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Temporomandibular Joint Involvement in Juvenile Idiopathic Arthritis: Can Clinical Examination and Panoramic Radiography Predict MRI Findings?

Giuliana Caserta [1], Rossella Ninivaggi [2,*], Cecilia Destefanis [2], Luca Cricenti [2], Allegra Comba [2], Nicola Scotti [2], Patrizia Defabianis [2] and Federica Romano [2,*]

[1] Private Practice, Pinerolo, 10064 Turin, Italy; giulicas86@gmail.com
[2] CIR Dental School, Department of Surgical Sciences, University of Turin, Via Nizza 230, 10126 Turin, Italy; cecilia.destefanis@unito.it (C.D.); luca.cricenti@unito.it (L.C.); allegra.comba@unito.it (A.C.); nicola.scotti@unito.it (N.S.); patrizia.defabianis@unito.it (P.D.)
* Correspondence: rossella.ninivaggi@unito.it (R.N.); federica.romano@unito.it (F.R.)

Abstract

Background/Objectives: Temporomandibular joint (TMJ) involvement is common in juvenile idiopathic arthritis (JIA) and may impair function and craniofacial growth. Although magnetic resonance imaging (MRI) is the preferred imaging modality, its routine use in children is limited by cost, examination time, and potential sedation requirements. This study evaluated the diagnostic performance of clinical examination and panoramic radiography (OPG) compared with MRI. Methods: Seventy patients with JIA (52 females; mean age 13.4 ± 2.8 years) underwent standardized TMJ assessment, OPG, and non-contrast enhanced MRI. A composite clinical score (0–7) was calculated based on muscle and TMJ tenderness, mandibular deviation, reduced maximum mouth opening and joint clicking. A score ≥3 was considered positive. MRI served as the reference standard, with TMJ involvement defined primarily by structural or functional abnormalities. Results: At least one clinical sign of TMJ involvement was observed in 41% of patients. MRI-detected TMJ involvement was significantly more frequent among patients with a clinical score ≥3 than among those with a score <3 (92.0% vs. 24.4%; $p < 0.001$). Clinical examination showed 67.6% sensitivity, 94.4% specificity, 92.0% positive predictive value (PPV), and 75.6% negative predictive value (NPV). OPG findings were positive in 85.3% of MRI-positive patients and negative in all MRI-negative patients ($p < 0.001$), corresponding to 85.3% sensitivity, 100% specificity, 100% PPV, and 87.8% NPV. Conclusions: Clinical examination and OPG may help identify patients with a higher likelihood of MRI-detected TMJ involvement who may benefit from further MRI evaluation.

Keywords: juvenile idiopathic arthritis; temporomandibular joint; magnetic resonance imaging; radiography; panoramic; clinical examination; diagnostic accuracy; craniofacial abnormalities; pediatrics

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1. Introduction

Juvenile idiopathic arthritis (JIA) is the most common chronic rheumatic disease of childhood and comprises a heterogeneous group of inflammatory arthritis of unknown origin. Current evidence supports a multifactorial disease process involving interactions among genetic susceptibility, immune dysregulation, and environmental factors. Although

arthritis is the defining clinical feature, JIA may also be associated with extra-articular manifestations, including uveitis, fever, and cutaneous involvement [1,2].

JIA can affect virtually any synovial joint, and the temporomandibular joint (TMJ) represents an important and frequently involved site. The reported prevalence of TMJ involvement varies widely, ranging from approximately 11% to 87%, depending on the characteristics of the study population, disease duration, and the diagnostic modality used [3–5]. TMJ arthritis may occur in any JIA subtype and may be unilateral or bilateral. Although its prevalence tends to increase with greater peripheral articular disease burden, the TMJ may also be the first, or even the only clinically affected joint [6].

The clinical relevance of TMJ arthritis is particularly important during childhood and adolescence because the mandibular condyle growth site contributes substantially to mandibular development. Persistent or recurrent inflammation may impair normal condylar development and lead to progressive structural and functional alterations, including mandibular hypoplasia, retrognathia, facial asymmetry, altered mandibular morphology, and malocclusion [7,8]. These abnormalities may have lasting functional, aesthetic, and psychosocial consequences and may persist into adulthood [9].

The potential for irreversible growth disturbance underscores the importance of identifying TMJ arthritis as early as possible. However, early detection remains challenging because TMJ arthritis in JIA is frequently asymptomatic or associated with subtle and nonspecific clinical findings. In addition, clinical symptoms and signs do not reliably correspond to imaging-detected TMJ involvement or its severity. Consequently, clinically silent TMJ arthritis may persist, while structural damage and disturbances in mandibular growth progress [10,11].

Several imaging modalities have been used to assess TMJ involvement in children with JIA. Panoramic radiography (OPG) is inexpensive, widely available, and commonly performed in routine dental assessment. However, OPG has limited ability to detect early inflammatory changes because it primarily depicts established osseous and morphological abnormalities and does not directly visualize active synovial inflammation [12]. Nevertheless, recent studies have demonstrated its ability to distinguish structural TMJ abnormalities in children with JIA, which are reported more frequently than in healthy controls [13].

Magnetic resonance imaging (MRI), particularly contrast-enhanced MRI, is currently considered the preferred imaging modality for detecting active TMJ arthritis in JIA. MRI can demonstrate synovial enhancement, joint effusion, bone marrow abnormalities, and early structural changes that may not be clinically apparent or visible on conventional radiography [14,15]. However, MRI is relatively costly and time-consuming and may be challenging in pediatric patients, particularly younger children who may require sedation or general anesthesia. These practical considerations limit the feasibility of routine MRI screening of all children with JIA.

Consequently, standardized clinical assessment has gained increasing attention as a first-line approach to identifying children at risk of TMJ involvement. International multidisciplinary consensus recommendations have established a standardized clinical orofacial examination incorporating TMJ tenderness, mandibular deviation, maximal mouth opening, facial symmetry, and facial profile [16]. However, clinical examination alone cannot reliably exclude subclinical TMJ arthritis [10,16]. Therefore, identifying combinations of clinical findings and readily available radiographic abnormalities that can help select patients who would benefit from MRI remains an important unmet clinical need.

