

Bony Changes of the Temporomandibular Joint in Symptomatic Versus Asymptomatic Individuals: Insights from CBCT Imaging

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Abstract

Introduction: Temporomandibular disorders (TMDs) are a leading cause of non-dental orofacial pain. Structural osseous changes of the temporomandibular joint (TMJ) can be observed in both symptomatic and asymptomatic individuals. This study compared bony changes in TMJs of patients with and without TMD symptoms using cone-beam computed tomography (CBCT).

Materials and Methods: In this historical cohort, 138 patients with clinically diagnosed TMD (RDC/TMD) and 132 asymptomatic controls who underwent CBCT for dental or maxillofacial purposes were evaluated. Standardized criteria were used to assess erosion, osteophytes, flattening, Ely cysts, sclerosis (condylar head and temporal), ankylosis, condylar size alterations, and joint space changes. Data were analyzed with Chi-square and t-tests ($p < 0.05$).

Results: Degenerative changes were more frequent in the TMD group. Erosion was the most common finding (52.2% vs. 13.6%, $p < 0.001$) and occurred across all age groups. Osteophytes (29.7% vs. 15.2%, $p = 0.003$) and flattening (27.5% vs. 7.6%, $p < 0.001$) were significantly higher, with age-related patterns. Temporal lobe sclerosis (12.3% vs. 0.8%, $p < 0.001$), condylar head sclerosis (10.9% vs. 3.8%, $p = 0.022$), and joint space changes (18.8% vs. 2.3%, $p < 0.001$) were strongly associated with TMD. Ely cysts differed only in the >41 -year group. Rare findings showed no significant differences.

Conclusion: CBCT revealed significantly more erosions, osteophytes, flattening, sclerosis, and joint space alterations in TMD patients compared to controls. Erosion may serve as an early diagnostic marker, while other features suggest chronic progression. CBCT is recommended in symptomatic TMD cases to facilitate early detection and guide management decisions.

Introduction

Temporomandibular disorders (TMDs) encompass a diverse range of musculoskeletal conditions and represent the most prevalent source of non-dental orofacial pain, ranking second only to low back pain among musculoskeletal complaints (1). Reported prevalence rates vary significantly—from 16.3% to 68% in adolescents and up to 43% in adults—a disparity attributed to differences in diagnostic criteria, study populations, and methodological approaches (2). The etiology of TMD is multifactorial, involving psychological contributors (e.g., anxiety, depression), parafunctional habits, socioeconomic factors, and genetic predisposition (3, 4). Notably, women are disproportionately affected, likely due to a combination of hormonal, anatomical, behavioral, and psychosocial influences (5, 6). Clinically, TMD manifests as temporomandibular joint (TMJ) pain or tenderness, restricted jaw mobility, and joint sounds, though patients may also report tinnitus, hearing alterations, otalgia, aural fullness, dysphagia, or dizziness (7, 8). While imaging is not always necessary, it plays a critical role when findings could inform diagnosis or guide treatment. The Research Diagnostic Criteria for TMD (RDC/TMD), particularly its 2009 update, provides standardized diagnostic protocols, including validated imaging criteria (9, 10). Structural changes both osseous and soft tissue are observed in a subset of TMD patients (11). Available imaging modalities include panoramic radiography, transcranial imaging, cone-beam computed tomography

(CBCT), and magnetic resonance imaging (MRI) (12). Although panoramic radiography remains widely accessible and cost-effective (13), its two-dimensional nature limits diagnostic accuracy for detecting subtle osseous changes such as erosions, flattening, sclerosis, or Ely cysts compared to CBCT (14, 15). TMJ osteoarthritis—marked by subcortical cysts, erosions, osteophytes, or sclerosis (10)—is more prevalent among elderly populations but also occurs in younger patients (16, 17). Intriguingly, structural TMJ abnormalities have been documented even in asymptomatic individuals (18), underscoring the importance of correlating imaging findings with clinical symptoms.

