A 2 Year Followup Study of Enhanced Magnetic Resonance Imaging and Clinical Examination of the Temporomandibular Joint in Children with Juvenile Idiopathic Arthritis

ANNELISE KÜSELER, THOMAS KLIT PEDERSEN, JOHN GELINECK, and TROELS HERLIN

ABSTRACT. ***Objective.*** Involvement of the temporomandibular joint (TMJ) in patients with juvenile idiopathic arthritis (JIA) can cause severe craniofacial growth disturbances if not treated in the initial stage. Magnetic resonance imaging (MRI) is an efficient method for detecting early inflammatory changes of the TMJ. We investigated correlation between findings from the clinical examination with MRI of the TMJ, and describe development of the MR image over time.

Methods. Fifteen children with newly diagnosed JIA (mean age 12.0 yrs) were examined clinically and with MRI enhanced with Gd-DTPA 4 times at 6–8 month intervals. Clinical and MRI findings were scored. MRI variables included T1 weighted images before and after administration of Gd-DTPA with and without fat suppression.

Results. A total of 115 joints were examined during the 2 year period: 93% showed enhancement, 71% condylar erosions, 26% pannus, and 23% joint fluid accumulation of the TMJ. In all except one child, one or both TMJ showed enhancement of the synovial membrane during the examination period. Symptoms were rare. All patients showing mild to severe findings by clinical examination also had pathological signs on the enhanced MRI, but not all patients without clinical findings had a normal MRI.

Conclusion. TMJ involvement in patients with JIA is very common, and MRI findings such as synovial enhancement, pannus, and joint fluid fluctuate over time. The clinical examination may be used as a filter, where children showing no clinical signs could be selected for enhanced MRI. (J Rheumatol 2005;32:162–9)

Key Indexing Terms:
TEMPOROMANDIBULAR JOINT
MAGNETIC RESONANCE IMAGING
JUVENILE CHRONIC ARTHRITIS
GADOLINIUM-DTPA

Involvement of the temporomandibular joint (TMJ) is reported to be seen in over 50% of patients with juvenile idiopathic arthritis (JIA)[1-3]. TMJ involvement can cause severe craniofacial growth disturbances resulting in micrognathia and so-called "birdface," whereas early treatment with a functional appliance, such as the distraction splint, may be able to limit these growth changes[3]. TMJ involvement in the early stages is often without subjective symptoms and has previously been considered to be without clear clinical signs. The problem is to detect the onset of the inflammatory changes of the synovial membrane. It has been reported that enhanced magnetic resonance imaging (MRI) is an efficient technique for diagnosing early inflammatory changes of the TMJ in patients with JIA[2] and in adult patients with rheumatoid arthritis (RA)[4,5]. It would be important to know if results of the clinical examination can be correlated with these early inflammatory changes, since it does not seem realistic to perform Gd-DTPA enhanced MRI in all children with JIA.

We compared clinical examination findings with MRI of the TMJ by following a group of patients with JIA diagnosed within 3 years for a period of 2 years. We introduce a clinical index for TMJ involvement in patients with JIA to be able to classify which patients could benefit from further diagnostic methods in order to be able to diagnose involvement of the TMJ as early as possible. In addition, we describe the development of the MRI image over time to follow alteration of the TMJ components in children with JIA.

From the Department of Orthodontics, Department of Radiology, and the Paediatric Rheumatology Clinic, University of Aarhus, Aarhus, Denmark.

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A. Küseler, PhD, DDS, Specialist in Orthodontics; T.K. Pedersen, DDS, PhD, Specialist in Orthodontics, Department of Orthodontics; J. Gelineck, MD, Associate Professor, Department of Radiology; T. Herlin, MD, PhD, Associate Professor, Paediatric Rheumatology Clinic.

Address reprint requests to Dr. A. Küseler, Department of Orthodontics, Royal Dental College, 9 Vennelyst Boulevard, DK-8000 Aarhus C, Denmark.

