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Imaging techniques for evaluating temporomandibular joint involvement in juvenile idiopathic arthritis: a systematic review

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Objective. Juvenile idiopathic arthritis (JIA) encompasses a group of chronic inflammatory disorders affecting children and adolescents, characterized by persistent arthritis of unknown etiology. Its pathogenesis is multifactorial, involving genetic, environmental, and immunological factors. This systematic review evaluates current diagnostic approaches for detecting temporomandibular joint (TMJ) involvement in JIA.

Materials and Methods. Following PRISMA guidelines and registered in PROSPERO (CRD 529873), a comprehensive search was conducted in PubMed, Scopus, and Web of Science for studies published between January 1, 2013, and August 1, 2024.

Search Terms Included. (Imaging OR CBCT OR cone beam OR MRI OR ultrasound OR magnetic resonance imaging) AND (juvenile idiopathic arthritis OR JIA) AND (temporomandibular joint OR TMJ). Studies focusing on TMJ diagnostic techniques in JIA patients were included.

Results. Out of 528 records, 18 studies met the inclusion criteria. The results emphasize the critical role of advanced imaging—particularly magnetic resonance imaging (MRI), cone beam computed tomography (CBCT), and ultrasound (US)—in detecting early TMJ changes. While MRI remains the gold standard for evaluating soft tissue and inflammatory activity, CBCT and US offer complementary insights. The review highlights the need for standardized diagnostic protocols and further studies to refine imaging strategies and improve clinical outcomes in JIA. (Oral Surg Oral Med Oral Pathol Oral Radiol 2025;140:769−782)

Juvenile idiopathic arthritis (JIA) is the most common chronic rheumatic disease in children and adolescents, characterized by persistent arthritis of unknown origin.[1,2]

The condition poses significant clinical challenges due to its heterogeneity in presentation, unpredictable progression, and potential for long-term disability.[3,4] According to the International League of Associations for Rheumatology (ILAR), JIA encompasses several clinical subtypes, including oligoarthritis, polyarthritis, systemic arthritis, psoriatic arthritis, enthesitis-related arthritis, and undifferentiated arthritis.[5−7] Although its pathogenesis remains incompletely understood, it is thought to result from a complex interaction of genetic susceptibility, environmental triggers, and immune dysregulation.[8,9] Despite advances in research, the multifactorial nature of JIA continues to challenge efforts at achieving early and precise diagnosis as well as individualized treatment strategies.[10,11]

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TEMPOROMANDIBULAR JOINT ANATOMY

The temporomandibular joint (TMJ) is a highly specialized synovial joint that connects the mandible to the temporal bone of the skull. It plays a critical role in essential functions such as mastication, speech, and swallowing.[12−15]

Structurally, the TMJ consists of the mandibular condyle articulating with the glenoid fossa and articular eminence, separated by a fibrocartilaginous articular disc.[15−23] This disc divides the joint into upper and lower compartments, allowing both rotational and translational movements, while also absorbing mechanical stress and distributing load evenly.[23−27]

Statement of Clinical Relevance

Early identification of temporomandibular joint involvement in juvenile idiopathic arthritis through imaging can guide timely interventions, potentially preventing irreversible joint damage and improving craniofacial development and quality of life in affected children.

The joint is enclosed by a fibrous capsule lined with a synovial membrane that secretes synovial fluid to ensure lubrication and metabolic support.[28–33]

Given its functional complexity and anatomical intricacy, the TMJ is particularly vulnerable to inflammatory and degenerative changes, especially in the context of systemic conditions such as JIA.[31,32,34–36]

TMJ INVOLVEMENT IN JIA

Although JIA typically affects peripheral joints such as the knees and wrists, TMJ involvement is increasingly recognized and may be present even in asymptomatic patients.[3,37–39]

Inflammatory activity in the TMJ can lead to synovitis, joint effusion, bone marrow edema, and progressive destruction of cartilage and subchondral bone.[40,41]

Chronic inflammation may result in structural changes such as condylar erosion, flattening of the articular surfaces, and widening of the glenoid fossa.[42–45]

These alterations can severely impair mandibular growth and function, particularly in children under the age of eight, potentially leading to facial asymmetry, micrognathia, malocclusion, limited maximal incisal opening, and chronic pain.[44,46–48] While TMJ development may proceed normally in the absence of joint involvement, early detection and treatment are critical to preserving joint integrity and preventing long-term complications.[49–51]

DIAGNOSTIC MODALITIES

Early and accurate identification of TMJ involvement in JIA is crucial for timely intervention and improved long-term outcomes.[52–55]

Imaging plays a central role in the evaluation of both structural and inflammatory changes within the joint.[54,56]

Cone beam computed tomography (CBCT) offers high-resolution, three-dimensional visualization of osseous structures and is particularly effective in detecting erosions, condylar remodeling, and joint asymmetry. However, it lacks sensitivity for soft tissue evaluation.[57–59]

Magnetic resonance imaging (MRI) is the gold standard for assessing TMJ involvement in JIA due to its superior ability to visualize soft tissues, including the articular disc, synovial membrane, and cartilage. It is highly sensitive to early inflammatory signs such as synovitis, joint effusion, and bone marrow edema. The addition of contrast-enhanced sequences further improves the detection of active inflammation.[60–63]

Ultrasound (US) is a noninvasive and radiation-free modality that allows real-time dynamic assessment of joint structures. Although it is limited in evaluating deeper bony anatomy, it is useful for detecting effusion, synovial hypertrophy, and disc displacement in a pediatric setting.[55,64–66]

TMJ involvement in JIA remains underdiagnosed and poorly addressed in clinical practice. This review aims to synthesize current evidence on diagnostic imaging to support early recognition and guide clinical decision-making (Figure 1).

