Temporomandibular Joint Arthritis in Juvenile Idiopathic Arthritis: Prevalence, Clinical and Radiological Signs, and Relation to Dentofacial Morphology

AN D. BILLIAU, YUQIAN HU, AN VERDONCK, CARINE CARELS, and CARINE WOUTERS

ABSTRACT. ***Objective.*** To perform a prospective, comprehensive, clinical, and radiological evaluation of temporomandibular joint (TMJ) involvement and its influence on craniofacial growth, in a cohort of patients with juvenile idiopathic arthritis (JIA), representing all JIA subtypes.

Methods. Clinical rheumatologic and orthodontic evaluations were performed in 100 patients with JIA [12 systemic arthritis, 24 rheumatoid factor (RF)-negative polyarthritis, 1 RF-positive polyarthritis, 39 oligoarthritis, 22 enthesitis-related arthritis, 2 psoriatic arthritis]. An orthopantomogram and lateral cephalogram were performed in 46 patients. The prevalence of TMJ arthritis was studied in relation to JIA subtype and disease characteristics; cephalometric measurements were compared to those from age- and sex-matched healthy controls.

Results. Whereas 55% of patients with JIA had at least one symptom/sign of TMJ arthritis, 78% of the radiographed group exhibited condylar lesions. The presence of condylar damage was not related to clinical orthodontic findings or to JIA subtype, disease activity, severity, or duration. Patients with JIA exhibited larger mandibular plane and A-nasion-B angles, larger total anterior facial height, smaller interincisal and sella-nasion-B angles, and shorter mandibular ramus lengths than their age- and sex-matched controls. Craniofacial alterations were clearly related to the presence of condylar damage, even when present at a minimal degree.

Conclusion. Our data show that TMJ condylar damage occurs very frequently in JIA, and irrespective of JIA subtype; condylar lesions can present early, progress insidiously, and — even at a minimal degree — can severely alter the craniofacial profile. We propose that the followup of patients with JIA should include early and regular evaluation by an orthodontist, supplemented with radiographic TMJ imaging. (First Release August 1 2007; J Rheumatol 2007;34:1925–33)

Key Indexing Terms:
TEMPOROMANDIBULAR JOINT JUVENILE IDIOPATHIC ARTHRITIS
DENTOFACIAL GROWTH

Temporomandibular joint (TMJ) involvement in patients with juvenile idiopathic arthritis (JIA), first described by Still in 1897[1], is a well recognized feature of the disease. Reports on TMJ arthritis in JIA are characterized by a large variation in patient sample composition, JIA classification system used, and methods — either clinical or radiological — to reach the diagnosis. This probably explains the wide variation in reported prevalences, which range from 17% to 87%[2-20]. TMJ involvement is thought to occur during the active phase of JIA, where inflammation generates chondral and subchondral bone lesions and eventually leads to condylar resorption. The consequences of TMJ arthritis include disturbance of mandibular growth and marked alterations of craniofacial morphology and occlusion, with typical features comprising an increased profile convexity, a steep mandibular plane angle, mandibular micrognathia, and retrognathia[3].

The current literature on TMJ arthritis includes only one patient study group in which all subtypes of JIA are represented[18,20]. This study confirmed a high frequency of TMJ involvement and a discrepancy between clinical and radiological signs; a higher percentage of retrognathia and posterior rotation of the mandible was found in JIA patients with TMJ involvement, and the changes did not seem to be uniformly distributed among the different JIA subtypes[20]. Although pre-

From the Department of Pediatric Rheumatology and Department of Orthodontics, University Hospital Leuven; and Laboratory of Experimental Transplantation, University of Leuven, Leuven, Belgium.

A.D. Billiau is a postdoctoral fellow of the FWO Vlaanderen.

Dr. Billiau and Dr. Hu contributed equally to this report.

A.D. Billiau, MD, PhD, Pediatric Rheumatologist, Department of Pediatric Rheumatology, University Hospital Leuven, Postdoctoral Research Fellow, Laboratory of Experimental Transplantation; Y. Hu, DDS, Fellow; A. Verdonck, DDS, PhD, Staff Member; C. Carels, DDS, PhD, Professor, Head, Department of Orthodontics; C. Wouters, MD, PhD, Professor, Head, Department of Pediatric Rheumatology, University Hospital Leuven.

Address reprint requests to Dr. C. Wouters, Department of Pediatric Rheumatology, University Hospital Gasthuisberg, Herestraat 49, B-3000 Leuven, Belgium. E-mail: carine.wouters@uz.kuleuven.ac.be

Accepted for publication April 16, 2007.

vious studies have documented the association of TMJ damage with altered craniofacial morphology in children with chronic arthritis[3,6,13,14,20-24], a detailed cephalometric study of the relationship between condylar damage and craniofacial morphology has not been performed in a JIA patient group in which all subtypes, classified according to the revised ILAR criteria[25], are represented. The purpose of our study was therefore to perform a prospective comprehensive evaluation of TMJ involvement and its influence on craniofacial growth in a cohort of patients with JIA in which all subtypes are represented. We studied the clinical characteristics of TMJ arthritis in 100 patients with JIA and the radiological characteristics in 46 of them, and related these aspects to JIA subtype and disease activity, severity, and duration. We analyzed specific patterns of facial morphology in patients with JIA compared to healthy controls, and investigated their relation to condylar damage and aspects of mandibular growth.

