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RHEUMATOID ARTHRITIS INVOLVING THE TEMPOROMANDIBULAR AND CERVICAL JOINTS: FUNCTIONAL AND RADIOLOGICAL ASSESSMENT

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Abstract
Rheumatoid arthritis (RA) is a chronic autoimmune disease that causes progressive synovial inflammation and joint destruction, frequently extending beyond peripheral joints to involve the temporomandibular joint (TMJ) and cervical spine. These sites of involvement can significantly compromise mastication, speech, and cervical mobility. Although recent advances in disease-modifying antirheumatic drugs have improved systemic control, TMJ and cervical manifestations remain under-recognized and inadequately characterized. The present study aimed to determine the prevalence, functional impact, and radiological characteristics of TMJ and cervical involvement in RA and to analyze their correlation with inflammatory activity and disease duration. A cross-sectional observational design was employed, involving 100 adult participants (60 RA patients and 40 age- and sex-matched controls) recruited from a tertiary care hospital. Standardized instruments such as the Helkimo Index for TMJ and the Neck Disability Index (NDI) for cervical function, were applied, complemented by radiological assessment through orthopantomography (OPG), magnetic resonance imaging (MRI), and lateral cervical radiographs. Quantitative results revealed significantly higher dysfunction among RA patients: mean Helkimo Index (8.2 ± 2.6) versus controls (2.1 ± 1.3, $p < 0.001$), and mean NDI (16.8 ± 5.7) versus controls (4.2 ± 2.3, $p < 0.001$). Radiological findings demonstrated condylar erosion in 58.3%, joint space narrowing in 61.7%, and atlantoaxial subluxation in 21.7% of RA patients, with all p-values < 0.001. Strong correlations were observed between TMJ dysfunction and cervical disability ($r = 0.62$), CRP levels ($r = 0.58$), and disease duration ($r = 0.66$). The study highlights that TMJ and cervical spine involvement constitute significant and interrelated aspects of RA pathology, reinforcing the need for routine clinical and imaging evaluation of these regions to prevent irreversible functional impairment.

Keywords: Rheumatoid arthritis, temporomandibular joint, cervical spine, Helkimo Index, radiological assessment

Introduction

Rheumatoid arthritis (RA) is a chronic systemic autoimmune disease characterized by synovial inflammation, progressive joint destruction, and extra-articular manifestations that can substantially impair function and quality of life. Although small peripheral joints of the hands and feet are most commonly associated with early clinical detection, RA is a disease of systemic synovitis that may involve multiple axial and craniofacial joints, including the temporomandibular joint (TMJ) and the cervical spine (Jahid *et al.*, 2023). TMJ and cervical joint involvement are clinically important because they can produce pain, functional limitation (chewing, speaking, neck mobility), and in severe cervical disease, catastrophic neurological complications due to atlantoaxial or vertical instability. Contemporary management of RA, particularly with disease-modifying antirheumatic drugs (DMARDs) and biologic agents, has substantially altered disease trajectories, but both TMJ and cervical complications still occur and may be under-recognized in routine rheumatologic care.

The TMJ is a unique synovial joint with complex biomechanics that governs mastication, speech, and facial symmetry. In RA, synovitis of the TMJ may manifest as pain, reduced maximum interincisal opening (MIO), crepitus, and later structural changes such as erosions and condylar flattening. Reported prevalence of TMJ involvement in RA varies widely across studies, with estimates ranging from roughly 20% to over 70%, depending on diagnostic criteria, imaging modality used, and whether symptoms alone or imaging-detected changes are counted (Gupta *et al.*, 2025). This variability speaks to both the heterogeneity of disease expression and the diagnostic challenges posed by subclinical TMJ inflammation detectable only by advanced imaging such as magnetic resonance imaging (MRI) or cone-beam computed tomography (CBCT). Given the potential for functional impairment and facial deformity in protracted disease, systematic assessment of TMJ function and structure in RA patients remains necessary.

Cervical spine involvement in RA most classically affects the atlantoaxial joint and subaxial cervical segments, producing a spectrum from pain and stiffness to atlantoaxial subluxation (AAS), basilar invagination, and subaxial subluxation (Goel *et al.*, 2017). These lesions result from pannus formation, ligamentous laxity, and bony erosion and may progress insidiously, sometimes despite apparent control of peripheral disease. Because of the risk of spinal cord compression and irreversible neurological deficit, accurate radiological assessment, often with plain radiographs supplemented by MRI or computed tomography (CT) where indicated, is integral to identifying patients at risk and planning timely management, which can include surgical stabilization. The natural history and predictors of progression in the era of modern DMARDs and biologic therapy remain active areas of investigation.

Functional assessment of TMJ and cervical involvement requires a combination of patient-reported measures (pain scales, functional questionnaires), objective clinical measures (MIO, lateral excursions, neck range of motion), and radiological evaluation. Studies have used instruments such as the visual analog scale (VAS) for pain, the Helkimo index or DC/TMD-based exam for TMJ dysfunction, and established neurological and neck disability indices for cervical function (Putri *et al.*, 2021). Imaging modalities differ in sensitivity for inflammatory versus structural lesions: MRI is preferred for early inflammatory and soft-tissue changes (synovitis, pannus), while CBCT and CT are superior for detecting osseous erosions and joint surface integrity. This multimodal approach forms the basis for the current study's combined functional and radiological assessment.

Despite growing evidence of TMJ and cervical disease in RA, several gaps persist. Prevalence estimates vary widely and comparative data linking specific functional deficits to radiological patterns in the same cohort are limited. Many prior reports are cross-sectional, small sample studies, or focused on pediatric/juvenile populations (e.g., JIA) where TMJ sequelae produce growth disturbances; fewer studies comprehensively evaluate adult RA patients with contemporaneous clinical, functional, and multimodality imaging data. Moreover, the impact of modern RA therapeutics on the incidence and radiological progression of TMJ and cervical disease is incompletely characterized. These gaps motivate a structured investigation combining validated functional metrics with targeted radiological techniques to better define the burden, patterns, and clinical correlates of TMJ and cervical involvement in RA (Vinayak *et al.*, 2024).

Therefore, the present study aims to (1) determine the prevalence and clinical spectrum of TMJ and cervical joint involvement among adult RA patients in a defined clinical population, (2) quantify functional impairment using standardized instruments and objective measures (MIO, neck ROM, pain indices), (3) characterize structural and inflammatory changes using radiography, MRI and CBCT where appropriate, and explore associations between clinical/functional indices and radiological findings to identify predictors of disability and potential targets for earlier intervention. By integrating functional assessment with state-of-the-art imaging, the study seeks to fill an evidence gap and produce clinically actionable data to inform screening and management strategies for TMJ and cervical involvement in RA (Amirian *et al.*, 2025).