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MATERIALS AND METHODS

Subjects. Out of 28 children aged 8 years and older diagnosed within the previous 3 years, 15 children agreed to participate. The 13 children that declined did not differ with respect to subtype or disease activity in general, but refused because they found participating too time consuming. All children had JIA according to the Durban classification criteria (ILAR)[6]. Mean age at the start of the investigation was 12.0 years (range 8–15). Two had systemic onset, 9 had oligoarticular onset, and 4 had polyarticular onset JIA. Two patients received methotrexate and prednisolone, 4 sulfasalazine, and 9 nonsteroidal antiinflammatory drugs (NSAID). One child was HLA-B27 positive. All children except one were rheumatoid factor (RF) negative. Laboratory data concerning hemoglobin and sedimentation rate were within normal ranges, except in 2 patients who had increased sedimentation rate and low hemoglobin. All patients except 2 showed either no or only slight (one or 2 active or swollen joints) involvement of other joints. We included patients older than 8 years with a disease duration not exceeding 3 years, in order to investigate children with relatively short disease duration who were able to cooperate during the MRI.

Clinical examination. Clinical examinations were performed together with MRI the same day for 4 times with 6–8 month intervals. The same orthodontist carried out the clinical examination of the TMJ, and the numbers of active joints (not including the TMJ) were recorded by a pediatric rheumatologist. Patient history regarding the TMJ was recorded and a thorough clinical examination was performed. The index we used in this study was based on weighting each clinical finding according to swelling, tenderness, and limitation of movement and was a modified version of the Helkimo index[7].

In the patient history there were questions about joint pain at rest, decreased opening capacity, presence of morning stiffness, pain on motion, decreased chewing capacity, and click or crepitations in the joints. Regarding the clinical examination, swelling was recorded as well as tenderness of one or both of the joints on palpation. The joints were palpated laterally and dorsally. Decreased opening capacity was recorded with a ruler as an opening capacity ≤ 40 mm by asking the patient to open as wide as possible and measuring between the central incisors adding the vertical overbite[8]. Decreased translation was recorded whenever no translation or decreased translation in one or both joints was palpated. Decreased laterotrusion was recorded when the patient was able to laterotrude (sideshift) ≤ 5 mm to either left or right[8]. Asymmetric opening as well as asymmetric protrusion were recorded when the movement was not completely straight. Decreased protrusion capacity was recorded when the patient was able to protrude only 7 mm or less (measuring between upper and lower incisors adding horizontal overjet)[8]. Click or crepitation was recorded when sounds were present in one or both joints. Presence of facial asymmetry was recorded when the patient showed an asymmetry of either the mandibular base or the height of the ramus, or when the chin was deviating to one side. Pain in jaw muscle was recorded when the patient expressed tenderness in one or several of the muscles palpated. These muscles included mm. temporalis vertical, horizontal and the temporal fascie, mm. masseteres superficialis and profundus, and mm. pterygoideus internus and externus. Scores are illustrated in Table 1. Whenever possible, a score for both joints was recorded. Maximum score for symptoms was 18 and maximum score for clinical findings was 34, giving a total possible maximum score of 52.

MRI. The MRI was carried out using a 1.0 Tesla Signa Horizon magnet (General Electric). The examination was performed with a dual TMJ coil with 3 inch coils around the TMJ. Imaging parameters included slices 3 mm thick with a 1 mm gap, 256 × 192 matrix, and a 17 cm field of view. An axial scout was made to find the long axis of the condyle. Oblique T_1 weighted images were made perpendicular to the long axis of the condyles. Oblique T_1 weighted images were made without and with fat suppression, TR/TE: 400/16 and 400/16, respectively, and coronal T_1 weighted images with a TR/TE: 400/15. T_1 weighted images were performed before and after injection of gadolinium-DTPA (Schering) 0.2 ml/kg into a cubital vein. Postcontrast examinations consisted of oblique sagittal T_1 weighted images with fat suppression and coronal T_1 weighted images. The MRI examination was completed in about 60 min.

Table 1. Scores for each symptom or clinical finding.

	Score		
	Right TMJ	Left TMJ	TMJ
Symptoms			
Pain at rest	3	3	
Decreased opening			3
Morning stiffness			2
Pain on motion	2	2	
Decreased chewing capacity			1
Click/crepitation	1	1	
Clinical findings			
Swelling	3	3	
Tenderness	3	3	
Decreased opening ≤ 40 mm			3
Decreased translation	2	2	
Decreased laterotrusion ≤ 5 mm	2	2	
Asymmetric opening			3
Asymmetric protrusion			2
Decreased protrusion ≤ 7 mm			2
Click/crepitation	1	1	
Facial asymmetry			1
Pain in jaw muscle			1

