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Detection and Severity Assessment of Temporomandibular Joint Osteoarthritic Changes in Patients with Temporomandibular Disorders Using CBCT

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ABSTRACT

Background and objectives: Osteoarthritis refers to a non-inflammatory condition often linked to aging. It involves the gradual breakdown of bone, cartilage, and surrounding soft tissues around the joints. The aim of this study is to detect osteoarthritic change in patients with temporomandibular disorder, to determine the severity of osteoarthritic changes, and to assess the relation of gender and age with the severity prevalence of temporomandibular joint osteoarthritis.

Material and method: This retrospective, cross-sectional study analyzed 100 cone beam computed tomography (CBCT) scans of the temporomandibular joint from patients diagnosed with temporomandibular disorder. To assess osteoarthritis in the temporomandibular joint, the study applied the research diagnostic criteria specific to temporomandibular disorder. The presence of osseous modifications, such erosion, flattening, sclerosis, subcortical, osteophyte, and resorption, was evaluated for condylar head and articular eminence. The impact of osteoarthritic alterations was assessed for each joint.

Result: The prevalence of osteoarthritic change in patients with temporomandibular disorder was 70%. A significant correlation was found in the prevalence of AO and age. The prevalence of OA was 90.6% among those aged less than 25 years old, and the lowest prevalence (53.8%) was in the age group 25–34. No significant association was detected between gender and the prevalence of OA: 72.7% in males and 68.7% in females. Erosion (65%) and flattening (64%), the most common findings of osteoarthritic changes of the condyle, the association between age and condylar osseous changes was not significant. There is no significant association between osteoarthritic change severity and gender or age. No significant association was detected between age and changes in articular eminence.

Conclusion: There is a high prevalence of osteoarthritic change among patients with temporomandibular disorder. The prevalence and severity of degenerative bone changes don't increase with age; they can occur in any age group.

Keywords: Cone beam computed tomography, Osteoarthritis, Temporomandibular joint, Temporomandibular joint Disorder.

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INTRODUCTION

The temporomandibular joint (TMJ) is made up of two parts: the mandibular condyle and the glenoid fossa of the squamous part of the temporal bone, which is a diarthrodial joint.[1] The mandible, which is the only bone that connects the TMJ to its contralateral counterpart, makes it distinct from other load-bearing joints.[2]

An age-related, non-inflammatory condition is called osteoarthritis (OA).[3] It is defined by a persistent deterioration of the osseous, cartilaginous, and musculoskeletal tissues within and surrounding the joint, which results in alterations to the peripheral and central pain processing systems.[4] In addition to affecting the cartilage, subchondral bone, and synovial membrane, osteoarthritis can also cause TMJ remodeling and articular cartilage abrasion. The TMJ may be the site of osteoarthritis.[5]

This condition often defined to as degenerative joint disease, initiates a remodeling process in the temporomandibular joint aimed at adapting its structure to mechanical stresses for normal function.[6] Excessive or persistent forces can progressively wear down the bony surfaces of the TMJ, eventually leading to radiographic signs of osteoarthritis. These indicators include joint surface flattening, osteophyte and loose body formation, erosion, reduced joint space, subcortical sclerosis and cyst development.[7]

CBCT offers high-resolution, 3D images for diagnosing TMJ degenerative changes, while delivering reduced radiation dosage, shorter exposure duration, enhanced spatial resolution, and reduced costs compared to computed tomography (CT).[8,9] Although CBCT is widely recognized for imaging the osseous structures of the TMJ, it also captures detailed images of TMJ structures, aiding in early osteoarthritis detection, staging, and tracking disease progression over time.[10]

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), a standardized technique established in 1992 for diagnosing TMD, was created to assist with imaging analysis for osteoarthritis.[6, 11]

The study aims to detect TMJ-OA using the RDC/TMD image analysis criteria, to determine the prevalence and severity of osteoarthritic changes, and to evaluate the correlations of gender and age with the prevalence and severity of TMJ-OA.