Materials and Methods

Study Design

This study was designed as a historical cohort study aimed at comparing bony changes of the temporomandibular joint (TMJ) between patients with clinical symptoms of temporomandibular disorders (TMD) and asymptomatic individuals, using cone-beam computed tomography (CBCT) imaging.

Study Setting and Population

The study population was drawn from the TMD patient registry at the TMD Treatment Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. The case group comprised patients who had been referred to the center with complaints suggestive of TMD, were clinically diagnosed with TMD based on the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), and had undergone CBCT imaging for other therapeutic purposes, such as sinus surgery or dental implant planning. The control group included individuals without any clinical signs or symptoms of TMD who had undergone CBCT imaging for unrelated dental or maxillofacial therapeutic reasons. All data were retrieved from the central radiology data repository of Shahid Beheshti University of Medical Sciences.

Diagnostic Criteria for TMD

Diagnosis of TMD in the case group was established according to the RDC/TMD, requiring at least one of the following: pain in the jaw, temple, face, preauricular, or intra-auricular regions at rest or during function; reported pain upon palpation of predefined muscle sites (including anterior, middle, and posterior temporalis; origin and insertion of the masseter muscle; posterior mandibular region; submandibular area; lateral pterygoid; and temporalis tendon), with at least one painful site corresponding to the side of the main complaint; restricted or painful unassisted jaw opening of less than 4 mm; a difference of less than 5 mm between maximum assisted and unassisted jaw opening; or the presence of joint sounds such as clicking, disc displacement, or incoordinate joint movement.

Inclusion and exclusion Criteria

Eligible participants were required to have a definitive clinical diagnosis of TMD based on RDC/TMD or DC/TMD and high-quality CBCT images free from significant artifacts that would impair bony

assessment. Participants were excluded if they were younger than 18 years or older than 60 years; had systemic bone or joint diseases such as rheumatoid arthritis, osteoarthritis, inflammatory arthritis, or metabolic bone disorders; had a history of TMJ surgery; were receiving medications that could influence bone metabolism (e.g., corticosteroids, NSAIDs, immunosuppressants, bisphosphonates, or hormonal agents); had incomplete or poor-quality CBCT images; suffered from severe psychiatric or neurological disorders that would impair study compliance; presented with active infection or severe inflammation in the TMJ region; were pregnant or lactating; or exhibited severe bruxism or significant occlusal wear that could independently induce TMJ bony changes.

CBCT Imaging Protocol

All CBCT images were obtained using a NewTom VGI 2022 system in axial, coronal, and sagittal planes. Imaging parameters included a field of view of 7.5×10 cm, voxel size of 0.2 mm, tube current of 10 mA, tube voltage of 90 kV, and an exposure time of approximately 16 seconds. Images were evaluated in a darkened room using a 22-inch monitor. Image analysis was performed with Romexis Viewer software (Planmeca, Helsinki, Finland) and On Demand software.

Radiographic Evaluation of Bony Changes

Bony changes in the TMJ were assessed according to standardized radiological definitions, including flattening of the articular surface, surface irregularity, sclerosis (increased cortical bone density extending into the medullary bone), Ely cysts (small, well-defined radiolucent areas surrounded by sclerotic margins within the subchondral bone), surface erosion (loss of cortical bone density with adjacent subcortical bone changes), condylar hypoplasia or hyperplasia, ankylosis (fibrous adhesions or bony fusion within the joint capsule), osteophyte formation (marginal bony outgrowths), and alterations in joint space width (narrowing or widening), with normal values defined according to Christiansen's study.

Statistical Analysis

Data analysis was conducted using SPSS software (version 25, IBM Corp., Armonk, NY, USA). Continuous variables were compared between groups using the Independent Samples t-test, and paired comparisons within groups were analyzed using the Paired t-test. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Research Ethics Committee of the School of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran. All CBCT data were anonymized prior to analysis to ensure patient confidentiality, and no personally identifiable information was reported.

