A Prospective Study of Magnetic Resonance and Radiographic Imaging in Relation to Symptoms and Clinical Findings of the Temporomandibular Joint in Children with Juvenile Idiopathic Arthritis

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ABSTRACT. ***Objective.*** In patients with juvenile idiopathic arthritis (JIA) temporomandibular joint (TMJ) involvement is a common cause of severe growth disturbances. Extent of growth deviation depends on age of onset and duration of arthritis in the TMJ. TMJ arthritis is difficult to diagnose at an early stage since relatively few symptoms and clinical findings are related to this joint. The pathologic process can affect growth long before radiographic changes are seen. We investigated the relationship between TMJ arthritis and symptoms and clinical findings to suggest a clinical routine for diagnosing TMJ arthritis. We also describe the course of TMJ arthritis in relation to a commonly used radiographic method versus MRI.

Methods. Fifteen children with JIA were examined 4 times at 6 month intervals for TMJ involvement by clinical examination, MRI-scanning, and orthopantomograms (OPG). At baseline, 10 healthy children served as a control group.

Results. Patients reported more inability to chew and open their mouth than the control group. Translation of the condyle and range of mandibular movements were diminished in the arthritis group. Decreased translation was correlated to condylar changes seen on both OPG and MRI. MRI was superior to OPG in following changes of the condyle over time, and inflammation was detected in nearly all joints.

Conclusion. OPG cannot be recommended for diagnosis or to follow the course of changes in the TMJ. We advocate recording condylar translation and mandibular range of motion as a current clinical routine to find early TMJ arthritis in contrast to the often used OPG performed in our study, which was an uncertain method. (First Release July 15 2008; J Rheumatol 2008;35:1668–75)

Key Indexing Terms:
TEMPOROMANDIBULAR JOINT RADIOGRAPHY EARLY DIAGNOSIS
ARTHRITIS JUVENILE IDIOPATHIC ARTHRITIS

Patients with juvenile idiopathic arthritis (JIA) are at high risk of developing arthritis in the temporomandibular joint (TMJ)[1,2]. It has been demonstrated that whenever TMJ arthritis causes changes in the joint components, mandibular and maxillary growth disturbances follow[3]. Morphology and jaw relationship can be severely affected, as well as dental occlusion [4,5]. The prevalence of resorptive changes has been discussed[1]. Changes in the TMJ and growth disturbances seem in many cases to be a consequence of longstanding chronic arthritis with few symptoms and clinical signs. Early stage TMJ inflammation responds to medical therapy, i.e., disease modifying antirheumatic drugs and intraarticular steroid injections[6,7], but the effects on longterm growth abnormalities are not sufficiently known. Potential for condylar remodeling in the TMJ of patients with JIA has been suggested, and studies on treatment with functional orthopedic appliances[8] may help avoid major growth disturbances, making early diagnosis mandatory[9-11].

We conducted a 2-year prospective study in patients with JIA to (1) suggest a clinical routine to diagnose TMJ arthritis based on possible relationships between enhanced magnetic resonance imaging (MRI), specific subjective and clinical findings, and radiographs; and (2) to describe the course of TMJ arthritis clinically and radiologically on orthopantomograms (OPG) and compare the radiographic findings with MRI.

MATERIALS AND METHODS

Twenty-eight consecutive patients with JIA according to the Durban criteria[12], with disease duration no longer than 3 years and age above 8 years, were chosen for a longitudinal study. The criterion of age > 8 years was chosen for 2 reasons: An earlier study[1] indicates a "latency" period from the time TMJ arthritis starts until changes in the joint appear. We anticipate

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age 8 to 10 years to be important in relation to development of TMJ remodeling and related growth disturbances in JIA patients. The other reason was the need for understanding and cooperation during examination. Written consent from parents in accordance with the Helsinki declaration was obtained from 15 patients, the final study group. The 13 patients who declined to participate did not differ from the study group concerning disease type or activity (their families found it too demanding). The study was approved by the ethical committee.