MATERIALS AND METHODS

Protocol and registration

This systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), and the protocol was registered at PROSPERO under the ID: CRD 529873.

Search processing

To find studies that investigated diagnostic tools to assess TMJ involvement in patients with JIA, a search was conducted on PubMed, Scopus, and Web of Science for papers published between January 1, 2013 and August 1, 2024. Boolean keywords have been used in the search strategy: (Imaging OR CBCT OR cone beam OR MRI OR ultrasound OR magnetic resonance imaging) AND (juvenile idiopathic arthritis OR JIA) AND (Temporomandibular joint OR TMJ).

Inclusion criteria

The following inclusion criteria were considered: (1) open-access studies; (2) studies that investigated diagnostic tools to assess TMJ involvement in patients with JIA; (3) randomized clinical trials, retrospective studies, case-control studies, and prospective studies; (4) English language, and (5) full-text.

Papers that did not meet the specified requirements were not accepted.

The PICOS criteria were used to conduct the review:

- Participants: adults, both male and female;
- Interventions: diagnostic tools;
- Comparisons: different diagnostic tools utilized;
- Outcomes: MRI and CBCT have proven effective in diagnosing JIA.
- Study: randomized clinical trials, retrospective studies, case-control studies, and prospective studies.

Exclusion criteria

The exclusion criteria were as follows: (1) animal studies; (2) in vitro studies; (3) off-topic; (4) reviews, case reports, case series, letters, or comments; (5) languages other than English.

Data processing

Based on selection criteria, three reviewers (M.G., I.P., and R.M.) independently accessed the databases to

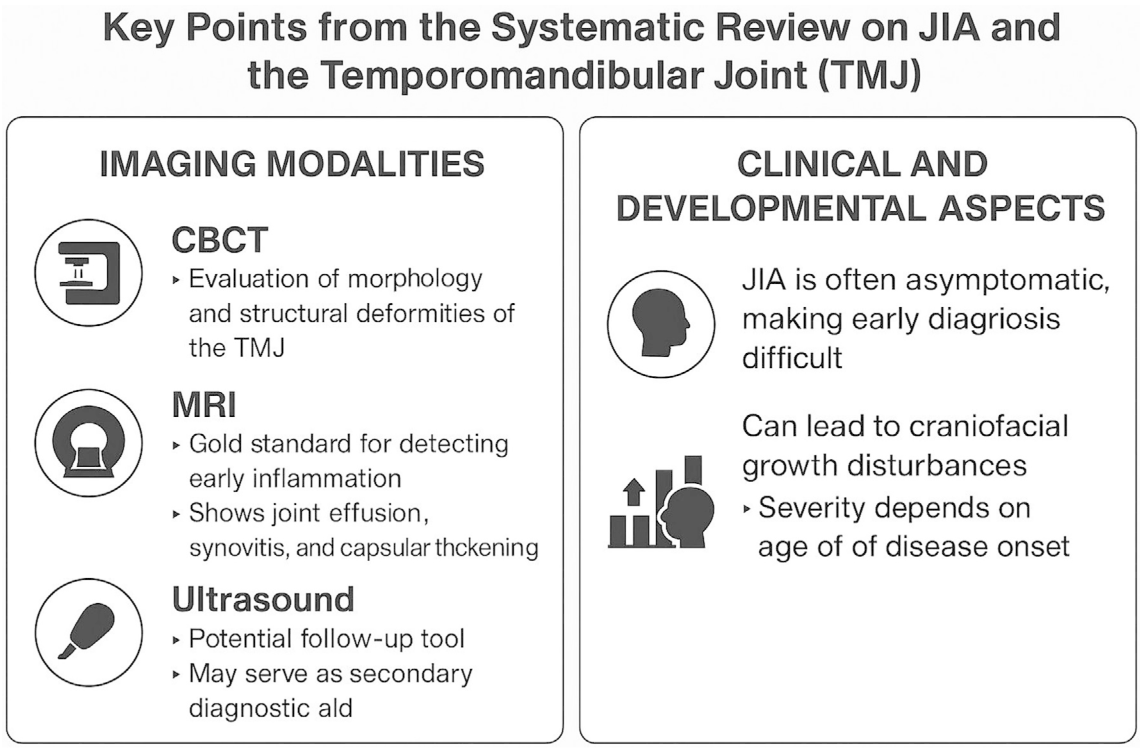

Fig. 1. Key findings of the review.

gather the studies and assigned a quality rating. Disagreements among the three writers were resolved through consultation with a senior reviewer (F.I.).

Quality assessment

The quality of the included papers was assessed by two reviewers, R.F. and E.I., using the ROBINS, a tool developed to assess risk of bias in the results of nonrandomized studies that compare the health effects of two or more interventions. Seven points were evaluated, and each was assigned a degree of bias. A third reviewer (F.I.) was consulted in the event of a disagreement. The question in the domains evaluated in the ROBINS test is the following:

- Bias due to confounding
- Bias arising from the measurement of exposure
- Bias in the selection of participants for the study
- Bias due to postexposure intervention
- Bias due to missing data
- Bias arising from the measurement of the outcome
- Bias in the selection of the reported results.

RESULTS

Study selection and characteristics

A total of 528 publications were found using the electronic database search (Scopus *N* = 136, PubMed *N* = 181, Web of Science *N* = 211); no additional articles were found using the manual search.

After removing duplicates (*N* = 238), the titles and abstracts of 290 papers were assessed to filter them. A total of 131 records were exclused out of 159 papers that did not match the inclusion criteria (101 off-topic, 39 reviews, 5 in vitro experiments, 14 animal studies). A total of 113 reports were removed for not meeting the inclusion criteria (109 off-topic, 4 reviews). A total of 18 records were chosen for qualitative analysis after being deemed eligible. Figure 2 and Table I, respectively, present the selection procedure and the summary of the records that were chosen.