In this context, the present study evaluated the diagnostic performance of a standardized clinical assessment and OPG, using MRI as the reference standard, to determine their potential utility in identifying children and adolescents with JIA who may warrant MRI assessment for TMJ involvement.

2. Materials and Methods

2.1. Study Design and Population

This cross-sectional study enrolled consecutive patients with JIA who underwent clinical assessment between June 2025 and July 2026 at the Pediatric Section of the CIR Dental School, University of Turin, Italy. All patients were referred by the Pediatric Immuno-Rheumatology Division of the Regina Margherita Children's Hospital of Turin for dental and TMJ assessment. The study was conducted in accordance with the principles of the Declaration of Helsinki and received approval from the institutional Ethics Committee. Written informed consent was obtained from the parents or legal guardians of all participants. The study was reported according to the STARD (Standards for Reporting Diagnostic Accuracy Studies) guidelines [17].

Patients were eligible if they were 6–16 years of age, had a confirmed diagnosis of JIA according to the International League of Associations for Rheumatology (ILAR) criteria [18], and had undergone both OPG and TMJ MRI for suspected joint involvement. Patients were excluded if OPG and TMJ MRI were unavailable or if the interval between the clinical examination and imaging assessment exceeded 1 month, to minimize potential discrepancies related to changes in disease status over time. Additional exclusion criteria included congenital or developmental craniofacial anomalies that could independently affect mandibular growth or TMJ morphology, such as hemifacial microsomia or cleft lip and palate, and a history of facial or mandibular trauma. No a priori sample size calculation was performed. The final sample size was determined by the number of consecutive patients meeting the predefined eligibility criteria who underwent clinical assessment during the study period.

2.2. Clinical Assessment

Clinical and demographic data were extracted from the medical records and included JIA category, disease duration, current disease activity, and relevant medication exposure. All patients underwent a standardized clinical examination to identify signs and symptoms potentially associated with TMJ involvement. The clinical assessment was performed by an experienced clinician blinded to radiological findings, according to the screening protocol proposed by the Temporomandibular Joint Juvenile Arthritis Working Group [16].

The following clinical parameters were recorded (Table 1):

- orofacial pain elicited by palpation of the temporal and masseter masticatory muscles;
- pain on palpation of the TMJ with the mouth closed (patients were asked to close the mouth with the teeth in light contact) and open (patients were asked to open the mouth as wide as possible);
- jaw deviation or deflection during mouth opening;
- intra-articular clicking on one or both joints during movement.
- limitation of maximum unassisted mouth opening defined as a value below the 3rd percentile according to age- and sex-specific reference values [19,20]. Mouth opening was measured in millimeters using a ruler as the distance between the incisal edges of the maxillary and mandibular central incisors, with adjustment for overbite.

Table 1. Clinical parameters and scoring system for TMJ assessment.

Clinical Item	Operational Definition	Score
Muscle pain	Pain on palpation of the masseter and/or temporalis muscles	0 = absent; 1 = present
TMJ pain	Pain on TMJ palpation with the mouth closed and/or open	0 = absent; 1 = present; 2 = bilateral

Table 1. *Cont.*

Clinical Item	Operational Definition	Score
Mandibular deviation/deflection	Lateral deviation/displacement during maximum opening	0 = absent; 1 = present
Limited maximum mouth opening	Maximum unassisted interincisal opening below the age-specific threshold	0 = absent; 1 = present
Joint clicking	Audible or palpable click during joint movement	0 = absent; 1 = present; 2 = bilateral

Each positive clinical parameter was assigned one point, while bilateral TMJ pain on palpation or intra-articular clicking was assigned two points. The resulting composite clinical score ranged from 0 to 7. A clinical examination score of ≥3 was defined a priori as the threshold for a positive clinical examination, corresponding approximately to the midpoint of the 0–7 index range.

Patient-reported symptoms were collected using a questionnaire completed by patients, with parental assistance when appropriate. The questionnaire assessed occasional or chronic pain during mouth opening and at maximal mouth opening, as well as pain in the TMJ or masticatory muscles. The questionnaire was developed specifically for this study and had not undergone formal validation. However, its symptom domains were consistent with those described in published TMJ screening protocols for children with JIA [16].

2.3. Imaging Assessment

All patients underwent OPG and MRI examination as part of their routine dental and TMJ assessment, irrespective of the initial clinical severity. The images were evaluated by an experienced specialist in oral and maxillofacial radiology who was blinded to the clinical findings. The two imaging modalities were assessed at separate time points to minimize the potential influence of findings from one modality on the interpretation of the other. Intra-rater reliability was assessed by repeating the evaluations of 20% of both OPG and MRI images after a 14-day interval (Cohen's kappa, K = 0.873 for OPG and K = 0.952 for MRI).

OPG images were assessed for morphological abnormalities of the mandibular condyles and other radiographic signs potentially associated with TMJ involvement. The following radiographic findings were considered: condylar flattening, sclerosis, reduction in the joint space, osteolytic changes, and partial or complete condylar destruction. For the purposes of the present study, an OPG examination was classified as positive for TMJ involvement when condylar deformity was identified. Vertical linear measurements were performed on the OPGs using ImageJ software (version 1.54u8). A tangent line was drawn through the most lateral points of the mandibular profile, and perpendicular lines to this tangent were constructed through the highest point of the condyle and the most lateral points of the condyle and mandibular ramus. The condylar length and ramus length were subsequently calculated as the corresponding vertical distances between the predefined anatomical landmarks.

Non-contrast-enhanced MRI was used as the reference imaging modality for the predefined structural and functional TMJ abnormalities assessed in this study, rather than as a definitive reference standard for active TMJ arthritis. MRI examinations of the TMJs were performed with the mouth in both closed- and open-mouth positions. Sagittal proton density- and T2-weighted sequences were obtained perpendicular to the long axis of the condyle, while coronal proton density-, T2-weighted, and STIR sequences were acquired

parallel to the condylar axis. MRI findings were assessed separately for the right and left TMJs. The non-contrast fluid-sensitive sequences, including T2-weighted and STIR imaging, were used to assess the predefined structural and fluid-sensitive TMJ abnormalities without additional contrast administration.

