Research Article

# Evaluation of Osseous Alterations of the Temporomandibular Joint Using Cone Beam Computed Tomography in Patients with Temporomandibular Joint Disorders: A Cross-Sectional Study

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**Abstract**

**Background:** Osseous alterations of the temporomandibular joint (TMJ), including flattening, erosion, sclerosis, osteophytes, and subchondral changes, are frequently detected on cone beam computed tomography (CBCT) in patients with temporomandibular disorders (TMD), but their relationship with clinical pain remains unclear.

**Aim:** To evaluate and compare TMJ osseous alterations on CBCT between TMD patients with and without pain.

**Materials and Methods:** This cross-sectional study included 81 TMD patients (40 with pain, 41 without pain) examined at a tertiary dental institution. CBCT scans were assessed in sagittal and coronal sections for ten osseous parameters, scored as present/absent for each side. Clinical diagnosis followed DC/TMD Axis I criteria, and pain intensity was recorded using a visual analogue scale. Associations between radiographic findings and pain status were analyzed using Fisher's exact test.

**Results:** The sample comprised 63% females, with 59.3% aged 11–30 years. Condylar flattening was the most prevalent finding (88.9% right, 82.7% left) and showed no association with pain. Sclerosis was significantly more common in the pain-free group on both sides (right: 51.2% vs 20.0%, p=0.005; left: 56.1% vs 20.0%, p=0.001), as was osteophyte formation (right: 36.6% vs 10.0%, p=0.008; left: 39.0% vs 15.0%, p=0.024). Subchondral changes were significantly more frequent in the pain group on the left side (20.0% vs 2.4%, p=0.014). Erosion and joint-space alterations showed no significant association with pain.

**Conclusion:** Osseous alterations are highly prevalent in TMD irrespective of pain status. Sclerosis and osteophytes appear to represent stabilized, adaptive changes associated with the absence of pain, whereas subchondral changes may relate more closely to active symptomatic disease. CBCT findings should complement, not replace, clinical evaluation in TMD management.

**Keywords:** Temporomandibular joint disorders; Cone beam computed tomography; Osseous alteration; Degenerative joint disease; Pain

## Introduction

The temporomandibular joint (TMJ) is a ginglymoarthrodial articulation in which the mandibular condyle interacts with the glenoid fossa, with the fibrocartilaginous articular disc facilitating both rotational and translational movements. [1, 2] (Figure 1). When this delicate anatomical and functional balance is disrupted, patients may develop temporomandibular disorders (TMDs), a heterogeneous group of musculoskeletal conditions affecting the joint and masticatory muscles that impact up to 28% of the population [3]. Clinically, TMDs may manifest with pre-auricular pain, joint noises, and limitations or deviations during mandibular movement. Under DC/TMD Axis I, these conditions are categorized into muscle disorders, disc displacement disorders, and joint disorders including arthralgia, arthritis, and arthrosis. [4]

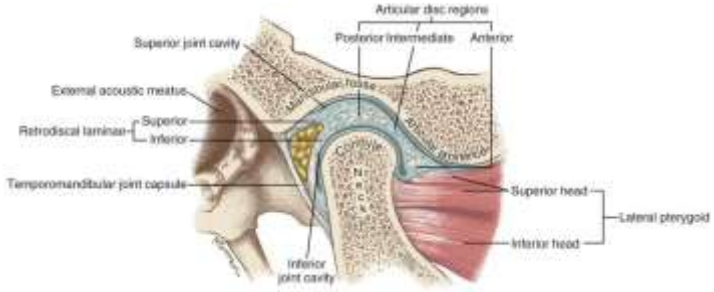
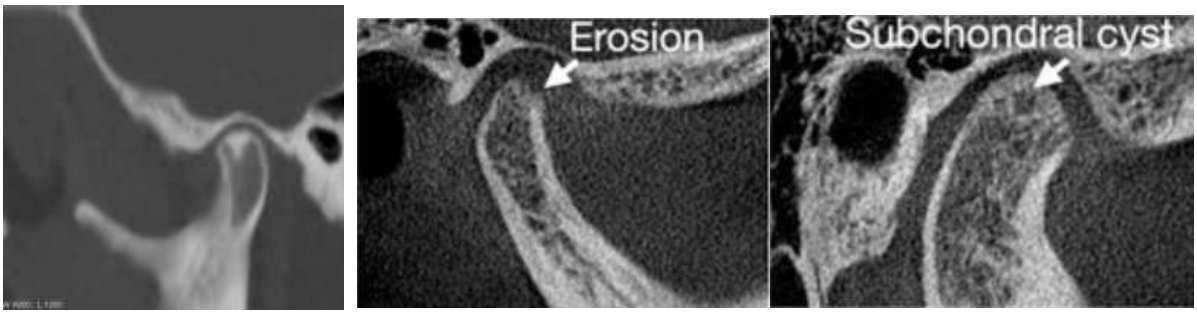


