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Original Article

Evaluation of temporomandibular joint morphology and morphometry in male osteoporotic patients using advanced imaging and biochemical markers: A cross-sectional study

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Abstract

Osteoporosis is a condition with reduced bone mass and disrupted architecture. Osteoporosis affects the Temporomandibular disorders (TMD) by changing bone density and quality. This study aims to determine the nature and extent of temporomandibular joint (TMJ) involvement in osteoporotic patients by correlating TMJ morphological changes detected by CBCT with systemic bone health indicated by BMD T-scores from DEXA and analyzing BTMs in serum and saliva. This study was a cross-sectional study conducted from May 2021 to December 2022. It involved 50 participants divided into two groups (N=25). One group was healthy male, while the other group had osteoporosis male. Saliva and blood samples were collected, and diagnostic imaging was conducted. The prevalence of various bone changes in the condyle was examined using CBCT. Erosion was found to be the most common, followed by Flattening, Osteophyte, and Subchondral cysts. The study group had significantly higher rates of smooth condyle, erosive lesions, and osteophytes compared to the control group. Pseudocyst decreased on the right side but increased on the left side. Pain on the right side increased more in the study group, and the T score for osteoporosis was higher in the study group. Joint spaces, condyle diameter, and glenoid cavity measurements differed significantly between sick and healthy people, as shown by CBCT ($P \leq 0.001$). Only the ALP parameter in the serum showed a significant increase in the study group compared to the control group. Saliva analysis revealed higher levels of calcium, osteocalcin, and ALP in the case group compared to the control group. The results of this study showed that CBCT as a specialized technique in imaging by providing detailed images can be used to evaluate osteoporosis and be used as an accurate diagnostic tool.

Keywords: Bone Turnover Markers, Bone Mineral Density, Cone Beam Computed Tomography, Osteoporosis, Temporomandibular Disorders

1. Introduction

Osteoporosis is a condition characterized by a reduction in bone mass and disruption of bone architecture, leading to reduced bone strength and an increased risk of bone fractures [1]. The World Health Organization (WHO) defines osteoporosis based on bone mineral density (BMD) measured by dual-energy X-ray absorptiometry (DXA). A BMD score (a T-score) of -2.5 standard deviations or lower than the young adult mean indicates osteoporosis [2].

The etiology of osteoporosis involves an imbalance between bone resorption and bone formation. Risk factors include aging, hormonal changes, inadequate nutrition, physical inactivity, and genetic predisposition [3]. Patients with osteoporosis often present no symptoms until a fracture occurs. Studies show that it is responsible for more than nine million fractures annually [4].

Temporomandibular disorders (TMD) encompass a group of conditions that affect the temporomandibular joint (TMJ), the muscles of mastication, and the associated structures [5]. Osteoporosis can impact the TMJ by altering its bone density and quality, potentially leading to degenerative changes. Research has indicated a link between systemic bone loss in osteoporosis and changes in TMJ morphology and function [6, 7]. It is estimated that between 5 and 15% of adults in the population suffer from TMD [8]. Individuals with TMJ disorders may experience pain, joint noises, restricted range of motion, and muscle tenderness [9].

Osteoporosis is typically diagnosed using BMD measurements through DXA [2], while TMD diagnosis is based on clinical examination, patient history, and imaging studies. Cone beam computed tomography (CBCT) has

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emerged as a valuable diagnostic tool for assessing TMJ morphology and morphometry, offering three-dimensional images with high resolution and accuracy [10].

In parallel, bone turnover markers (BTMs) markers provide a non-invasive method to evaluate the metabolic activity of bone tissue, which can be altered in osteoporosis and TMD [11]. BTMs in blood and saliva serve as non-invasive indicators of bone metabolism. These markers include substances released during bone formation, like osteocalcin, and resorption, such as C-terminal telopeptide (CTX). Monitoring these markers provides insight into the dynamic process of bone turnover, which is especially relevant in osteoporosis, where the balance between bone formation and resorption is disrupted [12, 13].

The results of Ahmed *et al.* [14] 's study , showed that CBCT can be a valuable diagnostic aid in evaluating different dimensions, joint spaces, and condyle volume at different levels, and as a result, it can be a useful predictor in evaluating the results of treatment of disorders affecting TMJ. In addition, the results of the study by Brown *et al*. [15]showed that BTMs is very useful for monitoring osteoporosis treatments.

As osteoporosis and TMJ disorders require special attention, integrating advanced imaging techniques such as CBCT with biochemical markers is necessary to improve the accuracy of diagnosing TMJ disorders in the context of osteoporosis. Since limited studies have examined these factors simultaneously; This study aims to determine the nature and extent of TMJ involvement in osteoporotic patients by correlating TMJ morphological changes detected by CBCT with systemic bone health indicated by BMD T-scores from DEXA and analyzing BTMs in serum and saliva.