Review of Literature

Temporomandibular joint involvement in rheumatoid arthritis has been described for decades, but recent imaging studies have clarified that TMJ pathology often occurs sub clinically. Older case reports and series established that RA can produce osseous erosions of the mandibular condyle, condylar flattening, and restricted mouth opening; more recent cross-sectional and imaging studies using MRI and CBCT have shown inflammatory and structural lesions in a substantial proportion of RA patients even when TMJ symptoms are absent or mild. A 2024 observational synthesis reported TMJ involvement estimates ranging broadly (19–86%), reflecting heterogeneity in detection methods and study populations; such variability underscores the need for standardized functional and imaging assessments in research and clinical practice (Farook & Dudley, 2024). Importantly, jaw pain and reduced mandibular mobility are the most consistently reported clinical manifestations when symptoms are present.

High-resolution imaging has shifted understanding from a primarily clinical diagnosis to one often reliant on imaging for early detection. MRI offers superior soft-tissue contrast to detect synovitis, joint effusions, and pannus formation in the TMJ and is sensitive for early inflammatory change; CBCT and CT provide high-resolution depiction of bony erosions, condylar morphology, and joint-space narrowing. Comparative studies suggest that MRI can detect soft-tissue and some osseous changes that plain radiographs miss, while CBCT excels at delineating cortical bone loss and erosions (Al-Saleh, 2017). Several recent articles recommend a tailored imaging strategy: MRI when inflammatory disease is suspected or to evaluate the disc and synovium, and CBCT when bony structural integrity is the principal concern or when surgical planning is contemplated. Practical imaging guidelines for TMJ in rheumatic disease now emphasize selecting modality based on the diagnostic question.

Functional measurement studies emphasize that TMJ involvement in RA affects mastication, speech, and oral function beyond pain alone. Objective measures such as maximum interincisal opening (MIO) and lateral excursions correlate with reported functional difficulty, while validated questionnaires (e.g., DC/TMD modules, Helkimo index, or disease-specific oral health-related quality-of-life instruments) capture patients perceived disability (Joaqui *et al.*, 2023). Notably, some investigations show discordance between imaging-detected TMJ changes and symptom severity: a subset of patients with clear erosive or inflammatory changes report minimal symptoms, while others with prominent pain may have limited radiographic evidence of joint destruction. This clinic radiological dissociation highlights the need for studies that directly relate quantitative imaging markers with standardized functional outcomes in the same patients.

Turning to the cervical spine, the atlantoaxial joint is the most perilous RA target because destructive synovitis may produce atlantoaxial subluxation (AAS), pannus formation, and vertical migration, with potential for spinal cord compression. The modern literature documents that although the incidence of severe cervical complications has declined with better systemic therapies, cervical lesions remain clinically relevant; they are reported both as symptomatic neck pain and as silent radiographic instability (Hauser *et al.*, 2015). Radiological surveillance typically begins with dynamic lateral cervical radiographs to detect instability (measuring atlanto-dental interval, ADI) and may be

followed by MRI to evaluate compressive pannus and spinal cord signal change. CT is valuable for detailed bony assessment when surgical planning is under consideration. Large cross-sectional imaging series and multicenter reviews have underscored the prevalence of radiographic cervical involvement and its association with longer disease duration, seropositivity (RF/anti-CCP), and higher cumulative disease activity (Manwatkar *et al.*, 2022).

Several cohort and cross-sectional studies have sought to relate clinical features and biomarkers with radiological severity in the cervical spine. Studies consistently find associations between longer RA duration and a higher frequency of radiographic cervical lesions; however, the relationship between peripheral joint disease activity and cervical instability is imperfect, with some patients developing cervical lesions despite apparent peripheral disease control (Macovei & Rezus, 2016). MRI-based studies have highlighted the role of pannus and inflammatory infiltration as correlates of neurological symptoms; when spinal cord signal changes are present on T2-weighted MRI, prognosis is worse and urgent neurosurgical evaluation is warranted. The literature therefore supports a high index of suspicion for cervical disease in RA patients with long-standing disease, seropositivity, or new neck pain or neurological signs.

Comparative and integrated analyses of TMJ and cervical involvement are relatively scarce. While both joint groups are synovial and subject to pannus-driven damage, the functional consequences differ: TMJ disease primarily degrades orofacial function and nutrition, while cervical disease risks myelopathy with life-altering neurological sequelae. A few recent investigations have adopted multimodal imaging and functional scales to probe associations between imaging severity and patient-reported outcomes; these studies suggest that structural lesions (erosions, condylar deformation, subluxation) are associated with worse function but that inflammatory activity measured on MRI may better reflect current pain and functional limitation (Maksymowych *et al.*, 2017). Yet methodological heterogeneity (varying imaging protocols, disparate functional instruments, and small sample sizes) limits the ability to synthesize findings and draws attention to the need for standardized protocols in research.

Treatment implications arising from the literature are twofold. First, targeted systemic control of RA with early DMARD and biologic therapy appears to reduce the incidence of progressive cervical instability and may limit TMJ synovitis, though definitive prospective evidence specific to TMJ outcomes is limited. Second, when structural damage is established, particularly in the cervical spine, surgical options such as posterior fusion for atlantoaxial instability are sometimes necessary to prevent or treat neurological compromise. For TMJ structural disease-causing severe dysfunction or deformity, maxillofacial surgical interventions including arthroplasty, joint reconstruction, or orthognathic procedures may be considered in a multidisciplinary context (Mallhi *et al.*, 2018). Rehabilitation and symptomatic management (physiotherapy, occlusal devices, intra-articular injections) are variably effective and require higher-quality trials in RA-specific TMJ disease.
Methodological limitations across studies constrain conclusions and inform the present study's design. Many existing reports are small, single-center, retrospective, or focus on pediatric cohorts; imaging strategies and functional measures are inconsistent, and longitudinal follow-up is often limited. There is a pressing need for studies that apply standardized clinical and radiological protocols, use validated patient-reported outcome measures, and attempt to correlate inflammatory imaging features with both functional status and serological markers. The present research is designed to address these deficiencies by combining thorough clinical functional assessment with prescribed imaging (radiographs, MRI and CBCT as indicated) and by analyzing associations between radiological patterns and quantifiable functional impairment in an adult RA cohort (Mupparapu *et al.*, 2019).

Methodology

3.1 Research Design

The present study employed a cross-sectional observational research design aimed at evaluating the involvement of the temporomandibular joint (TMJ) and cervical spine in patients diagnosed with rheumatoid arthritis (RA) (Kroese *et al.*, 2021). This design was selected to facilitate the simultaneous assessment of both functional and radiological parameters in a well-defined population of RA patients and to compare them with healthy controls. The approach allowed for the identification of correlations between disease severity and joint dysfunction without the need for long-term follow-up. This design also enabled the use of objective imaging and functional evaluation methods to establish a comprehensive understanding of joint involvement in RA.

