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Incidence of Degenerative Changes in the Mandibular Condyle of Patients with and without Posterior Teeth

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Abstract

Degenerative joint disease (DJD) of the temporomandibular joint (TMJ) is a common age-related condition characterized by the deterioration of the joint's articular surfaces. Approximately 50% of the general population experiences TMJ disorders. This study aimed to evaluate the degenerative changes in the condyles of patients with and without posterior teeth. The panoramic images of 237 patients aged between 18 and 75 years (mean age 33.6 ± 14.4 years; 109 males and 128 females), categorized into two groups based on dental status: Group A consisted of patients with complete upper and lower posterior dentition, while Group B included those who were completely edentulous in the upper and/or lower posterior regions. The images were selected based on defined inclusion and exclusion criteria. Various condylar changes were assessed, including hypoplasia, hyperplasia, internal resorption, erosion, subcortical sclerosis, osteophytes, subchondral cysts, and ankylosis. Statistical significance was set at $p<0.05$. Among the 237 patients, 79.7% had intact posterior dentition on the right side, and 76.8% on the left side. The most frequently observed degenerative changes included internal resorption (18.1%) on the left side and condylar hypoplasia (25.3%) on the right side. A significant difference in degeneration was noted between edentulous and dentulous individuals, particularly on the right side, with higher rates of internal resorption ($p<0.05$). Multinomial logistic regression indicated that the absence of posterior teeth significantly increased the risk for bone changes ($p< 0.05$) and erosion ($p< 0.05$). In conclusion, retaining posterior teeth is protective against specific TMJ degenerative changes, underscoring the importance of occlusal stability.

Keywords: Panoramic images, mandibular condyle, temporomandibular joint degeneration, dentulous, edentulous.

Introduction

Degenerative joint disease (DJD) of the temporomandibular joint (TMJ), often referred to as osteoarthritis, is a common age-related condition characterized by the gradual degeneration of the articular surfaces of both the mandibular condyle and the glenoid fossa (1). This deterioration is frequently attributed to increased mechanical loading on the joint during functional activities, as well as tooth loss, which can disrupt normal occlusion and alter the condylar position (2,3).

Alterations in condylar positioning, such as posterior or inferior displacement due to tooth loss, can lead to significant morphological and structural changes within the condyle itself (4,5). The condyle's morphology adapts to accommodate new stress patterns through a process called remodeling, which can become degenerative over time (4). Radiographic evaluations can reveal these changes even when clinical symptoms are absent. Common radiographic findings associated with DJD include condylar flattening, the formation of osteophytes (bony growths), loose bodies within the joint space, erosive changes, subcortical sclerosis (increased density of the bone beneath the outer layer), and the development of cysts (3,6).

A variety of imaging modalities are available for evaluating the TMJ, including panoramic radiography (PR), computed tomography (CT), cone-beam computed tomography (CBCT), magnetic resonance imaging (MRI), and ultrasonography (7-10). Although CBCT is considered the gold standard for imaging and assessing osseous DJD in the TMJ due to its ability to provide three-dimensional imaging without superimpositions and with minimal distortion and magnification (4,11,12), selection criteria—such as radiation exposure, cost, and diagnostic needs—are essential when choosing the most appropriate imaging modality (8).

Panoramic radiography (PR) is a vital component of nearly every routine oral and maxillofacial examination because it is relatively easy, affordable, and non-invasive. It offers a general view of the TMJ and surrounding structures, making it a potential screening tool for osseous changes (8). However, PR is a two-dimensional imaging technique and has limitations in detecting early or subtle bone changes due to image distortion caused by superimposition and magnification (13). The American Academy of Oral and Maxillofacial Radiology (AAOMR) highlights these limitations, acknowledging PR's potential role in the initial examination of patients with temporomandibular disorders (TMD) but noting its shortcomings in detecting early-stage TMJ alterations (14). Abnormal findings on PR should prompt the use of CBCT to confirm any osseous pathology (8).

In light of this, the purpose of the current study is to comprehensively evaluate degenerative bone changes (DBC) in the mandibular condyle of both posterior dentulous and edentulous patients, utilizing panoramic radiography as the primary imaging technique. This investigation aims to enhance understanding of the effects of degenerative changes on the TMJ within these patient populations, facilitating better diagnosis and management of TMJ disorders.