2. Methods and Materials

2.1. Study Design and Setting

This study was a cross-sectional study conducted from May 2021 to December 2022. It involved multiple locations for different parts of the study, including Shahid Dr. Hemn Consultative Hospital, a private dental clinic in Sulaimani City, and the Research Center of the College of Veterinary Medicine, Sulaiman University.

2.2. Participants

This study involved 50 participants, divided into two groups: a control group (n=25) and a study group (n=25). The control group consisted of healthy males or non-osteoporotic individuals, while the study group consisted of males diagnosed with osteoporosis. Both groups were further divided into asymptomatic and symptomatic patients with signs and symptoms consistent with temporomandibular disorders (TMD), including joint click/crepitation, joint pain, and muscle pain.

The inclusion criteria required participants to provide consent and be newly diagnosed with osteoporosis, aged 50 years or older. The exclusion criteria involved conditions such as endocrine disorders, renal disease, chemotherapy or radiotherapy treatment, smoking, alcoholism, and systemic diseases affecting bone mineral density.

2.3. Sample Collection and Biochemical Analysis

Unstimulated whole saliva samples were obtained from participants using the draining technique, as described by Bellagambi *et al*. [16]. Participants refrained from eating, drinking, and oral hygiene for a period before the collection. Using a sterile test tube and funnel, 5 ml of saliva was collected over 30 minutes. Collected samples were centrifuged at 3000 rpm for 20 minutes to remove solids, then the supernatant was aliquoted and stored at -80°C for future analysis.

Blood samples were taken by venipuncture from the antecubital fossa by a skilled nurse to collect 5 ml of venous blood using sterile syringes. The blood was then centrifuged at 3000 rpm for 15 minutes at room temperature. Biochemical assays were performed on the same day, and remaining serum was aliquoted and stored at -80°C.

Serum samples were analyzed for alkaline phosphatase, urea, creatinine, calcium, and inorganic phosphate using the Roche Cobas c-111 analyzer, which operates based on a laser chemical reaction. Additionally, intact parathyroid hormone and vitamin D levels were quantified using the Roche Cobas e-411 analyzer, employing the electrochemiluminescence (ECL) detection method.

Both saliva and serum were tested for the concentrations of Fibroblast Growth Factor 23 (FGF23) using the ELK Biotechnology human FGF23 ELISA kit (ELK1769), and Osteocalcin (OC) using the human OC ELISA kit (ELK2390). Calcium/Calmodulin-dependent protein kinase 2 (CAMKK2) was assayed with the ELK Biotechnology human CAMKK2 ELISA kit (ELK 7156), and alkaline phosphatase (ALP) with the human ALP ELISA kit (ELK 1941). These ELISA assays are based on the sandwich enzyme immunoassay principle. ALP, calcium, and OC levels were expressed in ng/ml, whereas FGF23 levels were reported in pg/ml. The absorbance of samples was measured spectrophotometrically at 450 nm ± 10 nm, and concentrations were deduced from a standard curve.

2.4. Diagnostic Imaging

For assessing bone density, the t-score at the lumbar spine was measured using the GE Healthcare iDXA lunar machine equipped with fan-beam technology and a 64-channel solid-state detector. This machine is capable of supporting patients up to 204 kg and is integrated with a computer system for image manipulation and monitoring. The diagnostic criteria based on the t-score were applied following the World Health Organization's (WHO) 1994 guidelines (Figure 1).

Patients were instructed to remove any clothing or accessories that could interfere with the imaging process.

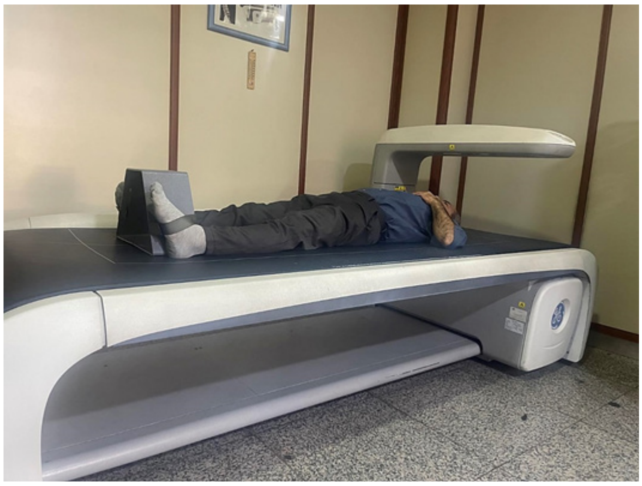

Fig. 1. The DXA machine shows the correct position of the patient.

They were then positioned centrally on the scan table with arms crossed over the chest. Laser positioning was used to align the patient and ensure accurate imaging.

Cone Beam Computed Tomography (CBCT) imaging of the TMJ was conducted at a private Maxillofacial Imaging and Design Center using a Photon CS3D 9600. The scanner was set to a maximum output of 120 kV and 5 mAs, with an exposure time of 40 seconds, a voxel size of 150 µm³, and a 16×12 cm field of view. Images were captured with a slice thickness of 0.15 mm and a slice spacing of 1 mm. Participants were positioned in the Frankfort plane, and the head was rotated 360 degrees during the scan. Two oral and maxillofacial radiologists conducted CBCT image analyses for TMJ abnormalities associated with osteoporosis (OP) (Figure 2).

