ORIGINAL ARTICLE

RADIOGRAPHIC FINDINGS OF TEMPOROMANDIBULAR JOINT OSSEOUS CHANGES USING CONE-BEAM COMPUTED TOMOGRAPHY IN A SAUDI POPULATION: A RETROSPECTIVE STUDY

Waleed Abdulhadi Alalawi[1]✉, Shaul Hameed Kolarkodi[2], Khalid Alotabiti[1], Abdulrahman Altwaijri[1], Faraj Alotaiby[2]

[1]Department of Oral and Maxillofacial Surgery, College of Dentistry, Qassim University. Qassim-Saudi Arabia
[2]Department of Oral and Maxillofacial Diagnostic Sciences, College of Dentistry, Qassim University. Qassim-Saudi Arabia

Background: The temporomandibular joint (TMJ) is a complex synovial articulation that plays a critical role in mastication, speech, and mandibular movements. Pathologies affecting the TMJ, such as internal derangement, osteoarthritis, and degenerative bone changes, can significantly impair function and quality of life. The objectives of the study were to evaluate the prevalence and pattern of osseous changes in the temporomandibular joint (TMJ) using cone-beam computed tomography (CBCT) in a Saudi population, with emphasis on diagnostic and surgical relevance. **Methods:** This retrospective study was conducted in the Department of Diagnostic Sciences, Qassim University, Saudi Arabia, and included 414 bilateral CBCT scans obtained between January 2020 and December 2024. Scans were evaluated for degenerative bony changes such as condylar flattening, erosion, osteophytes, subchondral sclerosis, and cysts. Two experienced radiologists performed independent assessments, and inter-examiner reliability was calculated. Demographic associations were analyzed using Chi-square and ANOVA tests, with significance set at $p<0.05$. **Results:** Of the 414 subjects, 260 (62.8%) were male and 154 (37.2%) female. Condylar flattening was the most frequent pathology, observed in 10.63% of right and 9.90% of left TMJs, followed by erosion and subchondral cysts. A total of 73.7% of cases exhibited radiographic abnormalities. Age was significantly associated with the presence of TMJ pathologies ($p<0.01$), particularly in individuals aged 40–60 years. No statistically significant association was found between gender and TMJ degeneration. **Conclusions:** Cone-beam computed tomography effectively detects subtle and early-stage TMJ osseous changes, with flattening, erosion, and cystic degeneration being the most prevalent findings. The strong age-related pattern of TMJ degeneration supports the need for early radiographic screening, especially in middle-aged adults. From a surgical perspective, CBCT imaging plays a vital role in preoperative planning, aiding in the decision-making process for conservative versus surgical interventions.

Keywords: Cone-beam computed tomography (CBCT); Temporomandibular joint (TMJ); Osseous changes; Degenerative joint disease; Condylar flattening; Erosion; Subchondral cyst; Saudi population; Surgical planning; TMJ imaging

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INTRODUCTION

The temporomandibular joint (TMJ) is a complex synovial articulation that plays a critical role in mastication, speech, and mandibular movements.[1] Pathologies affecting the TMJ, such as internal derangement, osteoarthritis, and degenerative bone changes, can significantly impair function and quality of life.[2] Accurate assessment of osseous changes within the TMJ is essential, particularly for surgical planning and evaluating long-term treatment outcomes. Cone beam computed tomography (CBCT) has emerged as a valuable diagnostic modality, offering high-resolution, three-dimensional visualization of bony structures with lower radiation exposure compared to conventional CT.[3]

Cone beam computed tomography allows for detailed evaluation of joint space narrowing, condylar surface irregularities, osteophyte formation, sclerosis, and condylar volume all of which are critical markers for TMJ degeneration and potential surgical intervention. A study by Berry *et al*., revealed that radiological scores derived from CBCT images were significantly higher in females and those with joint-related TMD compared to muscle-related cases, underlining the modality's potential for detecting subtle degenerative changes[4]. Talaat *et al*.,

demonstrated significant associations between clinical diagnoses of TMJ osteoarthritis and CBCT findings such as condylar flattening and osteophyte formation, supporting its diagnostic utility in pre-surgical evaluations.[5]

Moreover, morphometric studies like that of Nithin *et al.,* highlight gender-based differences in condylar dimensions and joint spaces, emphasizing the importance of individualized radiographic assessment before surgical intervention.[6] These morphological parameters are particularly valuable when planning procedures such as arthrocentesis, arthroscopy, or open joint surgery, where condylar anatomy and joint space considerations influence surgical access and prognosis.