Materials and Methods

In this cross-sectional study, the clinical examination files and panoramic images of 292 male and female patients, obtained from the Department of Dento-maxillofacial Radiology between 2023 and 2025 for various clinical reasons; primarily for orthodontics and implant planning, were reviewed retrospectively. High-resolution panoramic images of fully maxillary and mandibular posterior dentulous or edentulous patients aged 18 ≤ years were included in this study. Panoramic images of patients with no recorded medical information (n = 10); patients with limited mouth opening or parafunctional habits like bruxism; patients with dentures (n = 15); patients with systemic diseases, malformations, syndromes, musculoskeletal diseases, neurological conditions, or those taking medications that affect the joints and bone metabolism (n = 15); individuals with fractures or pathologies in the mandible (n = 7); and images that contained artifacts, positioning errors, or did not clearly show the area of interest (the mandibular condyle, articular eminence, glenoid fossa) (n = 8) were excluded from the study. Therefore, among the 292 images, 55 were excluded, resulting in a final sample size of 237 images: 128 (54.0%) from females and 109 (46.0%) from males, aged between 18 and 75 years. Demographic information of the patients, such as gender and age, was recorded. Power analysis was conducted to confirm the appropriateness of the sample size.

Before the imaging procedure, all patients provided written informed consent for the use of their images in scientific research. All procedures were performed in accordance with the standards of the Ethics Committee of Benghazi University (approval no: 0278) and complied with the ethical guidelines of the 1964 Declaration of Helsinki.
The panoramic images were taken using X-Mind Prime 2D panoramic machines (Acteon, France, Italy) operating at 76 kVp, 9 mA, and a 14-second scan time, utilizing Acteon Imaging Software (AIS). The sample was divided according to the dental status of the posterior teeth as follows:

- **Group A:** Completely dentulous maxillary and mandibular permanent posterior teeth (occlusal contact).
- **Group B:** Completely edentulous maxillary and/or mandibular permanent posterior teeth (no occlusal contact).

On all panoramic images, the following parameters were evaluated on the right and left condylar sides:

1. **No Bone Changes:** Normal condyle.
2. **Condylar Hypoplasia:** Milder, shorter, and poorly formed condylar processes.
3. **Condylar Hyperplasia:** Excessive growth of the condylar processes.
4. **Internal Resorption:** Decrease in bone density appearing as multiple ill-defined radiolucent areas within the bone.
5. **Erosion**: Loss of continuity in the cortical bone margin.
6. **Subcortical Sclerosis**: Increased density of cortical bone extending into the bone marrow.
7. **Osteophytes**: Marginal bony outgrowths on the condyle.
8. **Subchondral Cyst (Ely Cyst):** Round, well-defined radiolucent area located either beneath the cortical bone or deeper within the trabecular bone, without cortical destruction.
9. **Ankylosis**: Bony fusion between the condyle and fossa (12,15,16) (Figure.1).

These parameters are subjective; minor magnifications on the images should not affect the screening for these osseous changes. The assessment of condylar hyperplasia or hypoplasia was based on visual observation rather than measurement of size differences.

The right and left mandibular condyles were evaluated separately. All image analyses were performed in a darkened, quiet room by one oral radiologist with over 15 years of experience in panoramic examinations. To minimize potential technical errors, the same radiologist re-evaluated the images after two weeks without any prior knowledge of the patients' identities.

Statistical analysis was performed using SPSS version 25 for Windows (IBM, USA). Numbers and percentages were used as descriptive statistics. The Kappa value was calculated to evaluate the agreement between the first and second readings. The Chi-square test was used to assess differences between variables. Multinomial logistic regression was employed to evaluate the risk of degenerative changes. Statistical significance was accepted at $p < 0.05$.