Quality assessment and risk of bias of included articles

The risk of bias in the included studies is reported in Figure 3. Most studies have a high risk due to confounding. The bias arising from measurement is a parameter with a low risk of bias. Many studies have a low risk of bias due to bias in the selection of participants. Bias due to postexposure cannot be calculated due to high heterogeneity. The bias due to missing data is low in most studies. Bias arising from the measurement of the outcome is low. Bias in the selection of the reported results is high in most studies. The final results show that five studies have a low risk of bias, three have a very high risk of bias, and six have a high risk of bias.

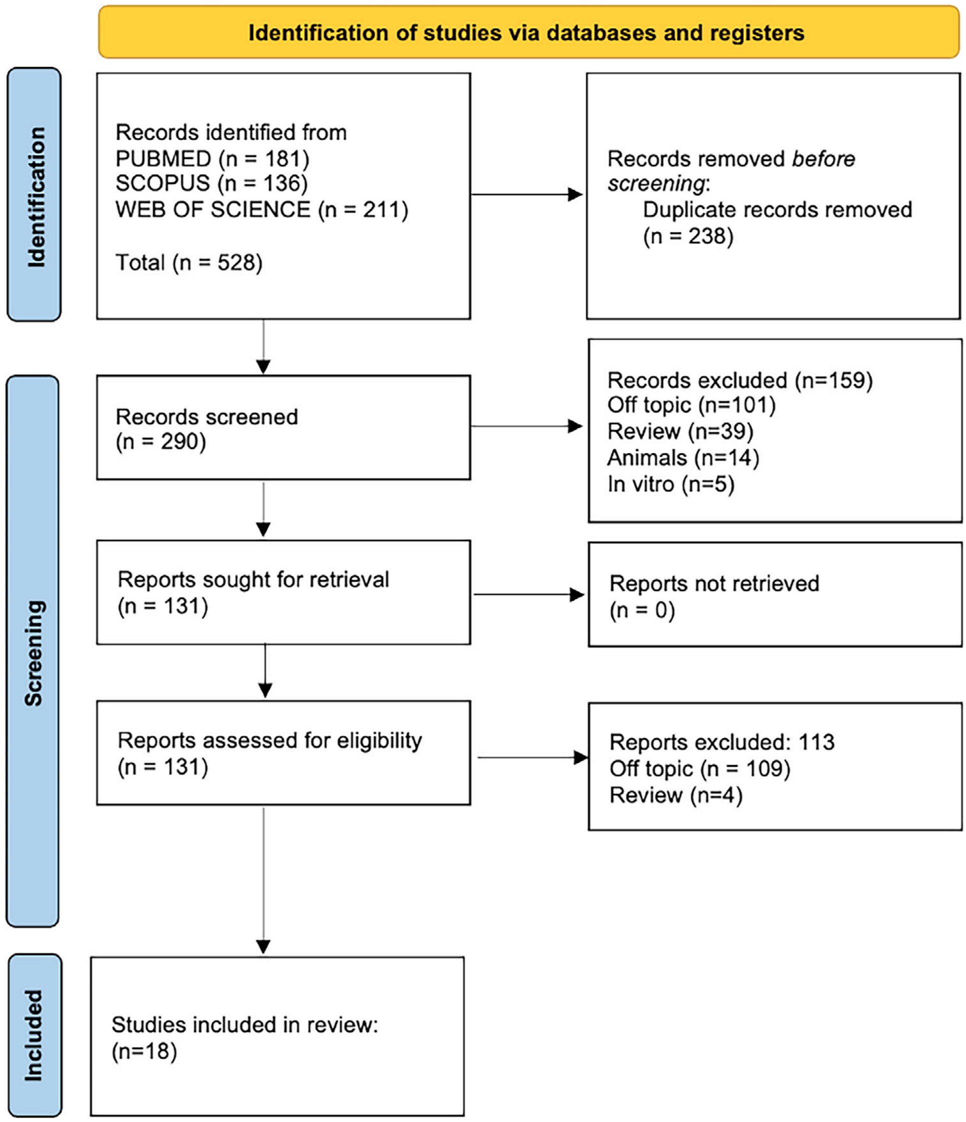

Fig. 2. Literature search Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram and database search indicators.

DISCUSSION

In the realm of rheumatology, evaluating TMJ involvement in JIA presents a multifaceted challenge.[79] A systematic review of scientific literature reveals a nuanced landscape of diagnostic tools and advancements aimed at enhancing our understanding and management of TMJ pathologies in JIA patients. Within this context, MRI and US emerge as pivotal modalities warranting special attention for their diagnostic capabilities and clinical relevance.

Calle et al.'s longitudinal prospective study, spanning from 2015 to 2020, delved into diagnostic tools for assessing TMJ involvement in JIA. Their comprehensive investigation underscored the significance of clinical examinations, self-assessment questionnaires, and CBCT in delineating TMJ-related pain and structural deformities. However, it also emphasized the necessity for longitudinal studies to comprehensively evaluate TMJ pathoses in JIA, highlighting the need for further research in this domain.[72]

Bousquet et al.'s retrospective analysis aimed to distinguish TMJ involvement in JIA from other causes of TMJ degeneration. By comparing TMJ MRIs of non-JIA subjects with clinical TMJ degeneration and JIA subjects with TMJ involvement, the study sheds light on the diagnostic nuances inherent in discerning JIA-related TMJ pathoses. Their findings emphasize the critical importance of meticulous diagnostic assessment in guiding treatment decisions.[68]

Ricardo et al. sought to evaluate the utility of texture analysis (TA) based on MRI in identifying patients at risk of TMJ damage due to JIA. Their retrospective