MATERIAL AND METHODS

This cross-sectional retrospective research analyzed 100 CBCT scans of the temporomandibular joints of patients who referred to the private dental radiology center in Hawler, Kurdistal region, for the evaluation of TMJs from April 2018 to December 2022. The CBCT scans were acquired using a NewTom Giano (Verona, Italy) device. Field of view (80 mm× 110 mm) with 0.300 mm voxel size and (90 kV, 6 mA, 3.6 second acquisition time) was used. An initial axial thickness of 0.15 mm was automatically generated after reconstructing the raw data. Scans were excluded if they showed motion artifacts or if the patient had a documented history of TMJ or jaw trauma, TMJ surgery, or condylar fractures. To qualify for inclusion in this study, at least one temporomandibular joint needed to be fully captured in the scan and visible within the view field. Both the right and left TMJs were imaged separately to meet study specifications.

The images were examined on a high-quality workstation, ensuring consistent lighting and minimal background noise. Using NNT Viewer version 14.0, interpretations were conducted across axial, coronal, and sagittal planes, with separate evaluations for the right and left TMJs. Sagittal images were oriented perpendicularly to the condyle's long axis, while coronal images ran parallel to it, providing clear and precise views for assessment.

To minimize misinterpretation, any changes had to appear in at least two consecutive sections. To assess intra-rater reliability, 20 randomly selected scans will be re-assessed by the same examiner following a 4-week gap, focusing on both the severity and prevalence of TMJ osteoarthritis. The criteria outlined by Ahmad et al. in the RDC/TMD guidelines were applied to find out the TMJ was impacted by osteoarthritis. [6] it is categorizing the joint as:

A. No Osteoarthritis

i. The condylar head has normal relative size; and
ii. There is an absence of subcortical sclerosis or flattening of the articular surface; and
iii. There is no deformation is observed cause of subcortical cysts, surface erosion, osteophytes, generalized sclerosis, or loose calcified bodies.

B. Indeterminate for Osteoarthritis

i. Standard relative size of the condylar head; and
ii. Subcortical sclerosis, regardless of articular surface flattening;

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iii. Articular surface flattening, regardless subcortical sclerosis;
iv. Absence of deformation due to subcortical cysts, surface erosion, osteophytes, generalized sclerosis, or loose calcified bodies.

C. Osteoarthritis

The existence or lack of the following qualities was assessed according to RDC/TMD2:

(a) Osseous changes of the condyles:

(1) Flattening refers to a planar bony profile diverging from the convex shape.
(2) Sclerosis refers to a region of heightened density in cortical bone that extends into the bone marrow; and
(3) Erosion denotes a region of diminished density in the cortical bone and the neighboring subcortical bone.
(4) Osteophytes are characterized as peripheral bony projections on the condyle.
(5) Resorption denotes a partial loss of the condylar head.[12]

(b) Osseous alterations of the mandibular fossae: characterized by

(1) Erosion
(2) Sclerosis
(3) Resorption

The severity of osteoarthritic alterations will be assessed for each joint according to the approach established by Alexiou et al.[13]

A four-point grading system (0–3) was utilized to classify the extent of erosion in the condylar head as follows:

0: absence of erosion.
1: **Minor erosion** characterized by a reduction in density confined solely to the cortical bone.
2: **moderate erosion** characterized by a decrease in density within the cortical bone that extends into the upper strata of the adjacent subcortical bone.
3: **extensive erosion** characterized by reduced density in the cortical bone that reaches beneath the top strata of the neighboring subcortical bone.

A four-point grading system was utilized to characterize the intensity of osteophyte formation in the condylar head as follows: 0: absence
1: **slight,** bony growth was observed on the condylar articulating surface measuring less than 1 mm.
2: **moderate**, bony growth was observed on the condylar articulating surface, it was 1–2 mm.
3: **extensive**, bony out growth was observed on the condylar articulating surface that was more than 2 mm.

RESULTS

The study involves 61 patients. Their mean age (SD) was 33.49 (13.67) years. The median was 29 years, and the age range was 16-76 years. It is evident in Table 1 that the largest proportion of the sample (37.7%) were aged 25-34 years, and more than two-thirds (67.2%) of the sample were females (Table 1).

Table 1: Age and gender distribution.