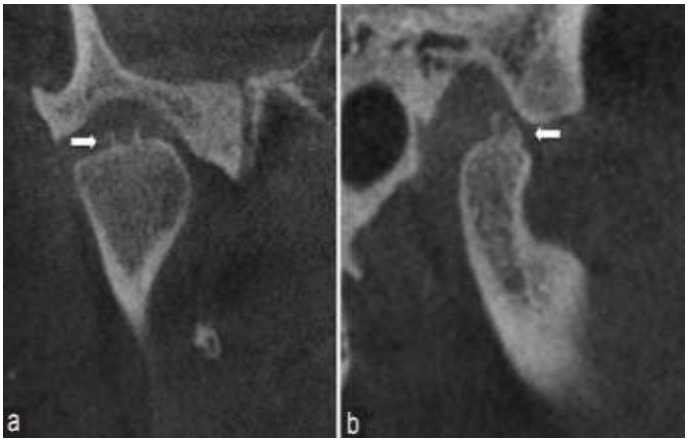

**Figure 1. Anatomy of the temporomandibular joint.**

Osseous changes involving the mandibular condyle and articular eminence, including flattening, erosion, osteophytes, sclerosis, and subchondral cysts, are important morphological features that may reflect degenerative joint disease (DJD). [5,6] Representative radiographic patterns of these alterations are illustrated in Figures 2–4.