Despite the increasing global interest in TMJ imaging, data from Middle Eastern populations, particularly Saudi Arabia, remain limited. Given the ethnic, anatomical, and lifestyle variations, it is crucial to establish population-specific baselines for TMJ morphology and pathology. This study aims to retrospectively evaluate TMJ bony changes in a Saudi cohort using CBCT imaging, to identify the prevalence and pattern of degenerative changes and contribute to evidence-based diagnostic and surgical decision-making.

MATERIAL AND METHODS

This retrospective radiographic study was conducted in the Department of Diagnostic Sciences, College of Dentistry, Qassim University, Saudi Arabia. Ethical approval for the study was obtained from the institutional review board of Qassim University No 24-82-09, and all data were anonymized prior to analysis to ensure patient confidentiality.

The study was carried out over a four-year period, from January 2020 to December 2024. A total of 414 CBCT scans of the temporomandibular joint (TMJ) were retrieved from the departmental archives. Patients who had undergone bilateral TMJ imaging during this period were included in the study. Inclusion criteria comprised complete, high-resolution CBCT scans originally acquired for diverse diagnostic indications, regardless of TMJ symptomatology, thereby allowing incidental identification of osseous changes. Exclusion criteria included a history of TMJ surgery, facial trauma, systemic conditions affecting bone metabolism, or incomplete scan data.

Cone beam computed tomography scans were obtained using a standardized imaging protocol with a Planmeca ProMax 3D Mid scanner (Planmeca Oy, Helsinki, Finland). Imaging was performed with a voxel size of 0.2 mm, a field of view (FOV) of 8×8 cm, and exposure parameters adjusted automatically by the manufacturer's software based on patient size and region of interest. The scans were reconstructed and evaluated using Planmeca Romexis® software (version 5.3), allowing multi-planar reformats and three-dimensional visualization of the condylar head, articular eminence, and glenoid fossa. This facilitated a detailed assessment of degenerative bony changes and joint space morphology. Each scan was assessed for the presence of radiographic changes such as condylar flattening, osteophyte formation, subchondral sclerosis, erosion, Ely's cysts, and joint space alterations.

Two experienced oral and maxillofacial radiologists independently evaluated all CBCT images. Prior to the formal evaluation, a calibration session was conducted using ten representative scans to establish consistent interpretation criteria. Inter-examiner reliability was determined using Cohen's kappa statistic for categorical variables and the intra-class correlation coefficient (ICC) for continuous variables. Kappa values above 0.80 and ICC values greater than 0.90 were interpreted as excellent agreement. Any discrepancies between the examiners were resolved through mutual discussion and consensus.

The data were compiled using Microsoft Excel and analyzed using SPSS software (version 27.0, IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize demographic information and radiographic findings. Frequencies and percentages were calculated for categorical variables, while continuous variables were reported as mean and standard deviation. Associations between demographic variables and radiographic findings were tested using Chi-square tests for categorical variables and independent sample t-tests or ANOVA for continuous variables. A *p*-value less than 0.05 was considered statistically significant.

RESULTS

Out of the total 414 patients included in the study, 260 (62.8%) were males and 154 (37.2%) were females (Table 1).

Table 2 presents the frequency and percentage distribution of osseous changes observed in the right and left temporomandibular joints (TMJ) based on CBCT scans of 414 individuals. A greater proportion of right-sided TMJs (296 cases; 71.5%) were free of pathological changes compared to the left side (276 cases; 66.67%), suggesting a slightly higher incidence of degenerative findings on the left. Condylar flattening was the most frequently observed abnormality on both sides, reported in 44 cases (10.63%) on the right and 41 cases (9.90%) on the

left. It was also commonly seen in combination with other changes such as erosion and depression.