Results

Cone-beam computed tomography (CBCT) assessment of 138 cases with temporomandibular joint disorders (TMJD) and 132 controls revealed a higher prevalence of degenerative and structural alterations (Fig. 1) in the TMJD group. The case group had a mean age of 36.45 ± 10.35 years, whereas the control group had a mean age of 34.82 ± 7.49 years; the difference was not statistically significant ($p = 0.141$). Osteophyte formation (Table 1) was detected in 41 cases (29.7%) compared with 20 controls (15.2%) ($p = 0.003$). Erosive changes were the most frequent abnormality, affecting 72 subjects (52.2%) with TMJD versus 18 controls (13.6%) ($p < 0.001$). Condylar flattening was observed in 38 patients (27.5%) in the TMJD group and 10 controls (7.6%) ($p < 0.001$). Ely cysts occurred in 27 participants (19.6%) with TMJD and 19 controls (14.4%), a difference that was not statistically significant ($p = 0.167$). Ankylosis was rare, recorded in 5 patients (3.6%) in the TMJD group and 2 controls (1.5%) ($p = 0.242$). Temporal lobe sclerosis (TLS) was identified in 17 cases (12.3%) with TMJD compared with 1 control (0.8%) ($p < 0.001$). Condylar head sclerosis (CHS) was found in 15 patients (10.9%) versus 5 controls (3.8%) ($p = 0.022$). Condylar hypoplasia was noted in 7 cases (5.1%) and absent in the control group, while condylar hyperplasia was extremely uncommon, affecting only 1 case (0.7%) and absent among controls. Alterations in joint space, including narrowing or widening, were seen in 26 TMJD cases (18.8%) compared with 3 controls (2.3%) ($p < 0.001$). Age-stratified analysis demonstrated (Table.2) that erosion remained significantly more frequent in TMJD across all age categories: among participants younger than 30 years, 24 cases (52.2%) compared with 7 controls (15.2%) ($p < 0.001$); in the 31–40-year group, 22 cases (48.7%) versus 11 controls (17.2%) ($p = 0.01$); and in those older than 41 years, 26 cases (56.5%) with TMJD, with no occurrences in controls ($p < 0.001$). Osteophyte prevalence was significantly higher only in the > 41-year group, affecting 19 patients (41.3%) compared with 1 control (4.5%) ($p = 0.001$), while differences in younger groups were nonsignificant. Condylar flattening reached statistical significance only in the 31–40-year subgroup, present in 15 cases (32.6%) compared with 4 controls (6.3%) ($p < 0.001$). Ely cysts differed significantly only in the > 41-year category, occurring in 14 patients (30.4%) versus 2 controls (9.1%) ($p = 0.046$). CHS was more common in TMJD across age groups but did not reach significance within any specific age category. Overall, erosive changes showed the strongest and most consistent association with TMJD across all age groups, while osteophyte formation and condylar flattening demonstrated age-related significance, suggesting links to chronic disease progression and adaptive bone remodeling. TLS, CHS, and joint space alterations also exhibited strong associations with TMJD, reinforcing their potential diagnostic value. In contrast, rare abnormalities such as ankylosis, condylar hypoplasia, and condylar hyperplasia did not differ significantly between groups, likely due to their low prevalence.

Table 1
Comparison of CBCT-Detected Osseous and Structural
Alterations Between Patients With Temporomandibular
Joint Disorders and Asymptomatic Controls

No	Variables	TMJD n:138	Control n: 132	P.value*
1	Osteophyte	41(29.7)	20(15.2)	0.003
2	Erosion	72(52.2)	18(13.6)	0.000
3	Flattening	38(27.5)	10(7.6)	0.000
4	Ely Cyst	27(19.6)	19(14.4)	0.167
5	Ankylosis	5(3.6)	2(1.5)	0.242
6	TLS	17(12.3)	1(0.8)	0.000
7	CHS	15(10.9)	5(3.8)	0.022
8	Joint Space	26(18.8)	3(2.3)	0.000
TMJD: <i>Temporomandibular Joint Disorders</i>				
TLS: Temporal lobe sclerosis				
CHS: Condylar Head Sclerosis				
*Chi Square				