Four examinations were performed at 6 to 8 month intervals: T1, T2, T3, and T4. Patients were interviewed about a history of the following symptoms: swelling of the TMJ, click sounds from TMJ with mandibular movement, crunch sounds from TMJ with mandibular movement, pain TMJ at rest, pain TMJ at movement, morning stiffness longer than 15 min, muscular soreness, headache, grinding teeth at nighttime, chewing disability, opening ability, neck stiffness, and neck tenderness.

A clinical examination included the following clinical characteristics: neck tenderness, neck stiffness, TMJ swelling, TMJ tenderness with palpation, TMJ clicking, translation of the condylar head, crepitation of the joint, tender chewing muscles, mouth opening capacity, and range of mobility. A clinical examination including the latter characteristics was carried out by the same examiner throughout the study. The examiner was not informed of the result of the radiographs or MRI at the time of examination. Movements of the jaw were considered to be decreased if opening was ≤ 40 mm, laterotrusion ≤ 5 mm, and protrusion ≤ 7 mm[13,14].

All patients were scanned using a 1.0 Tesla Signa Horizon magnet (Siemens, Erlangen, Germany) on the same day as the clinical examination. Three-inch TMJ coils were used preparing 3 mm slices parallel and perpendicular to the long axis of the condyle found after axial scouting. T1-weighted images were obtained before and after injection with a contrast medium (Gadolinium-DTPA, Bayer Schering Pharma, Germany).

OPG were taken in open and closed mandibular positions at the same time as clinical examination. The morphology of the condylar head was assessed according to grade of resorption[1]: 0: no resorption; 1: minor erosions; 2: flattening; and 3: total destruction. The MR-images were blindly evaluated by an experienced radiologist. The evaluation is described elsewhere[2,15].

The results from the interview, clinical examination, radiographs, and MRI were compared for correlations.

As controls, 10 children with a mean age of 11.5 years volunteered for clinical examination, and MRI was done once. For ethical reasons contrast-enhanced MRI was not performed in the control group. Parents of control group children gave their informed consent in writing before participating.

Mantel-Haenzel, Mann-Whitney, Pearson correlation, and t-test or Wilcoxon test were used for statistical testing. For linear measurement, error of the method was estimated in 10 JIA patients in the center, measured twice. The error of the method was < 0.3 mm and largest for the opening capacity.

RESULTS

Symptoms. The patients reported only a few mild symptoms from the TMJ at baseline (Figure 1A). Symptoms fluctuated somewhat in the observation time (Figure 1B).

No subject in the study group or the control group experienced swelling or crunching sounds of the joints at any time before or during the observation period. Symptoms TMJ clicking, TMJ pain at rest, TMJ pain on jaw movement, TMJ morning stiffness, and soreness in chewing muscles were not seen to a significant level compared to the control group (Figure 1A). No differences were seen in relation to change over time for these variables in the patient group (Figure 1B).

Headache and bruxism were found in both groups with no significant difference. Headache was significantly correlated with subjective pain (T1, $p < 0.05$) and observed neck stiffness (T2 and T3 $p < 0.05$) in the study group. There was a significant correlation between bruxism and changes in disc shape and pannus formation in the right joint at T4, where the changes were increased ($p < 0.05$). Stiffness and pain of the cervical spine were reported from 47% and 53%, respectively, in the patient group. Cervical symptoms were not found in the control group. The symptoms from the cervical spine were stable during the period. A positive correlation was seen between subjective stiffness and pain with palpation in the cervical column at all 4 examinations ($p < 0.01$).

The patient group differed significantly from the control group in having impaired chewing ability ($p < 0.05$, Mann-Whitney) and opening capacity ($p < 0.05$, Mann-Whitney). Chewing function was improved from T1 through T3. Changes were not significant and were not correlated to any MRI or radiographic findings. Decreased opening capacity disappeared at T3. From T3 to T4 it slightly increased again. No correlations were found according to MRI or radiographic findings.