Using CS3D software, axial views were analyzed to measure the mediolateral dimension of the condyle. Joint spaces, condylar height and width, and glenoid fossa dimensions were measured based on previous study protocols (Figure 3).

The examiners were blinded to the subjects' TMD status during evaluation. The presence of flattening, erosion, osteophytes, and pseudocysts on the condylar head was assessed by radiologists as indicators of degenerative joint disease, which were correlated with TMJ abnormalities associated with OP.

To confirm the presence of TMJ abnormality associated with OP, two oral and maxillofacial radiologists performed a radiographic CBCT interpretation. After uploading the image into CS3D, in the custom slicing and active TMJ

Fig. 2. The CBCT position of patient view; A and B: The eyes fixed on a point directly in front of the device, and the teeth in centric occlusion and parallel to the floor, C: The patient's head was rotated 360 degrees by the X-ray tube-detector system.

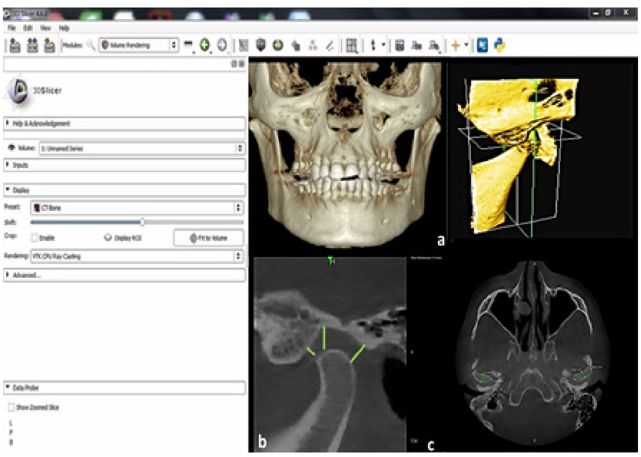

Fig. 3. CBCT image of the sample study group displaying the following: a: Three-dimensional superimposition of the maxilla and mandible; b: Axial view displaying the longest mediolateral length of the condyle; and c: Sagittal cross-sectional image displaying superior joint space, posterior joint space, and anterior joint space.

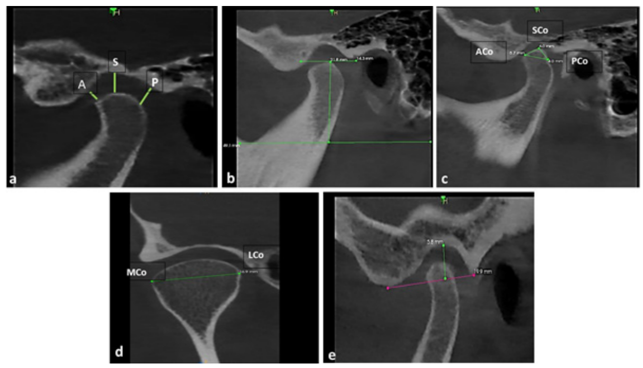

Fig. 4. Sagittal view of cone beam computed tomography image measurement of condylar process and the glenoid fossa's length, width, and height: a: The condylar showing superior joint space (Sjs), posterior joint space (Pjs), and anterior joint space (Ajs); b: Condylar height measurements, inferior-most point of the sigmoid notch (Inf Sig) and SCo, superior mandibular condyle; c: Anteroposterior condylar length, superior mandibular condyle (SCo), posterior-most mandibular condyle point (PCo), and anterior-most condylar point (ACo); d: Coronal view condylar width measurement between the lateral aspect of the condyle (LCo) and the mesial aspect of the condyle (MCo); e: linear measurements of depth and width of the glenoid fossa.

creation mode in the axial view presenting the maximum mediolateral dimension of the condyle using 1-mm thickness (Figure 3 a-c). All the measurement patterns used in this study were taken from previous studies [17,18]. All measurements were completed by the examiner without knowledge of the subjects' TMD status as follows (Figure 4).

1. Sagittal slices of 1 mm are created at the medial condyle of the orbit.
2. The joint spaces were examined and measured using the obtained reconstructed sagittal images.
3. The superior reference point was initially determined by drawing a horizontal line on the uppermost portion of the glenoid fossa and intersecting it with the glenoid fossa (S).
4. The most prominent points on the anterior (A) and posterior (P) aspects of the condyle were successively connected to the (S) point. Anterior and posterior joint spaces were used to measure the perpendicular distance between the A and P tangent points and the glenoid fossa (Ajs and Pjs).
5. The appropriate distance between the S point and the superior prominent point of the condylar head was considered to be the superior joint space (Sjs).
6. The final Ajs, Sjs, and Pjs were determined by averaging the above measurements on two central cuts (Figure 4a).
7. The height of the condyle was determined by measuring the angle between the superior mandibular condyle and a line drawn from the inferior-most point of the sigmoid notch to the tangent of the posterior surface of the ramus in the sagittal plane (Inf Sig) (Figure 4b).
8. A 2D sagittal slice that clearly showed the condyle and glenoid fossa was also chosen. The phrase "superior mandibular condyle" refers to the upper part of the mandibular condyle (SCo). The posterior-most mandibular condyle point (PCo) and anterior-most condylar point (AMCo), which are both on either side of the condyle and 4 mm away from the SCo, respectively, were chosen

(ACo). The condylar length was determined from this chosen sagittal slice (Figure 4c).