The following MRI findings were assessed:

- condyle hypomobility;
- condyle deformity;
- articular disc thinning.

An MRI examination was classified as positive when at least one of these predefined findings was identified in the TMJ. Minor findings such as a small amount of joint fluid or mild condylar flattening were interpreted cautiously, as these may represent physiological variations and do not necessarily indicate inflammatory TMJ disease [21]. These criteria were study-specific and were not based on a validated TMJ inflammatory scoring system. Because contrast-enhanced sequences were not acquired, the protocol was not designed to reliably assess synovial enhancement or establish the presence or absence of active synovial inflammation.

2.4. Comparison of Clinical and Imaging Findings

The primary analytical objective was to determine whether clinical findings and OPG abnormalities were associated with MRI-detected TMJ involvement.

The clinical examination was considered positive when the composite clinical score was ≥3. This threshold was selected a priori as a pragmatic cut-off approximating the midpoint of the possible score range, to distinguish patients presenting with multiple clinical findings from those with fewer findings. OPG was considered positive when a condylar deformity was identified. The diagnostic performance of the clinical examination and OPG was assessed using MRI as the reference standard.

2.5. Statistical Analysis

Continuous variables were expressed as mean ± standard deviation and categorical variables were reported as frequencies and percentages.

The Shapiro–Wilk test was used to assess the normality of the distribution of each variable. Associations between clinical signs/symptoms, OPG abnormalities, and MRI-detected TMJ involvement were assessed using appropriate parametric or non-parametric tests. Continuous variables were compared using Student's *t*-test or the Mann–Whitney U test, as appropriate, while categorical variables were analyzed using the chi-square test or Fisher's exact test.

The diagnostic performance of the clinical examination and OPG was evaluated using MRI as the reference standard. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), along with their corresponding 95% confidence intervals (CIs) calculated using the Wilson method, were determined to assess the diagnostic performance of clinical examination and OPG in identifying patients with MRI-detected TMJ involvement.

All statistical tests were two-sided, and a p-value <0.05 was considered statistically significant. Statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 28.0; IBM, New York, NY, USA).

3. Results

3.1. Participant Characteristics

Between June 2025 and July 2026, 92 patients attended the Pediatric Unit. Of these, 22 were excluded because one or both imaging assessments were unavailable (8 patients) or because the interval between the clinical and radiological examinations exceeded 1 month (14 patients). The final study sample comprised 70 patients with JIA (74.3% female and 25.7% male), with a mean age of 13.4 ± 2.8 years (range, 6–16 years) and a mean disease duration of 4.2 ± 1.9 years (range, 1–8 years).

The most frequent JIA subtype was oligoarticular arthritis (58.6%), followed by polyarticular arthritis (25.7%) and psoriasis-related arthritis (5.7%). Antinuclear antibodies (ANA) positivity was reported in 36 patients (51.4%), and RF positivity in 5 patients (7.1%). Patient characteristics and distribution of JIA subtypes are summarized in Table 2.

Table 2. Demographic characteristics and arthritis pattern in patients with JIA included in the study.

Variable	JIA
Female, *n* (%)	52 (74.3)
Age (yr), mean (± SD)	13.4 ± 2.8
Disease duration (yr), mean (± SD)	4.2 ± 1.9
JIA subtype, *n* (%)	
Oligoarticular	37 (52.9)
Oligoarticular extended	4 (5.7)
Polyarticular RF-pos	5 (7.1)
Polyarticular RF-neg	13 (18.6)
Psoriatic	4 (5.7)
Enthesitis	3 (4.3)
Systemic	1 (1.4)
Oligoarticular with uveitis	2 (2.9)
Polyarticular with uveitis	1 (1.4)
ANA positivity	36 (51.4)
Medication Exposure, *n* (%)	
Methotrexate	16 (22.9)
Biologics	13 (18.6)
Methotrexate and biologics	10 (14.3)
NSAIDs	4 (5.7)
Hydroxychloroquine	1 (1.4)
None	26 (37.1)

JIA, juvenile idiopathic arthritis; SD, standard deviation; NSAIDs, non-steroidal anti-inflammatory drugs.

At inclusion, 44 patients (62.9%) had ongoing pharmacological therapy for JIA. Of these, 16 were treated with methotrexate alone, 10 with methotrexate in combination with biologics (adalimumab or etanercept), and 13 with biologics alone. Four patients (5.7%) received non-steroidal anti-inflammatory drugs alone, while one received hydroxychloroquine (1.4%).

3.2. Association Between Clinical Examination and Imaging Findings

Forty-one patients (58.6%) had a score of 0, while 29 (41.4%) presented with at least one clinical sign. Among patients with a positive clinical score, a score of 4 was the most frequent (31.0%). Overall, 25 patients (35.7%) had an examination score ≥ 3. As summarized in Table 3, the most frequently detected clinical signs were limited opening (24.3%), TMJ pain on palpation (27.1%), and pain on muscle palpation (25.8%). More than one-third of patients (38.6%) experienced pain, mainly during mouth opening.

Table 3. Clinical and radiographic findings of TMJ dysfunction and patient-reported symptoms. Data are presented as numbers and percentages.

Variable	JIA
Clinical findings	
Jaw deflection	13 (18.6)
Jaw deviation	8 (11.4)
Clicking	2 (2.9)
Limited opening	17 (24.3)
Pain on TMJ palpation (unilateral)	7 (10.0)
Pain on TMJ palpation (bilateral)	12 (17.1)
Pain on muscle palpation	18 (25.8)
MRI scan findings	
Condyle hypomobility	8 (11.4)
Condyle deformity	5 (7.1)
Articular disk thinning	1 (1.4)
Condyle hypomobility and deformity	7 (10.0)
Condyle hypomobility, deformity and disk thinning	13 (18.6)
OPG findings	
Unilateral condylar head changes	12 (17.1)
Bilateral condylar head changes	17 (24.3)
Patient-reported symptoms	
None	43 (61.4)
Occasional pain on mouth opening	2 (2.9)
Occasional pain at maximum mouth opening	1 (1.4)
Chronic pain on mouth opening	14 (20.0)
Chronic pain at maximum mouth opening	7 (10.0)
TMJ or masticatory muscle pain	3 (4.3)

TMJ, temporomandibular joint; MRI, magnetic resonance imaging; OPG, panoramic radiography.