Clinical findings

Cervical spine. Tenderness of the cervical spine was a frequent finding but decrease of mobility was rarely seen, 53.3% and 20%, respectively. Tenderness varied through the observation period to 66.7% at T4 while mobility was almost constant. No clinical abnormality was found in the cervical spine in the control group. The difference between the occurrence of tenderness in the JIA versus control group was significant ($p < 0.005$, Mann-Whitney).

Temporomandibular joint (Table 1). Swelling of the TMJ was not seen in patients or controls. Joint tenderness increased slightly but not significantly during the observation period but at T4 no increase was seen. There was no correlation between tenderness on palpation and MRI variables or radiographic findings. In the control group tenderness was not found.

Joint clicking was constant during the 2 years, while there was a decrease from T1 to T2, although not significant. Crepitation that was observed in very few joints disappeared at T3. Clicking was not found in the control group. One patient in the control group had crepitation in one joint, and the MRI in this patient showed changes in disc position in both joints. No significant difference in crepitation was seen between the groups.

Decreased translation of the condylar head was seen in almost half the joints, and this significantly improved from T1 to T4 ($p < 0.05$). Decreased translation was correlated to reduced mouth opening capacity. At T1 decreased translation in the right joint correlated to less opening capacity and protrusion ($p < 0.05$), and at T2, T3, and T4 to laterotrusion ($p < 0.014$). At T3 and T4 changes in disc shape (MRI) were

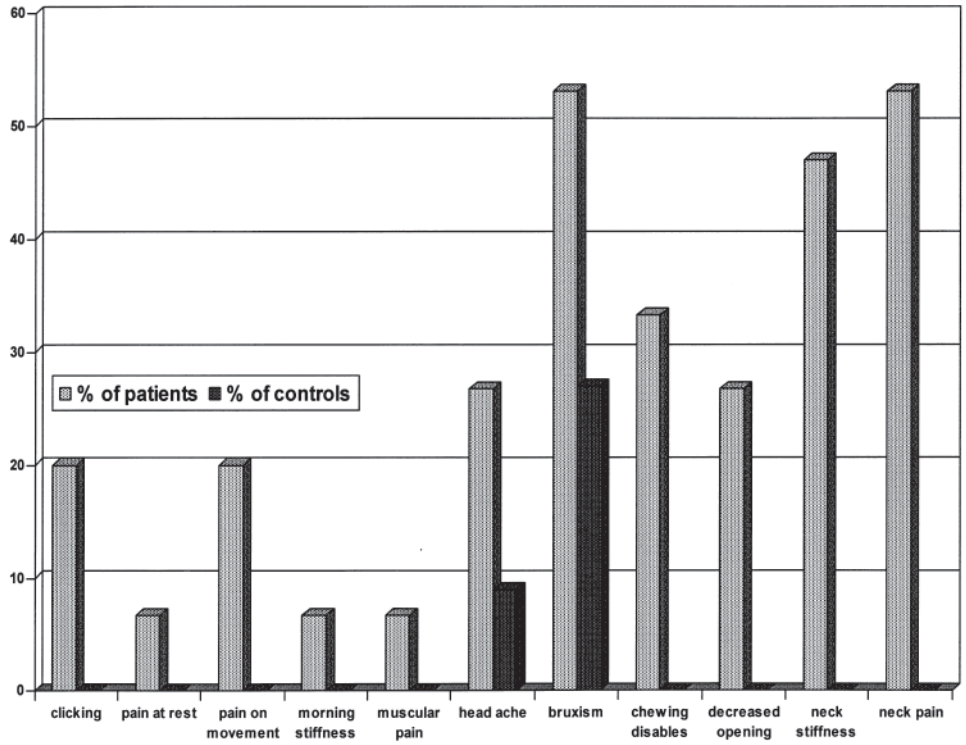

Figure 1A. Prevalence of symptoms in patients and controls.