Erosion was the second most prevalent finding, with a higher occurrence on the left side (27 cases; 6.52%) than the right (15 cases; 3.62%). Subchondral cysts were noted in 12 right-sided cases (2.90%) and 10 left-sided cases (2.42%), occasionally appearing alongside other features like depression. Sclerosis, both isolated and in combination, was more frequently observed on the left (3.14%) compared to the right (1.69%), while osteophyte formation also showed a slightly higher prevalence on the left (0.97%) than the right (0.72%).

Table 3 presents the age-wise distribution of the participants included in the study. The majority of the sample belonged to the 20–40-year age group (53.9%), followed by 40–60 years (31.9%). A smaller proportion of individuals were aged <20 years (5.6%) and 60–80 years (8.7%).

Table 4 illustrates the distribution of right-sided TMJ pathologies across different age groups based on CBCT findings. The prevalence of TMJ pathologies was notably higher in the 40–60-year group, where multiple pathologies such as erosion (12 cases), flattening (21 cases), and flattening with erosion (8 cases) were observed. The 20–40-year age group showed a greater number of cases with flattening (13 cases) and combined changes like flattening with erosion (5 cases) and subchondral cysts (5 cases). Pathologies were least frequent in individuals below 20 years of age, where no TMJ abnormalities were detected, and all 23 cases were categorized as "Non."

A progressive increase in degenerative changes such as erosion, sclerosis, and flattening are evident with advancing age. Notably, combined lesions like flattening + erosion + sclerosis and sclerosis + erosion + osteophyte bone appeared only in older individuals (60–80 years group), indicating a correlation between aging and TMJ degeneration. The highest number of normal (non-pathological) cases was seen in the 20–40 age group (188 cases), which also represents the largest segment of the study population. The association between age group and the presence of right-sided TMJ pathology was found to be statistically significant (p<0.01), indicating that age plays an important role in the radiographic presentation of TMJ degenerative changes.

Table 5 presents the age-wise distribution of left-sided TMJ pathologies detected on CBCT among 414 individuals. The majority of the cases were within the 20–40 and 40–60 year age groups, which also demonstrated the highest prevalence of TMJ pathologies. The most frequently observed changes were flattening (41 cases), followed by erosion (27 cases) and flattening with erosion (14 cases), with these lesions predominantly occurring in individuals aged 40–60 years. The presence of complex degenerative combinations, such as flattening with sclerosis and flattening with erosion and sclerosis, was more frequent in older age groups, especially those aged 60–80. No pathological findings were observed in participants under the age of 20, with all 23 cases in that group being classified as "Non."

Table 6 reveals distinct patterns in the prevalence of osseous changes. On both sides, the most frequently observed abnormality was condylar flattening, noted equally in males and females on the right side (22 cases each) and similarly on the left (21 males and 20 females). Erosion was also common, with higher occurrence in males, particularly on the right (11 males vs. 4 females) and left (15 males vs. 12 females), indicating a male predominance in this degenerative change.

Combined degenerative patterns such as flattening with erosion were more prevalent in males on both sides, especially on the right (11 males vs. 7 females) and the left (8 males vs. 6 females). Similarly, sclerosis, either isolated or in combination with other features, was consistently more common in males—observed in 7 right-sided and 9 left-sided cases, compared to none and 4, respectively, in females. Subchondral cysts also followed this trend, being more frequently seen in males (10 right, 8 left) than females (2 each side).

While most rare findings were isolated and balanced across genders, certain features like condylar fracture, sclerosis with depression, and flattening with erosion and sclerosis appeared exclusively in males, suggesting more complex degenerative involvement. On the other hand, anomalies like double cyst and the ambiguous "Bob" were unique to females, though reported in only single cases. A higher proportion of males (184 right, 177 left) than females (112 right, 95 left) exhibited no TMJ pathology, though the absolute number of pathologies was higher in males due to the larger sample size.