9. To measure the condylar width, which is the linear distance between the mandibular lateral (LCo) and medial pole (MCo) poles, the areas of maximum convex curvature on either side of the condyle in the coronal section were selected (Figure 4d). The distance between the most inferior point of the articular eminence and the most inferior point of the posterior glenoid process was finally used to calculate the glenoid fossa width.

10. The distance between the most superior point of the glenoid fossa and the line connecting the most inferior point of the articular eminence and the most inferior point of the posterior glenoid process was measured to determine the depth of the glenoid fossa (Figure 4e).

Bone changes in condyle in both joints were assessed by two oral radiologists. In the CBCT images, the radiographic sign of degenerative joint disease was as follows (Figure 5, [19]):

A. Flattening of the convex condylar head, (Figure 5a).

B. Erosion (the area of reduced density within the cortex and subcortical bone), (Figure 5b).

C. Osteophytes (bone outgrowths on the surface of the condyles), (Figure 5c)

D. Pseudo cysts (osteolytic, well delimited, localized in the subcortical area, the cortical layer is not destroyed in its course), (Figure 5d)

To confirm the presence of TMJ abnormality associated with OP, two oral and maxillofacial radiologists performed a radiographic CBCT interpretation. Following the subjects' enrollment in accordance with the selection criteria, all measurements were completed by the examiner without knowledge of the subjects' TMD status.

2.5. Statistical Analysis

The study's data were analyzed using SPSS software package V.22, and numerical data were tested for conformity to the normal distribution using Shapiro-Wilk analysis. The normally distributed variables in the two groups were compared using the Student T-test. One-way analysis of variance (One-way ANOVA (Post hoc: Duncan) between numerical variables were used to evaluate the association between different groups parameters including measurements' diameter and position (right and left) morphology for the condylar process and the glenoid fossa. A P-value less than 0.05 was considered significant.

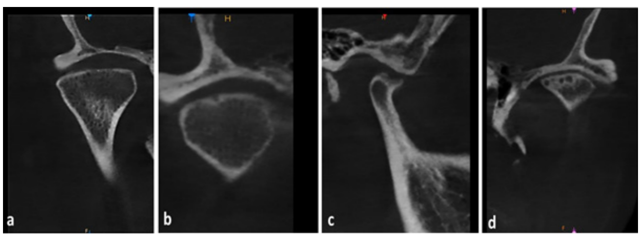

Fig. 5. The CBCT radiographic signs of degenerative joint diseases showing: a: Flattening of the condylar head convex; b: Erosion; c: Osteophytes; and d: Pseudocysts. See text for details.

2.6. Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board (IRB). Written informed consent was obtained from all participants prior to data collection. The study was conducted in accordance with the ethical principles stated in the Declaration of Helsinki. Participants confidentiality was maintained throughout the study, with data being anonymized and securely stored.

3. Results

Changes in condylar bone in CBCT examination showed that erosion had a prevalence of 54% among the examined men. The prevalence of Flattening was 50%, the prevalence of Osteophyte was 28%, and the prevalence of Subchondral cyst was 20% (Table 1).

3.1. Evaluation of Joint Abnormalities and muscle pain among the Male Population

The different values of the common degenerative joint issues and muscle pain among male groups are described in (Figure 5): For example, the flat condyle in the right aspect was found to be higher significantly ($P < 0.05$) in the study group vs. to the control group, (15 vs. 4) respectively, also this joint problem seen to be increased in incidence in the left side of the study group (10) than those found in the control group (6) significantly ($P < 0.05$) as seen in Figure 6a. For the erosion lesions frequency, the study group tends to be higher on both sides in comparison to the control group significantly (15 vs. 6 for Rt) and (12 vs. 6 Lt) as seen in (Figure 6b). While the ratio of the osteophytes was non-significantly higher in the study group's right side vs. the control group (5 vs. 3) correspondingly as in (Figure 6c), the same joint changes in the left side for the study group decreased non-significantly than those recorded in the control group (3 vs. 4) respectively. Whereas the pseudocyst decreased non-significantly ($P < 0.05$) in the study group's right aspect than those lesions found in the control group (5 vs. 6) consistently, while for the left side, a non-significant rise in occurrence was seen in the study group vs. to the control group (5 vs. 3) individually as seen in the (Figure 6d). For the joint pain opening the frequency was increased in the control group for the right side (3 vs. 2) while reduced in the left side (2 vs. 3) non-significantly in comparison to the study group (Figure 6e). Additionally, the joint pain closing showed an increase in occurrence in the right side vs. the study group (5 vs. 3) dependably, while the left side showed no variable changes in frequency (Figure 6f). Finally, the muscle pain recorded a higher frequency on both sides in the control group than those found in the study group, (5 vs. 4 for Rt) and (3 vs. 2

Table 1. The abnormalities in the condyle bone at the CBCT examination.