3.2 Study Setting and Duration

The research was conducted at the Department of Rheumatology and Radiology, in collaboration with the Department of Oral and Maxillofacial Surgery, at a tertiary care teaching hospital. Data collection was carried out over a period of twelve months, from January 2023 to December 2023. The radiological examinations were performed in the hospital's diagnostic imaging center, while the functional evaluations were carried out in the maxillofacial clinic. All patients were evaluated under standardized conditions to minimize inter-examiner variability and ensure consistency in measurement and interpretation.

3.3 Study Population and Sampling

The study population comprised adult patients aged between 20 and 60 years who were diagnosed with rheumatoid arthritis based on the 2010 American College of Rheumatology/European League Against Rheumatism (ACR/EULAR) criteria. Participants were recruited consecutively from the outpatient rheumatology clinics during routine follow-up visits. A control group of age- and sex-matched healthy volunteers without any history of systemic joint disease, trauma, or temporomandibular dysfunction was also included for comparison. Using a confidence level of 95% and an expected prevalence of TMJ involvement in RA of approximately 45%, a minimum sample size of 80 patients was estimated. Ultimately, a total of 100 subjects were enrolled, 60 RA patients and 40 healthy controls, to enhance statistical power and account for possible dropouts or incomplete data (Møller-Bisgaard *et al.*, 2019).

3.4 Inclusion and Exclusion Criteria

The inclusion criteria comprised all patients with a confirmed diagnosis of rheumatoid arthritis for at least six months and who consented to participate in the study. Only individuals within the specified age range and without any prior maxillofacial or cervical surgery were considered. Exclusion criteria included patients with other systemic inflammatory diseases such as systemic lupus erythematosus or ankylosing spondylitis, those with congenital or acquired craniofacial deformities, and individuals with a history of trauma, malignancy, or severe degenerative cervical spine disease unrelated to RA. Subjects on corticosteroid therapy exceeding six months or those with recent intra-articular injections in the TMJ were also excluded to eliminate potential confounding effects on imaging results.

3.5 Ethical Considerations

Written informed consent was obtained from all participants after explaining the purpose, procedures, potential risks, and benefits of the research in accordance with the Declaration of Helsinki (2013 revision). Participants were assured of confidentiality, and each was assigned a unique study identification number to anonymize their data. The imaging exposure was justified by clinical need, and radiological assessments were performed with minimal radiation exposure in compliance with ALARA (As Low As Reasonably Achievable) principles.

3.6 Data Collection Procedures

Each participant underwent a comprehensive clinical examination followed by radiological evaluation. Clinical assessment included the recording of demographic variables such as age, sex, and disease duration, followed by the evaluation of disease activity using the Disease Activity Score in 28 joints (DAS28). Functional assessment of the temporomandibular joint was performed by measuring the maximum mouth opening (MMO), lateral and protrusive mandibular movements, and the presence of joint sounds or pain during movement (Scolaro *et al.*, 2022). Cervical spine mobility was assessed using the range of motion (ROM) test for flexion, extension, lateral bending, and rotation. Pain levels were quantified using a Visual Analog Scale (VAS) ranging from 0 (no pain) to 10 (severe pain).

Radiological examination of the TMJ was carried out using both orthopantomography (OPG) and magnetic resonance imaging (MRI). OPG was used to screen for condylar deformities, erosions, and flattening, while MRI provided detailed visualization of the joint disc, effusion, and bone marrow edema (Al-Saleh, 2017). Cervical spine evaluation was conducted using lateral radiographs and, where indicated, MRI of the cervical spine to assess atlantoaxial subluxation, erosion of odontoid processes, and narrowing of intervertebral spaces. All radiographs were interpreted by two experienced radiologists independently, and discrepancies were resolved through consensus to ensure inter-rater reliability.

3.7 Functional Assessment Tools

Functional impairment of the temporomandibular joint was assessed using the Helkimo Index, which incorporates anamnestic, clinical, and dysfunction scores. This composite index provided a structured approach to quantify TMJ involvement and correlated well with the radiological findings. For cervical spine assessment, the Neck Disability Index (NDI) was used to evaluate the impact of pain and stiffness on daily activities (Cruz *et al.*, 2019). The use of standardized tools ensured objectivity and reproducibility across the study population. Each test was performed by a calibrated examiner blinded to the patient's radiological findings to minimize bias.

3.8 Radiological Assessment and Grading

Radiological changes in the temporomandibular joint were graded according to the RDC/TMD (Research Diagnostic Criteria for Temporomandibular Disorders) guidelines, which classify condylar alterations based on the severity of cortical erosion, flattening, and osteophyte formation. Similarly, cervical spine radiographs were analyzed for the presence of atlantoaxial subluxation, vertical subluxation, and apophyseal joint degeneration. The degree of cervical spine involvement was graded following the Kauppi radiological index. MRI findings were used to confirm the extent of soft tissue involvement and to detect early changes not visible on plain radiographs (Sadineni *et al.*, 2015). This dual-modality approach provided both structural and functional insights into joint pathology.

3.9 Data Analysis

All data were entered into the Statistical Package for the Social Sciences (SPSS) version 26.0 for analysis. Descriptive statistics, including means, standard deviations, and frequency distributions, were calculated for demographic and clinical variables. The Chi-square test was used to compare categorical variables, while the independent t-test or Mann–Whitney U test was applied for continuous variables, depending on the data distribution. Correlation between disease duration, DAS28 score, TMJ involvement, and cervical spine pathology was analyzed using Pearson's or Spearman's correlation coefficients (Freire *et al.*, 2018). A p-value of less than 0.05 was considered statistically significant. Interobserver agreement between radiologists was assessed using Cohen's kappa statistic to validate imaging reliability.

3.10 Reliability and Validity

To ensure the reliability of the study findings, intra- and inter-observer variability for both clinical and radiological measurements was minimized through training and calibration sessions. All measurements were performed twice, two weeks apart, by the same examiner, and the average value was used for analysis. Instrument validity was maintained by employing internationally recognized indices such as the Helkimo Index and NDI, while radiological reliability was ensured through standard positioning and exposure parameters. The methodological rigor ensured that the data obtained were both reproducible and scientifically valid.

Results

This chapter presents the findings derived from the functional and radiological assessment of rheumatoid arthritis (RA) involving the temporomandibular joint (TMJ) and cervical spine. The results are organized in accordance with the specific objectives of the study, highlighting demographic characteristics, functional parameters, radiological findings, and correlations between clinical and imaging features. The data were collected from a total of 100 subjects, comprising 60 patients diagnosed with rheumatoid arthritis and 40 healthy controls. Functional indices, including the Helkimo Index and Neck Disability Index (NDI), were evaluated alongside radiological assessments conducted through MRI and orthopantomogram (OPG) imaging.