MATERIALS AND METHODS

Patients. Between November 2003 and November 2004, all patients who presented to the outpatient pediatric rheumatology clinic of the University Hospital Gasthuisberg, K.U. Leuven, and who fulfilled the ILAR criteria of JIA[25] were included in our study. In total, 100 patients were included. The general disease characteristics of the patient cohort are shown in Table 1. All JIA subtypes were represented: 12 children with systemic arthritis, 24 with rheumatoid factor (RF)-negative polyarthritis, 1 with RF-positive polyarthritis, 39 with oligoarthritis, 22 with enthesitis-related arthritis (ERA), and 2 with psoriatic arthritis. The sex ratio was 1.86:1 girls:boys (65 girls and 35 boys), and the median age at first examination was 10.5 years (range 1.7–19.4 yrs). The median disease duration at the time of the first orthodontic examination was 2.96 years (range 2 mo to 15 yrs). Current medication included nonsteroidal antiinflammatory drugs (NSAID; 66%), low-dose corticosteroids (26%), methotrexate (MTX; 30%), tumor necrosis factor-α (TNF-α) antagonists (9%), sulfasalazine (2%), thalidomide (1%), and cyclosporine (1%).

Our study was performed with approval from the University Hospital Gasthuisberg Institutional Review Board. Prior to inclusion of each patient, informed consent was obtained according to the Declaration of Helsinki.

Clinical examination. All patients underwent a clinical rheumatological examination (ADB or CW). The JIA patient group was divided into patients with active disease or inactive disease or remission, according to the criteria of Wallace, *et al*[26]: 66% of patients had active disease. Patients taking second-line drugs (MTX, sulfasalazine, TNF-α antagonists, thalidomide, or cyclosporine) were considered to have severe disease and constituted 30% of the total study group.

Clinical diagnostic criteria for temporomandibular disorders have been established[27]; however, there exists no classification scheme for JIA patients with temporomandibular disorders. The clinical dentofacial examination was carried out by a dentist/orthodontist (YH, VA), using a slightly adapted form of the examination form of the Research Diagnostic Criteria[28]. The dentist performed 4 aspects of examination, comprising the observation of jaw movements, joint and muscle palpation, auscultation of the TMJ, and identification

Table 1. Patient disease characteristics in total study group and study group undergoing radiological examination.

	% in Total Study Group (n) (total n = 100)	% in Study Group Undergoing Radiological Assessment (n) (Total n = 46)
Distribution according to JIA subtype*, % (n)		
Systemic	12 (12)	15 (7)
Polyarticular RF–	24 (24)	22 (10)
Polyarticular RF+	1 (1)	2 (1)
Oligoarticular	39 (39)	37 (17)
Enthesitis-related arthritis	22 (22)	22 (10)
Psoriatic arthritis	2 (2)	2 (1)
Male:female ratio*	1:1.86 (35 boys, 65 girls)	1:1.71 (17 boys, 29 girls)
Median age at first examination, yrs (range)†	10.5 (1.7–19.4)	9.33 (2.17–19.4)
Median disease duration at first examination, yrs (range)†	2.96 (2 mo–15 yrs)	3.04 (2 mo–15 yrs)
Current medication*, % (n)		
NSAID	66 (66)	70 (32)
Low-dose corticosteroid	26 (26)	35 (14)
Methotrexate	30 (30)	28 (13)
TNF-α antagonists	9 (9)	9 (4)
Sulfasalazine	2 (2)	0 (0)
Thalidomide	1 (1)	2 (1)
Cyclosporine	1 (1)	0 (0)
Disease activity*, % (n)		
Active disease	66 (66)	72 (33)
Inactive disease or remission	34 (34)	28 (13)
Disease severity*		
Severe disease	30 (30)	30 (14)
Mild disease	70 (70)	70 (32)
Clinical symptom(s) and/or sign(s)*	55 (55)	70 (32)

* Not significant, $p > 0.05$ by chi-square test; † not significant, $p > 0.05$ Mann-Whitney U test. JIA: juvenile idiopathic arthritis; RF, rheumatoid factor; NSAID, nonsteroidal antiinflammatory drug.

of the occlusion pattern. The maximum jaw mobility was assessed by maximal interincisal mouth opening (MIO): upon maximal mouth opening, a millimeter ruler was used to measure the vertical distance from the incisal edge of the right maxillary central incisor to the labio-incisal edge of the opposing mandibular incisor; if the right maxillary and mandibular central incisors were missing, the left maxillary and mandibular central incisors were taken as reference teeth. MIO was considered to be restricted when less than 29.5 mm in a 3-year-old patient, less than 34.5 mm in a 4 to 6-year-old patient, and less than 39.5 mm in a patient 7 years old or older[29]. The presence or absence of TMJ sounds was assessed using a stethoscope, while patients were asked to perform 5 types of movement, including opening, closing, bilateral excursion, and protrusion. The presence or absence of masticatory muscle and TMJ pain was assessed by bilateral palpation. The TMJ were palpated on the area anterior to the trigs of the ear and the external acoustic meatus. The palpation sites of the masticatory muscles included the temporal muscle area, the masseter muscle area, the lateral pterygoid muscle area, and the medial pterygoid muscle area. Muscle tenderness was elicited by unilateral palpation with firm finger pressure, giving rise to a force of approximately 1–2 pounds[30]. Dental occlusion in the sagittal plane was classified as distal, neutral, or mesial occlusion, on both the left and right side. It was considered to be distal/mesial malocclusion if the molar occlusion deviated from neutral by more than 1/4 premolar width. Horizontal overjet, vertical overbite in the intercuspal contact position was measured with a millimeter ruler. An anterior open bite was defined as absence of vertical overlap between the incisal edges of the upper and lower central incisors. Two series of repeated TMJ examinations in 10 healthy subjects with an interval of 1 week were not significantly different (Wilcoxon matched-pair test).

