Japanese Dental Science Review (2008) 44, 83—89

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MINI REVIEW

Interpretation of images and discrepancy between osteoarthritic findings and symptomatology in temporomandibular joint

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Received 15 November 2007; accepted 25 February 2008

KEYWORDS
Osteoarthritis;
MR image;
Temporomandibular joint (TMJ);
Symptom

Summary The discrepancy between osteoarthritic findings on images and symptomatology can sometimes be problematic in clinical work. In this article, we focus on osteoarthritis and related entities on images, and especially on MR images.

1. Pitfalls of determining osteoarthritis in temporomandibular joint (TMJ) from X-ray images

Osteoarthritis is characterized by osseous changes such as flattening, irregularities of the articular surfaces, osteophytosis, and erosion on images.

The arrival of panoramic X-ray machines in private dental clinics in the mid 1970s enabled us to evaluate osseous changes in the TMJ and osteoarthritis.

In the clinic, patients often present with a painful TMJ. In such instances, even when a panoramic radiograph is obtained to evaluate any osseous abnormalities that might be present, these changes do not always appear on the images (Fig. 1). On the other hand, when a panoramic radiograph is taken to examine the entire dentition, together with both the mandible and maxilla, in a patient with no TMJ symptoms, severe osseous changes in the mandibular condyle may appear (Fig. 2).

Several studies found that osteoarthritis was not a significant factor in TMJ pain [1—5], whereas several other studies did [4,6—8]. Osteoarthritis is widespread among the elderly, and is usually completely asymptomatic. Symptoms related to temporomandibular dysfunction decrease with age, and are often remitting and self-limiting [9—12]. Kurita et al. [6] suggested that TMJ pain on mandibular movement was not a reliable predictor of osteoarthritis in the TMJ. Mechanical and chemical stimuli have been proposed as possible causes of pain in and around the osteoarthritic joint. This suggests that symptoms of problems with the TMJ are more likely to be associated with problems other than those brought about by osteoarthritic change.

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1882-7616/$ — see front matter
doi:10.1016/j.jdsr.2008.02.001

Figure 1 Panoramic radiograph. Patient complained of persistent pain in right TMJ. However, right TMJ showed normal osseous condition and, therefore, no evidence of osteoarthritis.

Osteoarthritis in the TMJ is generally recognized as a degenerative joint disease, and is often regarded as an age-related disease. It is often difficult, however, to distinguish radiographically between osteoarthritis and other conditions such as advanced remodeling and degenerative joint disease. One study has suggested that flattening and deformation of the articular eminence and regression of condylar size were likely to occur in joints with persistent non-reducing disk displacement, even after symptoms and signs of TMJ disorders had resolved or reduced [13].

This suggests that other imaging modalities such as magnetic resonance imaging (MRI) should be adopted in attempting a diagnosis of osteoarthritis.

2. Other entities related to osteoarthritis on magnetic resonance (MR) images

Temporomandibular joint imaging studies can provide us with an understanding of both the normal and pathologic anatomy of the joint and surrounding structures.

Although X-ray modalities provide relatively useful information on osseous changes in the joint, they do not give any information on soft tissue abnormalities, in spite of multiple attempts to indirectly diagnose such abnormalities by plain film criteria such as condyle position in the glenoid fossa. In the late 1970s, it became obvious that plain film findings on osseous abnormalities correlated poorly with symptomatology.

Figure 2 Panoramic radiograph. Irregularity of surface (erosion) (black arrows) is seen on upper portion of left condyle, indicating osteoarthritis. However, patient did not complain of pain in left TMJ.

Improvements in diagnostic imaging of the TMJ over the last two decades have revealed that disk displacement is the most frequent abnormality in patients with pain and dysfunction of the TMJ. This entity had already been described and surgically treated as early as 1887 [14], but its clinical significance remained unclear for a long time. More recently, the term "temporomandibular disorders" (TMD) has been introduced as an umbrella diagnosis for facial pain and jaw dysfunction [15]. In the late 1970s, Farrar [16] and Farrar and McCarthy [17] clarified the clinical significance of disk displacement in a series of clinical studies. Disk displacement represents one sub-category of TMD. Arthrography was applied to the TMJ in the early 1940s, but the diagnostic value was questioned, since no therapeutic methods were available at the time. Arthrography, introduced by Nørgaard [18] in the 1940s, was the prime imaging modality for demonstration of disk displacement during the 1970s and 1980s [19—23]. However, due to the time-consuming and technically difficult nature of this technique, clinicians gradually favored computed tomography (CT). Again, although CT met with initial enthusiasm, long-term experience showed that CT was not a very accurate technique for diagnosis of disk disorders.