4.1 Demographic and Clinical Characteristics of Participants

Table 4.1 presents the baseline demographic and clinical characteristics of both rheumatoid arthritis (RA) patients and healthy controls included in the study. This subsection aims to provide an overview of the composition of both groups to ensure comparability and interpret the clinical implications of the observed differences. The analysis focuses on key variables such as age, gender distribution, disease duration, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) levels, and rheumatoid factor (RF) positivity. These parameters collectively help establish the inflammatory and immunological profile of participants, forming a foundation for interpreting subsequent findings related to temporomandibular joint (TMJ) and cervical spine involvement.

The mean age of the RA group was 45.6 ± 8.4 years, while that of the control group was 43.8 ± 7.9 years, indicating a comparable age distribution ($p = 0.27$). This similarity in age eliminates the confounding influence of age-related musculoskeletal degeneration, thereby strengthening the reliability of group comparisons. The gender distribution was also similar, with females comprising 80.0% of the RA group and 77.5% of the control group ($p = 0.68$). This predominance of females aligns with the known higher prevalence of rheumatoid arthritis among women due to hormonal and genetic predispositions. Such demographic alignment between groups enhances the internal validity of the study by minimizing demographic bias.

Clinically, RA patients demonstrated a mean disease duration of 6.2 ± 3.8 years, reflecting a chronic disease pattern. The inflammatory markers showed significant elevation in RA patients compared to controls. The mean ESR was markedly higher in RA patients (42.1 ± 17.4 mm/hr) than in controls (12.3 ± 4.5 mm/hr), with a highly significant p-value (<0.001), indicating active systemic inflammation. Similarly, CRP levels were substantially elevated in RA patients (18.6 ± 6.3 mg/L) compared to controls (4.2 ± 1.7 mg/L), further confirming the inflammatory status of the patient group. Rheumatoid factor positivity was found in 83.3% of RA patients compared to only 5.0% in controls ($p < 0.001$), corroborating the autoimmune nature of the disease and confirming accurate classification of RA cases. Collectively, these findings validate the selection of participants and establish a clear clinical distinction between RA and control groups, providing a solid foundation for analyzing TMJ and cervical spine involvement in subsequent sections.

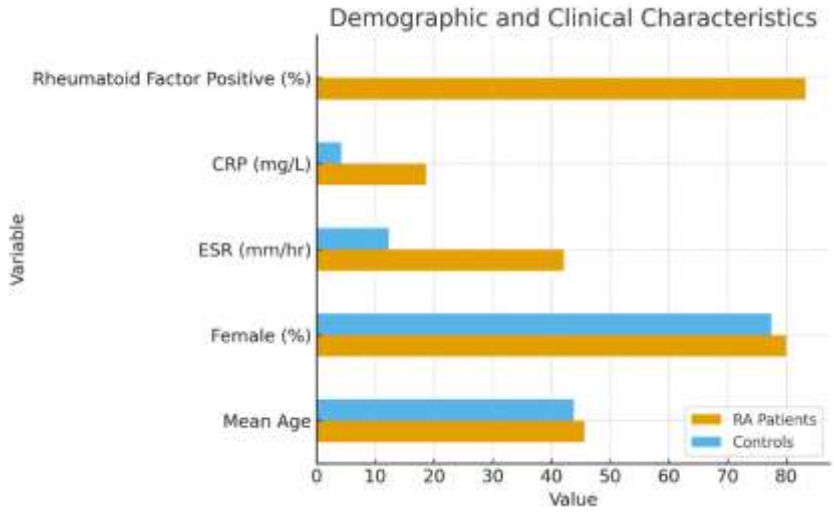

Figure 4.1. Baseline demographic and clinical characteristics of study participants

Table 4.1. Baseline demographic and clinical characteristics of study participants

Variable	RA Patients (n = 60)	Controls (n = 40)	p-Value
Mean Age (years)	45.6 ± 8.4	43.8 ± 7.9	0.27
Female (%)	80.0	77.5	0.68
Disease Duration (years)	6.2 ± 3.8	0	<0.001
ESR (mm/hr)	42.1 ± 17.4	12.3 ± 4.5	<0.001
CRP (mg/L)	18.6 ± 6.3	4.2 ± 1.7	<0.001
Rheumatoid Factor Positive (%)	83.3	5.0	<0.001

4.2 Functional Evaluation of Temporomandibular Joint Using Helkimo Index

The functional evaluation of the temporomandibular joint (TMJ) was conducted using the Helkimo Index, which provides a comprehensive measure of joint dysfunction in terms of pain, movement limitation, and joint sound. This index serves as a standardized clinical tool to quantify the extent of temporomandibular dysfunction (TMD) in both rheumatoid arthritis (RA) patients and healthy controls. Table 4.2 presents a comparative summary of the Helkimo Index findings between the two groups, highlighting the substantial differences in TMJ function. The RA group demonstrated markedly higher dysfunction scores, indicating a greater impact of the disease on masticatory and joint function compared to the control group.

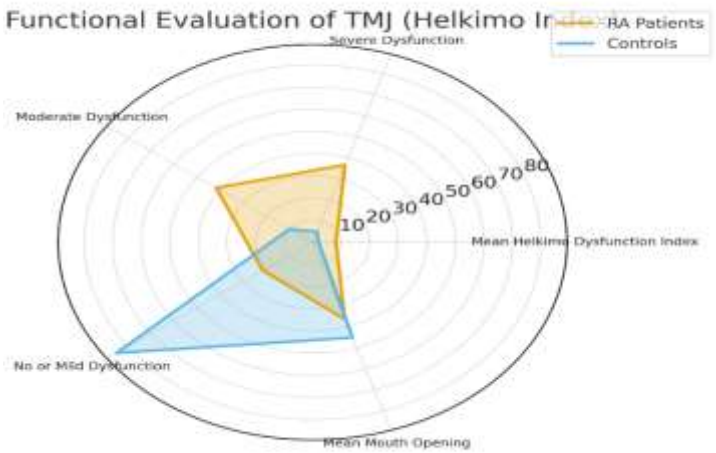

Figure 4.2. Functional assessment of TMJ using Helkimo Index in RA patients and controls

