patients with TMD, to identify whether there were differences in the usefulness of these two imaging modalities according to clinical symptoms and age, and to help imaging guidelines.

## 2. Materials and Methods

### *2.1. Subjects*

This study included 325 patients (age range: 12–74 years; mean age: 33.3 ± 16.23 years) with clinical symptoms of TMD who underwent both CBCT and MRI examinations within a 2-month interval, from January 2019 to December 2019, at Yonsei University Dental Hospital. Patients with a TMJ fracture, cyst, tumor and inflammation affecting the TMJ were excluded. Patients who received more than 2 months of treatment, including medication, physical therapy and splint therapy were excluded. The right and left joints were reviewed separately in each patient and the joints that did not cause symptoms were excluded. Finally, 473 joints associated with TMD symptoms were included in this study. The study was approved by the Institutional Review Board of Yonsei University Dental Hospital.

Clinical symptoms were classified as sound, pain and limited mouth opening, corresponding to the main symptoms of TMD. Patients with multiple clinical symptoms were recorded multiple times, since the analysis was conducted on the symptom level, not on the patient level.

### *2.2. Imaging Analysis*

Two experienced oral and maxillofacial radiologists randomly evaluated the CBCT and MRI images, and any instances of disagreement were resolved by consensus.

#### 2.2.1. CBCT Evaluation

The CBCT images of the TMJ were obtained with an Alphard 3030 device (Asahi Roentgen Ind. Co. Ltd., Kyoto, Japan) using the following parameters: tube voltage, 80 kVp; tube current, 8 mA; exposure time, 17 s; and field of view, 154 × 154 mm. Image reconstruction was performed to obtain a true sagittal and coronal TMJ view with a slice thickness of 1.0 mm according to the long axis of the condylar head by a skilled radiographer using OnDemand 3D software (Cybermed, Seoul, Korea).

The bony structures in the condylar head and articular fossa were evaluated. CBCT findings were defined as the presence of sclerosis (a condition in which the bone density is significantly increased), flattening (a loss of the round contour), erosion (an interruption or absence of the cortical lining), or osteophyte (marginal hypertrophic bone formation) according to the criteria proposed by Matsubara et al. [12] and Roh et al. [14] (Figure 1).

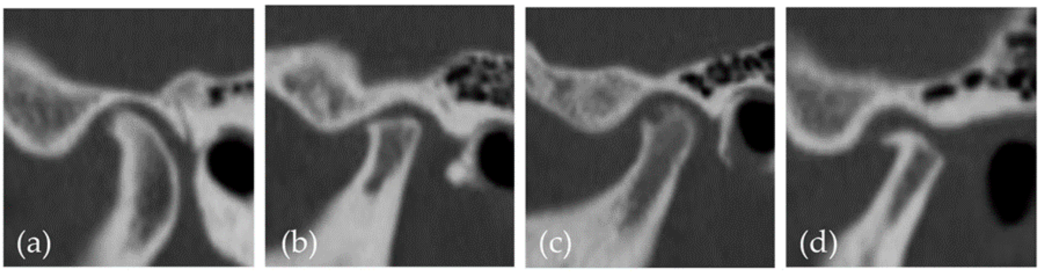


**Figure 1.** Cone-beam computed tomography (CBCT) findings: (**a**) sclerosis; (**b**) flattening; (**c**) erosion; and (**d**) osteophyte.

#### 2.2.2. MRI Evaluation

The MRI of the TMJ was conducted using a 3.0 T scanner (Pioneer; GE Healthcare, Waukesha, WI, USA) with 16-channel flex large coil. A sagittal section view, perpendicular to the long axis of the condylar head with a slice thickness of 2.5 mm, was obtained using proton density-weighted and T2 weighted sequences in the closed-mouth and open-mouth positions. A coronal section view, parallel to the long axis of the condylar head with a slice thickness of 2.5 mm, was obtained using proton density-weighted sequences in the closed-mouth position.

Disc deformity, disc derangement and the joint effusion on each joint were evaluated. Disc deformity was defined as the absence of a "bow tie" shape, with thick anterior and posterior bands and a narrow intermediate zone, according to Arayasantiparb et al. [15]. In accordance with to Koh et al. [16], we defined all cases as disc derangement unless the following criteria were satisfied: the posterior band was located above the apex of the condylar head in the closed-mouth position and the thin intermediate zone was located between the condyle and the articular eminence in the open-mouth position. Joint effusion was defined as when bright T2 signals took up more space than dots in the joint space according to previous reports [17,18]. MRI findings were defined as disc deformity, disc derangement and joint effusion (Figure 2).