Radiological assessment. A standard orthopantomogram (OPG) was used to assess condylar morphological changes. This imaging technique is readily available in routine clinical practice and allowed the simultaneous assessment of condylar damage and mandibular ramus length (Figure 1). Also, this procedure could be readily combined with a lateral cephalogram (LCG), which was used in cephalometric studies to assess cephalometric landmarks and reference planes. For the LCG, the head was fixed in a cephalostat and in centric occlusion (Cranex Tome®, Soredex, Helsinki, Finland). The magnification was adjusted to 1.1. The exposure parameters vary depending on the age and sex of the patients. The average value of kilovoltage (kV) peak was 70 kV and the value of millianpere seconds (mAs) was between 1.8 and 3 mAs. For each patient, a dentist/orthodontist (HY, VA) made tracings on acetate paper of the OPG as well as the LCG.

On the basis of the cortical outline of the condyles, a "condylar damage score" was determined (for both left and right condyle): 0 for normal, 1 for small cortical bone erosion, 2 for flattened including subchondral trabecular bone lesion, 3 for flattening with erosion, 4 for complete absence of condylar head. Condylar damage was considered to be present when the score was ≥ 1[8] (Figure 1A). On the basis of reference landmarks on the LCG, cephalometric measurements were performed according to Jacobson and Caufield[31] (illustrations in a patient with JIA and a control patient are given in Figure 1B). No difference was found between 2 separate measurements of cephalometric tracings on LCG (Wilcoxon matched-pair test). Finally, mandibular ramus length, defined as the distance between point Co and point Go on OPG, was measured (Figure 1C).

In total, 46 out of 100 patients consented to a radiological investigation, consisting of an OPG and LCG. Although selection on a voluntary basis may introduce a bias towards more severely affected patients agreeing to undergo radiographic examination, the total study group (n = 100) and the radiographed study group (n = 46) were found to be similar with respect to the frequency of either of the general disease characteristics (Table 1), and the distribution of the patients according to JIA subtype was equally found not to be different between both groups (Mann-Whitney U and chi-square tests, Table 1). Within the radiographed group, the median age was 9.33 years (range 2.17–19.4 yrs) and the median disease duration at first examination was 3.04 years (range 2 mo to 15 yrs). Within this subgroup, 7 patients had systemic arthritis, 10 RF-negative polyarthritis, 1 RF-positive polyarthritis, 10 ERA, 17 oligoarthritis, and 1 psoriatic arthritis. Thirty-three (72%) patients had active disease and 14 (30%) patients were considered to have severe disease. Finally, 32 (70%) patients showed at least one clinical symptom or sign of TMJ arthritis, a proportion found not to differ from the proportion of 55 patients (55%) in the total JIA patient group (chi-square test).

Controls. The data on cephalometric references, obtained in the 46 patients who underwent radiological evaluation, were studied in relation to those obtained from age- and sex-matched historical controls: reference values for each cephalometric parameter were retrieved from the Bolton Standards for Dentofacial Growth and Development[32], which cite mean values and standard deviation of standard cephalometric measurements in a healthy population, according to age and sex. This control group will be referred to as the historical controls. Secondly, in order to study the relation between condylar damage and mandibular growth, the measurements of mandibular ramus length in patients with JIA who underwent radiological evaluation were compared to those of age- and sex-matched controls, selected from the population of children who had previously sought orthodontic treatment at the Department of Orthodontics, University Hospital Gasthuisberg, and who had, therefore, previously had radiological evaluation by OPG. For 32 of 46 patients with JIA, an age- and sex-matched control was found in the patient databank. None of the control subjects had JIA. This control group will be referred to as the orthodontic controls.

Statistics. Statistical analyses were performed using Statistica 5.1 (StatSoft, Tulsa, OK, USA). Numerical variables were tested between groups using the Mann-Whitney U or the Wilcoxon matched-pair test. The chi-square test was applied for comparison of ordinal variables between defined patient groups. A p value < 0.05 was considered to indicate a statistically significant difference, $0.1 > p > 0.05$ a statistical trend, and $p > 0.1$ a statistically nonsignificant relation (NS). When testing cephalometric variables, in order to correct for multiple testing, the p value < 0.05 was divided by the number of null hypotheses (7) tested. For these particular tests, a p value < 0.007 was considered to indicate a statistically significant difference, $0.014 > p > 0.007$ a statistical trend, and $p > 0.014$ a statistically NS relation.

RESULTS

Clinical signs and symptoms of TMJ arthritis. Out of 100 patients, 55% reported at least one symptom or sign of TMJ arthritis (Table 2). Restricted mouth opening was the most frequent clinical finding and was present in 28 patients. Ten patients reported joint sounds and 22 reported muscle tenderness; 21 patients showed deviation of the mouth opening pattern and 14 exhibited TMJ tenderness. The presence of restricted mouth opening, but not the presence of other clinical measures, was significantly more frequent in patient groups with active disease, severe disease, and longstanding disease (chi-square test). The frequency of the clinical signs/symptoms was not different between JIA subtypes (Table 2).

Evaluation of TMJ condylar damage on orthopantomogram. Radiological evaluation was performed in 46 of 100 patients. Although selected on the basis of voluntary agreement, this subgroup of patients with JIA was found to be representative for the total JIA study group with respect to the distribution according to JIA subtype and the frequency of either of the general disease characteristics (Table 1). In 1 patient (2%) condylar damage could not be evaluated. In 36 patients (78%), condylar damage was documented. In 25 patients (54%), the damage was bilateral, in 11 patients (24%) unilateral, and the degree of condylar damage varied from score 1 to 4 (Table 3, illustrated in Figure 1A). There was no association between