Table I. Descriptive summary of item selection

Study	Study design	Number of patients	Average age and gender	Diagnostic tool	Outcomes
Fischer et al.[67]	Cross-sectional study.	228 children and adolescents aged 4-16 years were included in the study.	The median age of participants was 13.1 years (range 5.9-16.5 years). Gender distribution: 44% girls.	Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I, self-assessment questionnaire recommended by TMJaw, CBCT.	Nearly one-third (29%) of patients with JIA experienced pain on palpation at and around the lateral TMJ-pole, while almost 60% reported TMJ pain on jaw movement. Assessment by CBCT revealed that approximately one-third of TMJs in JIA patients exhibited structural deformities.
Bousquet et al.[68]	Retrospective cross-sectional study.	The study included 34 subjects: 16 non-JIA and 18 JIA patients.	For the non-JIA group, the average age was 13.9 years, with 75% females. For the JIA group, the average age was 13.6 years, with 77% females.	Gadolinium-enhanced TMJ MRI.	The primary outcome was the radiologist's accuracy in predicting the study grouping. Secondary outcomes included MRI characteristics such as inflammation, osseous damage, and articular disc morphology.
Ricardo et al.[63]	Retrospective study.	The study included 45 patients, divided into a control group (23 patients) and a JIA group (22 patients).	Specific average ages and gender distributions were not provided in the text.	Texture analysis (TA) based on MRI, utilizing grey-level co-occurrence matrix (GLCM) parameters.	The study demonstrated significant differences in texture parameters of the condyle between the JIA group and the control group. Additionally, a progressive loss of grayscale pixel uniformity on MRI was observed with increasing age in the JIA group.
Tonni et al.[69]	Comparative study.	The study included 29 children in the JIA group and 28 healthy children in the control group.	In the JIA group, the average age was 13 years, with no specific gender distribution mentioned. In the healthy group, the average age was 12.6 years, with no specific gender distribution mentioned.	Lateral Periarticular Space (LPAS) of TMJ is evaluated with Ultrasonography (USG) and MRI.	The study found that the LPAS width was larger in the group with JIA compared to the healthy group. Additionally, a positive correlation and good agreement were observed between MRI and USG measurements in the JIA group, suggesting that while USG cannot replace MRI for TMJ evaluation in JIA patients, it can serve as a supplementary imaging method.
Tonni et al.[70]	Comparative study.	The study included 8 JIA children with confirmed TMJ involvement by MRI in Group A and 7 healthy children without TMJ in Group B.	In Group A, the average age was 11.6 years, with no specific gender distribution mentioned. In Group B, the average age was 9.3 years, with no specific gender distribution mentioned.	US was used to evaluate the LPAS and joint effusion.	LPAS values were significantly higher in Group A compared to Group B, with no overlap in confidence intervals. Additionally, no joint effusion was detected in either group. US measurements showed a positive correlation with MRI findings, indicating its potential as a follow-up tool for assessing TMJ involvement in JIA patients.
Assaf et al.[71]	Prospective study.	The study included 20 children with TMJ disorders caused by JIA	The mean age of the patients was 11.06 years, with 17 females and 3 males included in the study.	High-resolution USG, using a 12 MHz array transducer, was employed to assess TMJ changes.	USG proved valuable, particularly for detecting condylar involvement in children with JIA, and could serve as a diagnostic alternative in various situations, such as when MRI is unavailable or when children fear MRI examination.
Calle et al.[67,72]	Prospective study.	72 patients were included in the study.	The median age of the participants was 13.1 years, ranging from 5.9 to 16.5 years. Approximately 44% of the participants were girls.	Diagnostic assessments included clinical examination using a shortened version of the Diagnostic Criteria for DC/TMD Axis I and a self-assessment questionnaire recommended by TMJaw.	The study aimed to examine the association between clinical signs/symptoms of TMD and structural TMJ deformities detected via CBCT in children and adolescents diagnosed with JIA. The main outcomes included the presence of TMD symptoms, TMJ pain on palpation and jaw movement, and TMJ deformities categorized based on CBCT findings.

(*continued*)

Table I. Continued

Study	Study design	Number of patients	Average age and gender	Diagnostic tool	Outcomes
Otero et al.[57]	Retrospective study.	The study included 11 patients diagnosed with JIA and 11 healthy controls.	The mean age of the JIA group was 11.9 years, with nine females and two males. The mean age of the control group was 11.7 years, with eight females and three males.	CBCT was used as the diagnostic tool.	The study aimed to present and evaluate a CBCT-based method for quantifying TMJ volumes and comparing them between JIA patients and healthy controls. Significant differences were observed in the amount of soft tissue present in the TMJ space between the two groups, suggesting potential utility as a quantitative marker for TMJ deformities in JIA.
Fischer et al.[73]	Prospective cohort study.	90 patients	Mean age of 12.8 years (range 4.9-16.3 years), including 33 boys and 57 girls.	MRI, CBCT, lateral cephalogram.	Precision of measurements for mandibular morphology in JIA patients. Intra- and interobserver agreement and variability for MRI, CBCT, and ceph-based measurements. Comparison between CBCT and MRI measurements for condylar height. Determination of clinically acceptable agreement levels. Identification of precise radiological measurements for dentofacial deformity assessment in JIA. Determination of the Minimal Detectable Change (MDC) for various measurements.
Al-Shwaikh et al.[58]	Cross-sectional observational study.	The study evaluated CBCTs of 65 patients with JIA and 30 patients without JIA, totaling 95 patients.	The mean age of the JIA group was 14.2 years, with a range of 9-17 years, including 45 females and 20 males. The mean age of the control group was 13.67 years, with a range of 10-17 years, including 24 females and 6 males.	CBCT was used for the examination and evaluation of the articular bony tissue structures of the TMJs.	The study aimed to assess the radiologic features of the TMJ osseous components in children with JIA compared to those without JIA using CBCT. The outcomes included identifying characteristic radiological diagnostic signs, evaluating disorders in males and females, and analyzing differences between the right and left sides of the TMJ.
Farronato et al.[33]	Observational study.	30 children.	Average age of 11.90 years (range: 4-14 years), with 23 females and 7 males.	CBCT.	JIA affects the TMJ asymptomatically in many cases. TMJ involvement can lead to severe craniofacial growth disturbances and facial deformities if not treated early. Symptoms of TMJ arthritis in JIA patients are often subtle and may not be indicative of underlying bony destruction. Clinical examinations alone are insufficient for reliably identifying TMJ damage in JIA patients. CBCT provides valuable information for diagnosing and treating TMJ involvement in JIA, offering accurate and precise quantitative and volumetric images of the mandibular structures.