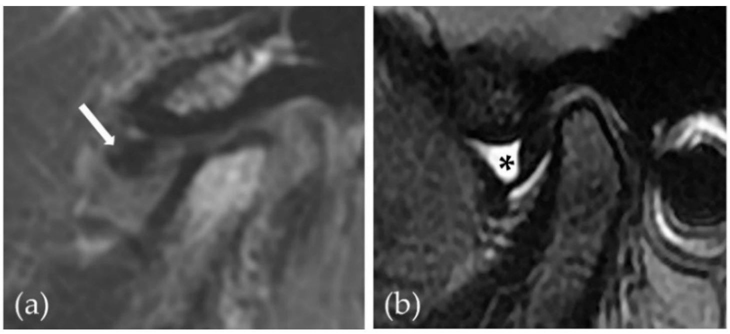


**Figure 2.** Magnetic resonance imaging (MRI) findings: (**a**) disc deformity and disc derangement (arrow); and (**b**) joint effusion (asterisk).

### *2.3. Data Grouping and Analysis*

The joints were categorized according to the presence of CBCT and MRI findings as follows:

Type I (neither CBCT nor MRI findings): no CBCT or MRI findings.
Type II (only CBCT findings): at least one CBCT finding, but no MRI findings.
Type III (only MRI findings): at least one MRI finding, but no CBCT findings.
Type IV (both CBCT and MRI findings): at least one CBCT finding and at least one MRI finding.

We compared the frequency of the four groups according to the clinical symptoms of TMD, and the distribution of four types was further assessed according to age.

Statistical analysis was performed using the chi-square test to analyze whether there were differences in the groups according to age. Statistical analysis was performed using the software SPSS version 25.0 for Windows (IBM Corp., Armonk, NY, USA).

## 3. Results

The age distribution of TMD patients (n = 325) was the highest at 20–29 years (28.9%), followed by 30–39 years (16.9%). The overall age distribution is shown in Figure 3. Female (n = 253) were 3.5 times more frequent than male (n = 72).

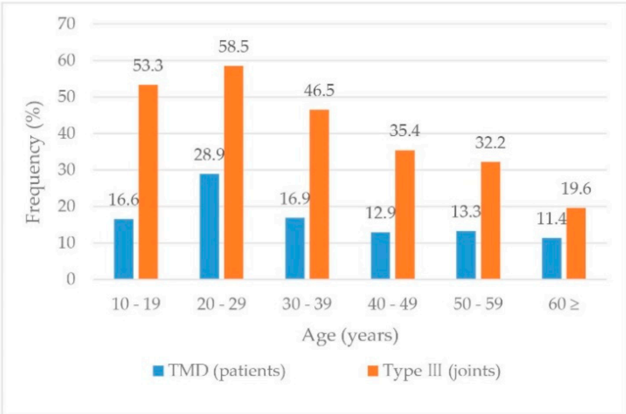


**Figure 3.** Age distribution of temporomandibular joint disorders (TMD) and type III.

The clinical symptom of 473 joints were frequent in order of pain (77.8%), sound (74.6%) and limited mouth opening (33.6%). In the image analysis, at least one MRI finding was found in 89.0% (n = 421) and at least one CBCT finding was found in 47.1% (n = 223). The proportions of types I–IV, defined based on the simultaneous presence of CBCT and MRI findings, were 7.6% (n = 36), 3.4% (n = 16), 45.2% (n = 214), and 43.8% (n = 207), respectively.

Table 1 shows the type of CBCT and MRI findings according to clinical symptoms. Type III showed a higher proportion than type II in all the clinical symptoms of pain, sound and limited mouth opening.

**Table 1.** Type of CBCT and MRI findings according to the clinical symptoms % (number).

| | Type I | Type II | Type III | Type IV |
|---|---|---|---|---|
| Sound (n = 353) | 7.9 (28) | 2.8 (10) | 47.9 (169) | 41.4 (146) |
| Pain (n = 368) | 7.1 (26) | 2.4 (9) | 41.0 (151) | 49.5 (182) |
| Limited mouth opening (n = 159) | 3.1 (5) | 5.0 (8) | 37.8 (60) | 54.1 (86) |

n; number.

Table 2 shows the distribution of the four types according to age. Type III was at a higher frequency than type II in all age groups and the frequency of type IV increased with age.

**Table 2.** Distribution of the four types according to age % (number).

| Age (years) | Type I | Type II | Type III | Type IV |
|---|---|---|---|---|
| 10–19 (n = 75) | 14.7 (11) | 1.3 (1) | 53.3 (40) | 30.7 (23) |
| 20–29 (n = 142) | 4.9 (7) | 5.6 (8) | 58.5 (83) | 31.0 (44) |
| 30–39 (n = 86) | 8.1 (7) | 1.2 (1) | 46.5 (40) | 44.2 (38) |
| 40–49 (n = 65) | 7.7 (5) | 1.5 (1) | 35.4 (23) | 55.4 (36) |
| 50–59 (n = 59) | 3.4 (2) | 3.4 (2) | 32.2 (19) | 61.0 (36) |
| 60 ≥ (n = 46) | 8.7 (4) | 6.5 (3) | 19.6 (9) | 65.2 (30) |

n; number.