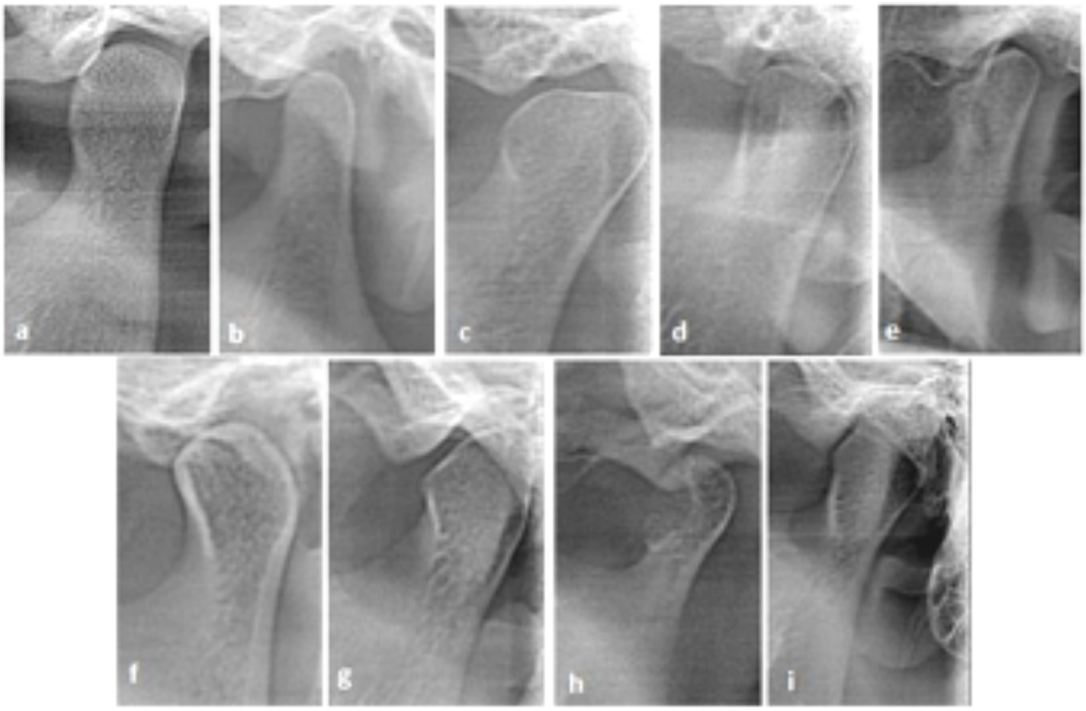

Figure.1. Degenerative bone changes observed on panoramic images of the condyle:(a) no bone changes, (b) Condylar hypoplasia, (c) Condylar hyperplasia,(d) Internal resorption, (e) Erosion,(f) Subcortical sclerosis, (g) Osteophytes, (h) A subchondral cyst, (i) Ankylosis

Results

The power analysis for the sample size (N = 237), using G*Power, confirmed a high probability (power ≥ 0.997) of detecting significant associations with minimal Type II error for Chi-square. Logistic regression analysis demonstrated moderate statistical power (62.2%).

In the current study, intraobserver agreement between the first and second readings was found to be excellent for dental status (Kappa: 0.817 on the right, 0.823 on the left) and substantial for degeneration type (Kappa: 0.726 on the right, 0.680 on the left).

Panoramic images of 237 patients (474 condyles), with a mean age of 33.6 ± 14.4 years, were included in the analysis. Among these, 79.7% of right condyles and 76.8% of left condyles had intact posterior dentition (group A), while the remainder were posteriorly edentulous (group B). Degenerative changes were observed across all categories in the sample population, with condylar hypoplasia and internal resorption predominating on the right side, whereas internal resorption and condylar hypoplasia most commonly seen on the left side (Table.1).

On the left side, the distribution of degeneration types did not differ between group A (intact posterior dentition) and group B (edentulous) ($p = 0.287$), with no condylar bone changes remaining the predominant pattern in both groups. In contrast, dental status was significantly linked to degeneration patterns on the right side (p = 0.040): while no condylar bone changes predominated in group A, edentulous patients (group B) exhibited disproportionately higher rates of internal resorption and combined degeneration, as well as modestly increased condylar hypoplasia and subcortical sclerosis changes. These results suggest that posterior tooth loss exerts a greater influence on right condylar degeneration than on the left side (Table. 2). This may be due to individuals having a dominant chewing side, often the right, leading to increased stress and wear on the right condyle during chewing.