Regarding radiographic findings (Table 3), 34 patients (48.6%) had MRI-detected TMJ involvement and 29 patients (41.4%) presented with unilateral or bilateral alterations in condylar head morphology in OPG images. The most frequently detected MRI findings were condylar hypomobility and deformity, observed either independently (11.4% and 7.1%, respectively) or in combination (28.6%). Their coexistence with articular disk thinning was also observed in 18.6% of cases, whereas isolated disk thinning was uncommon (1.4%).

Clinical scores were significantly associated with MRI findings ($p < 0.001$). Most patients with negative MRI findings had a clinical score < 3 (94.4%), whereas a score ≥ 3 was observed in 67.6% of patients with MRI-detected TMJ involvement.

Clinical scores were also significantly associated with OPG findings ($p < 0.001$). Among patients with negative OPG findings, 92.7% had a clinical score < 3, compared with 24.1% of patients with positive OPG findings. Conversely, a score ≥ 3 was observed in 75.9% of patients with positive OPG findings.

Among the individual clinical parameters, reduced mouth opening and patient-reported symptoms were significantly associated with OPG abnormalities (both $p < 0.001$). Normal mouth opening was observed in 95.1% of patients with negative OPG findings compared with 48.3% of those with positive OPG findings; conversely, reduced mouth opening was observed in 51.7% of patients with positive OPG findings. Similarly, 92.7% of patients with negative OPG findings were asymptomatic, compared with only 17.2% of those with positive OPG findings.

Regarding OPG images, no significant associations were observed between condylar head alterations and patients' age, disease duration or JIA subtype. Similarly, no statistically

significant differences were found in the ramus or condylar length (Table 4). A significant association was observed between the MRI and OPG findings ($p < 0.001$). All patients without MRI-detected TMJ involvement had negative OPG findings, while condylar abnormalities were detected on OPG in 85.3% of patients with MRI-confirmed TMJ involvement.

Table 4. Associations between OPG findings, demographic characteristics and arthritis pattern.

Variable	OPG Diagnosis		*p*-Value
	Positive	**Negative**	
Sex, *n* (%)			0.392
Female	20 (38.5)	32 (61.5)	
Male	9 (50.0)	9 (50.0)	
JIA subtype, *n* (%)			0.226
Oligoarticular	15 (36.6)	26 (63.4)	
Polyarticular RF-positive	3 (60.0)	2 (40.0)	
Polyarticular RF-negative	5 (38.5)	8 (61.5)	
Psoriatic	1 (25.0)	3 (75.0)	
Enthesitis	2 (66.7)	1 (33.3)	
Systemic	1 (100)	0 (0.0)	
Uveitis	2 (66.7)	1 (33.3)	
Age (yr), mean (± SD)	14.0 ± 2.4	13.0 ± 2.9	0.126
Disease duration (yr), mean (± SD)	4.2 ± 1.8	4.1 ± 2.0	0.896
Length condyle head left side (mm), mean (± SD)	4.8 ± 1.9	5.2 ± 1.3	0.432
Length ramus left side (mm), mean (± SD)	40.3 ± 5.7	40.7 ± 3.9	0.408
Length condyle head right side (mm), mean (± SD)	5.1 ± 1.4	5.2 ± 1.2	0.141
Length, right ramus (mm), mean (± SD)	40.9 ± 4.3	41.4 ± 4.9	0.445

JIA, juvenile idiopathic arthritis; SD, standard deviation; OPG, panoramic radiography.

3.3. Diagnostic Accuracy

Using non-contrast enhanced MRI as the reference standard (Table 5), the clinical examination showed a specificity of 94.4% and a PPV of 92.0% for detecting TMJ involvement. OPG demonstrated a specificity of 100% and a sensitivity of 85.3%.

To further investigate the correspondence between imaging findings, a side-specific, finding-by-finding analysis was performed (Table 6). The correspondence between OPG-detected condylar deformity and MRI findings varied according to the type of abnormality and the side examined. Although OPG-detected condylar deformity frequently co-occurred with MRI-detected condylar deformity, discrepancies were also observed. In 5 patients with negative OPG findings, MRI revealed bilateral abnormalities, consisting of condylar hypomobility in 4 patients and condylar deformity in 1 patient.

Table 5. Accuracy of clinical and panoramic radiography diagnosis.

MRI Diagnosis	Clinical Diagnosis						
	Score < 3	Score ≥ 3	Se (95% CI)	Sp (95% CI)	PPV (95% CI)	NPV (95% CI)	*p*-Value
Positive	11 (24.4%)	23 (92.0%)	67.6% (50.8–80.9)	94.4% (81.9–98.5)	92.0% (75.0–97.8)	75.6.% (61.3–85.8)	<0.001
Negative	34 (75.6%)	2 (8.0%)					

Table 5. *Cont.*

MRI Diagnosis	OPG Diagnosis						
	Positive	Negative	Se (95% CI)	Sp (95% CI)	PPV (95% CI)	NPV (95% CI)	*p*-Value
Positive	29 (100.0%)	5 (12.2%)	85.3% (69.9–93.6)	100.0% (90.4–100.0)	100% (88.3–100.0)	87.8% (74.5–94.7)	<0.001
Negative	0 (0.0%)	36 (87.8%)					

Se, sensitivity; Sp, specificity; PPV, positive predictive value; NPV, negative predictive value; 95% CI, 95% confidence interval; MRI, magnetic resonance imaging; OPG, panoramic radiography.