Condyle bone changes	Prevalence % in male
Erosion	54%
Flattening	50%
Osteophyte	28%
Subchondral cyst	20%

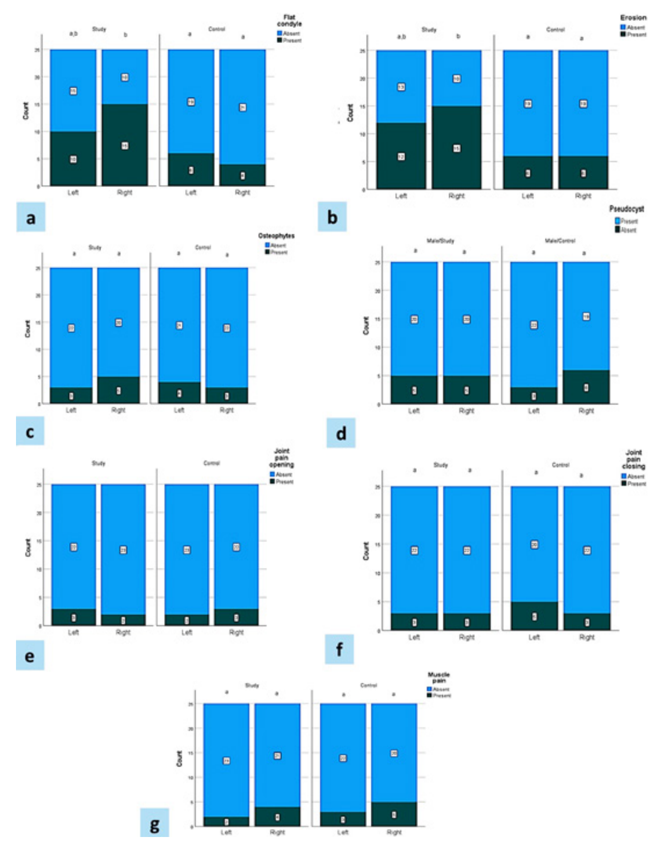

Fig. 6. The bar chart shows the frequency distribution of degenerative joint diseases and muscle pain on the right and left sides between groups in the male population. See text for details.

Lt) as seen in (Figure 6g).

3.2. TMJ assessment in the male population

In all, fifty adult patients were involved in this investigation. According to length, width, depth, and height, the distribution of the TM joint, condyle process, and glenoid fossa morphology is displayed in (Table 2).

The T score was significantly ($P < 0.05$) higher in the study group vs. in the control group.

Concerning the joint spaces (ASJ, SJS, and PJS) on the right side revealed a non-significant difference between groups, while for the left side, particularly both (SJS and PJS) showed a significant ($P < 0.05$) increase in the control group vs. to the study group (Table 2).

Regarding the diameter of the condyle measurement for the (length, width, and height) for the right aspect showed a non-significant difference increasing of measurement in the study group in comparison to the control group with an exception for the height that revealed a rise in value in the control group vs. to the study group. Whereas, for the left side the value for all parameters was increased in the control group vs. the study group that showed significance only ($P < 0.05$) for the condyle length.

For the Glenoid fossa's measurement, on the right side, the width value was significantly higher in the study group in comparison to the control group, while the depth data was non-significantly raised in the control group vs. the study group, in the left aspect also the width data increased in the study group vs. to the control group with non-significant difference, whereas the depth increased in the control group in comparison to the study group non-significantly.

3.3. Investigation of Serum and Saliva parameters in the male population

Concerning the biomarkers and bone turnover protein in the serum and saliva shown in (Table 3), only the ALP in the serum revealed a high significant difference ($P < 0.05$) in the increasing the level in the study group vs. the control group, while the other parameters in the serum including; the calcium, urea, creatinine, inorganic phosphate, and Vit D3, also the FGF-23 slightly-moderately elevated their level in the control group in comparison to the study group non-significantly. As in the serum, both parameters (PTH and Osteocalcin) were raised in the study group vs. the control group non-significantly.

In the saliva, the level of calcium, Osteocalcin, and ALP increased in the study group in comparison to the control group non-significantly, while the FGF-23 slightly increased in the control group in comparison to the study group.

4. Discussion

The present study was conducted to evaluate the TemporoMandibular Joint (TMJ) in osteoporosis patients by (CBCT) Cone Beam Computed Tomography. The morphology and morphometry of the temporomandibular joint (TMJ) components includes the joint space, height ,width and length of condyle and glenoid fossa.In this study, the relationship between radiographic changes in TMJ and markers of bone turnover in blood, saliva and value (T-score) obtained from DXA scan was also investigated.