An experienced radiologist assessed all MR images blindly after the last examination was finished. The variables evaluated were enhancement of the synovial membrane, condylar morphology, presence of pannus, and intraarticular fluid. Enhancement of the synovial membrane was defined as an increase in signal intensity of the synovium comparing the precontrast image with the postcontrast image (about 8 min after contrast injection). Pannus was defined as an intermediate signal of intraarticular mass on the precontrast T_1 weighted images. Intraarticular fluid was defined as low signal intensity mass within the joint cavity. Disc position and disc morphology were not scored, since studies have shown that alterations in these features are a common phenomenon also seen among healthy children[2] and healthy adults[9]. On the other hand, disc position is often normal in joints with chronic arthritic disease involvement[10]. The MR variables were scored as follows for each joint: enhancement (0 = no enhancement, 1 = slight enhancement, 2 = strong enhancement), condylar morphology (0 = no erosions, 1 = mild erosion, 2 = severe erosion), pannus (0 = no visible pannus, 1 = small amount of pannus, 2 = large amount of pannus), and intraarticular fluid (0 = no fluid, 1 = small amount of fluid, 2 = large amount of fluid). The maximum total MR score could therefore be 8 per joint or 16 per patient.

The study was performed in accord with the Declaration of Helsinki[11].

The first to fourth examination was defined as examination at time 1–4, respectively.

Control group. Five asymptomatic healthy adults volunteered to follow the MRI protocol and were MR scanned. These volunteers were selected among the persons working with this project. They had no clinical signs or symptoms of TMJ disturbance. The precontrast MRI showed an anteriorly displaced disc in 2 condyles in 2 different persons. These 2 persons were not scanned with contrast agent and were excluded from further examination. The 3 persons with no pathological signs on the precontrast image were scanned with Gd-DTPA following the same MR protocol as the children and served as a control group. The postcontrast images revealed no enhancement of the synovial membrane or any other pathological findings in condyles in the control group.

Statistics. A linear correlation analysis was performed in order to verify any correlation between total MRI score and total clinical score.

RESULTS

MRI of the TMJ was performed 4 times in 15 children. Since one child missed one appointment, a total of 118 joints were examined with MRI. Motion artefacts excluded 3 examinations, leaving 115 joints with value for assessment. One child missed one clinical examination, giving a total of 59 clinical examinations. Clinical examinations of the TMJ were performed together with the MRI, but on 3 occasions, MRI and clinical examination were assessed with an interval of more than 2 weeks and therefore not included. In total, 56 MRI examinations were performed together with clinical examinations over a period of 2 years.

Symptoms. Looking at each examination separately, no symptoms were reported in (41/59) 69.5% of subjects, mild symptoms (score 1 to 4) in (12/59) 20.3%, and severe symptoms (score ≥ 5) in (6/59) 10.2% (Figure 1). Looking at each individual child, 7 children showed no symptoms at all. Eight children reported symptoms related to the TMJ, and 2 of these children reported severe symptoms at one or more of the consultations (Table 2). One child reported severe symptoms at all 4 examinations.

Clinical findings. During examination we observed no clinical findings (score 0) in (15/59) 25.4%, mild abnormalities (score 1 to 4) in (19/59) 32.2%, and severe symptoms (score ≥ 5) in (25/59) 42.4% (Figure 1, Table 2). Looking at each individual child, all except 2 showed some kind of clinical sign of TMJ involvement and 8 children showed severe clinical findings at one or more of the examinations. Five of these children showed severe signs at all 4 examinations.