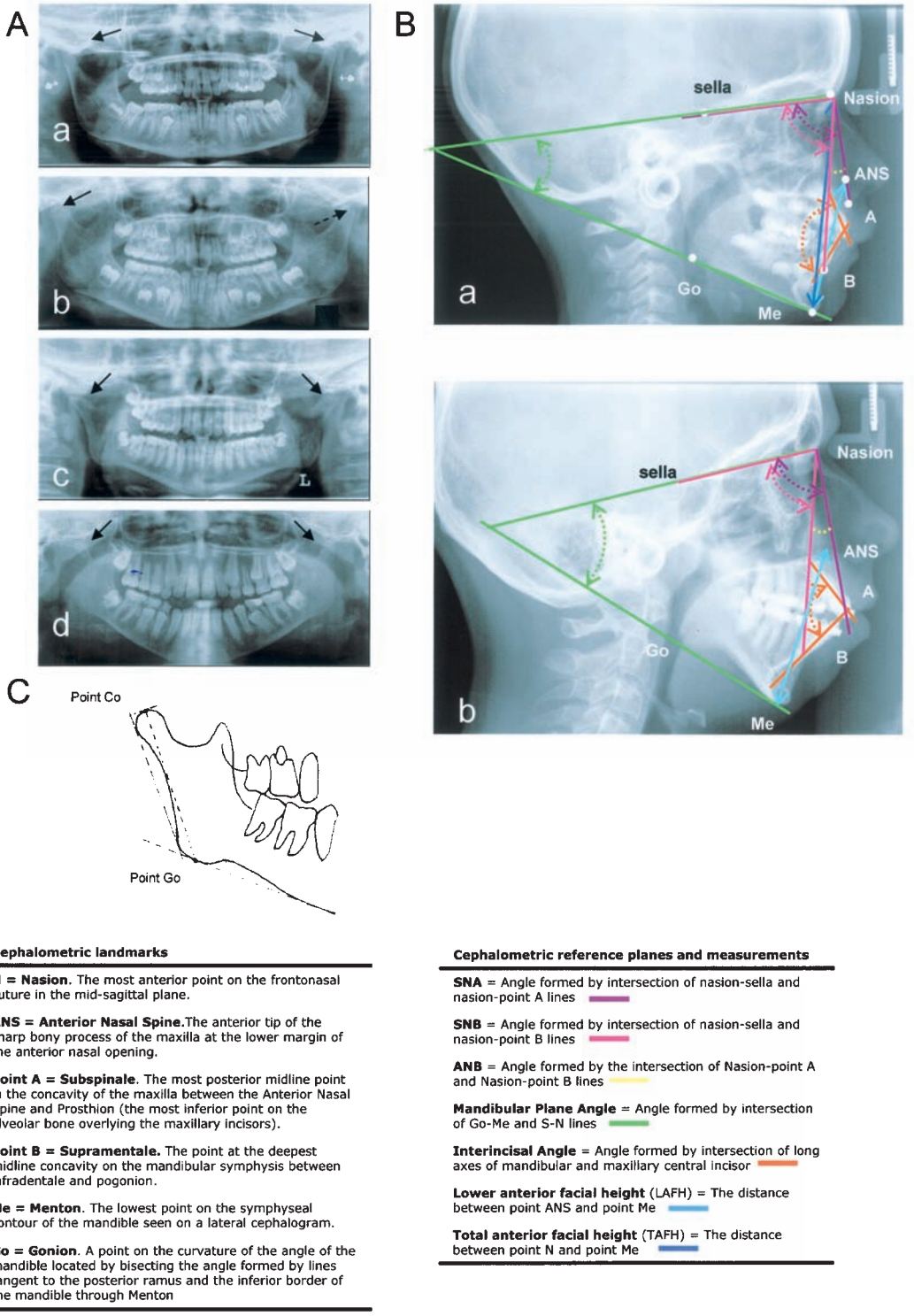

Figure 1. Radiographic measurements on orthopantomogram (OPG) and lateral cephalogram (LCG). A. OPG views of patients with varying degrees of condylar damage. a. Normal condylar image on both condyles (score 0) in an 11-year-old girl with enthesitis-related arthritis for 4 months; b. an 8-year-old girl with oligoarthritis for 5 years showing an oval cortical erosion on the posterior surface of the left condyle (score 1, arrow) and a flattened shape combined with a small erosion on the anterior surface of the right condyle (score 3, dashed arrow); c. an 11-year-old girl with systemic-onset JIA for 10 years, showing bilateral flattened condyles (score 2, arrow); d. bilateral complete absence of condylar heads in a 15-year-old boy with systemic onset JIA for 10 years (score 4, arrow). B. LCG of a control patient (seeking orthodontic advice) (a) and from a JIA patient with longstanding TMJ arthritis (b), illustrating an increase in mandibular plane angle, decrease in interincisal angle, decrease in ANB angle, and increase in lower anterior facial height. Definitions of cephalometric landmarks and cephalometric reference planes and measurements (based on Jacobson and Caufield[31]) are indicated. C. Measurement of mandibular ramus length: distance between point Co and point Go. Co: when drawing the tangent line to the outline of the ramus, a perpendicular line is drawn that is tangential to the condylar surface: the tangent point is Co.

Table 2. Frequency of clinical sign(s)/symptoms(s) and relation with disease characteristics. The frequency of each variable is indicated as % in total study group, n = 100.

Patients Exhibiting Clinical Sign/Symptom, % (n)		Relation with Disease Characteristics, (p*)			
		Active Disease	Severe Disease	Longstanding Disease	JIA Subtype
Joint sounds	10 (10)	NS	NS	NS	NS
Muscle tenderness	22 (22)	NS	NS	NS	NS
Deviating opening pattern	21 (21)	NS	NS	NS	NS
Restricted mouth opening	28 (28)	0.03	0.04	0.04	NS
TMJ tenderness	14 (14)	NS	NS	NS	NS

* Chi-square test; NS: not significant.

Table 3. Frequency and pattern of condylar damage (n = 46). Frequency of lesions on orthopantomogram: n = 46 patients, 1 patient could not be evaluated. Distribution according to condylar damage score: analysis performed on individual condyles: n = 46 patients, in 1 patient the condyle on one side could not be evaluated.