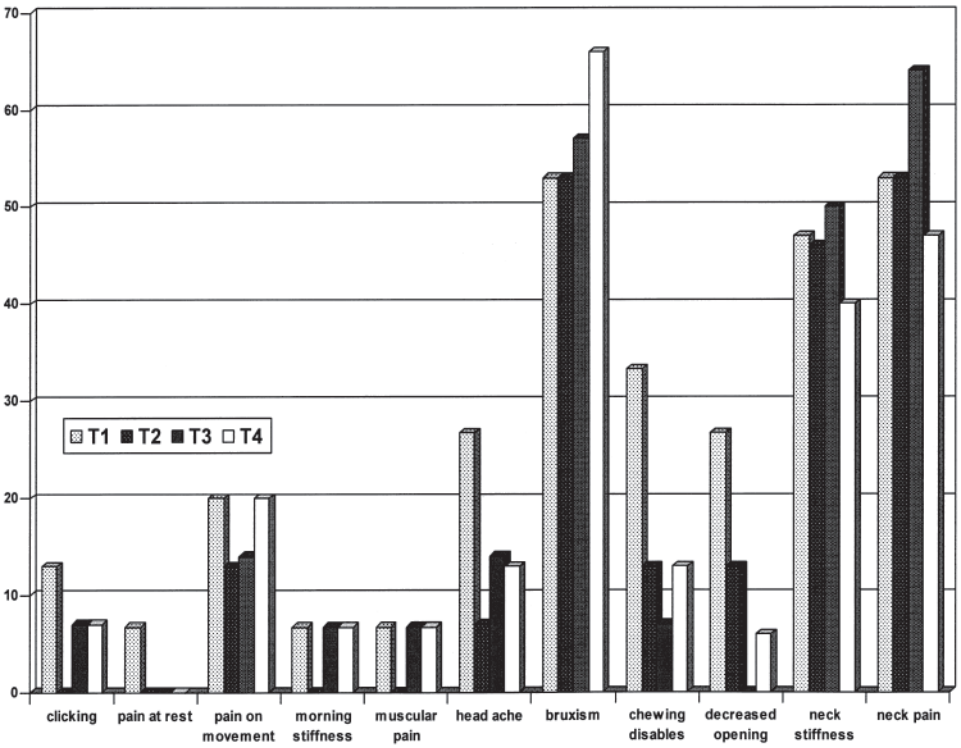

Figure 1B. Fluctuation of symptoms in the patient group.

Table 1. Objective clinical findings in the TMJ at time T1 to T4. Values are percentages of the total number of joints.

Clinical Findings	T1	T2	T3	T4	Control
Joint tenderness, %	7	20	14	7	0
Joint clicking, %	7	3	7	7	0
Translation decreased, %	43.3	30.0	25.0	13.3*	0
Crepitation, %	7	7	0	0	1

* T4 < T1 $p < 0.01$.

related to translation ($p < 0.05$). Through the observation period, decreased translation was significantly related to resorptive changes of the condylar head as diagnosed on MRI ($p < 0.04$) and on radiographs ($p < 0.015$). All patients in the control group had full translation in both joints. Translation was significantly diminished for the patient group compared to the control group ($p \leq 0.02$ Mann-Whitney).

Masticatory muscles. Moderate tenderness of the chewing muscles over the 2-year period was seen in 2 patients (13.3%), and no significant changes were observed over time. In the control group one (9.1%) individual had muscular tenderness that was not significant.

Range of jaw mobility (Table 2). Opening capacity was decreased for 3 patients at T1. The opening capacity increased significantly during the observation period. Only 2 patients had asymmetry on mouth opening. One had decreased translation on the right side thus deviating to the right when opening, which was persistent throughout the study. The other patient had transient absence of translation in both joints and deviated on opening to the left. The opening capacity and condylar resorption were significantly related, as shown on MRI and OPG ($p \leq 0.03$) at T1. For OPG the relation remained significant throughout the study but was no longer significant for MRI at T2–T3. Compared to the control group patients had significantly less opening capacity at T1 ($p < 0.002$), T2 ($p < 0.03$), and T3 ($p < 0.06$), but not at T4.

In the study group, laterotrusion, as well as protrusion, was constant both to the right and left side. The correlation between laterotrusion and condylar resorptions did not show clear relationship. No differences were seen in relation to the control group.