Since its clinical introduction in the mid 1980s, the magnetic resonance imaging has evolved as the prime diagnostic method for soft tissue abnormalities in the TMJ. It is non-invasive and more accurate than arthrography; it requires less operator skills and is well tolerated by the patient.

MR imaging can also identify other entities specifically related to osteoarthritis such as joint effusion or bone marrow abnormalities of the condyle.

3. Disk displacement

Disk displacement without reduction can be accompanied by stronger pain than other types of disk derangement.

In disk displacement without reduction (Fig. 3), the disk remains displaced relative to the condyle, regardless of the position of mandible. In the initial stages of this condition, mouth opening is typically limited, and the mandible deviates to the side of the affected joint. However, this clinical characteristic is typical only during the initial (early) phase; with time the opening capacity of the TMJ increases and the mandible no longer deviates to the affected side. This is the result of stretching, or progressive elongation, of the posterior disk attachment and, to a lesser extent, deformation of the disk itself. Osseous changes involving the condyle and temporal bone often occur as sequelae of disk displacement with reduction [1,19,24—27].

Osteoarthritis is frequently seen in joints with longstanding disk displacement and no reduction (Fig. 3) [1,28]. Disk displacement seems to be a precursor of osteoarthritis.

Osteoarthritis is infrequently seen in joints with normal superior disk position, occasionally in disk displacement with reduction, and more frequently when disk displacement without reduction has been present for some time. Imaging evidence of osteoarthritis can be seen in young patients with disk displacement without reduction. Disk displacement and internal derangement is, however, only one cause of osteoarthritis, the common final pathway for a multitude of primary joint lesions.