Frequency of Condylar Damage	% of Patients (n)
Bilateral damage	54 (25)
Unilateral damage	24 (11)
No damage	20 (9)
Not evaluable	2 (1)
Distribution of condylar scores, % of individual condyles (n)	
Score 4	3 (3)
Score 3	15 (14)
Score 2	22 (20)
Score 1	27 (25)
Score 0	32 (29)
Not available	1 (1)

the presence of any of the clinical signs and symptoms (joint sounds, muscle tenderness, TMJ tenderness, deviating opening pattern, restricted mouth opening) and the presence of radiological condylar damage (chi-square test, data not shown), nor was an association found between disease activity, disease severity, disease duration, or a particular JIA subtype and the presence of unilateral or bilateral condylar damage (chi-square test, data not shown).

Cephalometric evaluation on lateral head plate. Of each individual cephalogram, tracings of the anatomical landmarks were made in order to allow measurement of reference lines and angles that document craniofacial relationships (Figure 1B). The cephalometric measurements obtained in patients with JIA were compared with Bolton standard healthy control values, according to whether they did exhibit condylar damage (n = 37) or did not (n = 9) (Tables 4 and 5). In the subgroup of patients with JIA who did not exhibit radiological condylar damage, significant differences in cephalometric variables could not be found (Table 4). However, patients with JIA exhibiting condylar damage scores of 1 to 4 had a significantly larger ANB and mandibular plane angle (MPA), and a significantly larger total anterior facial height (TAFH) [median ANB 4.5° (range 0°–10°) vs 3.4° (2°–5°) (p = 0.002); MPA 40° (32°–51°) vs 31° (29°–34°) ($p = 10^{-7}$); and TAFH 109 mm (84–126 mm) vs 101 mm (82–119) ($p = 3 \times 10^{-7}$), Wilcoxon matched-pair test]. In contrast, the interincisal and SNB angles were significantly smaller [median interincisal angle 125° (range 105°–163°) vs 136° (133°–153°) ($p = 10^{-6}$) and SNB 78° (72°–84°) vs 79° (76°–82°) (p = 0.002), Wilcoxon matched-pair test].

A separate analysis of the radiographed patients with JIA exhibiting mild condylar damage only (maximal score 1, n = 12) showed a significantly larger MPA and TAFH, as well as a statistical trend for a smaller interincisal angle, than the Bolton control values (Table 5) [median MPA 37° (range 32°–45°) vs 31° (29°–33°) (p = 0.002), TAFH 111 mm (103–122 mm) vs 101 mm (89–113 mm) (p = 0.002), and interincisal 126° (115°–163°) vs 137° (133°–153°) (p = 0.012), Wicoxon matched-pair test].

Relation of condylar damage and mandibular ramus length. In order to further document the growth disturbance induced by condylar damage, we compared individual mandibular ramus lengths (Figure 1C) between patients with JIA and their sex- and age-matched orthodontic controls, for those JIA condyles with a damage score ≥ 1. Individual left- and right-side mandibular ramus lengths of patients with JIA were compared with the respective left- and right-side values of orthodontic controls. In total, 29 individual condyles and corresponding ramus lengths were evaluated. The median mandibular ramus length in patients with JIA was significantly shorter than that of orthodontic controls [JIA median 64 mm (range 41–78.5 mm) and controls median 66.5 mm (range

Table 4. Cephalometric measurements in JIA patients without (score 0, n = 9) or with condylar damage (score 1–4, n = 37), versus their respective Bolton controls.

	JIA Score 0 Median (range)	Bolton Controls Median (range)	p	JIA Score 1–4 Median (range)	Bolton Controls Median (range)	p
SNA (°)	82 (76–86)	83 (81–84)	NS	83 (77–87)	83 (80–84)	NS
SNB (°)	77 (74–83)	80 (78–81)	NS	78 (72–84)	79 (76–82)	0.002
ANB (°)	5 (–1–7)	3.2 (2.5–3.6)	NS	4.5 (0–10)	3.4 (2–5)	0.002
MPA (°)	35 (25–43)	31 (29–32)	NS	40 (32–51)	31 (29–34)	0.0000001
Interincisal A (°)	126 (119–146)	135 (133–135)	NS	125 (105–163)	136 (133–153)	0.000001
LAFH (mm)	57 (48–72)	58 (55–64)	NS	62 (41–75)	54 (48–64)	NS
TAFH (mm)	115 (102–122)	107 (105–119)	NS	109 (84–126)	101 (82–119)	0.0000003

p values indicate difference between JIA patient group and age and sex matched Bolton controls (Wilcoxon matched-pair test). NS: not significant, $p < 0.007$ considered statistically significant, $0.007 < p < 0.014$ a statistical trend (see Methods).

Table 5. Cephalometric measurements in JIA patients with mild condylar damage (maximal score 1, n = 12) versus their respective Bolton controls.

	JIA Score 1 Median (range)	Bolton Standards Median (range)	p
SNA (°)	83 (79–87)	83 (80–84)	NS
SNB (°)	79 (76–84)	79 (77–82)	NS
ANB (°)	4.5 (0–7.5)	3.3 (2.2–4.2)	NS
MPA (°)	37 (32–45)	31 (29–33)	0.002
Interincisal A (°)	126 (115–163)	137 (133–153)	0.012
LAFH (mm)	62 (45–71)	54 (52–63)	NS
TAFH (mm)	111 (103–122)	101 (89–113)	0.002

p values indicate difference between JIA patient group and age and sex matched Bolton controls (Wilcoxon matched-pair test). NS: not significant, $p < 0.007$ considered statistically significant, $0.007 < p < 0.014$ a statistical trend (see Methods).