Table 6. Side-specific distribution of OPG-detected condylar deformity and individual MRI findings. (**A**) Right TMJ. (**B**) Left TMJ.

(**A**)						
OPG Condylar Deformity	**MRI Hypomobility**		**MRI Deformity**		**MRI Articular Disk Thinning**	
	Absent	Present	Absent	Present	Absent	Present
Absent	42	4	45	1	46	0
Present	7	17	5	19	13	11
Total	49	21	50	20	59	11
(**B**)						
OPG Condylar Deformity	**MRI Hypomobility**		**MRI Deformity**		**MRI Articular Disk Thinning**	
	Absent	Present	Absent	Present	Absent	Present
Absent	44	4	47	1	48	0
Present	8	14	5	17	14	8
Total	52	18	52	18	62	8

Values are reported as numbers of TMJs (n = 70 per side). The 36 patients with no positive findings on either imaging examination were included in the absent/absent cells. OPG condylar deformity was compared separately with each predefined MRI finding.

4. Discussion

TMJ involvement is one of the most clinically relevant but frequently underdiagnosed manifestations of JIA. Early clinical manifestations are often subtle and non-specific, as the classical signs of inflammation are rarely observed in TMJ involvement associated with JIA [22–25]. Pain is frequently absent, edema is uncommon, and functional impairment may not be clinically apparent. Consequently, TMJ abnormalities may remain clinically silent for prolonged periods, delaying diagnosis and increasing the risk of irreversible joint damage [25–27]. Recent longitudinal and cross-sectional studies have further emphasized that TMJ involvement may be clinically inconspicuous despite radiographic or MRI abnormalities, supporting the need for systematic orofacial assessment in children with JIA [25,28,29].

In light of these considerations, the present study investigated whether clinical examination and OPG findings could identify patients at increased risk of TMJ abnormalities. Contrast-enhanced MRI was not performed in this study to minimize patient burden and examination complexity, particularly in growing patients. Avoiding intravenous contrast

also eliminated the need for venous access and the small risk of adverse reactions associated with gadolinium-based contrast agents. MRI positivity was defined based on structural or functional TMJ abnormalities. Therefore, these imaging findings should be interpreted as evidence of TMJ pathology rather than confirmation of active inflammatory arthritis, which is more reliably assessed using contrast-enhanced MRI.

Although clinical assessment has traditionally been considered insufficiently sensitive for the early detection of TMJ involvement [24,30], the present findings suggest that it may provide clinically relevant diagnostic information. In our cohort, 41.4% of patients exhibited at least one clinical sign suggestive of TMJ involvement, including muscle tenderness on palpation, TMJ pain elicited with the mouth in the open or closed position, mandibular deviation or deflection during mouth opening, and reduced maximal mouth opening. Clinical scores were significantly associated with radiographic findings. Among patients with MRI-positive findings, 67.6% had a clinical score ≥3, compared with 32.4% who scored <3. Conversely, among MRI-negative patients, 94.4% had a score < 3, whereas only 5.6% had a score ≥ 3. These findings suggest that a higher clinical score may help identify patients at increased risk of structural TMJ abnormalities.

However, the cut-off of ≥3 was pragmatically selected to identify patients presenting with multiple clinical findings and was not derived from an externally validated clinical decision rule [31]. Furthermore, the composite score represents a study-specific modification of an interdisciplinary consensus-based protocol [16]. Further studies in independent cohorts are needed to validate the score and establish the optimal cut-off for identifying TMJ involvement.

Previous studies have reported an association between specific clinical findings and the severity of TMJ abnormalities [10]. Among the clinical parameters assessed in the present study, reduced maximal mouth opening was associated with radiographic evidence of structural TMJ alterations on OPG. This finding suggests that limitation of oral opening may represent a clinically meaningful indicator of established or progressive joint involvement [10,32,33]. Moreover, longitudinal assessment of maximal mouth opening may be particularly useful for monitoring changes in TMJ status over time [33,34]. However, this association should be interpreted with caution, as it was evaluated against OPG findings rather than MRI abnormalities.

The diagnostic performance analysis further supported the potential value of clinical examination and OPG. Using MRI as the reference standard, clinical examination demonstrated a specificity of 94.4% and a positive predictive value of 92.0%, while OPG achieved a specificity of 100%. Notably, 24.4% of patients with a clinical score < 3 had MRI-positive findings suggestive of TMJ involvement, indicating that a low clinical score does not reliably exclude disease. In contrast, only 8% of patients with a score ≥ 3 had negative MRI findings, suggesting that the presence of multiple clinical abnormalities substantially increases the likelihood of MRI-detected TMJ involvement. Nevertheless, the imperfect correspondence between clinical and MRI abnormalities highlights the limitations of relying on symptoms or physical examination alone and supports their integration with imaging when TMJ involvement is suspected [24,27,30].

The specificity of OPG indicates a strong association between radiographic abnormalities and TMJ involvement in this cohort. Its sensitivity (85.3%) was also higher than that generally reported in previous studies [12,35], potentially reflecting differences in patient selection, imaging criteria, and the focus on structural condylar abnormalities. Moreover, the relatively small sample size and the use of non-contrast-enhanced MRI as the reference standard warrant cautious interpretation. Previous studies by Abramowicz et al. and Pedersen et al. have investigated the relationship between OPG findings, MRI abnormalities, and clinical signs and symptoms of TMJ involvement in children with JIA, highlighting the

limitations of conventional radiography in detecting these abnormalities [36,37]. Although OPG is widely available, relatively inexpensive, and routinely used in dental practice, it has limited sensitivity for early structural changes and cannot directly assess active synovial inflammation. Contrast-enhanced MRI remains the preferred imaging modality for evaluating synovitis and other soft-tissue abnormalities [11,35,38]. Nevertheless, OPG may serve as an initial imaging tool to identify patients with suspected structural TMJ abnormalities who may benefit from further MRI assessment [12,13,35]. Combined with targeted clinical examination, it may facilitate timely referral for more comprehensive imaging and appropriate clinical management. This approach is consistent with current consensus recommendations, which advocate standardized orofacial examination as part of the routine assessment of children with JIA, with imaging used when greater diagnostic sensitivity is required [15,16].