Today, the use of modern and advanced methods in dentistry, which can be effective in diagnostic and treatment procedures, has been given more attention. A study by Iwaszenko *et al.* [20], with the aim of determining the morphology of the temporomandibular joint (TMJ), which can be effective in the treatment process and to evaluate the treatment results; the mentioned study, the images obtained from CBCT clearly revealed the position of the condyle and cavities in the temporal space, and it can be concluded that examining TMJ morphology with CBCT can be associated with good results.

Despite the use of different imaging methods to examine TMJ, nowadays the use of CBCT is more important due to the low radiation doses and excellent spatial resolution of the images. A study by Dhabale and Bhowate [10] aimed to use CBCT to examine the TMJ in patients with osteoarthritis, reconstruction, ankylosis, trauma, rheumatoid arthritis, synovial chondromatosis and other intracapsular pathologies and its results showed that CBCT can provide three-dimensional images of TMJ bones and joint space and also compared to other imaging methods, it creates multi-dimensional images with very high resolution, which can help in the process of TMJ diagnosis and treatment. The results of the mentioned study, which confirm the results of the present study, showed that CBCT is very useful in evaluating the condyle and glenoid cavity, as well as the articular prominence and its trabecular pattern, the level of calcification of the condyle head and TMJ spaces and identify jaw abnormalities well.

Due to the fact that the disorder in the temporal joint is one of the most common abnormalities of the jaw and in most cases it is not possible to identify the disorders of this joint using clinical examination. For this reason, it is necessary to use the CBCT imaging method to investigate these disorders and determine an accurate treatment plan

Table 2. Measurement by Mean ± S.E of joint space, condylar dimension, and glenoid fossa dimension in the male population.

Variable	Study vs. Control groups	Mean ± S.E	P-value
T-Score	Study	-1.916 ± 0.406	*0.000***
	Control	0.312±0.134	
ASJ (Rt)	Study	2.412±0.152	0.63
	Control	2.324±0.105	
SJS (Rt)	Study	3.492±0.083	0.82
	Control	3.520±0.089	
PJS (Rt)	Study	2.048±0.134	0.54
	Control	2.160±0.121	
AJS (Lt)	Study	2.296±0.209	0.80
	Control	2.236±0.125	
SJS (Lt)	Study	3.240±0.119	*0.01**
	Control	3.624±0.100	
PJS (Lt)	Study	1.844±0.131	*0.04**
	Control	2.168±0.86	
Condyle's length (Rt)	Study	6.328±0.184	0.50
	Control	6.152±0.075	
Condyle's width (Rt)	Study	18.976±0.183	0.15
	Control	19.848±0.266	
Condyle's height (Rt)	Study	18.884±0.458	0.57
	Control	19.243±0.449	
Condyle's length (Lt)	Study	6.328±0.182	*0.02**
	Control	6.800±0.085	
Condyle's width (Lt)	Study	17.816±0.321	0.56
	Control	18.100±0.357	
Condyle's height (Lt)	Study	18.117±0.502	0.39
	Control	18.680±0.410	
Glenoid fossa's width (Rt)	Study	17.036±0.530	*0.05**
	Control	15.736±0.404	
Glenoid fossa's depth (Rt)	Study	6.324±0.220	0.65
	Control	6.476±0.257	
Glenoid fossa's width (Lt)	Study	16.016±0.314	0.65
	Control	15.756±0.486	
Glenoid fossa's depth (Lt)	Study	5.584±0.153	0.95
	Control	5.600±0.265	

Statistically significant values are shown in italics with **Significant difference (P < 0.05), Lt= left and Rt= right, no= 25 males in each studied group of examined joints.

in this direction. In the studies conducted in Iran by Maleki *et al.* [21] and Bianchi *et al.* [22]in the United States of America it was shown that a wide range of TMJ disorders, including flattening, sclerosis, osteophytes, and erosion, can be identified well with CBCT and for this reason, it can be used well for therapeutic and diagnostic purposes.

The changes of condyle bone in CBCT examination showed that Erosion has the highest prevalence and Flattening, Osteophyte and Subchondral cysts were respectively the highest prevalence among the examined people. In a review study conducted by Almpani *et al.*[23] in order to investigate the features and characteristics of the condyle in people with TMD using CBCT, the results showed that in 45 studies with inclusion criteria, it was shown that Erosion, Flattening, Osteophytes and Sclerosis were the most common changes in the condyle in individuals with TMD, which is consistent with the results of the present study. In the study of Paknahad *et al.*[24], the most common condyle disorders were Flattening, Erosion, Marginal sclerosis, Subchondral sclerosis and Osteophyte, and Cyst was not observed in the changes; This difference in the results can be caused by the examined sample and different methods in the work.