Table 1. Baseline characteristics of the study population

Variable		Frequency (%)
Dental Status (right side)	Group A	189 (79.7%)
	Group B	48 (20.3%)
Dental Status (left side)	Group A	182 (76.8%)
	Group B	55 (23.2%)
Degeneration Type (right side)	No bone changes	42 (17.7%)
	Condylar hypoplasia	60 (25.3%)
	Condylar	1 (0.4%)
	Internal resorption	33 (13.9%)
	Erosion	30 (12.7%)
	Subcortical sclerosis	24 (10.1%)
	Osteophytes	9 (3.8%)
	A subchondral cyst	10 (4.2%)
	Ankylosis	1 (0.4%)
	Combined	27 (11.4%)
Degeneration Type (left side)	No bone changes	39 (16.5%)
	Condylar hypoplasia	35 (14.8%)
	Condylar	3 (1.3%)
	Internal resorption	43 (18.1%)
	Erosion	31 (13.1%)
	Subcortical sclerosis	27 (11.4%)
	Osteophytes	25 (10.5%)
	A subchondral cyst	9 (3.8%)
	Ankylosis	2 (0.8%)
	Combined	23 (9.7%)

Chi Square test ,* Statistically significant at p < 0.05

The distribution of different types of degenerative changes in the condylar according to dental status (group A and group B) is shown in table 3. Regardless of the degeneration patterns, group B exhibited a significantly different degeneration pattern compared to group A (χ^2 = 19.40, p = 0.022). In group B, internal resorption and combined degeneration (C) changes were proportionally higher.

Table 2. Distribution of degeneration types in the right and left condyles according to dental status

Degeneration Type	Dental status on right side (%)		p value	Dental status on left side (%)		p value
	A (n=189)	B (n=48)		A (n=182)	B (n=55)	
No bone changes	37 (88.1%)	5 (11.9%)	**0.040***	36 (92.3%)	3 (7.7%)	0.287
Condylar hypoplasia	48 (80.0%)	12 (20.0%)		26 (74.3%)	9 (25.7%)	
Condylar	1 (100.0%)	0 (0.0%)		3 (100.0%)	0 (0.0%)	
Internal resorption	20 (60.6%)	13 (39.4%)		32 (74.4%)	11 (25.6%)	
Erosion	27 (90.0%)	3 (10.0%)		25 (80.6%)	6 (19.4%)	
Subcortical sclerosis	19 (79.2%)	5 (20.8%)		21 (77.8%)	6 (22.2%)	
Osteophytes	8 (88.9%)	1 (11.1%)		17 (68.0%)	8 (32.0%)	
A subchondral cyst	10 (100.0%)	0 (0.0%)		6 (66.7%)	3 (33.3%)	
Ankylosis	1 (100.0%)	0 (0.0%)		1 (50.0%)	1 (50.0%)	
Combined	18 (66.7%)	9 (33.3%)		15 (65.2%)	8 (34.8%)	

Chi Square test ,* Statistically significant at $p < 0.05$

Table 3. Distribution of different types of degenerative changes in the condyles among various the dental statuses

Degeneration Type	Group A: n (%) of 371	Group B: n (%) of 103	P value
No bone changes	73 (19.7%)	8 (7.8%)	**0.022***
Condylar	74 (19.9%)	21 (20.4%)	
Condylar	4 (1.1%)	0 (0.0%)	
Internal resorption	52 (14.0%)	24 (23.3%)	
Erosion	52 (14.0%)	9 (8.7%)	
Subcortical	40 (10.8%)	11 (10.7%)	
Osteophytes	25 (6.7%)	9 (8.7%)	
A subchondral cyst	16 (4.3%)	3 (2.9%)	
Ankylosis	2 (0.5%)	1 (1.0%)	
Combined	33 (8.9%)	17 (16.5%)	

Multinomial logistic regression, *Statistical significant

Multinomial logistic regression indicated that individuals in group A were less likely than those in group B to have bone changes (RRR = 0.19, 95% CI 0.07–0.53, p = 0.002) or erosion in the condylar (RRR = 0.27, 95% CI 0.10–0.77, p = 0.014). No significant associations were observed for condylar hypoplasia, hyperplasia, internal resorption, subcortical sclerosis, osteophytes, subchondral cysts, or ankylosis in relation to the dental status of posterior teeth (Table 4).