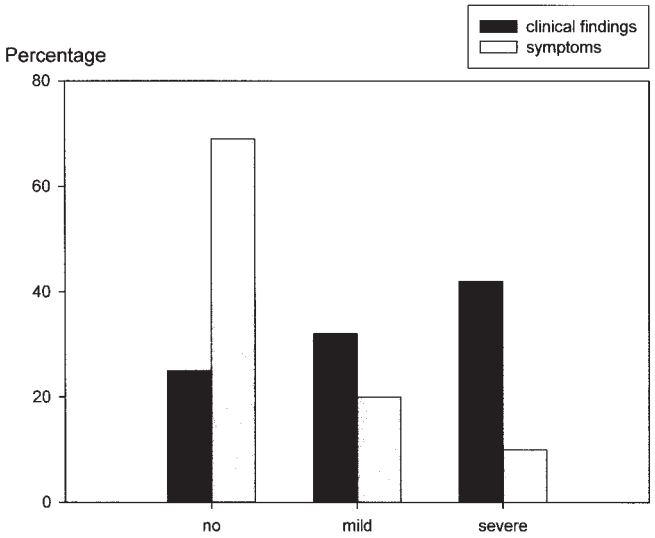

Figure 1. Scoring of symptoms and clinical findings in percentage of all examinations (n = 59) in the 15 patients. No symptom or clinical finding is defined as score 0, mild symptoms or clinical findings score 1 to 4, and severe symptoms or clinical findings score ≥ 5.

The 2 children with no clinical findings at any examination also did not report any symptoms (Table 2).

MRI examination. Of the total 115 joints examined with MRI, 107 (93%) joints showed enhancement after gadolinium uptake, of which 42 joints showed slight enhancement (37%) and 65 (57%) showed strong enhancement (Figure 2). Erosions were seen in 82 joints (71%), of which 54 (47%) were mild erosions in the cortical bone and 30 (26%) were severe erosions (Figure 3). Thirty joints (26%) showed pannus and 26 joints (23%) showed increased amounts of joint fluid. Mean scores for enhancement and erosion over time are shown in Figure 4.

No enhancement was found in only 3/56 MRI examinations (5%) and this was in the same child (Patient 3, Table 2); this was one of the patients without symptoms or clinical signs. In all other children, the MRI examinations showed a score of one or greater (Table 2). Three children had the highest score for enhancement at all 4 examinations (Patients 5, 7, and 13, Table 2) and 3 children had the highest score for erosions at all 4 examinations (Patients 7, 11, and 13), 2 of them being identical.

All joints showing pannus had enhancement of the synovial membrane. Pannus was seen in 10 patients and joint fluid accumulation was seen in 13 during the observation period. Looking at the single joint over time, the results showed that all the MR indicators except erosions fluctuated over time (Figure 4).

Only one joint had a total MR score of zero during all 4 MRI examinations, and the contralateral joint in this patient had a zero score at time 1, 3, and 4. At time 2, slight enhancement and increased amount of joint fluid could be seen on the MRI. This patient did not report any symptom at any time, or any clinical findings (Patient 3, Table 2).

All patients where the clinical examination showed moderate or severe signs of TMJ involvement had some pathological signs on the MRI, but not all patients with no or mild findings in the clinical examination revealed an MRI score of 0: in fact, 10 patients revealed a clinical score ≤ 4 during the 4 examinations and all of them except one (Patient 3, Table 2) revealed definite MRI changes.

We found no correlation between total MRI score and total clinical score (Figure 5).

Subtypes. The limited number of patients in the study did not allow us to differentiate between subtypes of JIA. However, one child with HLA-B27 positive JIA was the patient with the lowest MRI scores throughout the study and the only child without clinical findings at any examination.

Control group. The 3 adult volunteers without symptoms or clinical signs of TMJ involvement showed no enhancement of the synovial membrane.

DISCUSSION

Studies correlating changes in MRI results in joints other than the TMJ with histological findings have shown that

Table 2. Scores for symptoms, clinical findings, enhancement, and total MRI findings for each patient at all 4 examinations.

Patient	Symptoms (range 0–18) Time				Clinical Findings (range 0–34) Time				Enhancement Score (range 0–4) Time				Total MRI score (range 0–16) Time			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	0	0	1	1	2	2	3	3	2	3	3	4	4	8	8	8
2	0	0	0	0	4	10	9	9	2	4	3	2	4	8	6	9
3	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0
4	0	0	0	0	0	0	0	0	3	4	3	4	9	9	9	7
5	1	1	0	0	3	3	3	3	4	4	4	4	9	6	7	8
6	0	0	0	0	0	0	1	0	2	4	4	3	2	8	7	8
7	0	0	0	0	5	11	1	3	4	4	4	4	10	10	11	10
8	0	0	0	0	3	1	1	1	3	3	—	3	4	6	—	6
9	3	7	—	5	5	9	—	6	2	—	—	1	3	—	—	1
10	0	0	0	0	6	6	6	6	3	2	3	3	6	4	4	3
11	0	4	2	0	0	4	5	1	—	3	4	4	—	7	8	10
12	0	4	4	4	9	8	10	10	3	3	4	4	6	7	9	8
13	3	0	0	0	10	12	14	12	4	4	4	4	8	8	8	14
14	0	0	0	2	0	0	2	0	2	4	2	2	2	5	3	4
15	17	9	9	11	10	8	6	6	2	3	2	4	5	7	4	7