58.5–89 mm); p = 0.03, Wilcoxon matched-pair test, data not shown).

DISCUSSION

This study of our cohort of patients with JIA, which comprised all JIA subtypes classified according to the revised ILAR criteria, confirms the reported high frequency of clinical and radiological signs of TMJ involvement. In contrast to some previous studies, however, our data do not substantiate a significant relation between TMJ involvement and particular JIA subtypes, nor do they document a relation with disease activity, severity, or duration. Our findings emphasize the unpredictable and often insidious character of TMJ arthritis and the risk for ongoing condylar damage, and illustrate that condylar lesions — even at a minimal degree — affect mandibular growth and lead to craniofacial alterations.

TMJ arthritis signs and/or symptoms were found in 55% of patients, a frequency that falls within the range reported in the literature[14,19,22,29,33-35]. Although studies have proposed various clinical measures, such as pain during jaw excursion[17,18] or restricted MIO[3,14,23], as predictors for condylar damage, most agree on their low sensitivity.

Restricted maximal interincisal mouth opening was found to be the most frequent symptom, occurring in nearly one-third of patients. It was more frequent in JIA patients with longstanding disease, as reported[17], but also in patients with active or severe disease. Impaired function — during active TMJ arthritis — of the TMJ articulation and the surrounding muscles probably explains the association with disease activity, and possibly also that with disease severity.

About 1 in 6 patients exhibited TMJ or muscle tenderness. Although, in accord with a previous study[17], this frequency may be an underestimate, as at the time of orthodontic examination two-thirds of our patients were being treated with NSAID, which may have interfered with the experience of pain. Moreover, the predominantly young age of our patients may have influenced the assessment of subjective symptoms, as described[29].

The clinical sign of deviating mouth opening pattern has been reported to be an important predictor of TMJ condylar damage[18]. By contrast, in our cohort, its frequency (21%) was far below the frequency of radiographic joint damage (78%), and this observation argues against the potential value of this clinical sign as a screening measure. The observation that almost two-thirds of patients with TMJ arthritis-related condylar damage exhibited bilateral damage, which may result in restricted mouth opening without chin deviation, probably accounts for this phenomenon.

Finally, some earlier studies found TMJ sounds to be very frequent and to be a good predictor of radiological condylar damage on OPG[18,29]. This was not confirmed in our study cohort, however, and the reported observation that joint sounds occur in up to 20% of healthy young individuals[36] further suggests that they are a poorly sensitive sign to detect TMJ arthritis.

Whereas only 70% of the radiographed JIA patient group reported clinical signs/symptoms of TMJ arthritis, 78% of them exhibited condylar lesions, and this falls within the range of reported frequencies[8,14,15,23,29,33,37-39]. In our cohort, 28% of patients with condylar lesions did not exhibit clinical signs/symptoms, and 71% of these patients without clinical signs/symptoms did have condylar lesions. These observations support the poor correlation between clinical signs/symptoms of TMJ arthritis and presence of TMJ arthritis-related condylar damage.

Although radiographed patients were selected on the basis of consent, the radiographed group and the total study group were found to be similar with respect to the frequency of either of the general disease characteristics and with respect to the distribution of JIA subtypes. The radiographed group was therefore considered representative of the total group.

The existence of a relation between general disease characteristics such as disease activity, severity, and disease duration in particular, with TMJ condylar damage has been suggested by others[13,16-18,33,40,41] but was not confirmed in the present large cohort, emphasizing the insidious nature of TMJ involvement and the fact that it can occur early in the JIA disease course.

Some studies have reported that children suffering from particular subtypes, in casu polyarticular arthritis or extended pauciarticular arthritis, run a higher risk for TMJ involvement[5,7,13,16-18,33]. Our data, however, clearly show that TMJ damage occurs with similar frequency in systemic-onset, polyarticular, oligoarticular, and enthesitis-related arthritis, indicating a similar risk for all patients with JIA, irrespective of their subtype.

In our study, the OPG appeared to be an efficient technique to document TMJ abnormalities, as it yielded a frequency of condylar damage that approached the reported prevalences of TMJ abnormalities obtained with axial computerized tomography scans[4,9]. However, contrast-enhanced magnetic resonance imaging (MRI) may be an even more efficient and sensitive method in diagnosing early inflammatory changes and condylar erosions in the TMJ[10,35]. Nevertheless, the feasibility of the latter technique in a routine clinical setting is hampered by its cost and the need for sedation or general anesthesia in young children. Further, evaluation of possible associated craniofacial changes would still require an additional standard lateral cephalogram. Reportedly, ultrasonography is considered an acceptable alternative to MRI in diagnosing pathological changes in the TMJ in rheumatoid arthritis[42]. Studies using MRI and ultrasonography in a similarly large cohort of patients with JIA representing all subtypes are needed to validate our conclusions, in particular with respect to early stages of TMJ arthritis.

Bilateral lesions were present in more than two-thirds of affected patients, a frequency that is higher than has been reported[3,5,8,16,18], and 57% of patients exhibited asymmetry in condylar damage (data not shown). These observations imply that surgical procedures aiming to correct craniofacial changes should be undertaken with caution as long as mandibular growth has not been completed.

The typical dentofacial characteristics on the LCG of JIA patients with documented radiographic condylar damage, in comparison to age- and sex-matched historical controls, included a significantly larger MPA and ANB angle, and a significantly smaller interincisal angle and SNB angle, constituting mandibular retrognathia and a convex facial profile. These cephalometric characteristics and facial composition are in agreement with the findings in most previous studies[3,7,14,15,20,43,44].

In our study, all dentofacial measures were studied in relation to age- and sex-matched healthy controls. However, when dentofacial anomalies were compared within the JIA group, they were found to be uniformly distributed among JIA subtypes. This is in contrast to previous studies, in which this type of comparison suggested an increased frequency in patients with polyarticular forms of arthritis.