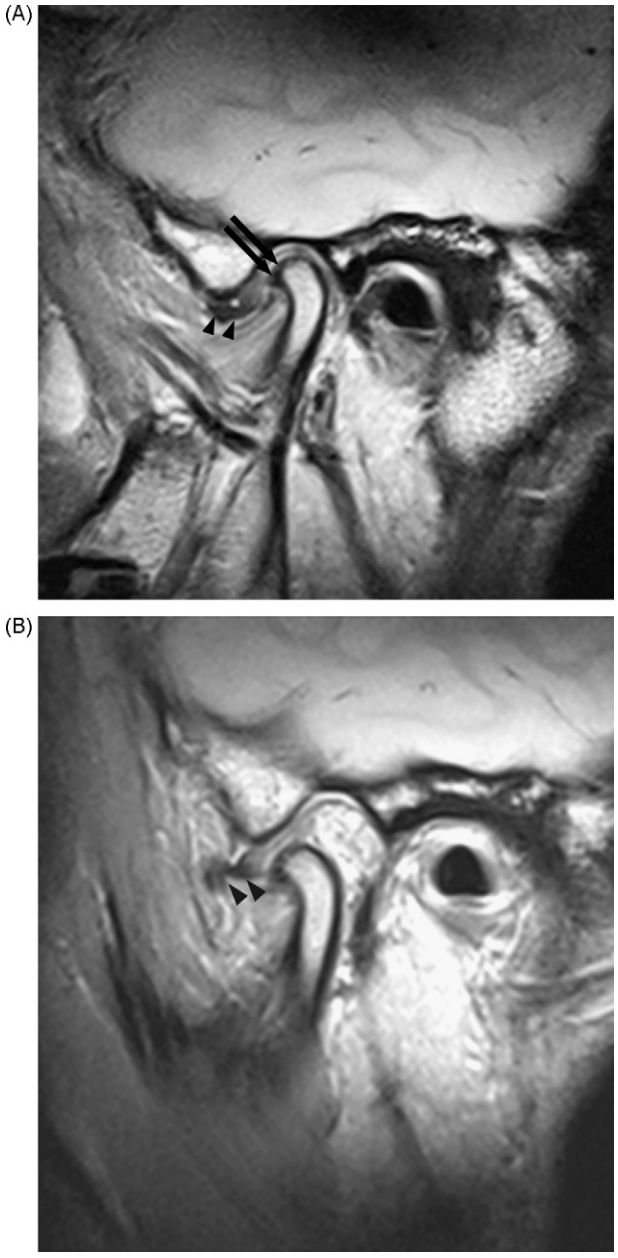

Figure 3 MR images. Parasagittal proton density-weighted closed-mouth image (A) shows anterior osteophyte of condyle (black arrows). Disk (black arrowheads) is anterior of condyle. On mouth opening (B), disk (black arrows) remained anterior. This was consistent with osteoarthritis associated with disk displacement without reduction.

When osteoarthritic change in the TMJ with normal disk displacement is encountered, we have to consider osteoarthritides as a differential diagnosis. Arthritides include rheumatoid arthritis, ankylosing spondylitis, and psoriatic arthritis [29,30].

4. Joint effusion

Joint effusion is generally defined as the pathological collection of TMJ fluid in the joint spaces (Fig. 4). It appears as an increased signal on T2-weighted MR images. With the knee joint, MRI can be used to distinguish effusion from synovitis [31]. However, with the TMJ, the joint spaces are too small, and the signal of effusion is quite similar to that of synovial fluid. This makes it difficult to distinguish joint effusion from normal synovial fluid in the TMJ on MR images. Therefore, criteria are needed to distinguish joint effusion from normal synovial fluid on MR images.

Westesson and Brooks [32] regarded images as showing joint effusion when more than one line of high signal in the upper or lower joint spaces was present on T2-weighted images. They determined frequency of joint effusion according to TMJ status on MR images. The highest frequency of effusion in their study was 50% (in joints with disk displacement without reduction), and the lowest 7% (in joints with normal superior disk position). Although our finding for the frequency of joint effusion in joints with normal superior disk position was higher (34%) than that of Westesson et al., there was a similarity between our findings in terms of the relationship between the status of the TMJ and the frequency of TMJ effusion: the highest frequency was seen in joints with disk displacement without reduction and the lowest was seen in joints with normal superior disk position [33].

Takahashi et al. [34] reported that joint effusion on MRI was seen in 63.3% of TMJs with internal derangement and in 75% of TMJs with osteoarthritis. Their criterion for internal derangement, namely ''locking of the TMJ'', corresponded to our category of disk displacement without reduction. In contrast to their findings, our study showed that frequency of joint effusion in joints with disk displacement without reduction was higher (68%) than that in joints with arthrosis (64%) (Fig. 4) [33]. One reason for this difference between the two studies may be the different objectives involved. All selected patients for Takahashi's study had been treated with nonsurgical modalities for at least 3 months, with no satisfactory improvement before intra-articular pumping and lavage were performed. Most, if not all, of the patients probably had persistent pain. On the other hand, in our study [33], the patients referred to us for MR imaging of the TMJ may, or may not, have had persistent pain. Therefore, the two studies addressed different types of patient. There is, however, another possible reason. Although Westesson and Brooks [32] and Murakami et al. [35] regarded more than one line of high signal as joint effusion, high signals are also visible on the T2-weighted images of asymptomatic volunteers. This suggests that this criterion for joint effusion is not sufficient to determine a pathological collection of TMJ fluid. Furthermore, differences in criteria for defining TMJ effusion might explain some of the differences in the frequencies reported in other studies.

Although disk displacement is the representative finding for TMJ disorders, it can also be seen in nearly one third of asymptomatic volunteers [36,37]. This suggests that disk displacement is a normal variant. To investigate this possibility, Larheim et al. [38] investigated correlation between prevalence and type of TMJ disk displacement in asymptomatic volunteers with that in patients. They found that disk displacement was less prevalent and of a different type in asymptomatic volunteers compared with in patients with pain and dysfunction. Moreover, Larheim et al. [39] proposed a way to grade the amount of TMJ fluid to determine the significance of TMJ fluid in TMJ disorders. They defined