enhancement of the synovial membrane on MRI is related to synovial inflammation[12-14]. Animal studies of TMJ arthritis comparing histological findings with MRI support this conclusion[15]. Further, the control group in this study, consisting of 3 adults with no signs or symptoms of TMJ disorders, revealed no enhancement on the postcontrast MRI. A limitation of this study is, of course, that the control group consisted of adults and not age matched children. It was not possible to obtain contrast enhanced MRI of healthy children for ethical reasons, and no group of children without JIA examined by MRI with contrast of the TMJ has been described in the literature.

The patients in our study were diagnosed within the 3 years before inclusion. They were diagnosed due to arthritis in joints other than the TMJ, and it was therefore surprising to see that the majority already had signs of TMJ involvement on the first MRI. Although few patients reported symptoms during the 2 years this study was running, all except one had clear pathological signs determined on the MRI. We also found a relation between erosions of the TMJ verified by MRI and orthopantomograms (OPG) of the children in this study; however, the radiographic findings demonstrated an important delay in time compared to the contrast enhanced MRI[16], and it seemed as if the MRI is more sensitive in detecting hard tissue changes, in agreement with the findings of Larheim, *et al*[17]. Four children had severe erosions on the TMJ at first examination. It is therefore possible that TMJ involvement will occur early during the disease course, with activity continuing for many years without presenting symptoms or clinical signs. Celiker, *et al*[18] verified TMJ involvement by means of MRI in arthritis patients with no clinical signs of TMJ disorders; and Lindegaard, *et al*[19] found that synovial hypertrophy on contrast enhanced MRI could be observed in a considerable number of joints (not TMJ) with no clinical signs in patients with recent onset RA. Suenaga, *et al* demonstrated that synovial proliferation, condylar bone marrow involvement, positional change of the disc, and joint effusion were early findings in the TMJ of adult patients with RA[4]. Synovial proliferation or enhancement and joint effusion were also observed in our study. Condylar bone marrow enhancement was not considered for evaluation in our study protocol because during growth in children the condylar head is covered by cartilage, which does not enhance post contrast. Suenaga, *et al* also verified positional change of the disc[4], but other studies show that this feature is a common phenomenon among healthy children[2,20] and therefore is not characteristic for TMJ involvement in this patient group only.

The mean enhancement of the synovial membrane increased from time 1 to time 2, but did not increase further at times 3 and 4. It therefore seems that the inflammatory process in the TMJ starts rather early after JIA has been diagnosed, and then continues without changes in intensity. Apparently, as a result of inflammatory activity of the synovial membrane, the score for erosions increased over time as a sign of a continuing destructive process of the bony structures more or less independent of the acute signs of inflammation as revealed by the enhancement score.

About one-fourth of all the joints in this study showed pannus and the mean pannus score was fairly stable during the 2 years. A majority of the patients will have pannus at some time. Pannus of arthritic joints is often associated with erosions[21]. In this study, pannus was found not only in the severely affected joints where a chronic stage has been reached, but also in joints with small erosions and strong

A

B

Figure 2. MRI of the TMJ (A) before contrast injection, (B) after contrast injection showing slight enhancement (arrow). Note no dislocation of the disc.