	No.	(%)
Age		
< 25	18	(29.5)
25-34	23	(37.7)
34-44	8	(13.1)
≥ 45	12	(19.7)
Gender		
Male	20	(32.8)
Female	41	(67.2)
Total	61	(100.0)

The total number of involved TMJs was 100 (affecting one side or two sides of the same patient). The majority (70%) had osteoarthritic changes, while 11% were equivocal. The following condylar osseous changes were observed: flattening (64%), subcortical sclerosis (41%), and resorption (21%). Regarding erosion, it was present in 65% of the joints, but most of them had slight erosion, and 10% only had extensive erosion. More than one third (34%) of the joints had mild osteophytes, and 1% only had extensive osteophytes (Table 2) and (Figure 1).

Table 2: TMJ osteoarthritic changes.

	No.	(%)
Osteoarthritis		
No osteoarthritis	19	(19.0)
Indeterminate	11	(11.0)
Osteoarthritis	70	(70.0)
Flattening		
No	36	(36.0)
Yes	64	(64.0)
Subcortical sclerosis		
No	59	(59.0)
Yes	41	(41.0)
Resorption		
No	79	(79.0)
Yes	21	(21.0)
Erosion		
Absent	35	(35.0)
Slight	40	(40.0)
Moderate	15	(15.0)
Extensive	10	(10.0)
Osteophyte		
Absent	59	(59.0)
Mild	34	(34.0)
Moderate	6	(6.0)
Extensive	1	(1.0)
Total	100	(100.0)

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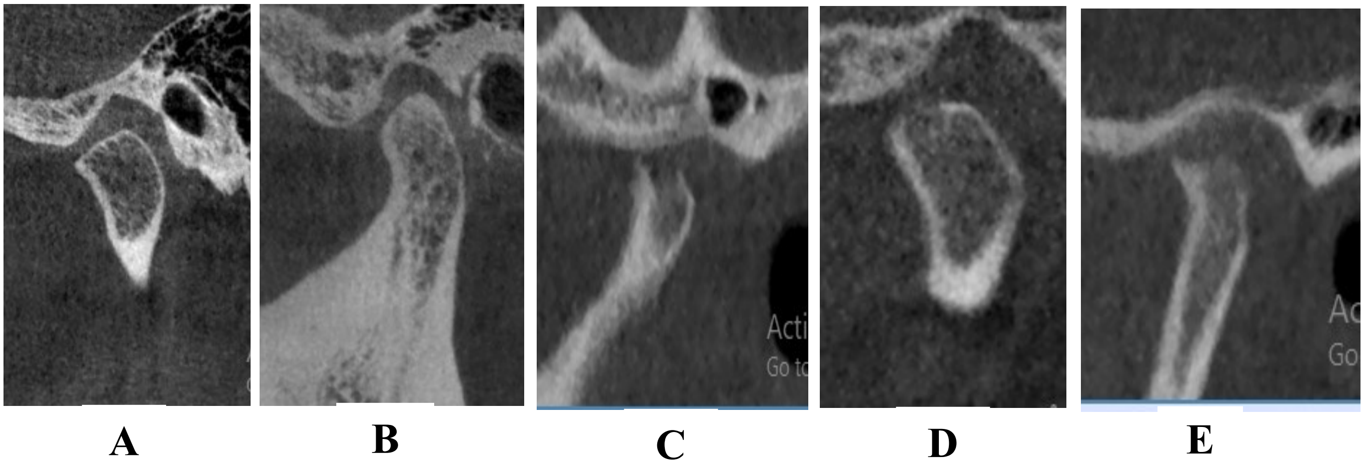

Figure 1: Oblique sagittal view of CBCT of TMJ osteoarthritic changes; A- Flattening, B- Subcortical sclerosis, C- Resorption, D- Erosion, E- Osteophyte.

There is a significant association between osteoarthritis (OA) and age (p = 0.024), where it is evident in Table 3 that the OA prevalence was 90.6% among those aged less than 25 years old, and the least prevalence (53.8%) was in the age group 25-34. No significant (p = 0.782) association was detected between gender and OA (Table 3).

Table 3: Osteoarthritis by age and gender.

		No OA	Indeterminate	OA	
	N	No. (%)	No. (%)	No. (%)	p
Age					
< 25	32	3 (9.4)	0 (0.0)	29 (90.6)	
25-34	39	11 (28.2)	7 (17.9)	21 (53.8)	
35-44	13	2 (15.4)	2 (15.4)	9 (69.2)	
≥ 45	16	3 (18.8)	2 (12.5)	11 (68.8)	0.024**
Gender					
Male	33	5 (15.2)	4 (12.1)	24 (72.7)	
Female	67	14 (20.9)	7 (10.4)	46 (68.7)	0.782*
Total	100	19 (19.0)	11 (11.0)	70 (70.0)	

*By Chi square test. **By Fisher's exact test. OA: Osteoarthritis.