Table 2
Age-Stratified Distribution of Key CBCT Findings in
Temporomandibular Joint Disorder and Control Groups

No	Variables	Group	Age Groups (Year)		
			Under 30 n:92	31–40 n:110	Above 41 n:68
1	Erosion	TMJD	24(52.2)	22 (48.7)	26 (56.5)
		Control	7(15.2)	11 (17.2)	0 (0)
		P.Value*	0.00	0.01	0.00
2	Osteophyte	TMJD	13(28.3)	9 (19.6)	19(41.3)
		Control	5 (10.9)	14(21.9)	1 (4.5)
		P.Value*	0.32	0.481	0.001
3	Flattening	TMJD	9 (19.6)	15 (32.6)	14(30.4)
		Control	5(10.9)	4 (6.3)	1 (4.5)
		P.Value*	0.192	0.000	0.13
4	Ely Cyst	TMJD	3(6.5)	10(21.7)	14 (30.4)
		Control	7 (15.2)	10(15.6)	2 (9.1)
		P.Value*	0.158	0.283	0.046
5	CHS	TMJD	7 (15.2)	5(10.9)	3(6.5)
		Control	3 (6.5)	2 (3.1)	0 (0)
		P.Value*	0.158	0.107	0.303
CHS: Condylar Head Sclerosis					
*Chi Square					

Discussion

In this CBCT-based analysis of 138 TMJD cases versus 132 controls, there was a clear predisposition to degenerative and structural condylar alterations among TMJD patients, in alignment with current imaging and epidemiologic evidence. Notably, erosive changes emerged as the most prevalent abnormality in TMJD, and this pattern held across all age strata including patients younger than 30 strongly suggesting that erosion is an early and robust indicator of TMJD rather than a mere consequence of advanced age or chronicity. This is consistent with previous CBCT-based studies, which identified erosion and osteophyte formation as frequent degenerative features in TMJ degenerative joint

disease (DJD) (19). Quantitative CBCT analyses have further demonstrated that condylar erosion is associated with subsequent condylar volume loss, indicative of accelerated bone resorption and progression in osteoarthritic joints (20). Osteophyte formation was significantly more frequent in TMJD (29.7% vs. 15.2%, $p = 0.003$), with age-related significance only in the > 41-year group. This supports the concept that osteophytes develop as part of chronic adaptive remodeling. Epidemiologic data also suggest that the incidence of TMJ DJD increases notably with age, with marked differences between younger and older age groups (23). These findings align with the chronic, progressive nature of bony remodeling in TMJ pathology. Condylar flattening was also significantly more common in TMJD (27.5% vs. 7.6%, $p < 0.001$), particularly in the 31–40-year group, indicating structural adaptation. Reviews have consistently recognized flattening as a hallmark of TMJ degeneration visible on CBCT (22). Condylar head sclerosis (CHS) and temporal lobe sclerosis (TLS) showed significant elevations in TMJD cases. Such sclerotic changes reflect subchondral reactions to mechanical overload and are well documented in CBCT evaluations of DJD (22, 24). Joint space alterations—including narrowing or widening—were also significantly more frequent in TMJD (18.8% vs. 2.3%, $p < 0.001$), consistent with positional and degenerative changes in the condyle. Some features—Ely cysts, ankylosis, hypoplasia, and hyperplasia—were less common and mostly statistically nonsignificant, likely due to their low prevalence and the limited statistical power to detect differences. Nevertheless, their presence in TMJD cases reflects the broader spectrum of osseous pathology affecting the joint (19, 22). The age-stratified results reinforce that while erosive changes are consistently prevalent across all ages, osteophytes and flattening tend to appear later, reflecting chronic disease and adaptive remodeling processes (23). This pattern matches established epidemiologic observations of DJD progression. These findings underscore CBCT's high diagnostic accuracy for detecting osseous pathology of the TMJ (21). CBCT is particularly valuable for evaluating features like erosion, osteophyte formation, sclerosis, and joint space alterations, although its limitation in soft tissue evaluation must be acknowledged. Clinical correlation is essential, as CBCT findings—especially erosions and osteophytes—are strongly associated with symptoms such as pain and joint noises (25). Several authors have advocated CBCT imaging in symptomatic patients, including young adults, to facilitate early diagnosis and intervention (26). Overall, the present findings reinforce the consistent association of erosions, osteophytes, flattening, sclerosis, and joint space changes with TMJD, and highlight erosion as an early and reliable marker. Age-related trends in osteophyte formation and flattening provide insight into disease progression, and further confirm CBCT as an indispensable imaging tool in TMJ assessment (25, 26). It is also important to note that the diagnostic reliability of CBCT in TMJ pathology is supported by broader dental imaging research. Studies on root canal morphology have demonstrated that CBCT provides highly accurate assessments of complex anatomic variations across different ages and sexes, underscoring its value in detecting subtle structural changes (27). Similarly, investigations into technical parameters such as object positioning have shown that CBCT maintains reliable diagnostic performance in challenging conditions, for example in identifying root fractures in teeth with intra-canal posts (28). These findings further validate CBCT as a robust and adaptable imaging modality whose diagnostic accuracy extends beyond endodontic and dental applications, making it particularly suited for detecting osseous changes in TMJD.