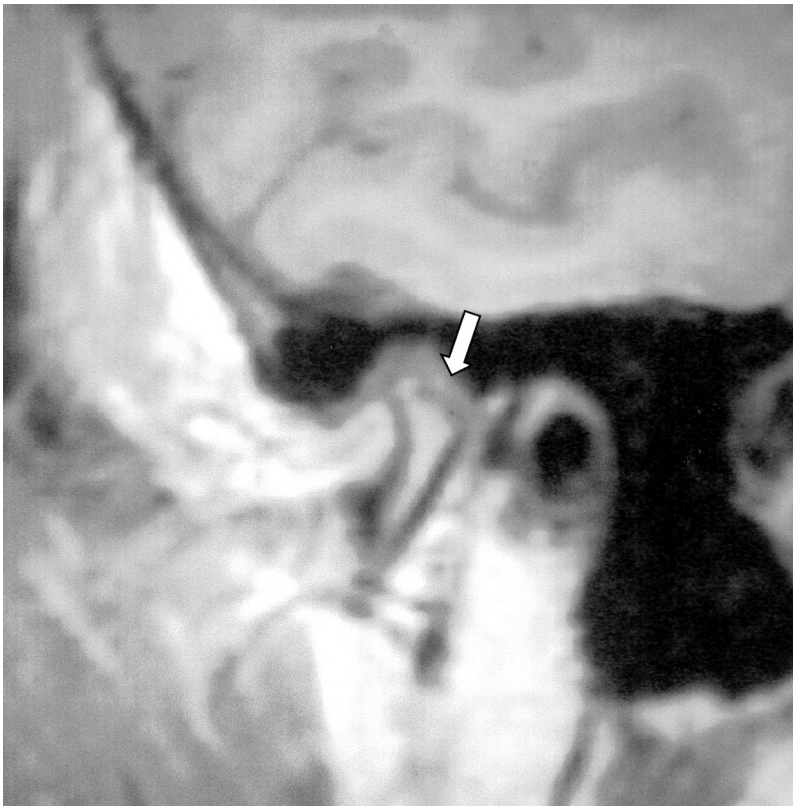

Figure 3. Severe erosions of the condylar head (arrow).

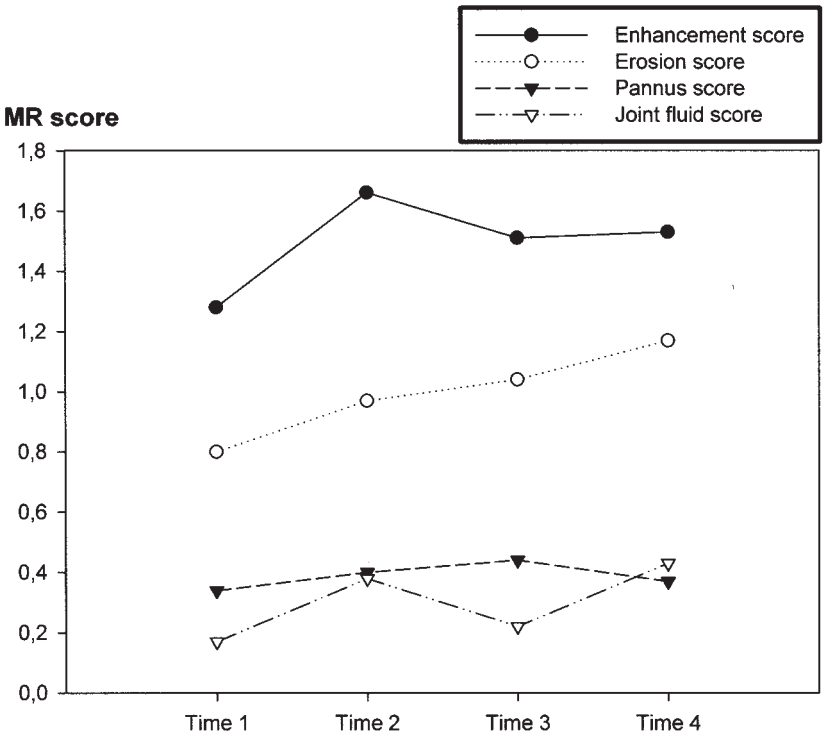

Figure 4. Mean MRI score for enhancement, erosions, pannus, and joint fluid over time.

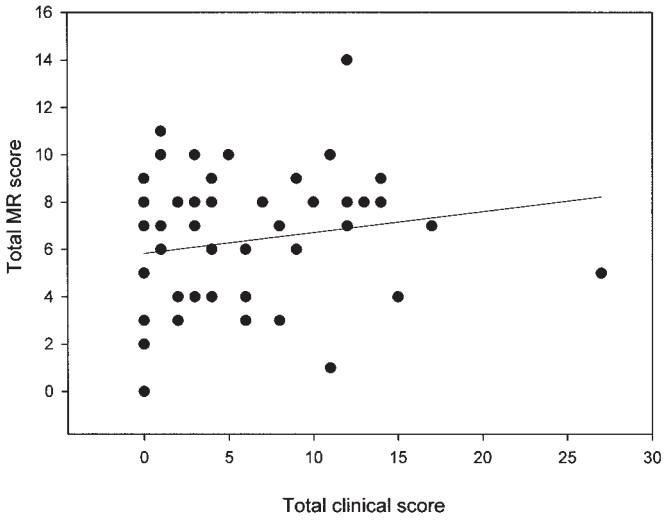

Figure 5. Total MRI score (sum of enhancement, erosion, pannus, and joint fluid score) compared to total clinical score (n = 56, $r^2 = 0.03$).

enhancement, indicating an earlier stage of TMJ involvement.