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The association in age and the following condylar osseous changes was not significant: flattening (p = 0.465), subcortical sclerosis (p = 0.501), resorption (p = 0.442), erosion (p = 0.127), and osteophyte (p = 0.123) (Table 4).

Table 4: Condylar osseous change by age.

	Age (years)				
	< 25 **(n = 32)**	**25-34** **(n = 39)**	**35-44** **(n = 13)**	**≥ 45** **(n = 16)**	**p**
Flattening	20 (62.5)	23 (59.0)	8 (61.5)	13 (81.3)	0.465*
Subcortical sclerosis	14 (43.8)	16 (41.0)	3 (23.1)	8 (50.0)	0.501*
Resorption	9 (28.1)	9 (23.1)	1 (7.7)	2 (12.5)	0.442**
Erosion					
Absent	5 (15.6)	21 (53.8)	4 (30.8)	5 (31.3)	
Slight	17 (53.1)	10 (25.6)	6 (46.2)	7 (43.8)	
Moderate	5 (15.6)	5 (12.8)	2 (15.4)	3 (18.8)	
Extensive	5 (15.6)	5 (12.8)	2 (15.4)	3 (18.8)	0.127**
Osteophyte					
Absent	14 (43.8)	25 (64.1)	11 (84.6)	9 (56.3)	
Mild	12 (37.5)	13 (33.3)	2 (15.4)	7 (43.8)	
Moderate	5 (15.6)	1 (2.6)	0 (0.0)	0 (0.0)	
Extensive	1 (3.1)	0 (0.0)	0 (0.0)	0 (0.0)	0.123**

*By Chi square test. **By Fisher's exact test.

It is evident in Table 5 that the prevalence of flattening among males was 75.8% , and among females was 58.2%, but the variation was not significant (p = 0.086). No significant association was determined among gender and the following changes: subcortical sclerosis (p = 0.819), resorption (p = 0.280), erosion (p = 0.146), and osteophyte (p = 0.292) (Table 5).

Table 5: Condylar osseous change by gender.

	Male (n = 33)	Female (n = 67)	Total (n = 100)	p
	No. (%)	No. (%)	No. (%)	
Flattening	25 (75.8)	39 (58.2)	64 (64.0)	0.086*
Subcortical sclerosis	13 (39.4)	28 (41.8)	41 (41.0)	0.819*
Resorption	9 (27.3)	12 (17.9)	21 (21.0)	0.280*
Erosion				0.146**
Absent	9 (27.3)	26 (38.8)	35 (35.0)	
Slight	15 (45.5)	25 (37.3)	40 (40.0)	
Moderate	3 (9.1)	12 (17.9)	15 (15.0)	
Extensive	6 (18.2)	4 (6.0)	10 (10.0)	
Osteophyte				0.292**
Absent	18 (54.5)	41 (61.2)	59 (59.0)	
Mild	11 (33.3)	23 (34.3)	34 (34.0)	
Moderate	4 (12.1)	2 (3.0)	6 (6.0)	
Extensive	0 (0.0)	1 (1.5)	1 (1.0)	

*By Chi square test. **By Fisher's exact test.

No significant association was detected among osteophyte severity and age (p = 0.123) (Table 6), but most of the cases with mild osteophyte were between the ages of 25 and 34) years, and moderate osteophyte was in the young age group <25 years. The mild osteophyte is most common in females, but there is no significant association between osteophyte severity and gender (p = 0.292).

Table 6: Osteophyte severity by age and gender.

		Osteophyte severity				
		Absent	Mild	Moderate	Extensive	
	N	No. (%)	No. (%)	No. (%)	No. (%)	P*
Age						
< 25	32	14 (43.8)	12 (37.5)	5 (15.6)	1 (3.1)	
25-34	39	25 (64.1)	13 (33.3)	1 (2.6)	0 (0.0)	
34-44	13	11 (84.6)	2 (15.4)	0 (0.0)	0 (0.0)	
≥ 45	16	9 (56.3)	7 (43.8)	0 (0.0)	0 (0.0)	0.123
Gender						
Male	33	18 (54.5)	11 (33.3)	4 (12.1)	0 (0.0)	
Female	67	41 (61.2)	23 (34.3)	2 (3.0)	1 (1.5)	0.292
Total	100	59 (59.0)	34 (34.0)	6 (6.0)	1 (1.0)	

*By Fisher's exact test.