Overall, these findings reinforce the importance of systematic TMJ surveillance in patients with JIA through an integrated multidisciplinary approach [15,16,25,27]. Given that TMJ involvement may remain asymptomatic until substantial structural damage occurs, with delayed diagnosis reported in approximately two-thirds of affected patients [37], standardized orofacial examination protocols [15] are essential for promoting early detection. Collaboration among pediatric rheumatologists, radiologists, pediatric dentists, and orthodontists is crucial to minimizing the risk of irreversible joint damage, mandibular growth disturbances, and craniofacial alterations [4,8]. Accordingly, structured surveillance combining patient-reported symptoms, targeted clinical examination, and appropriately selected imaging may facilitate timely diagnosis and management, while enabling longitudinal monitoring of mandibular function and craniofacial development in growing patients with JIA [15,29,38].

The present study has several limitations, including its relatively small sample size and cross-sectional design, which limit the generalizability of the findings and preclude assessment of the temporal relationships between clinical and imaging findings and disease progression. Requiring both OPG and TMJ MRI for inclusion may have introduced selection bias, as the study population may not be representative of the broader JIA population. Moreover, the use of non-contrast-enhanced MRI and study-specific imaging criteria without a validated TMJ inflammatory scoring system, such as JAMRIS-TMJ or the EuroTMjoint/OMERACT criteria, limits the interpretation of diagnostic accuracy to the detection of predefined structural and functional abnormalities rather than active inflammatory TMJ arthritis.

The absence of an a priori sample size calculation and the use of a non-validated pain questionnaire may also have affected the precision and reliability of the results. Finally, OPG and MRI examinations were performed at different radiographic centers, potentially introducing technical variability. All images were evaluated by the same experienced radiologist, who was blinded to the clinical findings and assessed OPG and MRI images independently on separate occasions. Although this approach ensured consistency in image interpretation, the use of a single clinician precluded the assessment of inter-reader agreement. The importance of standardized imaging protocols has also been emphasized in recent MRI recommendations for JIA [38].

5. Conclusions

Clinical examination and OPG may help identify patients with JIA who may have structural or functional TMJ abnormalities warranting further assessment. However, their moderate sensitivity limits their ability to reliably exclude TMJ abnormalities, and neither method can replace MRI for a comprehensive evaluation. Furthermore, the non-contrast-enhanced MRI protocol used in this study does not allow direct assessment of active synovial

inflammation. Larger, longitudinal, multicenter studies are needed to validate these findings, provide more precise estimates of diagnostic accuracy, and clarify the progression of TMJ involvement over time.

Routine dental assessment should be integrated into the multidisciplinary follow-up of patients with JIA, alongside rheumatologic and ophthalmologic monitoring, to facilitate the recognition of potential TMJ involvement and timely referral for further evaluation.

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Abbreviations

The following abbreviations are used in this manuscript:

95% CI	95% Confidence interval
JIA	Juvenile idiopathic arthritis
MRI	Magnetic resonance imaging
NPV	Negative predictive value
OPG	Panoramic radiography
PPV	Positive predictive value
TMJ	Temporomandibular joint
Se	Sensitivity
Sp	Specificity
SD	Standard deviation

References

1. Huang, H.Y.R.M.; Wireko, A.A.M.; Miteu, G.D.B.; Khan, A.M.; Roy, S.M.; Ferreira, T.M.; Garg, T.M.; Aji, N.; Haroon, F.M.; Zakariya, F.B.; et al. Advancements and progress in juvenile idiopathic arthritis: A review of pathophysiology and treatment. *Medicine* **2024**, *103*, e37567. [CrossRef] [PubMed]
2. La Bella, S.; Rinaldi, M.; Di Ludovico, A.; Di Donato, G.; Di Donato, G.; Salpietro, V.; Chiarelli, F.; Breda, L. Genetic background and molecular mechanisms of juvenile idiopathic arthritis. *Int. J. Mol. Sci.* **2023**, *24*, 1846. [CrossRef] [PubMed]
3. Stoll, M.L.; Kau, C.H.; Waite, P.D.; Cron, R.Q. Temporomandibular joint arthritis in juvenile idiopathic arthritis, now what? *Pediatr. Rheumatol. Online J.* **2018**, *16*, 32. [CrossRef] [PubMed]
4. Stoustrup, P.; Lerman, M.A.; Twilt, M. The Temporomandibular joint in juvenile idiopathic arthritis. *Rheum. Dis. Clin. N. Am.* **2021**, *47*, 607–617. [CrossRef] [PubMed]
5. Valesan, L.F.; Da-Cas, C.D.; Réus, J.C.; Denardin, A.C.S.; Garanhani, R.R.; Bonotto, D.; Januzzi, E.; de Souza, B.D.M. Prevalence of temporomandibular joint disorders: A systematic review and meta-analysis. *Clin. Oral Investig.* **2021**, *25*, 441–453. [CrossRef] [PubMed]
6. Bernardo, L.; Visioli, A.; Del Giudice, E.; Magenes, V.C.; Casini, F.; Chiaffoni, G.; Sandini, M.; Ansuini, V.; Lubrano, R.; Mauro, A. Isolated temporomandibular arthritis as presentation of juvenile idiopathic arthritis. *J. Craniofac. Surg.* **2025**, *36*, e422–e425. [CrossRef] [PubMed]