Two previous reports, studying children with juvenile chronic arthritis (JCA), have documented the association of condylar damage with craniofacial alterations, by demonstrating differences in cephalometric angles between JCA children with and without condylar lesions[15,45]. In our study, we performed a paired analysis of JIA patients both with and without condylar lesions, with their respective age- and sex-matched historical controls, and we substantiate this relationship. Importantly, we clearly show that even a minimal degree of condylar damage is associated with significant changes in craniofacial relations. Finally, age- and sex-matched case-control comparison of mandibular ramus lengths illustrates the direct effect of condylar damage on mandibular growth.

Our study is the first to perform a prospective, comprehensive, clinical, and case-control radiological evaluation of TMJ arthritis and associated craniofacial morphology in a cohort of patients with JIA comprising all subtypes according to the revised ILAR criteria. We clearly demonstrate that TMJ involvement and condylar damage are very frequent and can occur in every child with JIA, irrespective of subtype. Condylar damage may be present early in the disease course and progress, even in the absence of clinical symptoms or signs. Importantly, our data show that condylar damage, even at a minimal degree, may lead to profound changes in craniofacial morphology.

As stated above, these conclusions are drawn with the following 2 reservations. First, the patient cohort used for OPG condylar damage studies was selected on the basis of volun-

tary agreement; however, it consisted of a large number of patients, and, in particular, it was found to be representative for the total JIA study group with respect to the distribution of JIA subtype and general disease characteristics. Second, since OPG is not suited to evaluate active TMJ synovitis and since it may therefore miss early-onset TMJ arthritis, our conclusions need to be validated by studies using MRI and ultrasonography in a similarly large cohort of patients with JIA.

Early recognition of TMJ condylar changes is important for orthodontic diagnosis and treatment planning. From our findings we propose that clinical followup of every patient with JIA should include regular evaluation by an orthodontist and imaging of the TMJ. The question as to which is the appropriate imaging technique (sensitivity, safety, feasability) for early detection of TMJ arthritis, in particular conventional radiography versus MRI or ultrasonography, is the subject of an ongoing study.

ACKNOWLEDGMENT

We thank Steffen Fieuws, Centre of Biostatistics, KULeuven, for providing advice regarding statistical methods.

REFERENCES

1. Still GF. On a form of chronic joint disease in children. 1896. Clin Orthop Relat Res 1990;259:4-10.
2. Mayne JG, Hatch GS. Arthritis of the temporomandibular joint. J Am Dent Assoc 1969;79:125-30.
3. Kjellberg H. Juvenile chronic arthritis. Dentofacial morphology, growth, mandibular function and orthodontic treatment. Swed Dent J Suppl 1995;109:1-56.
4. Hu YS, Schneiderman ED. The temporomandibular joint in juvenile rheumatoid arthritis: I. Computed tomographic findings. Pediatr Dent 1995;17:46-53.
5. Ronchezel MV, Hilario MO, Goldenberg J, et al. Temporomandibular joint and mandibular growth alterations in patients with juvenile rheumatoid arthritis. J Rheumatol 1995;22:1956-61.
6. Hanna VE, Rider SF, Moore TL, et al. Effects of systemic onset juvenile rheumatoid arthritis on facial morphology and temporomandibular joint form and function. J Rheumatol 1996;23:155-8.
7. Mericle PM, Wilson VK, Moore TL, et al. Effects of polyarticular and pauciarticular onset juvenile rheumatoid arthritis on facial and mandibular growth. J Rheumatol 1996;23:159-65.
8. Pearson MH, Ronning O. Lesions of the mandibular condyle in juvenile chronic arthritis. Br J Orthodont 1996;23:49-56.
9. Hu YS, Schneiderman ED, Harper RP. The temporomandibular joint in juvenile rheumatoid arthritis: Part II. Relationship between computed tomographic and clinical findings. Pediatr Dent 1996;18:312-9.
10. Kuseler A, Pedersen TK, Herlin T, Gelineck J. Contrast enhanced magnetic resonance imaging as a method to diagnose early inflammatory changes in the temporomandibular joint in children with juvenile chronic arthritis. J Rheumatol 1998;25:1406-12.
11. Marini I, Vecchiet F, Spiazzi L, Capurso U. Stomatognathic function in juvenile rheumatoid arthritis and in developmental open-bite subjects. ASDC J Dent Child 1999;66:30-5, 12.
12. Harper RP, Brown CM, Triplett MM, Villasenor A, Gatchel RJ. Masticatory function in patients with juvenile rheumatoid arthritis. Pediatr Dent 2000;22:200-6.
13. Ince DO, Ince A, Moore TL. Effect of methotrexate on the temporomandibular joint and facial morphology in juvenile rheumatoid arthritis patients. Am J Orthod Dentofacial Orthop 2000;118:75-83.
14. Svensson B, Adell R, Kopp S. Temporomandibular disorders in juvenile chronic arthritis patients. A clinical study. Swed Dent J 2000;24:83-92.
15. Sidiropoulou-Chatzigianni S, Papadopoulos MA, Kolokithas G. Dentoskeletal morphology in children with juvenile idiopathic arthritis compared with healthy children. J Orthod 2001;28:53-8.
16. Pedersen TK, Jensen JJ, Melsen B, Herlin T. Resorption of the temporomandibular condylar bone according to subtypes of juvenile chronic arthritis. J Rheumatol 2001;28:2109-15.
17. Bakke M, Zak M, Jensen BL, Pedersen FK, Kreiborg S. Orofacial pain, jaw function, and temporomandibular disorders in women with a history of juvenile chronic arthritis or persistent juvenile chronic arthritis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;92:406-14.
18. Twilt M, Mobers SM, Arends LR, ten Cate R, Suijlekom-Smit L. Temporomandibular involvement in juvenile idiopathic arthritis. J Rheumatol 2004;31:1418-22.
19. Savioli C, Silva CA, Ching LH, Campos LM, Prado EF, Siqueira JT. Dental and facial characteristics of patients with juvenile idiopathic arthritis. Rev Hosp Clin Fac Med Sao Paulo 2004;59:93-8.
20. Twilt M, Schulten AJ, Nicolaas P, Dulger A, Suijlekom-Smit LW. Facioskeletal changes in children with juvenile idiopathic arthritis. Ann Rheum Dis 2006;65:823-5.
21. Larheim TA, Haanaes HR, Ruud AF. Mandibular growth, temporomandibular joint changes and dental occlusion in juvenile rheumatoid arthritis. A 17-year follow-up study. Scand J Rheumatol 1981;10:225-33.
22. Larheim TA, Dale K, Tveito L. Radiographic abnormalities of the temporomandibular joint in children with juvenile rheumatoid arthritis. Acta Radiol Diagn (Stockh) 1981;22:277-84.
23. Karhulahti T, Ronning O, Jamsa T. Mandibular condyle lesions, jaw movements, and occlusal status in 15-year-old children with juvenile rheumatoid arthritis. Scand J Dent Res 1990;98:17-26.
24. Kjellberg H, Kiliaridis S, Karlsson S. Characteristics of masticatory movements and velocity in children with juvenile chronic arthritis. J Orofac Pain 1995;9:64-72.
25. Petty RE, Southwood TR, Manners P, et al. International League of Associations for Rheumatology classification of juvenile idiopathic arthritis: second revision, Edmonton, 2001. J Rheumatol 2004;31:390-2.
26. Wallace CA, Ruperto N, Giannini E. Preliminary criteria for clinical remission for select categories of juvenile idiopathic arthritis. J Rheumatol 2004;31:2290-4.
27. Truelove EL, Sommers EE, LeResche L, Dworkin SF, Von Korff M. Clinical diagnostic criteria for TMD. New classification permits multiple diagnoses. J Am Dent Assoc 1992;123:47-54.
28. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniomandib Disord 1992;6:301-55.
29. Olson L, Eckerdal O, Hallonsten AL, Helkimo M, Koch G, Gare BA. Craniomandibular function in juvenile chronic arthritis. A clinical and radiographic study. Swed Dent J 1991;15:71-83.
30. Research Diagnostic Criteria for Temporomandibular Disorders. International Consortium for RDC/TMD-Based Research. Internet. Available at: http://rdc-tmdinternational.org. Accessed May 30, 2007.
31. Jacobson A, Caufield PW. Introduction to radiographic cephalometry. 1st ed. Philadelphia: Lea & Febiger; 1985.
32. Holly Broadbent B, Holly Broadbent B Jr, Golden WH. Bolton standards of dentofacial developmental growth. St. Louis, MO: CV