The prevalence rates of the changes in articular eminence among males did not significantly differ from those of females, as presented in Table 7, whether the change was sclerosis of articular eminence (p = 0.489), erosion (p = 0.539), or resorption (p = 0.597) (Table 7).

Table 7: Changes of articular eminence by gender.

	Male (n = 33)	Female (n = 67)	Total (n = 100.0)	
	No. (%)	No. (%)	No. (%)	p
Sclerosis of articular eminence	10 (30.3)	25 (37.3)	35 (35.0)	0.489*
Erosion of articular eminence	7 (21.2)	18 (26.9)	25 (25.0)	0.539*
Resorption of articular eminence	2 (6.1)	2 (3.0)	4 (4.0)	0.597**

*By Chi square test. **By Fisher's exact test.

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No significant association was detected among age and the following: sclerosis of articular eminence (p = 0.426) and erosion of articular eminence (p = 0.508). Regarding resorption of articular eminence, 3.1% of those aged < 25 had resorption, 18.8% of those aged ≥ 45 years had it, and none in the other age groups (p = 0.016) (Table 8).

Table 8: Changes of articular eminence by age.

	Age (years)				
	< 25 (n = 32)	25-34 (n = 39)	35-44 (n = 13)	≥ 45 (n = 16)	
	No. (%)	No. (%)	No. (%)	No. (%)	p
Sclerosis of articular eminence	11 (34.4)	13 (33.3)	7 (53.8)	4 (25.0)	0.426*
Erosion of articular eminence	11 (34.4)	8 (20.5)	2 (15.4)	4 (25.0)	0.508**
Resorption of articular eminence	1 (3.1)	0 (0.0)	0 (0.0)	3 (18.8)	0.016**

*By Chi square test. **By Fisher's exact test.

DISCUSSION:

This study aimed to assess the prevalence and severity of osteoarthritic changes and to analyses the relationships between gender and age with the severity and prevalence of TMJ-OA, especially in symptomatic people. Osteoarthritis is a multifaceted illness influenced by gender and age, characterized by a secretion of inflammatory mediators from cartilage, bone, and synovium. The intensity of the skeletal alterations escalates with age.[14] CBCT imaging are a useful technique for visualizing irregular bone changes, including alterations in the cortical outline on the surface and the trabecular structure located beneath the subchondral area of the mandibular condyle.[15]

We observed that 70% of the patients had bone-related abnormalities in their TMJs. This result is consistent with previous studies that used CBCT imaging, such as Al.Juhani et al. (78.6%), Koç (67%), and Anjos Pontual et al. (71%), [16, 17, 18]. Given that every patient in our sample had a CBCT examination after receiving a TMJ problem diagnosis, it is possible that this contributed to the higher frequency of bone abnormalities that we saw in our study.[18, 19]

The main observation in this investigation was erosion of the condylar articular surface, with the majority showing little erosion; this finding aligns with the data documented by Massilla Mani and Sivasubramanian.[20] However, this finding is incompatible with previous studies, which found condylar flattening to be the predominant finding,[17] and by Nah, who identified sclerosis as the prevalent finding.[21] The differences in these results can be clarified by the likelihood that condylar flattening, in the absence of further changes is seen as indicative of remodeling, leading to the assessment of joints with flattening alone being unclear for OA.[6]

Among the various factors contributing to OA, it is now widely accepted by researchers that age and gender play a significant role. In our current study, the patients with TMJ OA changes ranged in age from 16 to 76 years. We observed a statistically significant association between age and osteoarthritis (OA), with a p-value of 0.024. The prevalence of OA was notably high at 90.6% among those younger than 25 years old, while the lowest prevalence, at 53.8%, was in the 25-34 age groups. This finding suggests that OA is a condition that can affect even young adults, and this observation aligns with the results reported by other researchers.[18,22,23] Certain researchers have shown a link between advancing age and the occurrence of TMJ OA,[13,18] whereas others have discovered no such association.[24,25]