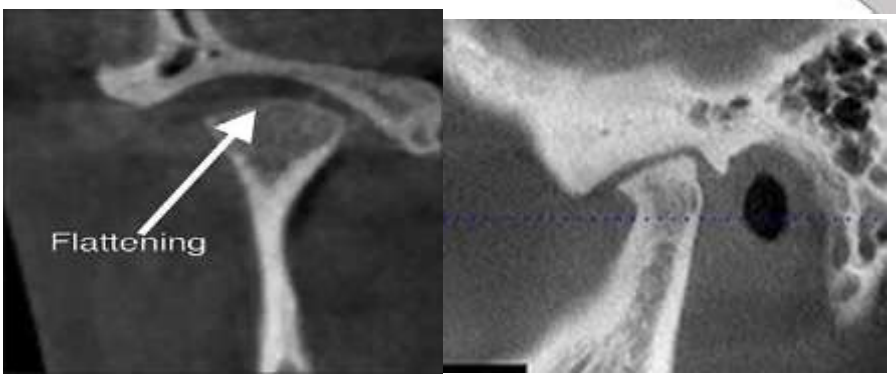

a b c

**Figure 2. Radiographic image of sclerosis (a), erosion (b) and subchondral cyst (c)**




a b

**Figure 3. Radiographic image of osteophyte(a) and joint mice (b)**




a b

**Figure 4. Radiographic image of flattening of condylar surface(a) and articular eminence (b)**

Conventional radiographic techniques may fail to demonstrate subtle osseous abnormalities because of anatomical superimposition. Although MRI provides superior assessment of soft tissues, it is less suited to detailed evaluation of cortical bone, whereas multidetector CT involves a comparatively greater radiation exposure [7]. For assessment of TMJ osseous morphology, CBCT provides high-resolution multiplanar imaging with relatively low radiation exposure and has consequently become an important imaging modality for evaluating bony joint changes. [8, 9]
However, the clinical relevance of individual osseous abnormalities identified on CBCT remains uncertain. Several studies report significant associations between radiographic changes particularly osteophytes and surface irregularities and clinical TMD or pain, while others find comparable degenerative changes in symptomatic and asymptomatic joints, implying that structural damage can occur without clinical manifestation. These conflicting observations make it difficult to determine the appropriate clinical significance of CBCT findings during diagnosis and treatment planning.
This cross-sectional study was therefore designed to systematically evaluate the spectrum and prevalence of TMJ osseous alterations on CBCT in patients with TMD, and to compare their distribution between patients presenting with and without joint pain, in order to clarify which radiographic parameters carry genuine clinical relevance.

## MATERIALS AND METHODS

This cross-sectional study was conducted between September 2025 and March 2026 in the Department of Oral and Maxillofacial Radiology at a dental teaching institution in Navi Mumbai, following institutional ethical clearance. Patients clinically diagnosed with TMD according to DC/TMD Axis I (Group II and Group III), aged 14 years and above, without prior TMJ pathology, trauma, orthodontic treatment, systemic bone disease, or previous TMJ surgery, were included. The minimum sample size, calculated from an expected prevalence of condylar flattening of 73.3% with 95% confidence and 10% precision, was 76 subjects; 81 patients were ultimately enrolled.
Clinical assessment was performed according to the DC/TMD Symptom Questionnaire and Examination Protocol and comprised TMJ and masticatory muscle palpation, measurement of mandibular opening, and assessment of joint sounds. Patients were allocated to Group 1 (TMD with pain, n=40) if arthralgia was reported or elicited on palpation/function, and Group 2 (TMD without pain, n=41) if clinical TMD signs were present without pain. Pain intensity was recorded separately for each side using a 10-cm visual analogue scale (0–10).
CBCT scans were acquired using a Kodak Carestream CS9600 unit (Figure 9) with a voxel size of 0.3 mm (120 kV, 5 mA, 24-second scan), and reconstructed into multiplanar sagittal, coronal, and axial images using Carestream CS 3D Imaging Software.



**Figure 5. Photograph of Carestream CS9600 CBCT unit.**

For each TMJ, ten osseous parameters were independently assessed on the right and left sides in sagittal and coronal sections and recorded as present or absent, illustrated in Figures 6–15:
(1) Sclerosis — localized increase in cortical or sub-cortical bone density appearing as a radiopaque area on CBCT.



**Figure 6. CBCT based images of sclerosis**

(2) Erosion — localized area of cortical discontinuity or surface defect with reduced bone density.



**Figure 7. CBCT based images of erosion.**

(3) Osteophyte — marginal bony outgrowth projecting from the condylar surface.



**Figure 8. CBCT based images of osteophyte.**

(4) Joint mice — loose, calcified or ossified intra-articular bodies detached from the articular surfaces.

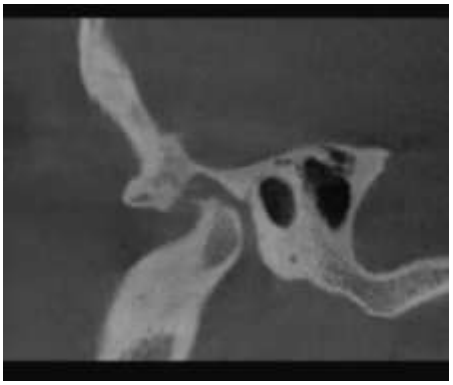


**Figure 9. CBCT based images of joint mice.**

(5) Subchondral / Ely's cyst — a well-circumscribed radiolucent area beneath the articular surface without cortical perforation.