The assessment of TMJ joint abnormalities showed that there is an increase in smooth condyle and erosive lesions, an increase in the proportion of osteophytes and an increase in cysts in the study group compared to the control group. In the study conducted by Vasegh *et al.*[25], temporomandibular joint (TMJ) changes in patients with temporomandibular disorder (TMD) were investigated using CBCT.

Its results showed that 200 patients including 123 women and 67 men were examined. For each patient, the TMJs of both sides were examined and a total of 400 TMJs were examined. The most common changes in the condylar bone were osteophyte, followed by flattening of

Table 3. Measurement by Mean ± S.E of various biochemical parameters and growth factors in the serum and saliva in the male population.

Variable	Study vs Control group	Mean ± S.E	P-value
ALP (U/L)	Study	228.36±11.25	*0.000***
	Control	100.15±3.955	
Calcium (mg/dl)	Study	8.076±0.084	0.43
	Control	8.176±0.097	
Urea (mg/dl)	Study	35.520±2.370	0.96
	Control	35.680±2.302	
Creatinine (mg/dl)	Study	0.673±0.026	0.95
	Control	0.675±0.024	
Inorganic phosphate (mmol/L)	Study	3.388±0.119	0.71
	Control	3.452±0.127	
PTH (pg/mL)	Study	33.760±1.790	0.86
	Control	33.320±1.584	
Vit D3 (ng/mL)	Study	20.640±1.487	0.88
	Control	20.960±2.113	
Osteocalcin (ng/mL)	Study	14.227±0.503	0.08
	Control	12.824±0.610	
FGF-23	Study	43.586±4.166	0.22
	Control	50.822±4.108	
Osteocalcin-S (ng/mL)	Study	2.330±0.148	0.43
	Control	2.171±0.137	
FGF23 -S	Study	35.087±2.294	0.98
	Control	35.164±3.378	
Calcium -S (mg/dl)	Study	3.083±0.125	0.90
	Control	3.064±0.110	
ALP-S (U/L)	Study	3.001±0.124	0.28
	Control	2.818±0.116	

Statistically significant values are shown in italics with **Significant difference (P < 0.05), No= 25 males in each studied group of examined serum and saliva. S= saliva.

the joint surface, erosion, ankylosis, and sclerosis, and no increase in cysts was observed among the changes in this study. Despite these results, this study showed that CBCT can be used as an accurate and efficient imaging method for TMJ evaluation. In another study by Semerci *et al.*[26] has been performed, the TMJ was examined using CBCT. In the mentioned study, the images of 65 patients (130 temporomandibular joints) were evaluated using CBCT; The results showed that erosion, flattening, subcondylar sclerosis, osteophytes, cysts, articular eminence resorption and articular eminence flattening had a significant increase in the study group compared to the control group, and these changes are in line with the condyle changes in the present study.

Examination of TMJ joint pain using CBCT showed an increase in pain in the right side of the jaw in the study group compared to the control group, but these changes were not evident in the left side. The examination of TMJ joint pain has been shown in other studies, which is in line with the findings of this study. In these studies, it was shown that one of the important findings in the changes of the jaw joint is the increase in pain [27, 28].

The measurement of the T score for measuring osteoporosis showed a significant difference between the two groups and showed that the score was higher in the study group. Accordingly, the results of this study showed that CBCT can be used as a valuable tool in the diagnosis of osteoporosis in TMD disorders. Studies conducted in Egypt by Yousef *et al.* [29] and in South Korea by Park *et al.*[30] showed that the use of CBCT is a valuable tool for the diagnosis of osteoporosis in TMD.

Changes in joint spaces, condyle diameter (length, width and height) and measurement of glenoid cavity showed that there are significant changes between sick people and healthy people, and in sick people these changes were detected using CBCT. Other studies also showed that CBCT can identify TMJ morphological changes among patients and can be used as a powerful diagnostic tool in TMD disorders [31–33].

Examination of serum and saliva parameters showed that in the serum parameters, only the ALP parameter had a significant increase in the study group compared to the control group and regarding other parameters, despite the changes, these changes were not significant. In the analysis of saliva parameters, it was shown that the level of calcium, osteocalcin and ALP increased in the case group compared to the control group. This increase was not significant compared to the control group, while FGF-23 increased slightly in the control group compared to the study group. bone turnover markers (BTMs) are used to evaluate the extent of bone remodeling and bone turnover in osteoporosis. ALP increase in patients with osteoporosis is associated with changes in blood circulation and bone regeneration [34]. In this study, it was shown that ALP level can be an important factor in T score and with the increase of ALP, the T score changes and is proposed as a predictive factor of osteoporosis, which is consistent with the results of other studies that introduced ALP as a predictor of T score [35, 36].

Because the level of ALP can be affected by various factors such as age, gender, use of drugs and patient conditions, To diagnose osteoporosis, other diagnostic methods are needed in addition to ALP, and its interpretation will be very important according to the patient's clinical condition [37].

The level of calcium, osteocalcin and ALP was increased among patients in the case group, which was increased as a marker in other studies [38, 39]. The important point is that salivary biomarkers are used along with other circulating biomarkers to evaluate osteoporosis [40].