(*continued*)

Table I. Continued

Study	Study design	Number of patients	Average age and gender	Diagnostic tool	Outcomes
Stoll et al.[74]	Prospective study.	The study included 122 children without arthritis as control group and 35 newly diagnosed children with JIA.	Specific average ages and gender distributions were not provided in the text.	The control group patients, undergoing contrast-enhanced MRI of the head, were prospectively enrolled to undergo concurrent contrast-enhanced MRI of TMJs. For comparison, the initial TMJ MRI scans of 35 newly diagnosed children with JIA were retrospectively evaluated.	Children with JIA seem to have an equivalent likelihood of findings associated with minimally active TMJ arthritis compared to noninflamed controls.
von Kalle et al.[61]	Retrospective study.	50 patients with JIA and 46 patients as control group.	Mean age at the time of MR imaging in patient group:12.0 years. Gender distribution: 40 females, 10 males.	MRI with dynamic contrast enhancement.	In dynamic contrast-enhanced MRI, the significant overlap of results made it challenging to differentiate between TMJs showing signs of inflammation and those without. Consequently, relying solely on the degree of contrast enhancement was insufficient for this distinction. Instead, thickening of the soft joint tissue appeared to be the earliest reliable indicator of TMJ arthritis.
Tolend et al.[75]	Observational study.	21 patients.	Age range 6-16 years, gender distribution not specified.	MRI scans evaluated with three different scoring system (German, American, Swiss).	Development of a novel TMJ MRI scoring system through consensus among JIA experts.
Angenete et al.[62]	Prospective, longitudinal observational study.	86 patients.	Median age 13 years; 51 F, 35 M.	MRI imaging of TMJ.	Proposed scoring system for TMJ involvement in children with JIA.
Vaid et al.[76]	Observational study.	Not specified.	Not specified.	MRI protocols, particularly utilizing 1.5 T or 3.0 T magnets with dedicated surface coils or high-definition Cranio-Spinal coils.	The study assessed MRI scoring reliability for TMJ changes in children with JIA, covering normal anatomy and disease-related alterations. It highlighted serial MRI's role in tracking disease progression and treatment response, notably with intra-articular steroids. The proposed MRI scoring system aims to quantify TMJ arthritis changes for clinical trial facilitation, acknowledging challenges like sedation and cost.
Tolend et al.[77]	Prospective cohort study.	120 participants.	Mean age of 42 years (SD $\pm$ 5.6), 60% male, 40% female.	MRI scans.	The reliability of semiquantitative MRI lays the groundwork for its potential application in assessing changes over time and response to therapy, which is clinically significant.
Resnick et al.[78]	Retrospective case-control study.	The JIA group comprised 74 subjects, while the control group included 71 subjects.	In the JIA group, the mean age was 13.19 years, with 80% female participants. In the control group, the mean age was 11.4 years, with 54% female participants.	MRI with gadolinium was used to assess synovial enhancement in the TMJs of both groups.	The study demonstrated that an enhancement ratio (ER) of 1.55 discriminated between TMJs with synovitis and unaffected controls with a sensitivity of 91% and a specificity of 96%.

review revealed significant differences in condyle texture parameters between control and JIA groups, highlighting the potential of MRI TA in the early detection of TMJ involvement. These findings portend a promising avenue for leveraging advanced imaging techniques to enhance the precision and timeliness of TMJ pathoses detection in JIA patients.[63]

Tonni et al.'s exploration of US as an alternative diagnostic tool for detecting acute signs of TMJ involvement in JIA patients revealed promising results.

By evaluating the Lateral Periarticular Space and joint effusion in JIA children with confirmed TMJ involvement by MRI, their research highlighted the potential of US as a supplementary imaging method. The study's findings underscore its role as a viable follow-up tool for assessing TMJ involvement in JIA.[70]

Tonni et al.'s comparative evaluation of ultrasonography (USG) and MRI in assessing TMJ involvement offered valuable insights into Lateral Periarticular Space width and the potential role of USG as a supplementary imaging modality. Their investigation revealed significant differences in Lateral Periarticular Space width between JIA and healthy groups, with positive correlation and good agreement between MRI and US measurements, underscoring the complementary nature of these diagnostic modalities.[69]

Assaf et al.'s study delved into the efficacy of high-resolution USG in detecting TMJ changes in children with JIA, shedding light on its diagnostic utility and clinical implications. By prospectively investigating TMJ disorders in children with JIA, their analysis unveiled various TMJ changes, showcasing the value of high-resolution USG in detecting TMJ changes and its potential as a valuable diagnostic alternative in clinical practice.[71]

The collective findings of these studies offer comprehensive insight into the diagnostic landscape of TMJ involvement in JIA. From longitudinal prospective studies to retrospective analyses, from TA based on MRI to the evaluation of USG as an alternative diagnostic tool, each study contributes to our understanding of TMJ pathology in JIA patients.