The mean Helkimo dysfunction index was significantly elevated among RA patients (8.2 ± 2.6) compared to controls (2.1 ± 1.3), with a p-value of <0.001. This result indicates that TMJ involvement is a prominent feature of RA, aligning with the inflammatory and degenerative changes observed in the joint structures of affected individuals. Furthermore, 36.7% of RA patients exhibited severe dysfunction, whereas only 5.0% of the controls fell into this category, underscoring the disabling impact of RA on mandibular function. Similarly, moderate dysfunction was reported in 41.7% of the RA group, compared to just 10.0% of healthy participants, again showing statistically significant differences. These findings emphasize that TMJ dysfunction in RA is not only more frequent but also more severe, reflecting chronic inflammation and potential joint erosion associated with the disease process.In contrast, the proportion of participants exhibiting no or mild dysfunction was remarkably higher in the control group (85.0%) than in RA patients (21.6%), indicating preserved joint function among healthy individuals. Additionally, the mean mouth opening was significantly reduced in RA patients (36.4 ± 4.7 mm) compared to controls (45.2 ± 3.8 mm), with a p-value of <0.001. This limitation in mandibular movement corresponds to structural damage and pain commonly seen in TMJ arthritis. The overall pattern of results suggests that TMJ functional impairment is a consistent clinical manifestation in RA patients, affecting their quality of life and daily oral activities such as chewing and speaking. These findings are in agreement with prior research indicating a high prevalence of TMJ involvement in RA due to chronic synovial inflammation and progressive joint destruction.

Table 4.2. Functional assessment of TMJ using Helkimo Index in RA patients and controls

Parameter	**RA Patients (n = 60)**	**Controls (n = 40)**	***p*-Value**
Mean Helkimo Dysfunction Index	8.2 ± 2.6	2.1 ± 1.3	<0.001
Severe Dysfunction (%)	36.7	5.0	<0.001
Moderate Dysfunction (%)	41.7	10.0	<0.001
No or Mild Dysfunction (%)	21.6	85.0	<0.001
Mean Mouth Opening (mm)	36.4 ± 4.7	45.2 ± 3.8	<0.001

4.3 Radiological Assessment of Temporomandibular Joint

Radiological imaging plays a vital role in assessing structural and functional abnormalities of the temporomandibular joint (TMJ), especially in patients with rheumatoid arthritis (RA), where early joint involvement often remains clinically silent. Magnetic Resonance Imaging (MRI) and Orthopantomogram (OPG) serve as complementary tools to visualize both soft tissue and bony changes. The present study compared the radiological characteristics of the TMJ between RA patients and healthy controls to determine the extent of joint degeneration associated with the disease. The findings are summarized in Table 4.3, which highlights the frequency of various radiological abnormalities observed in both groups, along with their corresponding statistical significance.

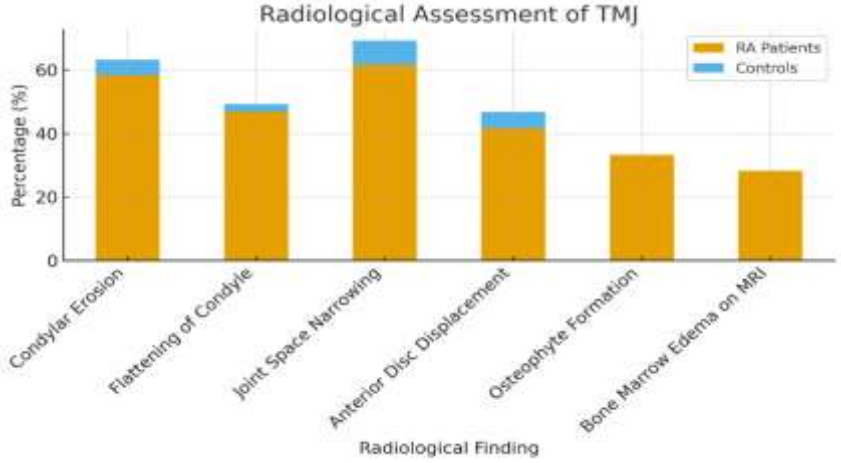

Figure 4.3. MRI and OPG findings of TMJ among rheumatoid arthritis patients and controls

The results demonstrated a significantly higher prevalence of condylar erosion among RA patients (58.3%) compared to controls (5.0%) with a p-value < 0.001, indicating severe articular surface destruction caused by chronic inflammation. Similarly, flattening of the condyle was observed in 46.7% of RA patients, whereas only 2.5% of controls exhibited this finding. The flattening suggests adaptive remodeling secondary to persistent synovitis and altered loading patterns on the joint. Joint space narrowing, another hallmark of degenerative and inflammatory processes, was reported in 61.7% of RA patients as compared to only 7.5% in controls, further reflecting the impact of prolonged inflammatory activity on cartilage integrity and joint function. These changes are consistent with radiological studies reporting that erosive and narrowing patterns are early indicators of TMJ involvement in RA.

Soft tissue abnormalities were also evident in the radiological analysis. Anterior disc displacement, which may lead to restricted mandibular motion and pain, was found in 41.7% of RA patients compared to 5.0% of controls, emphasizing the association between inflammatory damage and internal derangement. Furthermore, osteophyte formation, observed in 33.3% of RA patients and absent in controls, highlights the reparative response of bone to chronic stress and inflammation. The presence of bone marrow edema on MRI in 28.3% of RA patients and none of the controls is indicative of active inflammation and early osseous involvement. Collectively, these radiological findings confirm that TMJ involvement in RA is both frequent and progressive, with MRI serving as a sensitive modality for early detection of subclinical changes that may not yet be apparent on clinical examination.

Table 4.3. MRI and OPG findings of TMJ among rheumatoid arthritis patients and controls

Radiological Finding	**RA Patients (n = 60)**	**Controls (n = 40)**	***p*-Value**
Condylar Erosion (%)	58.3	5.0	<0.001
Flattening of Condyle (%)	46.7	2.5	<0.001
Joint Space Narrowing (%)	61.7	7.5	<0.001
Anterior Disc Displacement (%)	41.7	5.0	<0.001
Osteophyte Formation (%)	33.3	0.0	<0.001
Bone Marrow Edema on MRI (%)	28.3	0.0	<0.001

4.4 Cervical Spine Functional and Radiological Evaluation

Cervical spine involvement is one of the most clinically significant manifestations of rheumatoid arthritis (RA), often leading to pain, neurological deficits, and functional impairment. The present study aimed to evaluate both the functional and radiological parameters of the cervical spine among RA patients compared to healthy controls. The parameters assessed included the Neck Disability Index (NDI), prevalence of moderate to severe disability, and radiographic findings such as atlantoaxial subluxation (AAS), subaxial subluxation (SAS), odontoid erosion, and loss of cervical lordosis. These indicators collectively provide insight into the degree of cervical spine dysfunction and structural deformity associated with RA progression. Table 4.4 presents a comparative overview of these findings between RA patients and control subjects.