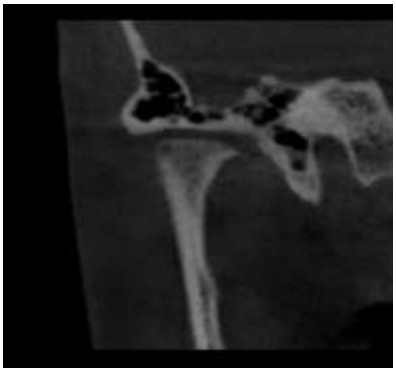


**Figure 10. CBCT based images of subchondral cyst / Ely's cyst.**

(6) Flattening of the condyle — loss of the normal convex outline of the condylar head.



**Figure 11. CBCT based images of flattening of condyle.**

(7) Flattening of the articular eminence — loss of the normal convex contour of the articular eminence.

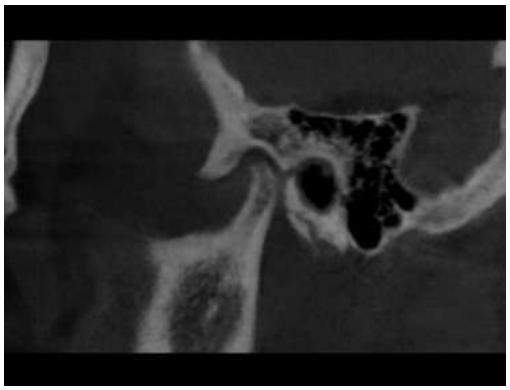


**Figure 12. CBCT based images of flattening of articular eminence.**

(8) Joint symmetry — comparison of right and left condylar height, position, and morphology to assess bilateral equality.

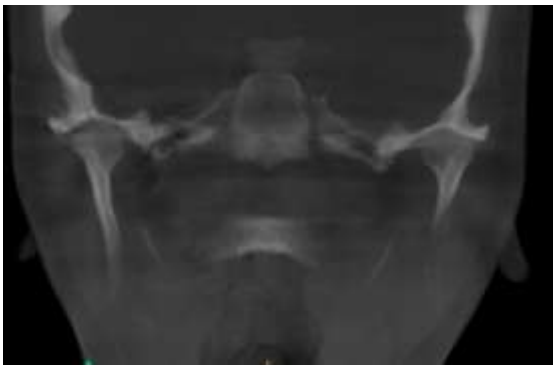


**Figure 13. CBCT based images of both condyles.**

(9) Increased joint space — widening of the radiolucent space between the mandibular condyle and glenoid fossa beyond normal limits.

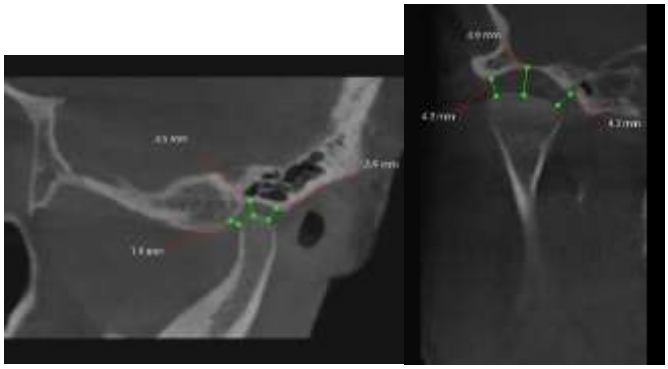


**Figure 14. CBCT based images of increased joint space.**

(10) Reduced joint space — narrowing of the radiolucent space between the mandibular condyle and glenoid fossa below normal limits. Normal joint-space ranges (Ikeda and Kawamura, 2009) are: anterior 1.5–2.5 mm, superior 2.0–3.5 mm, posterior 1.5–2.5 mm.