The study by Fischer et al., conducted from 2015 to 2020, involved 228 children and adolescents diagnosed with JIA. The authors used a combination of diagnostic tools to assess TMJ involvement. Patients were evaluated using a shortened version of the Diagnostic Criteria for DC/TMD Axis I and a self-assessment questionnaire recommended by TMJaw. This combined approach aims to overcome the reported limitations of DC/TMD alone in TMJ evaluation. Clinical examinations included pain assessment and CBCT imaging, with CBCT used to categorize the severity of TMJ deformities. Statistical analyses were conducted to explore associations between TMJ pain and structural deformities visible on CBCT. It's important to note that nearly a third of JIA patients experienced TMJ pain, while structural deformities were observed in about a third of the TMJs. However, no significant associations were found between clinical signs/symptoms and deformities detected via CBCT overall. However, subgroup analysis revealed an association between the persistent oligoarticular JIA subtype and TMJ pain symptoms correlated with deformities detected on CBCT. These findings highlight the complexity of TMJ involvement in JIA and suggest the need for further longitudinal studies to better understand the relationship between clinical symptoms and structural changes over time.[67]

The study by Otero et al. aimed to present and evaluate a CBCT-based method for quantifying TMJ volumes, comparing JIA patients with healthy controls. In this retrospective study, patients diagnosed with JIA were examined for TMJ involvement and dentofacial deviation. The study group comprised 11 patients referred from the Pediatric Rheumatology Clinic to the Regional Craniofacial Specialist Clinic. CBCT scans were performed based on clinical findings, including reduced chewing function and asymmetric growth. A control group of 11 patients undergoing orthodontic treatment was also included. CBCT images were processed to measure the soft and bony tissue volumes of the TMJ. Results showed significant differences in soft tissue volumes between JIA patients and controls, indicating TMJ pathologies. The study suggests that CBCT imaging may provide quantitative measures for TMJ evaluation in JIA, potentially serving as a screening tool for early diagnosis of TMJ involvement in affected children. Limitations include the retrospective nature of the study and the small sample size, necessitating further research to validate the proposed methodology and its clinical utility.[57]

The study by Fischer et al., conducted between 2015 and 2020, involved 90 JIA patients undergoing MRI, CBCT, and lateral cephalometric examinations, aiming to compare the accuracy of MRI and CBCT in measuring mandibular morphology. MRI measurements showed relatively narrow intra- and inter-observer agreement limits for total mandibular length but wider agreement limits for posterior mandibular height and condylar height. CBCT measurements showed wider agreement limits for condylar height but acceptable intra-observer agreement. Cephalometric measurements demonstrated narrow agreement limits for some angles but wider agreement limits for others, indicating variable accuracy. While MRI showed wide variation and limited accuracy, CBCT demonstrated acceptable precision for clinical use, particularly for condylar height measurement, suggesting its superiority in this context.[73]

The study by Al-Shwaikh et al. aimed to evaluate the radiological characteristics of the TMJ in children with JIA compared to those without JIA, using CBCT. A total of 95 patients (65 with JIA and 30 controls) underwent clinical and radiological examinations, with evaluations focused on condylar and glenoid fossa characteristics. Statistical analysis revealed significant differences in the prevalence of TMJ bone structural changes between the JIA and control groups, with flattening of the surface, erosion, and osteophyte