Conclusion

In this CBCT-based investigation, degenerative condylar changes especially erosive alterations were significantly more prevalent in TMJD patients compared to controls, across all age groups. Osteophyte formation, condylar flattening, sclerosis (both condylar and temporal lobe), and joint space changes further distinguished TMJD patients, often with age-related patterns suggesting chronic progression. These findings affirm CBCT as a highly effective modality for identifying osseous pathology in TMJD, with erosion serving as a crucial early diagnostic indicator

Recommendation

Routine CBCT evaluation should be considered in TMJD patients especially those presenting with pain or crepitus as early detection of erosive and degenerative changes can guide timely therapeutic interventions. Future longitudinal and quantitative CBCT studies, including condylar volume assessment, are recommended to monitor progression, evaluate treatment response, and improve prognostic stratification.

Abbreviations

CBCT

Cone-beam computed tomography

TMJ

Temporomandibular joint

TMD

Temporomandibular disorder

Declarations

Ethics approval:

This study was approved by the Research Ethics Committee of the School of Dentistry, Shahid Sadoughi University of Medical Sciences and Health Services, Yazd, Iran (Approval ID: IR.SSU.DENTISTRY.REC.1403.091; approval date: 10.03.2025).

Human Ethics and Consent to Participate:

This study is retrospective and based solely on anonymized radiological data extracted from registries. No direct access to patients was obtained during the research. Therefore, individual informed consent was not required.

Consent to Publish:

Not applicable, as no personal or identifiable data are included in this article.

Availability of data and materials:

All data and materials are available for submission upon request.

Conflict of interest:

The authors declare no conflict of interest.

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Authors' contributions:

- YA: Data gathering, manuscript writing, direct supervision, and submission.
- HR: Study planning.
- YS: Data preparation and case selection.
- MZ: Data gathering.
- HRS: Data analysis and manuscript revision.
- RJ: Manuscript writing.