Table-1: Gender distribution of the study population

Gender	Frequency (n)	Percent (%)
Female	154	37.2
Male	260	62.8
Total	**414**	**100.0**

Table-2: Frequency and percentage distribution of right and left TMJ pathologies (N = 414)

Pathology	Right Frequency (%)	Left Frequency (%)
Bifid Condyle	2 (0.48%)	2 (0.48%)
Cyst	1 (0.24%)	—
Double Cyst	—	1 (0.24%)
Depression	5 (1.21%)	8 (1.93%)
Erosion	15 (3.62%)	27 (6.52%)
Erosion + Depression	2 (0.48%)	—
Erosion + Subchondral Cyst	1 (0.24%)	—
Erosion + Sclerosis	—	2 (0.48%)
Flattening	44 (10.63%)	41 (9.90%)
Flattening + Cyst	1 (0.24%)	—
Flattening Condyle	1 (0.24%)	1 (0.24%)
Flattening + Depression	2 (0.48%)	3 (0.72%)
Flattening + Erosion	17 (4.11%)	14 (3.38%)
Flattening + Erosion + Depression	—	1 (0.24%)
Flattening + Sclerosis	1 (0.24%)	6 (1.45%)
Flattening + Erosion + Sclerosis	—	1 (0.24%)
Subchondral Cyst	12 (2.90%)	10 (2.42%)
Subchondral Cyst + Depression	1 (0.24%)	—
Osteophyte	3 (0.72%)	4 (0.97%)
Sclerosis	7 (1.69%)	13 (3.14%)
Sclerosis + Erosion + Osteophyte Bone	1 (0.24%)	—
Sclerosis + Depression	—	2 (0.48%)
Condylar Fracture	—	1 (0.24%)
Bob (Unclear/possible data error)	—	1 (0.24%)
Non (No Pathology)	296 (71.50%)	276 (66.67%)
Total	414 (100%)	414 (100%)

Table-3: Age distribution of the study population (N = 414)

Age Group (Years)	Frequency	Percentage (%)
< 20	23	5.6
20–40	223	53.9
40–60	132	31.9
60–80	36	8.7
Total	**414**	**100.0**

Table-4: Age-wise distribution of right-sided temporomandibular joint (TMJ) pathologies

		Category				Total	*p*-value
		<20	20-40	40-60	60-80		
Right TMJ pathology Identified	Bifid condyle	0	1	1	0	2	<0.01*
	cyst	0	0	0	1	1	
	depression	0	2	2	1	5	
	erosion	0	1	12	2	15	
	erosion +depression	0	1	1	0	2	
	erosion +subchondral cyst	0	0	1	0	1	
	flattening	0	13	21	10	44	
	flattening + Cyst	0	0	1	0	1	
	flattening condyle	0	1	0	0	1	
	flattening depression	0	0	2	0	2	
	flattening erosion	0	5	8	4	17	
	flattening sclerosis	0	0	1	0	1	
	flattening subchondral cyst	0	0	2	0	2	
	Non	23	188	70	13	294	
	osteophyte	0	1	1	1	3	
	sclerosis	0	2	3	2	7	
	sclerosis + erosion + osteophyte bone	0	0	0	1	1	
	Subcondral cyst	0	5	6	1	12	
	Subcondral cyst depression	0	1	0	0	1	
Total		**23**	**223**	**132**	**36**	**414**	

Table-5: Age-wise distribution of left-sided temporomandibular joint (TMJ) pathologies

Left TMJ Pathology Identified	<20	20–40	40–60	60–80	Total
Flattening Condyle	0	1	0	0	1
Bifid Condyle	0	2	0	0	2
Bob	0	0	1	0	1
Condylar Fracture	1	0	0	0	1
Depression	1	6	1	0	8
Double Cyst	0	1	0	0	1
Erosion	0	11	14	2	27
Erosion + Sclerosis	0	0	2	0	2
Flattening + Erosion + Depression	0	1	0	0	1
Flattening	0	11	22	8	41
Flattening + Depression	0	1	2	0	3
Flattening + Sclerosis	0	0	4	2	6
Flattening + Erosion	0	5	5	4	14
Flattening + Erosion + Sclerosis	0	1	0	0	1
Non	21	174	67	14	276
Osteophyte	0	3	0	1	4
Sclerosis	0	4	5	4	13
Sclerosis + Depression	0	0	2	0	2
Subcondral Cyst	0	2	7	1	10
Total	**23**	**223**	**132**	**36**	**414**