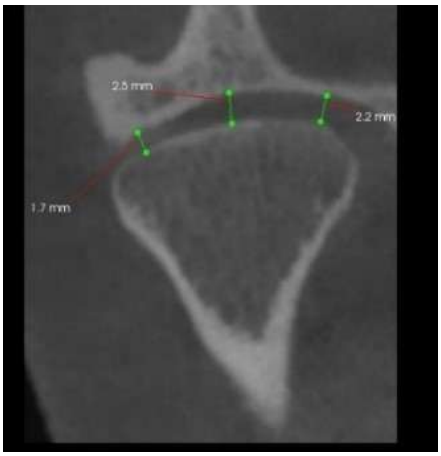



**Figure 15. CBCT based images of reduced joint space.**

Data were analysed using IBM SPSS Statistics. Categorical variables were summarized as frequencies and percentages. Associations between each radiographic parameter and pain status were assessed separately for the right and left sides using Fisher's exact test, given expected cell counts below five in several comparisons. A two-tailed p-value ≤0.05 was considered statistically significant, with values between 0.05–0.10 regarded as borderline.

## RESULTS

Eighty-one subjects were included: 40 in the pain group and 41 in the non-pain group. The majority of patients (59.3%) were aged 14–30 years (Table 1), and females predominated (63%, n=51) (Table 2).

**Table 1. Age distribution of the study population (N = 81)**

| Age group | Frequency | Percent |
|---|---|---|
| 14 to 30 | 48 | 59.3 |
| 31 to 50 | 21 | 25.9 |
| 51 to 70 | 12 | 14.8 |

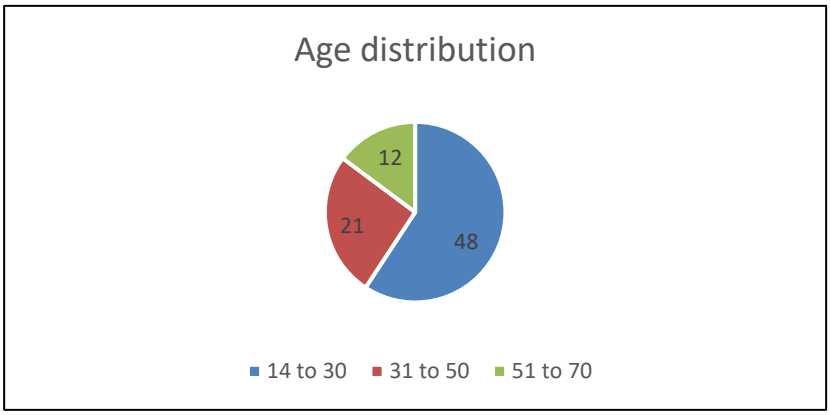



**Figure 16: Age distribution of the study population (N = 81)**

**Table 2. Gender distribution of the study population (N = 81).**

| Gender | Frequency | Percent |
|---|---|---|
| Male | 30 | 37 |
| Female | 51 | 63 |

**Figure 17. Gender distribution of the study population (N = 81).**

On the right side (Table 3), condylar flattening was the most prevalent finding overall (88.9%), followed by erosion (59.3%) and reduced joint space (53.1%), with no significant difference between pain groups for either. Sclerosis was significantly more frequent in the non-pain group (51.2% vs 20.0%, p=0.005), as was osteophyte formation (36.6% vs 10.0%, p=0.008). Subchondral changes showed a borderline association, more common in the pain group (17.5% vs 4.9%, p=0.088).

**Table 3. Comparison of prevalence of TMJ changes on the right side between subjects with TMD with and without pain.**

| Parameter | With pain | Without pain | Total | p-value |
|---|---|---|---|---|
| Sclerosis | 8 (20.0%) | 21 (51.2%) | 29 (35.8%) | 0.005* |

| | | | | |
|---|---|---|---|---|
| Erosion | 25 (62.5%) | 23 (56.1%) | 48 (59.3%) | 0.653 |
| Subchondral changes | 7 (17.5%) | 2 (4.9%) | 9 (11.1%) | 0.088* |
| Osteophyte | 4 (10.0%) | 15 (36.6%) | 19 (23.5%) | 0.008* |
| Joint mice | 1 (2.5%) | 0 (0.0%) | 1 (1.2%) | 0.494 |
| Joint asymmetry | 6 (15.0%) | 5 (12.2%) | 11 (13.6%) | 0.756 |
| Increased joint space | 18 (45.0%) | 19 (46.3%) | 37 (45.7%) | 1.000 |
| Reduced joint space | 22 (55.0%) | 21 (51.2%) | 43 (53.1%) | 0.825 |
| Flattening of condyle | 36 (90.0%) | 36 (87.8%) | 72 (88.9%) | 1.000 |
| Flattening of articular eminence | 13 (32.5%) | 15 (36.6%) | 28 (34.6%) | 0.816 |