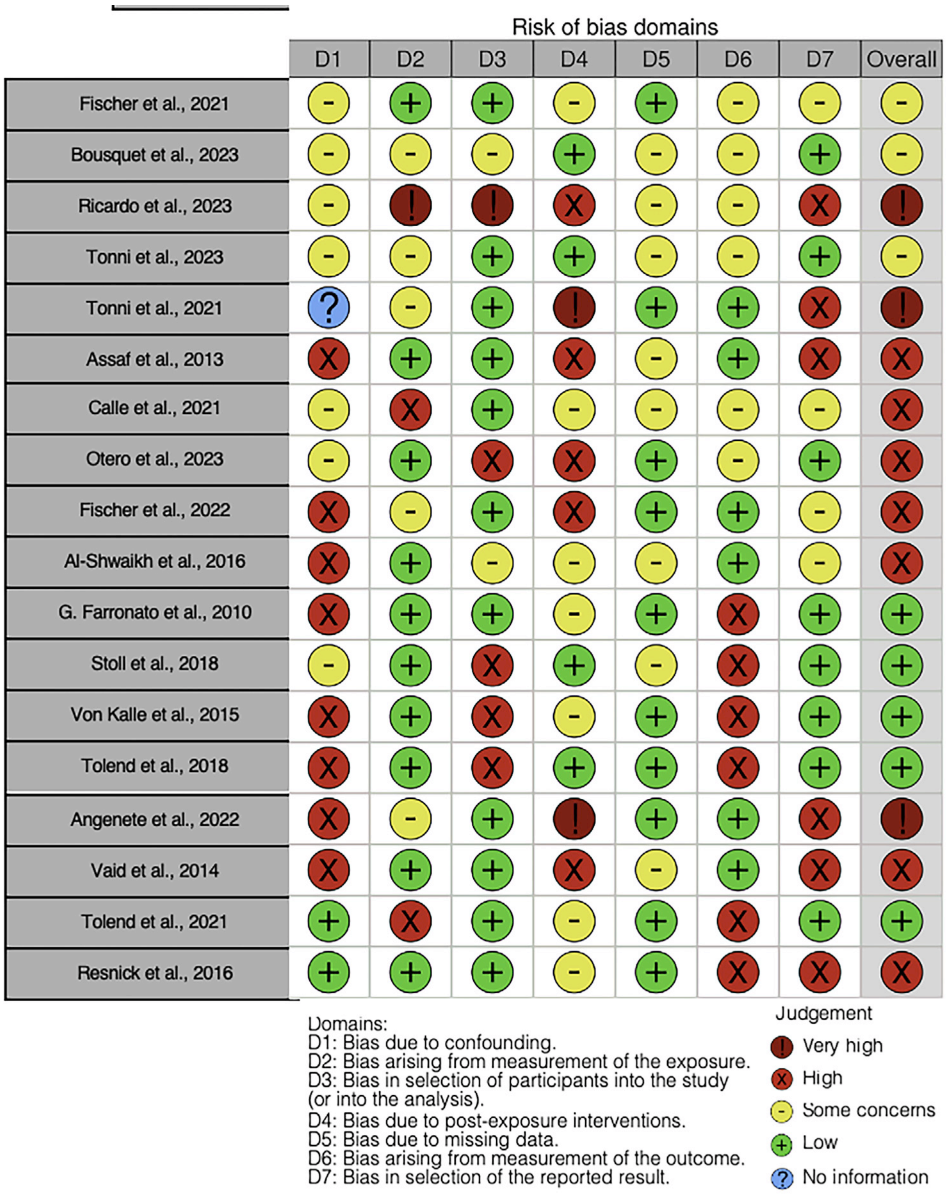

Fig. 3. Bias assessment.

formation being more common in the JIA group. Gender-specific analyses highlighted significant differences in radiological characteristics, with a higher prevalence in females. The study underscores the importance of CBCT in identifying TMJ involvement in JIA patients and suggests the need for further research to explore the relationship between JIA subtypes, disease duration, occlusion, clinical symptoms, and specific radiological characteristics observed. Additionally, the results emphasize the need to carefully evaluate radiographic images in all planes to distinguish pathological changes from normal growth and development processes, especially in pediatric populations. Overall, the study provides valuable insights into TMJ pathoses in JIA and highlights the potential of CBCT as a diagnostic tool in this context.[58]

The study by Farronato et al. enrolled 34 patients with JIA diagnosed according to the ILAR revised criteria. Patients with certain medical conditions were excluded. Clinical and radiographic evaluations were conducted to assess TMJ involvement using CBCT, which offers reduced radiation dosage compared to traditional methods. CBCT provided detailed 3D images, allowing accurate assessment of TMJ morphology and volumetric measurements of mandibular components. Results revealed significant differences in volumes between healthy and affected TMJ components. CBCT proved valuable for diagnosing and monitoring TMJ involvement in JIA patients, offering precise quantitative data and enhancing understanding of mandibular changes associated with the condition. Early detection via CBCT is crucial for preventing severe craniofacial growth disturbances and facial deformities in JIA patients.[33]

These studies have highlighted the importance of early detection and monitoring of TMJ involvement to prevent long-term complications such as severe craniofacial growth disturbances and facial deformities. While CBCT emerges as a valuable diagnostic tool offering precise quantitative data and detailed 3D images for assessing TMJ morphology and volumetric measurements, further research is warranted to validate methodologies, explore associations between clinical symptoms and radiological findings, and delineate the nuanced relationships between JIA subtypes, disease duration, occlusion, and TMJ characteristics.

Stoll et al. conducted an evaluation of diagnostic tools for assessing JIA involvement in the TMJ. A prospective assessment of 122 children undergoing brain MRI, irrespective of TMJ arthritis, revealed effusions up to 1.4 mm in 62 subjects and contrast enhancement up to 1.8 mm in 120 subjects. Surprisingly, effusions were more common in controls compared to JIA patients, with larger effusions (>1.5 mm) exclusively seen in JIA patients. The study suggests discrepancies in findings among nonarthritic subjects, possibly attributed to methodological differences, MRI field strengths, or patient populations. While small joint effusions and enhancement may not indicate pathology, larger effusions (>1.5 mm) are associated with JIA. Nonetheless, chronic changes and extensive effusions remain specific to JIA. Despite limitations, including variations in MRI field strength and treatment effects, the study underscores the importance of timely TMJ MRI follow-up in JIA patients to monitor disease progression. Overall, findings suggest that while minimally active TMJ arthritis may occur similarly in JIA and noninflamed controls, chronic changes and extensive effusions are indicative of JIA.[74]

A multicenter retrospective case-control investigation aimed to evaluate diagnostic tools for assessing JIA involvement in the TMJ. Patients from various hospitals were included, with subjects divided into a JIA group and a control group. The JIA group consisted of children and adolescents diagnosed with JIA who met specific criteria, including MRI imaging and complete clinical records. The control group comprised individuals without TMJ pathology, undergoing MRI for other indications. MRI image acquisition and calculation of the enhancement ratio were performed using standardized protocols. Results showed a significantly higher enhancement ratio in the JIA group compared to controls, with certain medications associated with lower ER in the JIA group. This method presents promise for early detection and treatment assessment in JIA-related TMJ arthritis, with potential applications in other synovial joints.[78]

The study, conducted from December 2005 to January 2011, aimed to assess diagnostic tools for evaluating TMJ involvement in JIA Fifty consecutive JIA patients (40 females, 10 males), aged 6.3-18 years, underwent MRI due to TMJ complaints or clinical findings. Additionally, 100 dynamic contrast-enhanced MRI studies of 46 children (26 males, 20 females) served as controls. All examinations followed a standardized protocol on a 1.5-T scanner, focusing on morphology, contrast enhancement, and dynamic scanning. Morphological abnormalities were found in 37 of 50 patients, with signs including focal erosions, synovial proliferation, and abnormal condyle shapes. Dynamic contrast-enhanced MRI revealed biphasic enhancement patterns in all joints, with significant overlap between arthritic and normal joints. While contrast enhancement alone did not reliably differentiate between inflamed and noninflamed joints, thickening of enhancing joint tissue remained the earliest reliable indicator of TMJ arthritis. These findings underscore the complexity of diagnosing TMJ involvement in JIA and emphasize the need for cautious interpretation of MRI results in clinical decision-making.[61]