Table 4. Adjusted relative-risk ratios for types of condylar degeneration based on dental status

Degeneration Type	RRR (B and A)	95% CI	p-value
No bone changes	0.185	0.065 – 0.527	**0.002 ***
Condylar hypoplasia	0.645	0.269 – 1.549	0.327

Condylar hyperplasia	___	—	0.846
Internal resorption	0.609	0.249 – 1.489	0.277
Erosion	0.271	0.096 – 0.767	**0.014 ***
Subcortical sclerosis	0.938	0.325 – 2.708	0.905
Osteophytes	0.469	0.154 – 1.430	0.183
A subchondral cyst	0.282	0.061 – 1.306	0.106
Ankylosis	0.623	0.036 – 10.696	0.744

Multinomial logistic regression, *Statistical significant

Discussion

This study aimed to assess condylar changes in completely posterior dentulous or edentulous patients. The study utilized panoramic radiographs due to their easier availability, in line with recent studies conducted by Esfehani et al (17) and Nelke et al. (18).

The current study revealed that 393 (82.9%) of the analyzed condylar images showed degenerative changes. This rate is somewhat in line with the PR study reported by Mathew et al. (19) (81.3%). However, it contrasts with the higher rates reported in the CBCT study by Görürgöz1 et al (20) (91.1%).

Based on the findings of the current study, the most common skeletal changes in the condyle were hypoplasia and internal resorption, followed by erosion and sclerosis. These results align with the MRI study by De Melo et al. (21). Unlike this study, Cho et al (22) and Talaat et al (23) found that sclerosis and erosion were the most common osseous changes in the condyle when using CBCT, while Mani et al. (24) reported erosion as the most common condylar change. Others have noted that Ely's cyst is most frequently seen in the condyle (25).

Discrepancies in findings may be due to differences in patient age ranges, sample sizes, radiographic modalities, and interpretation of radiographs (26-29). The inherent two-dimensional nature of panoramic radiographs can lead to the superimposition of structures, potentially obscuring the presence of some radiolucent areas within the bone, such as internal resorption and Ely's cysts. This limitation may result in underdiagnosis or misdiagnosis of degenerative joint diseases (DJD).

In the present study, dental status significantly influenced the pattern of condylar degeneration. The majority of patients with condylar changes were found to be edentulous in the upper and/or lower posterior regions (no occlusal contact). This finding is consistent with previous studies (30-32), contrasting with the results of Paknahad and Mathew (19) and Esfehani et al. (17).

The role of tooth loss as a risk marker for TMDs is hypothesized to stem from the lack of molar support, which can lead to a flawed condylar position, causing upward and backward movement of the condyles and resulting in adverse loading of the joint apparatus (33).

In the current study, condylar hypoplasia was the most common bony change noted in posterior dentulous patients, while internal resorption was most common in posterior edentulous patients. According to available literature, flattening is the most common bony change noted in dentulous patients (2), whereas subchondral cysts (11) and subcortical sclerosis (17) were the most common changes in edentulous patients.

Few CBCT and PR studies have investigated the relationship between dental status and condylar bony changes (25,34). Significant correlations have been found between dental status and condylar bony changes in the CBCT studies conducted by Maryam Paknahad (34), Altun et al. (32), and Giesen et al. (35), aligning with the current findings. However, these results conflict with PR studies conducted by those of Ta-Kayama et al. (25) and Esfehani et al. (36).

In this study, the significant difference in degeneration between edentulous and dentulous individuals, especially on the right side with higher rates of internal resorption, underscores how posterior tooth loss affects TMJ health. Without posterior support, the right TMJ often bears more functional stress, particularly if it becomes the preferred side for chewing. This leads to biomechanical imbalances, increased wear, and susceptibility to degeneration, highlighting the pronounced impact of tooth loss on right-sided TMJ degeneration in edentulous patients. Additionally, multinomial logistic regression indicated that individuals in group A were less likely than those in group B to experience degenerative bone changes. Given that no studies in the literature have evaluated the relationship between these variables, no direct comparisons could be made.

This study has several limitations. Being retrospective, it did not address the clinical symptoms of TMD or the time since tooth loss. Longitudinal studies are needed for a better evaluation of the TMJ with these variables in mind. Furthermore, due to the two-dimensional nature of panoramic images, sagittal, vertical, and transverse relationships of both the jaws and teeth could not be evaluated, and bone changes might be obscured by superimposition of adjacent structures. Moreover, assessing only intra-observer reliability represents another methodological limitation.

In conclusion, edentulous patients exhibited significantly different degeneration patterns compared to dentulous patients, particularly on the right side. This study highlights the importance of dental status in affecting condylar changes. The findings suggest that tailored clinical assessments could improve outcomes. Future research using 3-D images like CBCT is necessary to validate these findings.