Asymmetry on protrusion was seen in 3 patients at T1. Two had obvious resorptive changes in the joints and one only had enhancement seen on MRI. Correlation between protrusion and condylar resorption was seen only at T1 ($p < 0.05$). There was no difference between patients and controls.

TMJ condylar changes (Table 3). Radiographic findings seen on OPG did not change during the period. Flattening of the condylar head was observed in 30% of the joints. Extended resorption (grade 2) was seen in 23.3% of the affected joints. However, no total resorption (grade 3) was seen in this sample. The frequency of radiographic changes was significantly lower than those seen on MRI ($p \leq 0.003$). The condylar abnormality seen on MRI increased with time, ending with resorptions in 80% at time T4 ($p < 0.01$). We found concordance between OPG and MRI for grade 2 resorptions but not for grade 1 changes. Only one patient did not develop condylar changes, as shown on MRI, during the 2 years.

MRI findings (Table 4). The shape of the discus changed from normal to flat over time, but not significantly. However, the changes in disc shape correlated to the increased condylar erosions over time ($p < 0.018$).

Abnormal disc position was seen in only one patient. The disc was located anteriorly in the right joint at T1, but normalized at T2, where it became flat. In the control group 3 joints were seen with a flattening of the disc and 3 joints with changed disc position. There was no significant difference in disc shape or disc position between patient and control group.

Enhancement of the synovial membrane after injection of GDTPA was seen in almost all joints, pannus formation in 20 to 30%, and joint fluid accumulation in 13 to 31%, but with no significant changes over time.

No erosions, pannus, or joint fluid were seen in the control group.

DISCUSSION

Former studies indicate involvement of the TMJ in 60% of cases[1], but our study shows TMJ involvement more often than previously anticipated when observed as radiographic changes alone. The progression of changes in condylar morphology is characteristic of JIA where early changes cause

Table 2. Objective functional findings of jaw mobility at T1 to T4. Values are mean ± SD, in mm. The opening capacity of the control group was significantly different ($p < 0.05$) at T1, T2, T3.

Functional Findings	T1	T2	T3	T4	Control
Opening capacity	44.7 ± 7.1	47.9* ± 7.5	48.3** ± 8.1	50.7*** ± 8.6	53.7 ± 2.7
Laterotrusion right	8.8 ± 2.4	8.5 ± 2.6	8.5 ± 3.5	9.3 ± 2.2	9.6 ± 1.6
Laterotrusion left	8.5 ± 1.8	8.6 ± 1.9	8.4 ± 3.0	8.4 ± 1.7	9.1 ± 2.6
Protrusion	8.6 ± 2.4	8.5 ± 2.0	8.4 ± 1.4	8.1 ± 2.3	8.9 ± 3.1

* T1 < T2 $p < 0.002$; ** T3 < T4 $p < 0.007$; *** T1 < T4 $p < 0.002$.

Table 3. Changes in the condylar head found on OPG and MRI at T1–T4. Values are percentages of joints.

Resorptive Changes	T1		T2		T3		T4		Control	
	OPG	MRI	OPG	MRI	OPG	MRI	OPG	MRI	OPG	MRI
TMJ changes, %	30	58.6	30	72.4	30	74.1	30	80.0	—	0
Grade 1, %	6.7	37.9	6.7	48.3	6.7	48.1	6.7	50.0	—	0
Grade 2, %	23.3	20.7	23.3	24.1	23.3	25.9	23.3	30.0	—	0
Grade 3, %	0	0	0	0	0	0	0	0	—	0

Table 4. MRI findings at T1-T4. Values are percentages of joints.

MRI	T1	T2	T3	T4	Control
Abnormal disc shape, %	20	26.7	26.7	33.3	15.8
Abnormal disc position, %	3.3	0	0	0	15.8
Enhancement, %	93.1	96.6	92.6	90.0	—
Pannus, %	20.7	27.6	29.6	26.7	0
Joint fluid, %	13.8	31.0	18.5	23.3	0

impaired function, the most important clinical sign of TMJ arthritis. Joint function can improve even though condylar changes increase over time. Involvement of the TMJ has a chronic course over a long period with mild, fluctuating symptoms and clinical findings. The interindividual variation in the features is high and fluctuates with time.