Three TMJ MRI scoring systems were analyzed, originating from German, American, and Swiss institutions. The German and American systems were semi-quantitative and additive, with varying item weights and grading scales. The German system consisted of five items graded from 0 to 3, while the American system included seven items with variable weights ranging from 0 to 4. The Swiss system was progressive, with sub-scores determined based on the most severe feature. Seven readers from different centers in four countries independently scored MRI images using these systems. The sample comprised 21 patients aged 6-16 years, with predominantly female subjects and various JIA presentations. The study established a novel consensus TMJ MRI scoring system through structured communication and consensus-forming techniques involving 10 experts. Reliability analysis showed high agreement among readers for total scores, particularly in assessing osteochondral changes. The consensus system integrated eight reliable items, emphasizing early signs of TMJ arthritis. Further refinement and validation of this scoring system are planned to enhance its utility in clinical practice and research on JIA-associated TMJ involvement.[75]

The study, part of the Norwegian JIA Study, investigated diagnostic tools for evaluating TMJ involvement in JIA through MRI imaging. The cohort comprised 86 children diagnosed with JIA, recruited from tertiary pediatric hospitals. MRI protocols included various sequences and gadolinium contrast injections. Independent assessment of images was conducted by experienced radiologists using predefined scoring systems. Good agreement was observed for markers of anatomical features, structural changes, and inflammation. A scoring system incorporating precise imaging features was proposed, highlighting 11 relevant markers. However, challenges were noted in assessing certain variables, emphasizing the need for further research. Despite limitations, the study provides valuable insights into TMJ assessment in JIA, suggesting a robust scoring system for clinical application.[62]

The focus of the study lies on MRI protocols, particularly utilizing 1.5 T or 3.0 T magnets with dedicated surface coils or high-definition Cranio-Spinal coils. Precontrast imaging includes T1 coronal, T2 fast spin-echo fat-suppressed coronal, sagittal, and proton density sagittal for detailed anatomy, followed by postcontrast fat-suppressed coronal and sagittal T1-weighted images. MRI scoring reliability was tested through interrater and intrarater analyses, demonstrating substantial agreement for acute and chronic scores. Normal TMJ anatomy and acute/chronic changes in JIA are described, emphasizing synovial enhancement, effusion, bone marrow edema, and chronic features like pannus formation and condylar erosions. Serial MRI evaluations depict disease progression and response to therapy, particularly intra-articular steroids. The proposed MRI scoring system aims to quantify TMJ arthritis changes over time, facilitating clinical trials. Despite limitations such as sedation requirements and cost, validation of this scoring system is crucial for future treatment trials in children with JIA-associated TMJ arthritis.[76]

The study investigated the reliability of JAMRIS-TMJ, a scoring system for assessing MRI-observable changes in the TMJs of children with JIA. The system consists of 8 weighted items grouped into inflammatory and osteochondral damage domains. Items include bone marrow edema, joint effusion, and condylar flattening. TMJ MRI exams are conducted using specific imaging sequences and coils. The study involved 20 readers grouped into radiologists, surgeons, rheumatologists, and orthodontists. The results showed moderate-to-good reliability in scoring TMJ pathology, with varying impacts of calibration aids and reader specialty. However, challenges persist in scoring due to anatomical complexity and image interpretation pitfalls. Future research should focus on standardizing imaging parameters and accounting for longitudinal changes in TMJ pathology.[77]

CONCLUSIONS

In conclusion, the exploration of diagnostic tools and methodologies for evaluating TMJ involvement in JIA offers a nuanced understanding of this complex condition. Studies have underscored the significance of comprehensive assessments integrating clinical examinations, self-assessment questionnaires, and advanced imaging modalities such as MRI, CBCT, and US. While MRI and CBCT remain pivotal for accurate diagnosis and monitoring of TMJ pathoses, emerging techniques like TA, based on MRI and high-resolution US, show promise as supplementary tools for early detection and characterization of TMJ involvement. Moreover, the development of standardized scoring systems for MRI evaluations enhances the consistency and reliability of diagnostic interpretations. Despite the progress made, challenges persist in distinguishing JIA-related TMJ pathosis from other causes and understanding the dynamic interplay between clinical symptoms and radiological findings. Further longitudinal studies are warranted to elucidate the natural history of TMJ involvement in JIA, optimize diagnostic algorithms, and inform personalized treatment strategies aimed at mitigating long-term complications and improving patient outcomes.

ABBREVIATIONS

CBCT: Cone-Beam Computed Tomography
DC/TMD: Diagnostic Criteria for Temporomandibular Disorders
ER: Enhancement Ratio
GLCM: rey-Level Co-occurrence Matrix
JIA: Juvenile Idiopathic Arthritis
LPAS: Lateral Periarticular Space
MIO: Maximal Incisal Opening
MRI: Magnetic Resonance Imaging
TA: Texture Analysis
TMJ: Temporomandibular Joint
US: Ultrasound
USG: Ultrasonography

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The authors declare no conflicts of interest. All authors have read and agreed to the published version of the manuscript. Please turn to the for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Gianna Dipalma: Writing – review & editing, Project administration, Investigation, Conceptualization.

Alessio Danilo Inchingolo: Visualization, Data curation, Conceptualization. **Mariafrancesca Guglielmo:** Methodology. **Roberta Morolla:** Writing – original draft, Formal analysis, Conceptualization. **Irene Palumbo:** Writing – review & editing, Methodology, Formal analysis. **Lilla Riccaldo:** Writing – original draft, Validation, Software. **Daniela Di Venere:** Validation, Resources, Methodology. **Andrea Palermo:** Visualization, Validation. **Angelo Michele Inchingolo:** Writing – review & editing, Data curation. **Francesco Inchingolo:** Writing – original draft, Supervision, Software, Resources, Project administration.

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