Declarations

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None

Ethics statement

The authors declare that the author approved that this research follows the journal's Attach Ethic Approval guidelines as appeared on the journal's author guidelines page.

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Competing interest's statement

Not applicable **,** the authors declare that they have no conflict of interest.

Author contributions

EABA**.** conception and design of the work; acquisition, analysis, and interpretation of data, drafting the work and revising it critically for important intellectual content. FRAA**.** acquisition, analysis, and interpretation of data. NAA and SMA. conception and design of the work.

References

1. Peck CC, Goulet JP, Lobbezoo F, et al. Expanding the taxonomy of the diagnostic criteria for temporomandibular disorders. J Oral Rehabil. 2014;41(1):2–23.
2. Gharge NR, Ashwinirani S, Sande A. Comparison of temporomandibular changes in edentulous and dentulous patients using digital panoramic imaging. J Oral Res Rev. 2020;12(1):17.
3. Mathew AL, Sholapurkar AA, Pai KM. Condylar changes and its association with age, TMD, and dentition status: A cross-sectional study. Int J Dent. 2011;2011.
4. Yap AU, Lei J, Zhang X, Fu K. TMJ degenerative joint disease: relationships between CBCT findings, clinical symptoms, and signs. Acta Odontol Scand. 2023;81(7):562–8.
5. Daneshmehr S, Razi T, Razi S. Relationship between the condyle morphology and clinical findings in terms of gender, age, and remaining teeth on cone beam computed tomography images. Brazilian J Oral Sci. 2022;21:1–10.
6. Koç N. Evaluation of osteoarthritic changes in the temporomandibular joint and their correlations with age: A retrospective CBCT study. Dent Med Probl. 2020;57(1):67–72.
7. Wojciechowska B, Szarmach A, Michcik A, Sikora M, Drogoszewska B. Is Ultrasonography an Effective Method for Diagnosing Degenerative Changes in the Temporomandibular Joint?. Biomedicines. 2024. 21;12(12):2915. doi: 10.3390/biomedicines12122915.
8. Maita I, Dhillon A, Friesen R, Almeida FT. Diagnostic value of panoramic radiographs in the assessment of degenerative joint disease: A retrospective study. Int Dent J. 2025;75(5):100910. Available from: https://doi.org/10.1016/j.identj.2025.100910.
9. Yasan GT, Adiloglu S, Tuz HH, Sahar D. Evaluation of clinical signs and magnetic resonance imaging findings in patients with temporomandibular disorders. J Cranio-Maxillofacial Surg. 2023;51(7–8):441–7.
10. Cayón-Somacarrera S, Gutiérrez-Rodríguez R, Muñoz-Guerra MF et al. Unlocking the Temporomandibular Joint: CT, MRI, and Arthroscopic Correlation. Radiographics. 2024;44(10):e240025. doi: 10.1148/rg.240025. PMID: 39325658.
11. Khabadze Z, Mordanov O, Davreshyan G et al. Degenerative changes in the temporomandibular joint in elderly patients with posterior edentulous maxilla and mandible according to cone-beam. Open Dent J. 2021;15:191–5.
12. Vasegh Z, Safi Y, Azar MS, Ahsaie MG, Arianezhad SM. Assessment of bony changes in temporomandibular joint in patients using cone beam computed tomography – a cross-sectional study. Head Face Med. 2023;19(1):1–11.
13. Singer SR, Mallya SM. Temporomandibular joint imaging. Dent Clin North Am. 2023;67(2):227–41.
14. Mallya SM, Ahmad M, Cohen JR, Kaspo G, Ramesh A. Recommendations for imaging of the temporomandibular joint: Position statement from the American Academy of Oral and Maxillofacial Radiology and the American Academy of Orofacial Pain. J Oral Facial Pain Headache. 2023;37(1):7–15.
15. Cömert Kiliç S, Kiliç N, Sümbüllü MA. Temporomandibular joint osteoarthritis: cone beam computed tomography findings, clinical features, and correlations. Int J Oral Maxillofac Surg. 2015;44(10):1268-74. doi: 10.1016/j.ijom.2015.06.023.