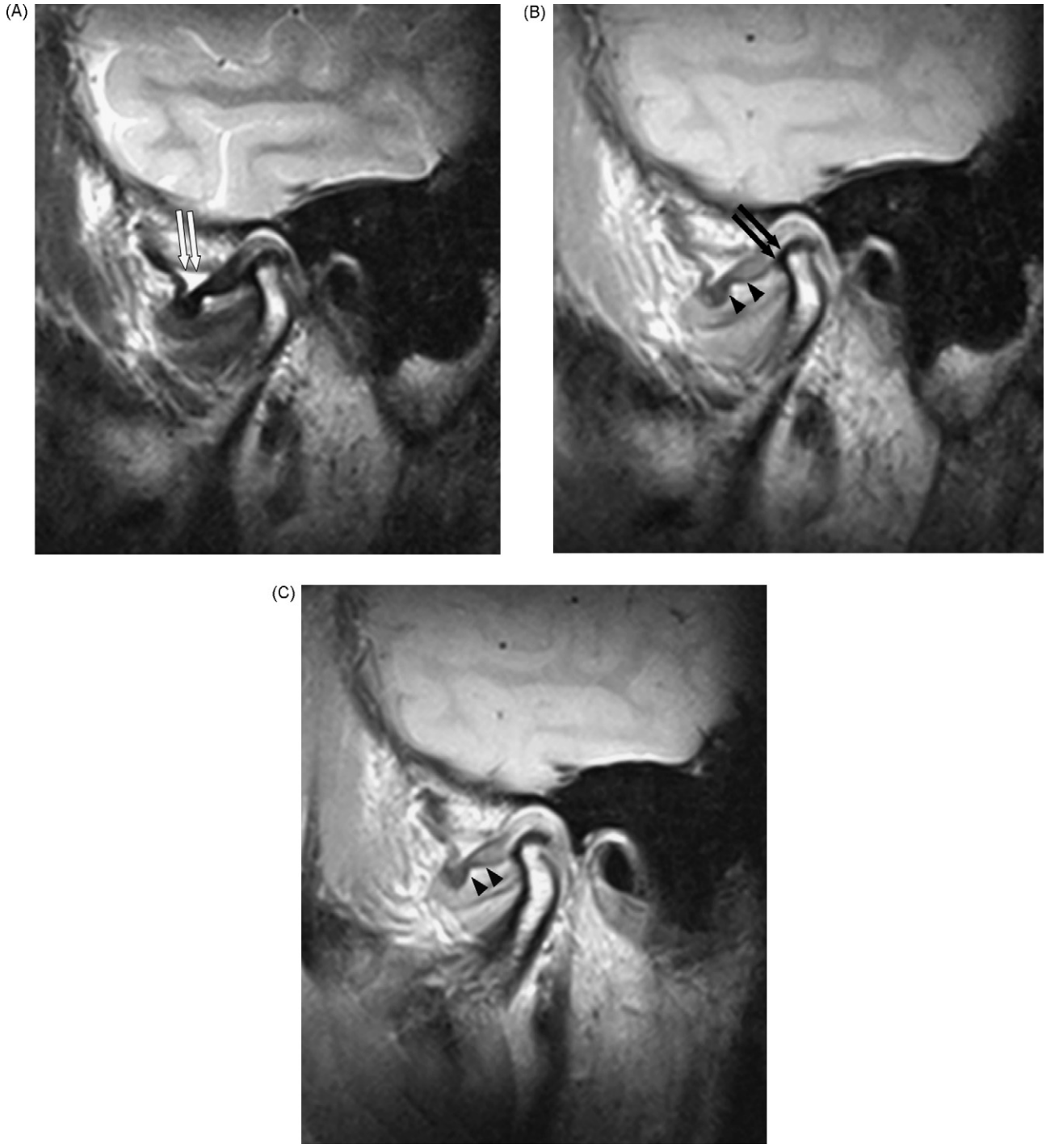

Figure 4 MR images. On parasagittal T2-weighted closed-mouth image (A), there was joint effusion in upper joint space (white arrows). Parasagittal proton density-weighted closed-mouth image (B) shows deformed condyle with anterior osteophyte (black arrows). Disk (black arrowheads) is also anterior of condyle. On mouth opening (C), disk (black arrows) remained anterior. This was consistent with osteoarthritis and joint effusion in the joint space.

marked and extensive fluid as TMJ effusion because no joints with marked or extensive fluid were found in asymptomatic volunteers. They found the frequency of TMJ effusion was 13.4% in symptomatic patients and 7.3% in symptomatic joints. In our study, the frequency of TMJ effusion was 13.7% in joints with pain and dysfunction. According to Larheim's criteria for effusion, frequency tends to be less varied and approximately 10%.