Fisher's exact test; * indicates a significant difference at $p \leq 0.05$.

On the left side (Table 4), a similar pattern was observed: sclerosis was significantly more prevalent without pain (56.1% vs 20.0%, p=0.001), as was osteophyte formation (39.0% vs 15.0%, p=0.024), while subchondral changes were significantly more frequent with pain (20.0% vs 2.4%, p=0.014). Flattening of the condyle again showed no association with pain (82.9% vs 82.5%).

**Table 4. Comparison of prevalence of TMJ changes on the left side between subjects with TMD with and without pain.**

| Parameter | With pain | Without pain | Total | p-value |
|---|---|---|---|---|
| Sclerosis | 8 (20.0%) | 23 (56.1%) | 31 (38.3%) | 0.001* |
| Erosion | 25 (62.5%) | 18 (43.9%) | 43 (53.1%) | 0.178 |
| Subchondral changes | 8 (20.0%) | 1 (2.4%) | 9 (11.1%) | 0.014* |
| Osteophyte | 6 (15.0%) | 16 (39.0%) | 22 (27.2%) | 0.024* |
| Joint mice | 2 (5.0%) | 0 (0.0%) | 2 (2.5%) | 0.241 |
| Joint asymmetry | 6 (15.0%) | 6 (14.6%) | 12 (14.8%) | 1.000 |
| Increased joint space | 22 (55.0%) | 18 (43.9%) | 40 (49.4%) | 0.377 |

| | | | | |
|---|---|---|---|---|
| Reduced joint space | 19 (47.5%) | 23 (56.1%) | 42 (51.9%) | 0.508 |
| Flattening of condyle | 33 (82.5%) | 34 (82.9%) | 67 (82.7%) | 1.000 |
| Flattening of articular eminence | 15 (37.5%) | 13 (31.7%) | 28 (34.6%) | 0.645 |

Fisher's exact test; * indicates a significant difference at $p \leq 0.05$.

Across both sides, erosion, joint mice, joint asymmetry, increased/reduced joint space, and flattening of the articular eminence showed no statistically significant differences between the pain and non-pain groups. The overall pattern of significant findings is summarized graphically in Figure 20.