Table-6: Gender-wise distribution of right and left TMJ pathologies (N = 414)

TMJ Pathology Identified	Female Right	Male Right	Female Left	Male Left
Bifid Condyle	0	2	1	1
Cyst	0	1	—	—
Double Cyst	—	—	1	0
Depression	2	3	2	6
Erosion	4	11	12	15
Erosion + Depression	1	1	—	—
Erosion + Subchondral Cyst	1	0	—	—
Erosion + Sclerosis	—	—	1	1
Flattening	22	22	20	21
Flattening + Cyst	0	1	—	—
Flattening Condyle	0	1	0	1
Flattening + Depression	0	2	1	2
Flattening + Erosion	7	11	6	8
Flattening + Erosion + Depression	—	—	0	1
Flattening + Sclerosis	0	1	3	3
Flattening + Erosion + Sclerosis	—	—	0	1
Subchondral Cyst	2	10	2	8
Subchondral Cyst + Depression	0	1	—	—
Osteophyte	1	2	1	3
Sclerosis	0	7	4	9
Sclerosis + Erosion + Osteophyte Bone	1	0	—	—
Sclerosis + Depression	—	—	0	2
Condylar Fracture	—	—	0	1
Bob (Unclear/possible data error)	—	—	1	0
Non (No Pathology)	112	184	95	177
Total	154	260	154	260

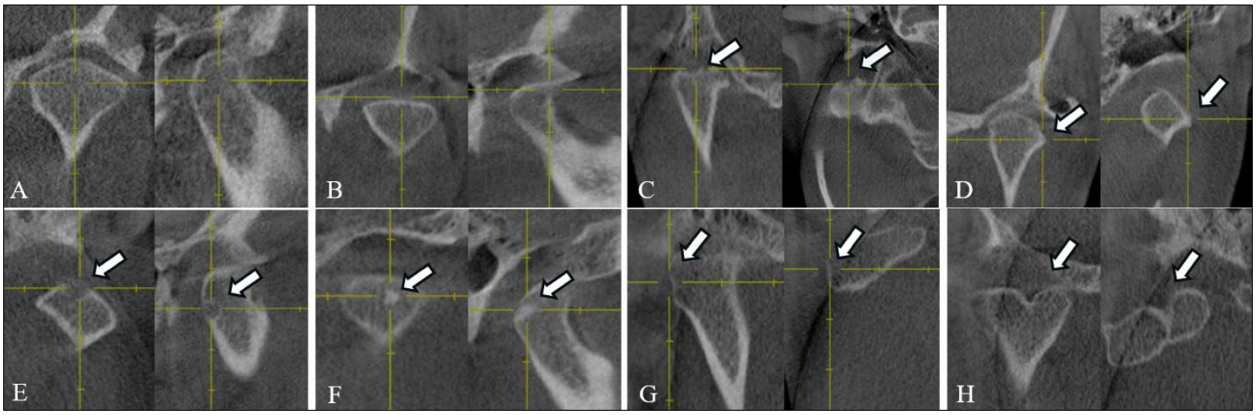

Fig.1 Cone-beam computed tomography CBCT Axial, Coronal and Sagittal views of the temporomandibular joints (TMJs). Osseous changes in the condyle are (A)normal (B)flattening (C) erosion (D) osteophyte (E) subchondral cysts (F) sclerosis (G) depression (H) Bifid condyle

DISCUSSION

In the present retrospective CBCT-based study evaluating TMJ osseous changes in a Saudi population, 414 scans were assessed to determine the prevalence and characteristics of TMJ pathologies. The most frequent radiographic finding was condylar flattening, followed by erosion and subchondral cysts. The most commonly observed finding in the present study was condylar flattening, present in 10.6% of cases on the right side and 9.9% on the left. This aligns with the study by Singh *et al*., who reported flattening as the most prevalent incidental finding (35.6%) in their large-scale evaluation of 1,850 CBCT scans.[7] They emphasized the importance of thoroughly evaluating CBCT scans for subtle degenerative markers, even in asymptomatic individuals. Berry *et al*. (2021) reported degenerative changes, including flattening, in 96.5% of evaluated joints, underscoring the sensitivity of CBCT in detecting early osseous alterations.[4]