The association between joint effusion and pain has been investigated several times, and is still controversial [32,34,35,39—44]. In 1992, Westesson and Brooks [32] showed that the frequency of joint effusion was higher in more painful joints than in less painful joints, and concluded that TMJ effusion was strongly associated with joint pain. However, Murakami et al. [35] showed that there was no significant statistical correlation between pain level and the

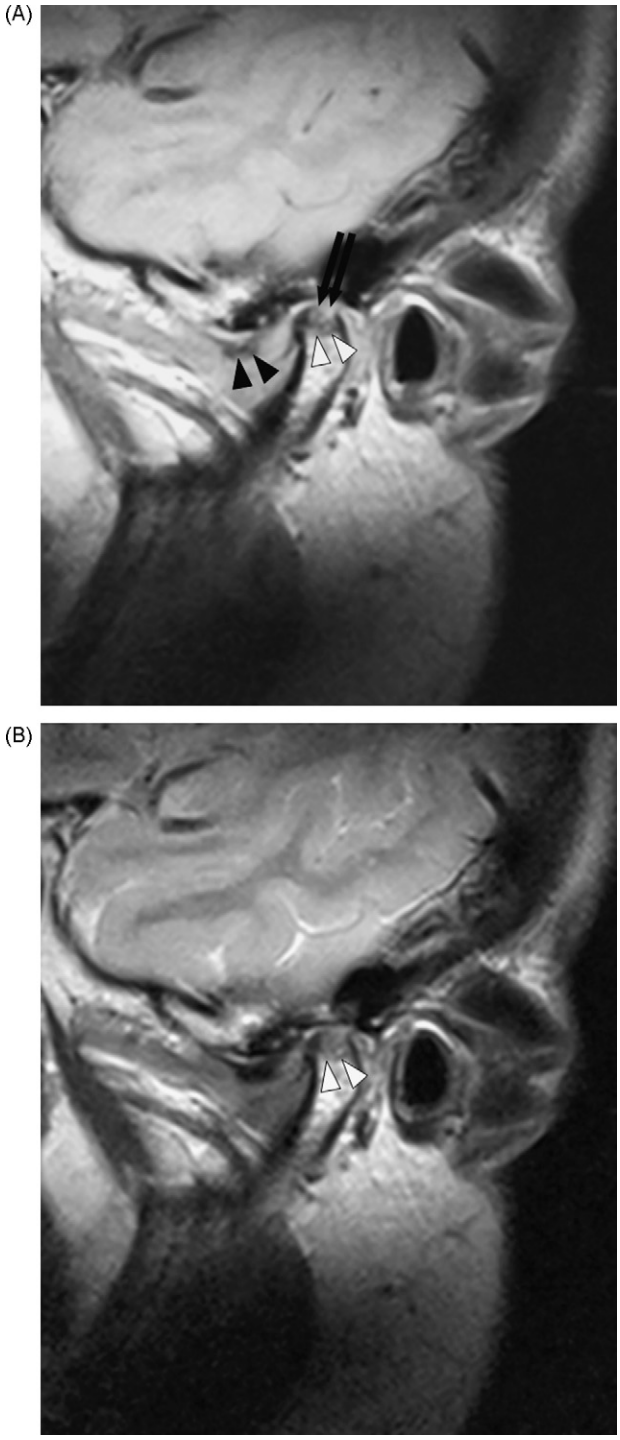

Figure 5 MR images. Parasagittal proton density-weighted closed-mouth image (A) shows decreased signal from bone marrow of condyle (white arrowheads). There was also irregularity of upper surface (erosion) of condyle (black arrows) and temporal joint component suggestive of osteoarthritis. Disk was anteriorly displaced and deformed (black arrowheads). Parasagittal T2-weighted closed-mouth image (B) shows decreased signal from bone marrow of condyle suggestive of osteonecrosis (white arrowheads).

presence of a high signal on T2-weighted images, and argued that joint effusion was somewhat inappropriate as a screening sign for a painful TMJ. The disagreement between these two studies may be rooted in differences in the subjects of their studies, i.e., Murakami only included patients who complained of unilateral painful hypomobility of the TMJ with a diagnosis of closed lock.