The age distribution of type III is shown in Figure 3. Type III had the highest frequency at 20–29 years, followed by a frequency at 10–19 years, and tended to decrease with age.

For the age group of 10–29, type III was statistically significantly more frequent than other types (Type I, II, IV) (Table 3).

**Table 3.** Distribution of type III and other types (Type I, II, IV) according to the age group number (%).

| Age (Years) | Type III | Type I, II, IV | *p*-Value |
|---|---|---|---|
| 10–29 (n = 217) | 123 (56.7) | 94 (43.3) | < 0.001 * |
| 30 ≥ (n = 256) | 91 (35.5) | 165 (64.5) | |

Chi-square test, * $p < 0.05$.

## 4. Discussion

TMD occurs more commonly in women than in men, and although it can occur at any age, it is especially common among those who are 20–40 years of age [19–21]. In recent decades, the number of patients seeking medical care for TMD symptoms is increasing, and they are doing so at a younger age. In this study, similarly to the previous study, TMD was most common at 20–39 years, followed by 10–19 years. The sex distribution was 3.5 times higher for female than for male.

TMD is the only musculoskeletal disorder of the head and neck that causes pathological changes in both soft tissue and hard tissue. CBCT or CT is useful for evaluating TMJ bony changes such as erosion and osteophyte [3–5], whereas MRI is useful for evaluating disc morphology, internal disc derangement, joint effusion and soft tissue changes [6]. During the process of TMJ disease, soft tissues of TMJ are affected in the earlier stage and hard tissues are affected in the later stage [22]. MRI is suitable for evaluating early stage and CBCT or CT are suitable for late stage TMD evaluation. Zain-Alabdeen et al. reported that CBCT and CT accuracy were comparable in detecting osseous surface changes and CBCT required less radiation exposure, so CBCT should be encouraged for imaging TMJ with suspected osseous surface changes [4]. However, it is not easy to determine which of CBCT (CT) or MRI images is suitable due to various symptoms in TMD patients. It is challenging to predict image findings from clinical symptoms because the association between clinical symptoms and image findings is not well founded. Ohlmann et al. reported that changes such as joint effusion and disc displacement on MRI did not correlate with pain [23]. Wiese et al. did not find any correlation between degenerative bony change and pain [24]. On the other hand, Emshoff et al. reported a correlation between erosion and pain on CBCT [25]. Matsubara et al. reported a correlation between joint effusion and pain on MRI [12].

When joints were divided into four groups in terms of the co-occurrence of CBCT and MRI findings, Type I (neither CBCT nor MRI findings) was 7.6%. Type I most likely reflects problems with masticatory muscles, such as temporal muscles and masseter muscles, rather than internal derangement of the joint.

Type III (only MRI findings) were more common in all three clinical symptoms (sound, pain and limited mouth opening) than in type II (only CBCT findings). This shows that MRI may be more useful than CBCT for all three of these clinical symptoms. These results indicate that MRI may be preferable over CBCT for symptomatic TMD patients when suitable imaging guidelines are not judged. In particular, MRI was more useful than CBCT for the symptom of sound. MRI is superior to CBCT (CT) images for the diagnosis of TMJ internal derangement [26–28]. TMD is a chronic disease and according to Wilkes' internal derangement classification [22], sound is usually related to the internal arrangement and occurs at an early stage, and limited mouth opening is a symptom that occurs after the intermediate stage. Pain can occur at any time, except at the early stage of the disease. During the internal derangement of the TMJ, bony change of the TMJ is rare in the early stage; instead, it tends to occur in the late intermediate stage or late stage [22]. Therefore, it is considered that the frequency of type III is the highest in clinical symptoms of sound than in other clinical symptoms.

The proportion of type III tended to increase with younger age. Type III was statistically significantly more frequent than other types (Type I, II, IV) for the age group of 10–29, and this frequency exceeded

50%. Therefore, MRI may be more suitable than CBCT in younger TMD patients, especially those aged 10–29 years.

The major limitation of this study is that the total number of samples was small and the number of samples was not uniform across age groups. Further research is needed with more samples and a more uniform age distribution.

In summary, CBCT and MRI play a complementary role in the evaluation of TMD and are both useful imaging modalities. Clinicians should perform MRI first when the clinical symptoms are related to internal derangement, soft tissue or early stage in the disease. MRI is also recommended as the first-line imaging modality in young patients or if it is unclear which imaging modality is more suitable.

**Author Contributions:** The authors made most of the contributions regarding the conceptualization, development of theory, validation, discussion of the results, as well as the final manuscript. Individual contributions were as follows: conceptualization, K.J.J. and S.-S.H.; methodology, K.J.J. and S.-S.H.; investigation, K.J.J., C.L. and Y.J.C.; writing—original draft preparation, K.J.J.; review and editing, S.-S.H. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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