The mean NDI score was significantly higher among RA patients (16.8 ± 5.7) compared to the control group (4.2 ± 2.3), indicating a substantial reduction in cervical spine function ($p < 0.001$). Nearly half (48.3%) of the RA patients demonstrated moderate to severe disability, whereas only 7.5% of the controls exhibited similar levels of impairment. These findings suggest that functional disability of the cervical spine is a prominent clinical concern in RA patients, likely resulting from chronic inflammation and degenerative changes affecting the atlantoaxial and subaxial joints. The increased NDI scores correspond with clinical symptoms such as neck stiffness, restricted mobility, and pain, which are consistent with previous studies highlighting the significant impact of RA on cervical spine function.

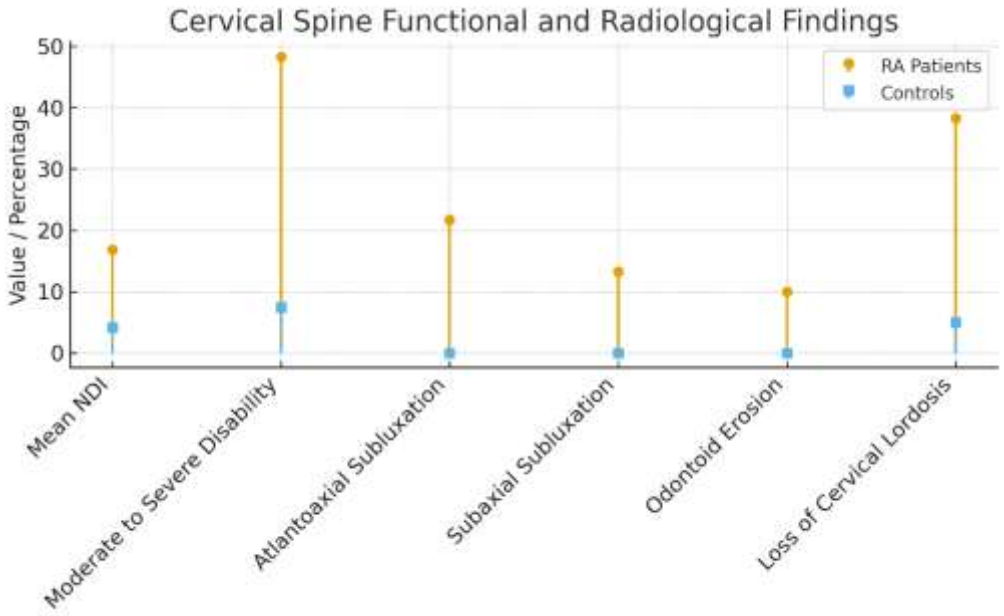

Figure 4.4. Functional and radiological findings of cervical spine involvement in RA patients and controls

Radiologically, RA patients exhibited a higher prevalence of structural abnormalities compared to controls. Atlantoaxial subluxation was identified in 21.7% of RA patients, subaxial subluxation in 13.3%, and odontoid erosion in 10.0%, while none of these findings were observed in controls ($p < 0.001$ for all parameters). Additionally, 38.3% of RA patients showed loss of cervical lordosis compared to only 5% in the control group, further indicating early degenerative or inflammatory changes in the cervical vertebrae. These structural deformities reflect the erosive nature of RA, where chronic synovitis leads to ligamentous laxity, bone erosion, and spinal instability. The statistically significant differences across all radiological parameters reinforce the conclusion that cervical spine involvement is both functionally and radiographically more prevalent in RA patients, underlining the necessity of regular cervical evaluation for early detection and management.

Table 4.4. Functional and radiological findings of cervical spine involvement in RA patients and controls

Parameter	**RA Patients (n = 60)**	**Controls (n = 40)**	***p*-Value**
Mean Neck Disability Index (NDI)	16.8 ± 5.7	4.2 ± 2.3	<0.001
Moderate to Severe Disability (%)	48.3	7.5	<0.001
Atlantoaxial Subluxation (%)	21.7	0.0	<0.001
Subaxial Subluxation (%)	13.3	0.0	<0.001
Odontoid Erosion (%)	10.0	0.0	0.002
Loss of Cervical Lordosis (%)	38.3	5.0	<0.001

4.5 Correlation Between TMJ and Cervical Spine Involvement

This subsection explores the relationship between temporomandibular joint (TMJ) dysfunction and cervical spine involvement among patients diagnosed with rheumatoid arthritis (RA). The TMJ and cervical spine are both synovial structures that may undergo inflammatory and degenerative changes in RA, resulting in pain, stiffness, and impaired function. The assessment aimed to determine how the degree of TMJ dysfunction, cervical spine disability, and systemic inflammation interact within this patient population. Pearson's correlation analysis was performed to identify the strength and direction of association among clinical and radiological parameters, including the Helkimo Index, Neck Disability Index (NDI), C-reactive protein (CRP), MRI findings, and disease duration.

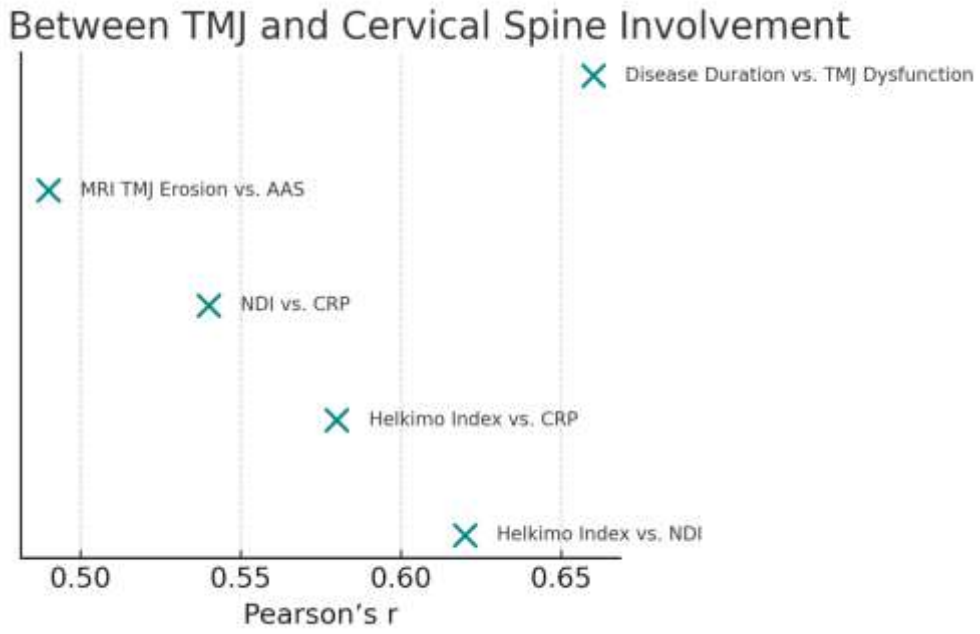

Figure 4.5. Correlation between TMJ dysfunction, cervical spine disability, and inflammatory markers