16. Ahmad M, Hollender L, Anderson Q et al. Research diagnostic criteria for temporomandibular disorders (RDC/TMD): Development of image analysis criteria and examiner reliability for image analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107(6):844.
17. Esfehani M, Tofangchiha M, Poorsayyah N et al. Relationship between posterior permanent dentition pattern and radiographic changes of the mandibular condyle. Methods Protoc. 2022;5(6):1–9.
18. Nelke K, Łuczak K, Janeczek M et al. What features on routine panoramic radiographs could help orthodontists estimate the occurrence of condylar hyperplasia from other mandibular asymmetries: A retrospective analysis study. Symmetry (Basel). 2022;14(7):1287.
19. Mathew AL, Sholapurkar AA, Pai KM. Condylar changes and its association with age, TMD, and dentition status: A cross-sectional study. Int J Dent. 2011;2011:413639. doi: 10.1155/2011/413639.
20. Görürgöz C, İçen M, Kurt MH et al. Degenerative changes of the mandibular condyle in relation to the temporomandibular joint space, gender, and age: A multicenter CBCT study. Dent Med Probl. 2023;60(1):127–35.
21. de Melo DP, Melo SLS, Oliveira LSD et al. Evaluation of temporomandibular joint disk displacement and its correlation with pain and osseous abnormalities in symptomatic young patients with magnetic resonance imaging. Oral Surg Oral Med Oral Pathol Oral Radiol. 2015;119:107–12.
22. Cho BH, Jung YH. Osteoarthritic changes and condylar positioning of the temporomandibular joint in Korean children and adolescents. Imaging Sci Dent. 2012;42(3):169–74.
23. Talaat W, Bayatti SA, Kawas SA. CBCT analysis of bony changes associated with temporomandibular disorders. Cranio. 2015;34(2):88–94. doi:10.1179/2151090315Y.
24. Mani FM, Sivasubramanian SS. A study of temporomandibular joint osteoarthritis using computed tomographic imaging. Biomed J. 2016;39(3):201–6.
25. Takayama Y, Miura E, Yuasa M, Kobayashi K, Hosoi T. Comparison of occlusal condition and prevalence of bone change in the condyle of patients with and without temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;105:104–12.
26. Gil C, Santos KC, Dutra ME, Kodaira SK, Oliveira JX. MRI analysis of the relationship between bone changes in the temporomandibular joint and articular disc position in symptomatic patients. Dentomaxillofac Radiol. 2012;41(5):367–72.
27. Nah KS. Condylar bony changes in patients with temporomandibular disorders: A CBCT study. Imaging Sci Dent. 2012;42(4):249–53.
28. Campos MI, Campos PS, Cangussu MC, Guimaraes RC, Line S. Analysis of magnetic resonance imaging characteristics and pain in temporomandibular joints with and without degenerative changes of the condyle. Int J Oral Maxillofac Surg. 2008;37(6):529–34. doi:10.1016/j.ijom.2008.02.011.
29. List T, Wahlund K, Larsson B. Psychosocial functioning and dental factors in adolescents with temporomandibular disorders: A case-control study. J Orofac Pain. 2001;15:218–27.
30. Jalalian E, A. Evaluation of radiographic changes of the mandibular condyle and its relationship with age, joint disorders, and Eichner's model. J Isf Fac Dent. 2020;15:365–75.

31. Takayama E, Miura M, Yuasa K, Kobayashi K, Hosoi T. Comparison of occlusal condition and prevalence of bone change in the condyle of patients with and without temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;105(1):104–12.
32. Altun BD, Bayramov N, Ercalik SEY. Radiological associations between posterior edentulism and condylar bony changes: A retrospective study. J Stomatol Oral Maxillofac Surg. 2024;125(2).
33. Javed MU, Asim MA, Afreen Z, Afreen A, Khalil A. Association of tooth loss with temporomandibular disorders. Khyber Med Univ J. 2020;12(1):29–33.
34. Paknahad M, Paknahad M. Association between condylar bone changes and Eichner index in patients with temporomandibular dysfunction: A cone beam computed tomography study. J Dent. 2023;24:12–8.
35. Giesen EBW, Ding M, Dalstra M, Eijden V. Changed morphology and mechanical properties of cancellous bone in the mandibular condyles of edentate people. J Dent Res. 2004;83(3):255–9.
36. Esfehani M, Tofangchiha M, Poorsayyah N, Rahimi H. Relationship between posterior permanent dentition pattern and radiographic changes of the mandibular condyle. Methods Protoc. 2022;5(6):97.