7. Artamonov, A.K.; Kaneva, M.A.; Gordeeva, N.A.; Sorokina, L.S.; Kostik, M.M. Temporomandibular joint involvement in juvenile idiopathic arthritis: The results from a retrospective cohort tertial center study. *Life* **2023**, *13*, 1164. [CrossRef] [PubMed]
8. Cedströmer, A.L.; Andlin-Sobocki, A.; Abbu, N.; Hedenberg-Magnusson, B.; Dahlström, L.; Berntson, L. Condylar alterations and facial growth in children with juvenile idiopathic arthritis. *J. Orofac. Orthop.* **2020**, *81*, 163–171. [CrossRef] [PubMed]
9. Romano, F.; Di Scipio, F.; Baima, G.; Franco, F.; Aimetti, M.; Berta, G.N. Health-related quality of life in juvenile idiopathic arthritis: A systematic review of phase III clinical trials. *J. Clin. Med.* **2025**, *14*, 254. [CrossRef] [PubMed]
10. Scolozzi, P.; Rabufetti, A.; Hanquinet, S.; Hofer, M.; Courvoisier, D.S.; Antonarakis, G.S. A clinical and MRI retrospective cohort study of patients with juvenile idiopathic arthritis (JIA) to determine if initial temporomandibular joint (TMJ) examination findings are associated with severity of TMJ arthritis. *J. Craniomaxillofac. Surg.* **2022**, *50*, 328–335. [CrossRef] [PubMed]
11. Hara, G.F.; de Souza-Pinto, G.N.; Brasil, D.M.; Poluha, R.L.; Iwaki, L.C.V.; Filho, L.I.; Neto, F.H. What is the image appearance of juvenile idiopathic arthritis in MRI, CT, and CBCT of TMJ? A systematic review. *Clin. Oral Investig.* **2023**, *27*, 2321–2333. [CrossRef] [PubMed]
12. Rosa, V.L.M.; Zwir, L.M.F.; Dutra, M.E.P.; Russo, G.C.S.; Rodrigues, W.D.R.; Terreri, M.T. Does the use of panoramic radiography add information in the temporomandibular joint evaluation in juvenile idiopathic arthritis patients? A case control study. *Adv. Rheumatol.* **2023**, *63*, 6. [CrossRef] [PubMed]
13. Collin, M.; Christidis, N.; Ernberg, M.; Wiklander, L.; Arvidsson, L.Z.; Larheim, T.A.; Hedenberg-Magnusson, B. Panoramic imaging may detect morphologically abnormal temporomandibular joints in children with juvenile idiopathic arthritis. *Pediatr. Dent. J.* **2023**, *33*, 52–60. [CrossRef]
14. Onel, K.B.; Horton, D.B.; Lovell, D.J.; Shenoi, S.; Cuello, C.A.; Angeles-Han, S.T.; Becker, M.L.; Cron, R.Q.; Feldman, B.M.; Ferguson, P.J.; et al. 2021 American College of Rheumatology guideline for the treatment of juvenile idiopathic arthritis: Therapeutic approaches for oligoarthritis, temporomandibular joint arthritis, and systemic juvenile idiopathic arthritis. *Arthritis Care Res.* **2022**, *74*, 521–537. [CrossRef] [PubMed]
15. Stoustrup, P.; Resnick, C.M.; Abramowicz, S.; Pedersen, T.K.; Michelotti, A.; Küseler, A.; Koos, B.; Verna, C.; Nordal, E.B.; Granquist, E.J.; et al. Management of orofacial manifestations of juvenile idiopathic arthritis: Interdisciplinary consensus-based recommendations. *Arthritis Rheumatol.* **2023**, *75*, 184–194. [CrossRef] [PubMed]
16. Stoustrup, P.; Herlin, T.; Spiegel, L.; Rahimi, H.; Koos, B.; Pedersen, T.K.; Twilt, M. Temporomandibular Joint Juvenile Arthritis Working Group. Standardizing the clinical orofacial examination in juvenile idiopathic arthritis: An interdisciplinary, consensus-based, short screening protocol. *J. Rheumatol.* **2020**, *47*, 1397–1404. [CrossRef] [PubMed]
17. Bossuyt, P.M.; Reitsma, J.B.; E Bruns, D.; A Gatsonis, C.; Glasziou, P.P.; Irwig, L.; Lijmer, J.G.; Moher, D.; Rennie, D.; de Vet, H.C.W.; et al. STARD 2015: An updated list of essential items for reporting diagnostic accuracy studies. *BMJ* **2015**, *351*, h5527. [CrossRef] [PubMed]
18. Petty, R.E.; Southwood, T.R.; Manners, P.; Baum, J.; Glass, D.N.; Goldenberg, J.; He, X.; Maldonado-Cocco, J.; Orozco-Alcala, J.; Prieur, A.M.; et al. International League of Associations for Rheumatology classification of juvenile idiopathic arthritis: Second revision, Edmonton, 2001. *J. Rheumatol.* **2004**, *31*, 390–392. [PubMed]
19. Müller, L.; van Waes, H.; Langerweger, C.; Molinari, L.; Saurenmann, R.K. Maximal mouth opening capacity: Percentiles for healthy children 4–17 years of age. *Pediatr. Rheumatol.* **2013**, *11*, 17. [CrossRef] [PubMed]
20. Rongo, R.; Ekberg, E.; Nilsson, I.M.; Al-Khotani, A.; Alstergren, P.; Conti, P.C.R.; Durham, J.; Goulet, J.P.; Hirsch, C.; Kalaykova, S.I.; et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for children and adolescents: An international Delphi study—Part 1—Development of axis I. *J. Oral Rehabil.* **2021**, *48*, 836–845. [CrossRef] [PubMed]
21. Angenete, O.W.; Augdal, T.A.; Jellestad, S.; Rygg, M.; Rosendahl, K. Normal magnetic resonance appearances of the temporomandibular joints in children and young adults aged 2–18 years. *Pediatric Radiol.* **2018**, *48*, 341–349. [CrossRef] [PubMed]
22. Cedströmer, A.L.; Andlin-Sobocki, A.; Berntson, L.; Hedenberg-Magnusson, B.; Dahlström, L. Temporomandibular signs, symptoms, joint alterations and disease activity in juvenile idiopathic arthritis—An observational study. *Pediatr. Rheumatol. Online J.* **2013**, *11*, 37. [CrossRef] [PubMed]
23. Koos, B.; Twilt, M.; Kyank, U.; Fischer-Brandies, H.; Gassling, V.; Tzaribachev, N. Reliability of clinical symptoms in diagnosing temporomandibular joint arthritis in juvenile idiopathic arthritis. *J. Rheumatol.* **2014**, *41*, 1871–1877. [CrossRef] [PubMed]
24. Pawlaczyk-Kamienska, T.; Pawlaczyk-Wróblewska, E.; Borysewicz-Lewicka, M. Early diagnosis of temporomandibular joint arthritis in children with juvenile idiopathic arthritis: A systematic review. *Eur. J. Paediatr. Dent.* **2020**, *21*, 219–226. [CrossRef] [PubMed]
25. Glerup, M.; Tagkli, A.; Küseler, A.; Christensen, A.E.; Verna, C.; Bilgrau, A.E.; Nørholt, S.E.; Herlin, T.; Pedersen, T.K.; Stoustrup, P. Incidence of orofacial manifestations of juvenile idiopathic arthritis from diagnosis to adult care transition: A population-based cohort study. *Arthritis Rheumatol.* **2023**, *75*, 1658–1667. [CrossRef] [PubMed]
26. Assaf, M.; Fratzl-Zelman, N.; Kreczy, A.; Gahleitner, A.; Langs, G.; Luder, H.U.; Stöger, H.; Pertl, C.; Fürst, A.; Zwerina, J.; et al. Temporomandibular joint involvement in juvenile idiopathic arthritis: A review of the literature and current concepts. *Rheumatol. Int.* **2013**, *33*, 179–187.