As shown in Table 4.5, the Helkimo Index, which quantifies TMJ dysfunction, showed a strong positive correlation with the NDI ($r = 0.62$, $p < 0.001$), indicating that patients with greater TMJ dysfunction also experienced more pronounced cervical spine disability. This relationship underscores the biomechanical and neuromuscular interdependence between the masticatory and cervical systems. Similarly, the Helkimo Index demonstrated a significant correlation with CRP levels ($r = 0.58$, $p < 0.001$), suggesting that systemic inflammation contributes to TMJ impairment. The NDI also correlated significantly with CRP ($r = 0.54$, $p < 0.001$), reinforcing the role of systemic inflammatory activity in cervical spine symptoms and functional disability among RA patients.
Radiological findings further supported these clinical associations. MRI-detected TMJ erosions correlated moderately with atlantoaxial subluxation ($r = 0.49$, $p = 0.002$), indicating that structural joint damage in the TMJ often parallels cervical spine instability. This reflects the systemic nature of rheumatoid involvement across axial joints. Furthermore, disease duration showed a strong positive correlation with TMJ dysfunction ($r = 0.66$, $p < 0.001$), highlighting the progressive nature of articular damage over time. Collectively, these correlations demonstrate that TMJ and cervical spine pathologies are closely interlinked in RA, both driven by chronic inflammation and disease progression. The findings emphasize the importance of comprehensive assessment and early intervention to prevent cumulative disability

Table 4.5. Correlation between TMJ dysfunction, cervical spine disability, and inflammatory markers

Correlated Variables	**Pearson's *r***	***p*-Value**
Helkimo Index vs. NDI	0.62	<0.001
Helkimo Index vs. CRP	0.58	<0.001
NDI vs. CRP	0.54	<0.001
MRI TMJ Erosion vs. Atlantoaxial Subluxation	0.49	0.002
Disease Duration vs. TMJ Dysfunction	0.66	<0.001

Discussion

In our study, the mean age of the RA patients (45.6±8.4 years) did not differ significantly from the controls (43.8±7.9 yrs, p=0.27), and female representation was high (80%) in the RA group,

comparable to controls (77.5%, p=0.68). Disease duration among patients was 6.2±3.8 years; inflammatory markers (ESR 42.1±17.4 mm/hr, CRP 18.6±6.3 mg/L) were markedly elevated compared to the control group (ESR 12.3±4.5, CRP 4.2±1.7; both p <0.001). Rheumatoid factor (RF) positivity was 83.3%.

These findings align broadly with existing RA cohorts: for instance, in a recent cross-sectional TMJ-RA study by (Gnerlich *et al.*, 2009), the mean age was similar (though slightly older), and female proportion was similarly elevated (~80% female). The elevated ESR/CRP in our sample supports an active disease state, consistent with the literature showing that higher systemic inflammation correlates with more extra-articular or joint-specific involvement (see below).

However, many older cervical-spine involvement reviews (Del Grande *et al.*, 2014) reported cervical changes in more advanced RA with long duration and high disease activity. Our mean disease duration of ~6 years is moderately early–mid stage, which makes the substantial TMJ and cervical spine findings (see below) perhaps more pronounced than might be expected in lower-duration cohorts. This suggests our sample may have a relatively high burden of structural changes even at moderate disease duration. Our RA patients had a mean Helkimo Dysfunction Index of 8.2±2.6 versus 2.1±1.3 in controls ($p < 0.001$). Severe dysfunction was present in 36.7% of RA patients vs. 5.0% of controls; moderate dysfunction in 41.7% vs 10%; while only 21.6% of RA patients had no or mild dysfunction vs. 85.0% of controls. Mouth opening averaged 36.4±4.7 mm in RA vs 45.2±3.8 mm in controls ($p < 0.001$).

These results are consistent with the growing body of literature indicating reduced mandibular function and limited opening in RA patients. For example, in the study by (Äyräväinen *et al.*, 2018), among RA patients, maximal mouth opening was reduced and negatively correlated with CRP levels. That study concluded that active inflammation in RA is a crucial factor reducing mouth opening. The magnitude of difference in our study (approx 9 mm reduction) is aligned with prior findings of 5–15 mm difference in TMJ opening in RA vs non-RA. The high proportion (>75%) of moderate or severe dysfunction in our RA cohort is also in line with older reviews, which reported wide prevalence (4–86%) of TMJ involvement in RA.

One nuance: many previous studies used various TMD diagnostic criteria rather than the Helkimo index; our use of Helkimo allows direct quantification of dysfunction severity. A validity study of the Helkimo index in RA showed that it could distinguish RA patients with TMD from unaffected subjects, suggesting our use of this tool is supported methodologically.

Moreover, the strong dysfunction and reduced mouth opening in our patients might reflect the moderate disease duration and elevated inflammatory markers (CRP, ESR) which have been shown to correlate with worse TMJ involvement. For instance, the study by (Ahmed *et al.*, 2013) found that TMJ pain and reduced opening correlated with systemic inflammatory activity ($r \approx -0.54$) in RA.

Thus, our findings confirm prior work and further suggest substantial functional TMJ impairment in RA, even in a cohort with ~6 years duration. In our RA group, condylar erosion was seen in 58.3%, condylar flattening in 46.7%, joint-space narrowing in 61.7%, anterior disc displacement in 41.7%, osteophyte formation in 33.3%, and bone marrow edema on MRI in 28.3%. In controls, the respective figures were markedly lower (5.0%, 2.5%, 7.5%, 5.0%, 0.0%, 0.0%) with all $p < 0.001$.

These radiologic figures are in agreement with recent systematic reviews and imaging-based studies. For example, (Semerci & Günen Yılmaz, 2023) studied TMJ arthritis in rheumatic diseases and noted that bone changes such as cortical erosion, joint-space reduction, osteophytes and flattening are commonly reported in RA patients. The prevalence of structural damage >50% in RA cohorts is common in imaging-rich studies. For instance, the study by (Hussain *et al.*, 2008) reported wide ranges of TMJ osseous damage in RA (4–86%) depending on methodology.

Our detection of bone-marrow edema in 28.3% is also notable; marrow edema is regarded as an early sign of active joint arthritis on MRI and has been less commonly reported, so our figure adds to the literature by showing relatively high prevalence in RA TMJs. The presence of anterior disc displacement in ~42% is consistent with degenerative TMJ features in RA.