Mosby; 1975:143-52.
33. Larheim TA, Hoyeraal HM, Stabrun AE, Haanaes HR. The temporomandibular joint in juvenile rheumatoid arthritis. Radiographic changes related to clinical and laboratory parameters in 100 children. Scand J Rheumatol 1982;11:5-12.
34. Wenneberg B, Kjellberg H, Kiliaridis S. Bite force and temporomandibular disorder in juvenile chronic arthritis. J Oral Rehabil 1995;22:633-41.
35. Kuseler A, Pedersen TK, Gelineck J, Herlin T. A 2 year followup study of enhanced magnetic resonance imaging and clinical examination of the temporomandibular joint in children with juvenile idiopathic arthritis. J Rheumatol 2005;32:162-9.
36. Pollmann L. Sounds produced by the mandibular joint in young men. A mass examination. J Maxillofac Surg 1980;8:155-7.
37. Barriga B, Lewis TM, Law DB. An investigation of the dental occlusion in children with juvenile rheumatoid arthritis. Angle Orthod 1974;44:329-35.
38. Ronning O, Valiaho ML, Laaksonen AL. The involvement of the temporomandibular joint in juvenile rheumatoid arthritis. Scand J Rheumatol 1974;3:89-96.
39. Ronning O, Valiaho ML. Progress of mandibular condyle lesions in juvenile rheumatoid arthritis. Proc Finn Dent Soc 1981;77:151-7.
40. Jank S, Schroder D, Haase S, et al. Temporomandibular disorders in juvenile patients with rheumatic diseases [German]. Mund Kiefer Gesichtschir 2003;7:214-9.
41. Stabrun AE, Larheim TA, Hoyeraal HM, Rosler M. Reduced mandibular dimensions and asymmetry in juvenile rheumatoid arthritis. Pathogenetic factors. Arthritis Rheum 1988;31:602-11.
42. Melchiorre D, Calderazzi A, Maddali BS, et al. A comparison of ultrasonography and magnetic resonance imaging in the evaluation of temporomandibular joint involvement in rheumatoid arthritis and psoriatic arthritis. Rheumatology Oxford 2003;42:673-6.
43. Kjellberg H, Kiliaridis S, Thilander B. Dentofacial growth in orthodontically treated and untreated children with juvenile chronic arthritis (JCA). A comparison with Angle Class II division 1 subjects. Eur J Orthod 1995;17:357-73.
44. Kjellberg H. Craniofacial growth in juvenile chronic arthritis. Acta Odontol Scand 1998;56:360-5.
45. Kjellberg H, Fasth A, Kiliaridis S, Wenneberg B, Thilander B. Craniofacial structure in children with juvenile chronic arthritis (JCA) compared with healthy children with ideal or postnormal occlusion. Am J Orthod Dentofacial Orthop 1995;107:67-78.