Erosion, the second most prevalent finding in the present study, was noted more frequently in males and was significantly associated with advancing age. This is consistent with the findings by de Holanda *et al*., who reported mandibular condylar erosion in 12.69% of asymptomatic subjects, with a significant correlation to older age and reduced dentition.[8] The association between degenerative joint disease (DJD) and edentulism further supports the role of mechanical stress and occlusal loading in the pathogenesis of TMJ degeneration.

Gender-based differences in TMJ changes in the current population were not statistically significant ($p>0.05$). This contrasts with Berry *et al*., and Singh *et al.,* who observed higher radiological scores or degenerative findings in females, suggesting possible hormonal or anatomical predispositions.[4,7] On the other hand, Nithin *et al*., observed that condylar dimensions and joint spaces were significantly greater in males, suggesting structural factors could influence degenerative patterns.[6] The present study findings support the latter, where degeneration was evenly distributed across genders in terms of flattening and erosion.

With respect to age, the association was statistically significant ($p<0.01$) in both right- and left-sided TMJ degeneration, with most pathologies clustering in the 40–60-year group. This trend is supported by de Holanda *et al*., and Nithin *et al*., who both reported a higher frequency of TMJ abnormalities with increasing age.[6,8] This reinforces the understanding that degenerative TMJ changes are cumulative and more apparent in middle-aged and older adults.

In the current study findings, flattening with erosion and sclerosis, representing advanced degenerative patterns, was almost exclusively seen in patients over 40 years, especially those between 60–80 years. This is congruent with the work by Pushpraj Singh *et al*., who found that osteoarthritic changes and sclerosis increased with age and were significantly more common in males.[7] The presence of rare findings such as bifid condyle and condylar fractures was minimal in both the current study and earlier reports, indicating their limited role in non-symptomatic populations.

Furthermore, the high prevalence of TMJ pathologies observed in this study (73.7%) aligns with the findings of Theodoridis *et al*. and Price *et al*., who highlighted the clinical significance of incidental findings detected through CBCT imaging.[9,10] Theodoridis *et al*. reported that nearly all full-volume CBCT scans presented with some form of incidental findings, and although many were minor, a significant number warranted monitoring or referral.[9] The present study supports this conclusion, showing that a significant portion of TMJ changes were incidentally found during routine scans performed for unrelated dental complaints.

This study was limited by its retrospective design, which did not allow for the inclusion of clinical symptoms or functional assessments that could support radiographic findings. Additionally, the evaluation was restricted to osseous changes observable on CBCT, excluding soft tissue structures such as the articular disc. Future studies should adopt a prospective design incorporating clinical correlation and multimodal imaging to provide a more comprehensive understanding of TMJ disorders.

CONCLUSION

Condylar flattening was the most commonly observed pathology, followed by erosion and subchondral cysts, with 73.7% of the evaluated joints exhibiting radiographic abnormalities highlighting the diagnostic utility of CBCT in identifying even subtle or asymptomatic TMJ changes. A statistically significant association was noted between increasing age and the presence of TMJ pathologies, particularly in individuals aged 40–60 years, suggesting a progressive and age-related degenerative process, while no significant gender differences were observed.

AUTHORS' CONTRIBUTION

WAA, SHK, KA, AA and F.A conception of the study, definition of the methodology, literature search, drafting of the manuscript, critical revision of the article, visualization, supervision, Statistical analysis and final review. All authors approved the final version of the manuscript.

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Address for Correspondence:

Waleed Abdulhadi Alalawi, Department of Oral and Maxillofacial Surgery, College of Dentistry, Qassim University. Qassim-Saudi Arabia

Cell: +966550019446

Email: W.ALALAWI@qu.edu.sa