Takahashi et al. [34], Haley et al. [42], Larheim et al. [39], and Rudisch et al. [43] also agreed that there was a significant relationship between joint effusion and TMJ pain [33]. However, they questioned whether an MRI finding of joint effusion was useful for clinical diagnosis.

5. Marrow abnormalities of mandibular condyle

A number of MRI studies have described abnormalities of the mandibular condyle as being similar to the appearance of osteonecrosis in the femoral head (Fig. 5) [40,45—48]. This has led to the assumption that osteonecrosis can also affect the mandibular condyle [40,45—48]. This entity was discussed long before MRI became available [49], but has remained controversial, as no histologic correlations have been available. A recent study analyzed core biopsies from 50 mandibular condyles and noted that edema and osteonecrosis may occur in the condylar marrow. Histologic evidence of bone marrow edema was also found without evidence of osteonecrosis, suggesting that edema may be a precursor to osteonecrotic development, as known from other joints [50]. The presence of osteonecrosis in the mandibular condyle has not been generally accepted, and osteoarthritis has been discussed as an alternative explanation for these MRI findings in the mandibular condyle [51,52]. This is contrary to the experience with other joints, where osteonecrosis was considered to be a separate entity with a different etiology from osteoarthritis [53]. The principle difference between the two disease entities is that osteonecrosis starts in the bone marrow, and osteoarthritis starts in the articular surface [54,55].

In clinical work, we encounter MR abnormalities in joints that do not exhibit signs of osteoarthritis, and the purpose of our study was to use MR images to analyze the relationship between bone marrow abnormalities and osteoarthritis of the mandibular condyle [56].

Our study [56] revealed that osteoarthritis was seen in 22 of 37 joints with bone marrow abnormalities (Fig. 5), whereas the remaining 15 joints with bone marrow abnormalities showed no MR evidence of osteoarthritis. There was an association between type of bone marrow change and osteoarthritis, and more advanced bone marrow changes (combination of edema and sclerosis) were more frequently seen in joints with osteoarthritis than in joints without osteoarthritis. Edema of the bone marrow without sclerosis was, on the other hand, more frequently seen in the joints without osteoarthritis.

Our analysis of MR images from TMJ patients revealed that nearly one half of joints with MR evidence of bone marrow abnormalities showed normal contour of the mandibular condyle and temporal joint component on MR imaging, which was interpreted as no evidence of osteoarthritis. This indicated that bone marrow abnormalities can be present without

osteoarthritis, and contradicts the suggestions of earlier studies that bone marrow abnormalities were secondary to osteoarthritis [51,52]. We, therefore, have postulated that conditions in the TMJ are similar to those in other joints, namely, that abnormalities suggestive of edema and osteonecrosis in the bone marrow are separate entities from osteoarthritis [50].

In an earlier study, we found that joints with bone marrow abnormalities in the mandibular condyle were markedly more painful than those without [57]. Increased intra-articular pressure in conditions such as synovitis and hemophilia has also been suggested as an etiology for osteonecrosis [53]. A correlation between osteonecrosis and increased joint fluid has also been reported [48,50]. In another study, we suggested that pain was more severe in TMJs with marrow edema of the mandibular condyle than in those with osteonecrosis [58]. However, another study has suggested that bone marrow edema pattern in the mandibular condyle does not always contribute to the occurrence of joint pain in patients with TMJ disorders [59].

In a recent study, we found that symptomatic osteoarthritic TMJ could accompany bone marrow change in the upper portion of the condyle, adjacent to osseous changes, showing increased signals on proton density images [60].

This result, showing increased proton density-weighted signal in TMJ with symptomatic osteoarthritis may reflect early stage edema.

In view of all these findings, osteoarthritis and related entities may be reflected in clinical symptoms of problems with the TMJ, but there is still sometimes a discrepancy between findings obtained by imaging and patient symptomatology [61]. This highlights the need for effective clinical examination in determining which findings are significant.

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