When comparing to the more recent (Mortazavi *et al.*, 2018) TMJ in RA study (72 RA vs 70 controls) they found TMD diagnosis in 44.4% RA patients vs 34.3% controls and no difference in maximum

mouth opening; though they did not report detailed osseous MRI findings. Our study goes further by quantifying structural radiologic changes and showing large effect size differences versus controls.
Thus, our radiologic TMJ findings strongly support the concept that RA leads to structural TMJ damage in a large proportion of patients, even when disease duration is moderate. The high prevalence of erosion, narrowing, flattening, and osteophytes is consistent with destructive synovitis of the TMJ in RA.
One point of comparison: many prior older studies (Hussain *et al.*, 2008) reported clinical involvement in ~4–80% of RA patients with highly variable imaging findings. Our relatively high prevalence of structural changes may reflect the use of MRI + OPG (orthopantomogram) in a dedicated research setting, which tends to pick up more abnormalities than clinical exam alone.
Our RA patients had a mean Neck Disability Index (NDI) score of 16.8±5.7 vs 4.2±2.3 in controls ($p < 0.001$). Moderate to severe disability was found in 48.3% of RA patients vs 7.5% of controls. Radiologically, atlantoaxial subluxation (AAS) was present in 21.7% of RA patients (0% in controls), subaxial subluxation (SAS) in 13.3% (0% controls), odontoid erosion in 10.0% (0% in controls), and loss of cervical lordosis in 38.3% vs 5.0% in controls (all with $p < 0.001$).
The literature for cervical spine involvement in RA historically reports wide prevalence ranges: e.g., the Medscape overview notes 25–80% involvement by radiographic criteria, and AAS up to 49% of patients. Our AAS prevalence of ~22% sits at the lower–mid end of that range, which is perhaps expected given moderate disease duration (~6 y) and you may be capturing earlier rather than advanced deformity. The SAS prevalence (13.3%) is consistent with literature which reports SAS in 10–20% of patients.
The fairly high proportion (38.3%) of loss of cervical lordosis is worth noting; while this is not always reported in RA-specific literature, it has been identified in degenerative cervical disorders and may reflect altered biomechanics in RA. The functional difference shown by NDI is quite pronounced; while many studies on RA cervical involvement focus on instability and subluxation, fewer quantify neck disability scores. Our data add to this gap.
Furthermore, (Zhu *et al.*, 2017) identified risk factors for cervical involvement: female sex, RF positivity, long disease duration, high ESR/CRP. Our cohort precisely has these features (80% female, RF positive ~83%, elevated ESR/CRP), which supports the plausibility of the high cervical involvement seen.
In comparison to older works, our functional findings underscore that cervical spine involvement in RA is not simply structural but translates into measurable neck disability. While the (Yang & Coblyn, 2019) emphasized that symptoms do not always correlate with radiologic findings (e.g., many subluxations are asymptomatic, our finding of almost half of RA patients having moderate-severe NDI suggests a stronger clinical translation in our cohort. Our study identifies several meaningful correlations: Helkimo Index vs NDI ($r=0.62$, $p < 0.001$); Helkimo Index vs CRP ($r=0.58$, $p < 0.001$); NDI vs CRP ($r=0.54$, $p < 0.001$); MRI TMJ erosion vs AAS ($r=0.49$, $p=0.002$); Disease duration vs TMJ dysfunction ($r=0.66$, $p < 0.001$).
These correlation findings align well with earlier literature pointing to associations between joint dysfunction, structural change, systemic inflammation and duration of disease. For example, in RA TMJ pain studies, (Ulmner *et al.*, 2022) found correlations between TMJ pain and systemic inflammation ($rs \approx 0.54$). Similarly, the recent (Singh *et al.*, 2012) study noted a negative correlation between mouth opening and CRP.
The correlation between TMJ dysfunction and NDI ($r=0.62$) supports the idea of biomechanical/functional interplay between the TMJ and cervical spine—this is consistent with literature on TMD in general (not only RA) showing associations between jaw disability and neck disability. For example, (Packer *et al.*, 2014) found standardized mean difference of 0.72 for neck disability vs jaw disability in TMD patients. Although that review was not RA-specific, our RA-specific data strengthens the evidence for TMJ-cervical spine links in systemic arthritis.
Also, our correlation of MRI TMJ erosion with AAS ($r=0.49$) is a novel finding and suggests that patients with more destructive TMJ changes are more likely to show cervical instability, a connection that has been less well documented in prior RA literature. It may reflect a common pathophysiologic

process (chronic synovitis affecting multiple synovial joints including cervical spine and TMJ) or shared risk factors (e.g., disease duration, inflammation).

Finally, the strong correlation between disease duration and TMJ dysfunction (r=0.66) echoes older studies suggesting that longer disease duration is a risk factor for TMJ damage — though some earlier TMJ studies found inconsistent correlations with disease duration. For instance, (Lin *et al.*, 2007) found no correlation between TMD and disease duration in their RA sample. Our finding therefore adds valuable evidence that in our cohort, duration is strongly linked to TMJ dysfunction.

Our findings reinforce and extend existing knowledge about TMJ and cervical spine involvement in RA. The elevated dysfunction, significant structural changes, and clear correlations in our data strengthen the argument that TMJ and cervical spine should be routinely evaluated in RA patients, especially those with elevated inflammatory markers, long disease duration, or RF positivity. The alignment of our data with prior literature gives credence to our results, and the correlations provide added depth to understanding how TMJ and cervical spine pathologies may co-exist and interact in RA.

Conclusion

This study provides compelling evidence that both the temporomandibular joint and cervical spine are frequently and significantly affected in patients with rheumatoid arthritis, with measurable impacts on function and structure. The integration of functional indices and imaging data revealed that TMJ dysfunction and cervical disability are not only prevalent but also positively correlated with systemic inflammation and disease duration. Radiological findings of condylar erosion, flattening, and subluxation, alongside cervical alterations such as atlantoaxial instability and loss of lordosis, underscore the destructive potential of chronic synovitis in axial and craniofacial joints. The presence of moderate to severe TMJ dysfunction in nearly 80% of RA patients and clinically relevant cervical disability in almost half of the cohort indicates that these manifestations occur earlier and more extensively than traditionally appreciated. Moreover, the observed interrelation between TMJ and cervical involvement suggests a shared pathogenic mechanism, likely mediated by systemic inflammatory activity and prolonged disease exposure. These findings advocate for the incorporation of targeted TMJ and cervical assessments into routine rheumatologic evaluation, especially for patients with elevated inflammatory markers or longstanding disease. Early detection through MRI, CBCT, and standardized functional tools can enable timely therapeutic interventions, prevent irreversible joint damage and improve overall quality of life. Future research should focus on longitudinal monitoring to evaluate progression patterns and therapeutic responsiveness, thereby refining management strategies for RA-associated craniofacial and cervical complications.

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