According to the study, the prevalence of TMJ-OA much higher in females compare to males, but not significant. Several studies have indicated that women have a more likelihood of developing OA, primarily due to the hormonal distinctions among men and women.[13,18,26]

Another objective of this study was to evaluate the relationship between age and the prevalence and severity of condylar osseous changes. The current study's findings indicate that there were no significant mean age differences concerning the presence or absence of condylar osseous changes, as reflected in the p-values for flattening ($p = 0.465$), subcortical sclerosis ($p = 0.501$), resorption ($p = 0.442$), erosion ($p = 0.127$), and osteophyte ($p = 0.123$). The findings indicate that condylar osseous changes may represent a physiological response rather than an indication of related to age degeneration. This aligns with the findings of other studies, such as Alexious et al.[13] It is anticipated that individuals in older age categories will exhibit a higher occurrence and greater severity of bone alterations compared to those in younger age groups. The disparities in these outcomes could be linked to variations in gender and age, differences in racial or ethnic backgrounds, and variances in the criteria used for diagnosing OA.

This study found that there was no significant distinction between male and female patients statistically regarding osteophyte formation and condylar erosion, which are indicators used to assess the severity of TMJ-OA. Furthermore, there is no correlation was found between gender and other changes significantly, including subcortical sclerosis, resorption, and flattening of the condylar head. Our study's findings contradict those of another study, but they are reinforced by the results of a study conducted by Mani, who likewise detected a female inclination for TMJ-OA in their CT research's.[20]

Osteophytes develop during the later stages of degeneration as the body undergoes adaptations to repair the joint.[9] Osteophytes seem to serve the purpose of stabilizing and widening the joint's surface as an adaptation to manage the increased stress from occlusal forces. They represent regions of newly formed cartilage. In current study, no substantial relationship was noted between the severity of osteophytes and age, as indicated by a p-value of 0.123 (see Table 6). However, most cases of mild osteophytes were found among individuals aged 25–34, while moderate osteophytes were more common in the younger age group of less than 25 years. This contrasts with findings from other studies, which indicated that the mean age of patients with TMJ osteophytes was significantly greater than that of patients without osteophytes, suggesting a higher prevalence of TMJ osteophytes among older individuals,[12,13,17] and no one of the patients has extensive osteophytes. This is a retrospective study and may also attributed to the limited sample size.

In this research, female participants exhibited a noticeably greater occurrence of mild osteophyte formation compared to their male counterparts, but this disparity did not yield a significant association regarding the severity of osteophytes and gender, as indicated by a p-value of 0.292. Our findings deviate from those of previous studies.[20,27,28]

Previous studies have noted that alterations in the bone structure of the mandibular fossa are frequently observed in individuals with osteoarthritis due to the continuous process of joint remodeling.[29,30] This study identified sclerosis of the articular fossa as the least prevalent radiographic observation, accounting for 35% of cases. This finding is consistent with another study where sclerosis of the mandibular fossa was the most frequent, present in 48% of joints, and in disagreement with the other study, they found the most radiographic erosion in the articular fossa.[17]

In this study, all radiographic changes of OA (sclerosis, erosion, and resorption of articular eminence) were more common in females than males but statistically not significant.

There were no notable correlations between age and two specific factors: Sclerosis and erosion of the articular eminence. However, concerning the resorption of the articular eminence, 3.1% of individuals under the age of 25 exhibited this condition, whereas 18.8% of those aged 45 years or older had it, with a p-value of 0.016 (see Table 8).

This finding is consistent with another study that observed changes in the articular eminence, including erosion, sclerosis, and resorption, commonly occurring in the fourth decade of life and beyond.[29]

This study had certain limitations. Firstly, the uneven distribution of participants among age groups and the unequal gender representation could have affected the precision of our statistical analysis. Secondly, taking into account the specific ethnic or racial backgrounds of the participants would have yielded more precise results, shedding light on the regional prevalence of TMJ-OA. However, due to concerns about radiation exposure, we conducted a retrospective study and didn't investigate all parameters involved in the development of TMJ-OA.

CONCLUSION

Among patients suffering from TMJ dysfunction, osteoarthritic changes are highly prevalent. Degenerative bone alterations can occur in any age group, and their frequency and severity do not increase with age.

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