MRI is increasingly used for current evaluation of the TMJ; for previous studies it was used to evaluate subjective symptoms and clinical signs, before and after steroid injections[7]. The present study is the first longitudinal study of symptoms, clinical findings, and radiographic changes evaluated by MRI to investigate relations between clinical examination and inflammation in the TMJ.

That involvement of the TMJ in JIA causes growth disturbances of the temporomandibular complex has been well documented[3-5,16]. However, micrognathia was not seen among our patients, probably because the children had a relatively short disease duration (< 3 yrs) and we previously demonstrated that destruction of the TMJ is strongly dependent on disease duration[1].

Despite destructive changes of the TMJ observed by OPG and MRI, only sporadic symptoms were observed as listed above. It has been shown that in a group of 706 healthy school children 14 to 16 years old, the prevalence of moderate functional symptoms in the masticatory system (joint clicking, pain, tenderness of masticatory muscles, decrease in movement capacity) was 19% and for severe symptoms 11%[17]. The symptoms found in our present JIA group could therefore be related to common functional problems. These findings also correspond with earlier studies where symptoms were uncommon in young arthritis patients but more frequent in older patients with JIA[18]. It has been reported that even severe destruction of the condylar head does not necessarily cause pain[19]. Thus, symptoms reported by patients are not sensitive variables for determining whether there is early arthritis in the TMJ. In younger age groups, the rare cases of symptoms may be a sign of acute inflammation, while in older children symptoms originate from either non-arthritis related TMJ disorders or dysfunction caused by alteration of condylar morphology and joint reorganization.

Overload and functional disturbance causing derangement of the TMJ is a common feature in healthy individuals[20,21], and all patients in our study, except one, had signs of bruxism (attrition facets), which may cause TMJ derangements[22]. Headache might be correlated to tension in the chewing muscles but in our group headache was correlated to pain or stiffness in the cervical spine. On the other hand, the clinical findings indicated more pronounced signs of impaired function in the arthritis group compared to the control group, increasing the risk for tension in the chewing muscles.

Classical inflammatory signs such as swelling and tenderness occurred rarely, but range of motion based on mouth opening capacity was clearly decreased, explained by the high occurrence of condylar resorption/remodeling. The correlation between decreased opening/condylar resorption was clear for resorption seen on OPG and for MRI at T1, which suggests a diagnostic value for opening capacity similar to that for OPG; although abnormalities develop, function does not constantly decrease. This significant relation remained for OPG at later examinations since no changes occurred in the relation of condylar resorptions/opening ability, except for increase in opening. The relationship disappeared for the MRI findings since there was development in these findings for all the patients, indicating that opening capacity was no longer a sign of condylar remodeling since nearly all patients presented changes in the TMJ. The term destruction or resorption of the condylar head might be an imprecise designation. Remodeling, reorganizing, or growth disturbance of the condyle is a possible explanation for the fact that function improves but MRI condylar changes increase. Decreased opening capacity could be a clinical sign of a subacute stage in the inflammatory process followed by developing MRI changes where remodeling or reorganizing improves function at a later stage.

For laterotrusion the difference versus the control group was not as evident as for the opening capacity (Table 2). Tenderness on palpation of the muscles was not seen very often; a finding evident in earlier studies[18], but it was a

slightly more common finding in the arthritis group compared to the control group. This could be considered to be a reaction of functional problems in the masticatory system in the patients. The ability to open the mouth increased during the 2 years and was similar to the control group at the last examination. Adult JIA patients have prevalence of condylar radiographic changes similar to children[23], and although TMJ abnormalities seem to be a condition under continuous remodeling[24] and these abnormalities restrict opening capacity, the joint may adapt in order to function, resulting in an increase in opening capacity.