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Figures

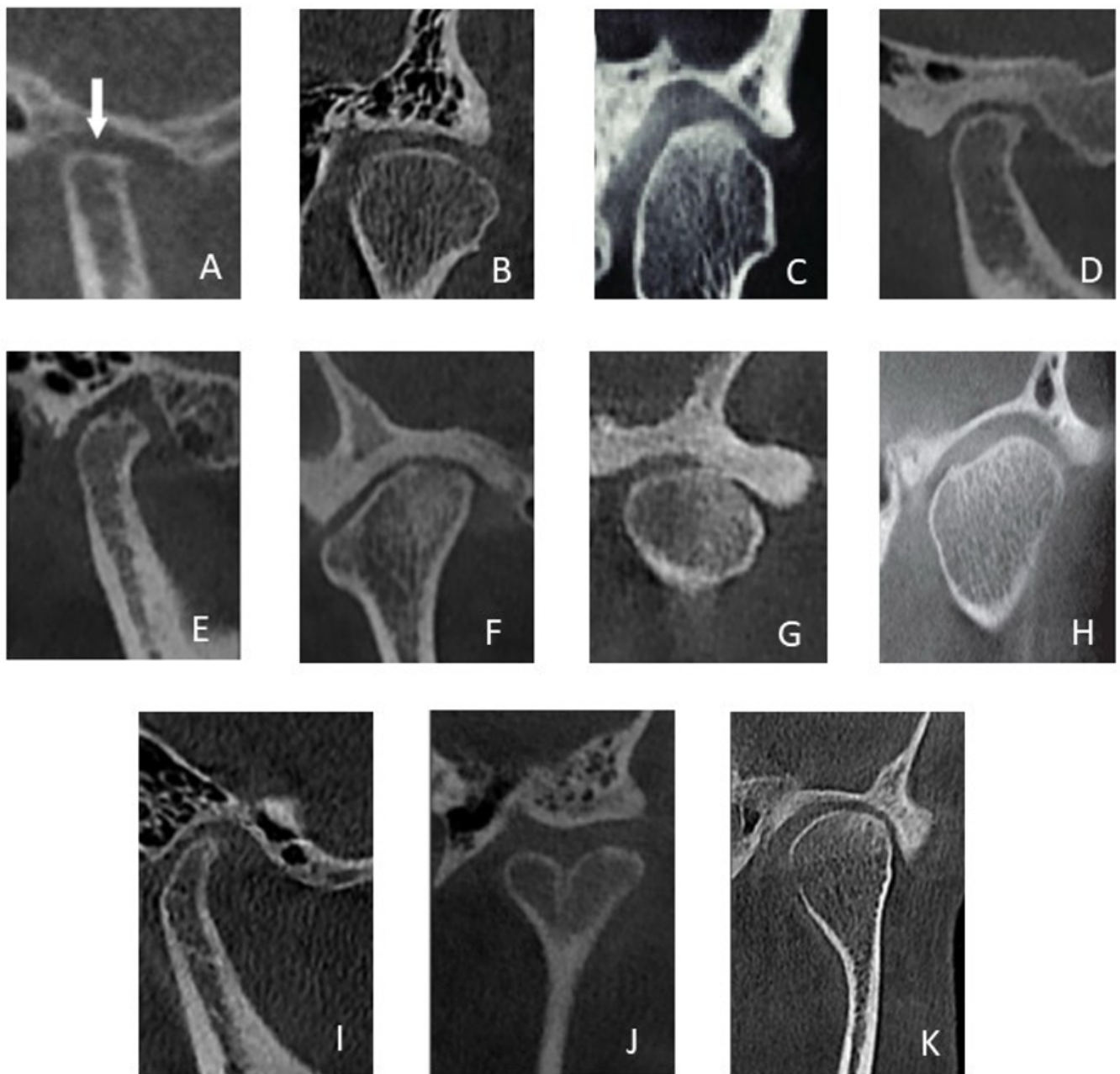


Figure 1

CBCT images showing different bony changes in patients with temporomandibular joint disorders. (Flattening, B: Erosion, C: Condylar head hyperplasia, D: Osteophyte, E: Ely Cyst, F: Temporal sclerosis, G: Ankylosis, H: Condylar head Sclerosis, I: Condylar head hypoplasia, J: Bifid Condyle, K: Decreased joint spaced)