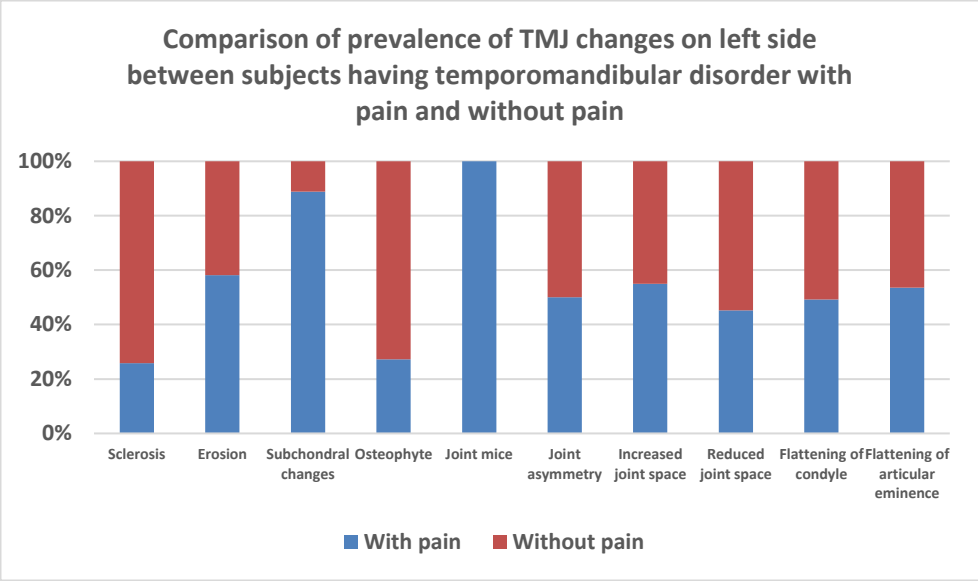



**Figure 18. Prevalence of key TMJ osseous alterations (with significant or borderline associations) by pain status. * $p \leq 0.05$.**

## DISCUSSION

This study evaluated ten CBCT osseous parameters in 81 TMD patients stratified by pain status. The female predominance (63%) and young age distribution (59.3% aged 11–30 years) mirror established TMD epidemiology, in which women are affected up to seven times more often than men and symptoms commonly emerge in the second to fourth decades of life.

Condylar flattening was observed in the large majority of subjects (88.9% right, 82.7% left), exceeding rates reported by dos Anjos Pontual et al. (59%) and Bae et al. (77.4%), likely reflecting the exclusively TMD-diagnosed sample. The absence of an association between condylar flattening and pain, in agreement with Shahidi et al., suggests that flattening may frequently represent an adaptive response to altered mechanical loading rather than evidence of active painful disease..

Sclerosis and osteophyte formation were both significantly more prevalent among pain-free patients on both sides. The greater prevalence of these findings among pain-free patients is consistent with the observations of Bae et al., who reported an inverse relationship between osteophyte frequency and pain intensity. This pattern may indicate a

more established stage of structural remodeling following chronic joint loading rather than ongoing nociceptive activity. From a clinical standpoint, identification of sclerosis or osteophytes on CBCT in a pain-free patient may reasonably support conservative management rather than invasive intervention.

Unlike the findings for sclerosis and osteophytes, subchondral changes were significantly more frequent on the left side among patients with pain (20.0% versus 2.4%, p=0.014). This observation is comparable to the pattern reported by Hilgenberg-Sydney et al. for subchondral cysts in painful degenerative joint disease. This suggests that subchondral pathology may reflect more active disease processes and could warrant closer monitoring or more active therapeutic consideration in symptomatic patients.

Erosion, while highly prevalent (59.3% right, 53.1% left), did not differ significantly by pain status, in contrast to Bae et al., who found a direct relationship between erosion and pain intensity. This discrepancy may reflect differences in disease duration, sample composition, or the high baseline prevalence of erosion in both study groups, echoing Shahidi et al.'s similar finding of no significant difference in erosion between symptomatic and asymptomatic subjects.

A key objective of this study was to determine whether osseous change can exist without pain. The non-pain group demonstrated a substantial radiographic burden — including sclerosis, erosion, and osteophytes in over one-third of joints — corroborating prior reports that 39–87% of asymptomatic or pain-free individuals show degenerative CBCT findings. These findings emphasize that the presence of radiographic abnormalities alone cannot be taken as evidence of clinical pain. Accordingly, CBCT findings should be interpreted alongside a comprehensive clinical assessment rather than used as its replacement. Taken together, these findings suggest a staged model of TMJ degeneration: subchondral change and possibly erosion may mark earlier, more active and painful disease, while sclerosis, osteophytes, and flattening may represent later, adapted, and comparatively pain-free states. Side-specific analysis further demonstrated that TMD often presents asymmetrically, reinforcing the value of independently evaluating each joint rather than relying on bilateral averages.

## LIMITATIONS

This study's cross-sectional design precludes causal inference regarding the proposed remodeling sequence. The predominantly young, female cohort limits generalizability to older or male populations. Osseous changes were recorded as binary present/absent without severity grading, and pain was assessed using a single-item VAS without validated multidimensional instruments. Soft-tissue imaging (MRI) was not performed, so disc displacement and synovitis could not be accounted for as independent contributors to pain.