One of the most significant clinical findings was the decrease in palpable translation of the condylar head during mouth opening. Translation increased over time and function improved (Table 1). A significant increase in opening was seen together with increased translation over time. The decrease in translation can be considered a result of the erosive and reorganizing process of the condyle. It has been suggested that, when noticeable changes are seen, movements of the TMJ only take place in the upper joint compartment[19]. A consequence of this assumption emphasizes the value of the clinical impression of the movement of the

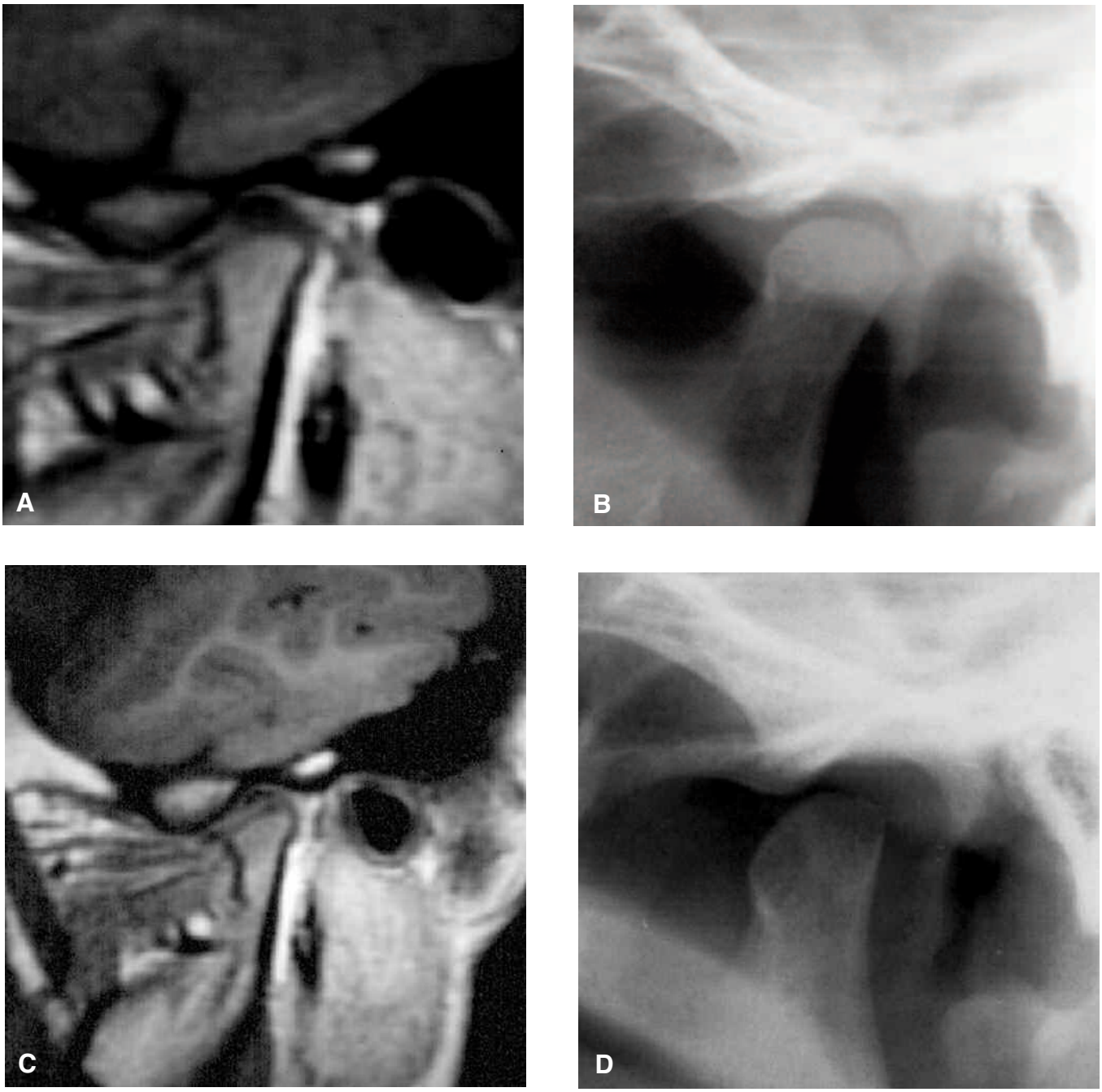

Figure 2. Development of condylar destruction seen on MRI (A and C) and OPG (B and D) at T1 and T4.