27. Costello, A.; Twilt, M.; Lerman, M.A.; CARRA Registry Investigators. Provider assessment of the temporomandibular joint in juvenile idiopathic arthritis: A retrospective analysis from the CARRA Database. *Pediatr. Rheumatol. Online J.* **2024**, *22*, 41. [CrossRef] [PubMed]
28. Lercara, A.; Martino, S.; Crepaldi, G.; Cirillo, S.; Davico, M.; Marouen, S.; Vandelli, E.; Lomater, C.; Pers, Y.M.; Licciardi, F. Temporo-Mandibular joint alterations in juvenile idiopathic arthritis and young-onset inflammatory arthropathies: A magnetic resonance imaging study with ultrasound comparison. *Pediatr. Rheumatol. Online J.* **2026**, *24*, 38. [CrossRef] [PubMed]
29. Vallogini, G.; Michelotti, A.; Magni Manzoni, S.; Festa, P.; Putrino, A.; Uomo, R.; Gregori, L.M.; Piga, S.; De Benedetti, F.; Galeotti, A. Temporomandibular joint involvement in paediatric patients affected by juvenile idiopathic arthritis. *J. Oral Rehabil.* **2026**, *53*, 1530–1542. [CrossRef] [PubMed]
30. Dimitrijevic Carlsson, A.; Wahlund, K.; Klintström, E.; Salé, H.; Kindgren, E.; Starkhammar Johansson, C.; Alstergren, P. Juvenile idiopathic arthritis and the temporomandibular joint: A case-control study of magnetic resonance imaging findings in relation to clinical and psychosocial factors. *Eur. J. Paediatr. Dent.* **2023**, *24*, 69–76. [CrossRef] [PubMed]
31. Steenks, M.H.; Giancane, G.; de Leeuw, R.R.; Bronkhorst, E.M.; van Es, R.J.; Koole, R.; van Bruggen, H.W.; Wulffraat, N.M. Temporomandibular joint involvement in juvenile idiopathic arthritis: Reliability and validity of a screening protocol for the rheumatologist. *Pediatr. Rheumatol.* **2015**, *13*, 15. [CrossRef] [PubMed]
32. Topaloglu Yasan, G.; Adiloglu, S.; Tuz, H.H.; Sahar, D. Evaluation of clinical signs and magnetic resonance imaging findings in patients with temporomandibular disorders. *J. Craniomaxillofac. Surg.* **2023**, *51*, 441–447. [CrossRef] [PubMed]
33. Huhtanen, M.; Mikola, K.; Kiukkonen, A.; Palotie, T. Maximal mouth opening is a simple method to evaluate the treatment outcome of temporomandibular joint arthritis in patients with juvenile idiopathic arthritis. *Acta Odontol. Scand.* **2025**, *83*, 682–689. [CrossRef] [PubMed]
34. Halbig, J.M.; Stoustrup, P.; Kristensen, K.D.; Frid, P.; Rypdal, V.; Songstad, N.T.; Augdal, T.A.; Fischer, J.; Gil, E.G.; Cetrelli, L.; et al. Temporomandibular disorder in children with juvenile idiopathic arthritis with and without temporomandibular joint involvement compared to controls—A two-year prospective multicenter cohort study. *BMC Oral Health* **2026**, *26*, 334. [CrossRef] [PubMed]
35. Dipalma, G.; Inchingolo, A.D.; Guglielmo, M.; Morolla, R.; Palumbo, I.; Riccaldo, L.; Venere, D.; Palermo, A.; Inchingolo, A.M.; Inchingolo, F. Imaging techniques for evaluating temporomandibular joint involvement in juvenile idiopathic arthritis: A systematic review. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol.* **2025**, *140*, 769–782. [CrossRef] [PubMed]
36. Abramowicz, S.; Simon, L.E.; Susarla, H.K.; Lee, E.Y.; Cheon, J.E.; Kim, S.; Kaban, L.B. Are panoramic radiographs predictive of temporomandibular joint synovitis in children with juvenile idiopathic arthritis? *J. Oral Maxillofac. Surg.* **2014**, *72*, 1063–1069. [CrossRef] [PubMed]
37. Pedersen, T.K.; Küseler, A.; Gelineck, J.; Herlin, T. 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. *J. Rheumatol.* **2008**, *35*, 1668–1675. [PubMed]
38. Navallas, M.; Tolend, M.; Otobo, T.M.; Panwar, J.; Inarejos Clemente, E.J.; Hemke, R.; van Rossum, M.A.; Doria, A.S. Developing standards for MRI evaluation of joints in children with juvenile idiopathic arthritis utilizing the temporomandibular joint as a model. *Jpn. J. Radiol.* **2024**, *42*, 56–68. [CrossRef] [PubMed]

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