## CONCLUSION

A wide spectrum of TMJ osseous alterations flattening, erosion, sclerosis, osteophytes, and subchondral changes is highly prevalent in TMD patients regardless of pain status. Sclerosis and osteophyte formation were significantly more common in pain-free patients, suggesting they represent stabilized, adaptive joint remodeling, whereas subchondral changes were associated with pain, particularly on the left side, indicating a possible link to active disease. Condylar flattening, despite near-universal prevalence, was not associated with pain. Overall, the observed CBCT abnormalities were not reliable indicators of symptomatic status. Therefore, management decisions in TMD should remain primarily guided by the patient's clinical presentation, while CBCT serves as an adjunctive tool for diagnosis, assessment of structural changes, and treatment planning.

## References:

1. Alomar X, et al. Anatomy of the temporomandibular joint. Semin Ultrasound CT MRI. 2007;28(3):170–183.
2. Okeson JP. Management of Temporomandibular Disorders and Occlusion. 8th ed. Elsevier; 2019.
3. Perschbacher S. Temporomandibular joint abnormalities. In: Oral Radiology: Principles and Interpretation. 7th

ed. Elsevier; 2014.
4. Schiffman E, et al. Diagnostic Criteria for TMD (DC/TMD). J Oral Facial Pain Headache. 2014;28(1):6–27.
5. dos Anjos Pontual ML, et al. Evaluation of bone changes in the TMJ using cone beam CT. Dentomaxillofac Radiol. 2012;41(1):24–29.
6. Ahmad M, et al. RDC/TMD: image analysis criteria. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(6):844–860.
7. Alkhader M, et al. Diagnostic performance of MRI for TMJ osseous abnormalities. Dentomaxillofac Radiol. 2010;39:270–276.
8. Barghan S, Tetradis S, Mallya SM. CBCT for TMJ assessment. Aust Dent J. 2012;57(Suppl 1):109–118.
9. ain-Alabdeen EH, Alsadhan RI. Comparative study of MDCT and CBCT for TMJ surface osseous changes. Dentomaxillofac Radiol. 2012;41(3):185–191.
10. Talaat W, Al Bayatti S, Al Kawas S. CBCT analysis of bony changes associated with TMD. Cranio. 2016;34(2):88–94.
11. Hilgenberg-Sydney PB, et al. Comparative analysis of TMJ morphology in DJD. Saudi Dent J. 2024;36(5):756–760.
12. Shokri A, et al. Comparison of bony changes of TMJ with and without TMD complaints using CBCT. J Dent (Tehran). 2018;19(2):142–149.
13. Bakke M, et al. Bony deviations revealed by CBCT of the TMJ in subjects without ongoing pain. J Oral Facial Pain Headache. 2014;28(4):331–337.
14. Ikeda K, Kawamura A. Assessment of optimal condylar position with limited CBCT. Am J Orthod Dentofacial Orthop. 2009;135(4):495–501.
15. Tanaka E, Detamore MS, Mercuri LG. Degenerative disorders of the TMJ. J Dent Res. 2008;87(4):296–307.
16. Yap AU, et al. TMJ degenerative joint disease: relationships between CBCT findings, clinical symptoms and signs. Acta Odontol Scand. 2023;81(7):562–568.
17. Bae S, et al. Correlation between pain and degenerative bony changes on CBCT images of TMJ. Maxillofac Plast Reconstr Surg. 2017;39(1):19.
18. Shahidi S, et al. Comparison of bony changes of TMJ in patients with and without TMD complaints using CBCT. J Dent (Shiraz). 2018;19(2):142–149.
19. Bianchi J, et al. Radiographic interpretation using high-resolution CBCT to diagnose degenerative TMJ disease. PLoS One. 2021;16(8):e0255937.
20. Massilla Mani F, Sivasubramanian SS. A study of TMJ osteoarthritis using CT imaging. Biomed J. 2016;39(3):201–206.