condylar head in relation to early degenerative changes in the joint, but we were not able to find any relation between a decrease in translation and MRI enhancement, indicating that changes in translation alone will not directly reflect inflammatory changes. Therefore, translation alone cannot be used as an indicator for inflammation. As the joint reorganizes, translation improves. For T2–T3 the amount of laterotrusion seems to correlate to translation. It was indicated that laterotrusion to the left was influenced by decreased translation in the right joint, and vice versa.

Condylar destruction was seen on radiographs in 30% of patients. This is a low prevalence compared to other studies showing about 60% of involved joints[1,25]. This might be explained by the inclusion criteria (disease duration not longer than 3 yrs) since it has been shown that the prevalence of condylar erosions increases with early onset[1]. Also, the relatively high number of extended resorptions (grade 2) found on MRI was remarkable. Concordance was seen between OPG and MRI for grade 2 changes but not for grade 1, indicating low sensitivity of OPG compared to MRI. As it can be seen from Table 3, the radiographic impression of the destructive process in the joints was not changing. If this is compared with the impression on the MRI significant dynamic changes and resorption took place in the joints in spite of normal impression on the OPG (Figure 2A–D). Whenever changes could be seen on OPG, they could also be found on MRI, while the opposite was not the case. In some cases destruction could not be diagnosed on OPG during the observation period, while critical developments could be seen on MRI (Figure 2A-D). The difference between OPG and MRI was distinct where the resorptions were minor, indicating higher sensitivity for MRI in detecting modest changes. Changes on OPG in the example in Figure 3 were evident 2.4 years after T4 (Figure 2B). We therefore consider OPG to be without diagnostic value when the aim of examination is to detect early changes in the TMJ. Also, OPG is unsuitable for following changes in the joint over a short time; however, the technique can still be useful for prevalence studies and screening procedures.

Figure 3. OPG taken 2.4 years after T4, at which time the first changes were seen on MRI (Figure 2A-D).

Injection of gadolinium demonstrates an inflammatory state in the joint on the MR image but could also be the result of other types of TMJ disease, i.e., temporomandibular disorders. For ethical reasons the control group did not have MRI examination using contrast medium, but other signs of TMJ pathology, pannus formation, and joint fluid found in the study group, were not seen in the control group. We previously described gadolinium-DTPA injections and MRI in healthy individuals and no enhancement was seen[15].

MRI of the TMJ revealed a current process changing joint components resulting mainly in destruction of the condyles, but also with changes to the temporal bone and in the shape of the discus as described[26]. On the other hand, these changes might be expected also to be part of a reparative development[10,26]. This balance between destruction and repair may have potential for effect of treatment with functional orthopedic appliances to minimize growth disturbances due to TMJ involvement.

Diagnosis of TMJ arthritis presents an extraordinary problem in the treatment of specific facial growth disturbance caused by destruction and impaired function of this joint. Our present study indicates that subjective symptoms underestimate inflammatory TMJ findings. Inflammation seems to start early in the course without causing symptoms, while changes due to resorption/remodeling and resulting temporomandibular dysfunction cause symptoms at a later age. Thorough clinical examination is recommended every 6 months in active arthritis cases, with focus on regular measurement of mandibular movement (opening capacity) and translation in the joint, as important for establishing TMJ involvement. Measurements should be compared over time, with decrease in functional status indicating arthritis of the TMJ. MRI can be recommended for diagnosis of inflammation and condylar growth alterations. OPG is not valid for diagnosing condylar destruction since changes are not seen until long after involvement of the joint; OPG can therefore only be recommended for following diagnosed cases on a longterm basis.

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