Increased amounts of joint fluid were seen in 23% of all joints. This is in accord with findings by Smith, *et al*[9], where 2 of 12 rheumatic TMJ showed increased amounts of joint fluid on the MRI. Increased amount of joint fluid was seen in 13 patients at some time, but not constantly during the study. However, differentiation between joint fluid and enhancement of the synovium on postcontrast T1 weighted images may be difficult to interpret. Joint fluid enhancement is expected to be considerably slower than enhancement of the synovium because joint fluid enhancement is a result of diffusion from the synovium. Ostergaard, *et al*[22] suggest that dynamic MRI of the synovial membrane should be obtained within about 10 minutes after contrast injection to achieve the most accurate distinction between synovium and joint fluid. We evaluated the postcontrast MRI roughly 8 minutes after contrast injection, and therefore it is not likely that the observed enhancement was joint fluid.

Only a few of the children reported symptoms in their patient history. This is in accord with other studies of TMJ involvement in patients with JIA or RA[23,24]. Clinical examination seems to be more reliable than asking for symptoms, since all patients showing mild to severe findings by clinical examination also had pathological signs on the postcontrast MRI. However, not all patients without clinical findings were without pathological signs on MRI, since some of these patients even had a total MR score up to 10. Poor correlation between clinical signs and symptoms and the presence of TMJ involvement when evaluated by either radiographs[1,17,24-26] or MRI[9,18] is reported in other studies.

It would be beneficial for the clinician to have an index for diagnosing the initial stage of TMJ involvement in patients with JIA. The results from the clinical examination were scored using a modified version of the Helkimo index[7] (Table 1). Since the Helkimo index was devised for large epidemiological trials on the pathology of TMJ, it does not seem suitable for use in clinical studies. The literature on indices for clinical studies of TMJ pathology is sparse, and the indices are based upon adult patients with RA. We therefore reviewed the index and based it on weighting of each clinical finding according to the classical signs of arthritis. The categorization of mild/severe symptoms and signs was made based on our clinical experience. Maximum score for symptoms was 18 and for clinical signs 34. A child achieves the maximum score very rarely, and if the score is 5 or greater it represents so many symptoms or signs that it seems reasonable to talk about severe symptoms or signs of TMJ involvement.

In this study, no correlation was found between total score for the clinical examination and total score of the MRI examination (Figure 5). The disagreement between clinical and MRI findings is most likely explained by the fact that symptoms and clinical signs are not characteristic of JIA, as pointed out by Olson, *et al*[27]. However, all patients with clinical findings also revealed pathological signs on the MRI and should therefore be offered treatment. It seems more reasonable to select those patients without clinical findings for MRI examination in order to diagnose possible TMJ involvement.

Children with either clinical signs or MRI signs of TMJ involvement were offered treatment with the distraction splint, which is our usual choice of treatment[28]. The primary purpose of this treatment is to control growth and not to reduce the inflammation in the joint, and we saw no differences in the enhancement score over time between children in treatment compared to those who were not in treatment.

Due to the small number of patients, this study does not allow conclusions regarding differentiation between subtypes of JIA. However, the patient with JIA who was HLA-B27 positive had no sign of TMJ involvement in either the clinical findings or the MRI results. This is in accord with a study[29] showing that HLA-B27 positive patients have less risk of TMJ involvement.

TMJ involvement determined by pathological changes on the MRI is a very common phenomenon, and most children with JIA can be expected to have TMJ involvement at some time during their disease that will affect growth of the temporomandibular complex. Further, MRI indications such as synovial enhancement, pannus, and joint fluid fluctuate over time. The clinical examination can be used as a "filter," where children without clinical signs might be selected for MRI with contrast, since enhanced MRI is a helpful tool in detecting onset of the initial inflammation.

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