5. Conclusions

This study showed that CBCT, as a specialized imaging technique, can be used to evaluate osteoporosis by providing accurate images and an accurate. Compared to other imaging methods such as magnetic resonance imaging (MRI) and computed tomography (CT), CBCT has higher image clarity and resolution, less radiation, and less imaging time. Evaluation of bone and calcification is also possible in CBCT, while this is not possible in other imaging methods.

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Consent for publications
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Ethics approval and consent to participate
The study was conducted in accordance with the ethical principles stated in the Declaration of Helsinki.

Informed Consent
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Availability of data and material
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References

1. Chang X, Xu S, Zhang H (2022) Regulation of bone health through physical exercise: Mechanisms and types. Front Endocrinol (Lausanne) 13 1029475.
2. Golding PH (2022) Dual-energy X-ray absorptiometry (DXA) to measure bone mineral density (BMD) for diagnosis of osteoporosis-experimental data from artificial vertebrae confirms significant dependence on bone size. Bone Reports 17 101607.
3. Cheng CH, Chen LR, Chen KH (2022) Osteoporosis due to hormone imbalance: an overview of the effects of estrogen deficiency and glucocorticoid overuse on bone turnover. Int J Mol Sci 23 (3): 1376.
4. Björnsdottir S, Clarke BL, Mannstadt M, Langdahl BL (2022) Male osteoporosis-what are the causes, diagnostic challenges, and management. Best Pract Res Clin Rheumatol 36 (3): 101766.
5. Palmer J, Durham J (2021) Temporomandibular disorders. BJA Educ 21 (2): 44–50.
6. Kim SY, Yoo DM, Kwon MJ, Kim JH, Kim J-H, Byun S-H, et al (2022) Increased Risk of Temporomandibular Joint Disorder in Osteoporosis Patients: A Longitudinal Study. Front Endocrinol (Lausanne) 13 835923.
7. Alqhtani NR, Alkhaldi MS, Alanazi AF, Alabdulsalam AS, Alenazi A, Zaman MU, et al (2022) Temporomandibular Joint Space Dimensions among Saudi Patients with Temporomandibular Disorders: MRI-Based Retrospective Study. Int. J. Clin. Pract. 2022
8. Li DTS, Leung YY (2021) Temporomandibular disorders: current concepts and controversies in diagnosis and management. 11 (3): 459.
9. Maini K, Dua A (2024) Temporomandibular Syndrome. StatPearls.
10. Dhabale GS, Bhowate RR, Bhowate R (2022) Cone-beam computed tomography for temporomandibular joint imaging. Cureus 14
11. Yasuda K, Okada S, Okazaki Y, Hiasa K, Tsuga K, Abe Y (2020) Bone turnover markers to assess jawbone quality prior to dental implant treatment: a case-control study. Int J Implant Dent 6 1–9.
12. Kakali L, Giantikidis I, Sifakakis I, Kalimeri E, Karamani I, Mavrogonatou E, et al (2022) Fluctuation of bone turnover markers' levels in samples of gingival crevicular fluid after orthodontic stimulus: a systematic review. Syst Rev 11 (1): 3.
13. Callegari ET, Garland SM, Gorelik A, Chiang CY, Wark JD (2018) Bone turnover marker determinants in young women: results from the Safe-D study. Ann Clin Biochem 55 (3): 328–340.
14. Nithin 1, Ahmed J, Sujir N, Shenoy N, Binnal A, Ongole R (2021) Morphological assessment of TMJ spaces, mandibular condyle, and glenoid fossa using cone beam computed tomography (CBCT): a retrospective analysis. Indian J Radiol Imaging 31 (01): 78–85.
15. Brown JP, Don-Wauchope A, Douville P, Albert C, Vasikaran SD (2022) Current use of bone turnover markers in the management of osteoporosis. Clin. Biochem.
16. Bellagambi FG, Lomonaco T, Salvo P, Vivaldi F, Hangouët M, Ghimenti S, et al (2020) Saliva sampling: Methods and devices. An overview. TrAC Trends Anal Chem 124 115781.
17. Yasa Y, Akgül HM (2018) Comparative cone-beam computed tomography evaluation of the osseous morphology of the temporomandibular joint in temporomandibular dysfunction patients and asymptomatic individuals. Oral Radiol 34:31-9.
18. Soydan D, Doğan S, Canger EM, Coşgunarslan A, Akgün IE, Kış HC (2020) Effect of internal derangements and degenerative bone changes on the minimum thickness of the roof of the glenoid fossa in temporomandibular joint. Oral radiol 36:25-31.
19. Lukšić I, Lužnik Ž, Pelivan I, Čimić S (2020) Use of Cone Beam Computed Tomography for Studying Temporomandibular Joint Morphology. Coll Antropol 44: 103-6.
20. Iwaszenko S, Munk J, Baron S, Smoliński A (2021) New method for analysis of the temporomandibular joint using cone beam

computed tomography. 21 (9): 3070.
21. Maleki FH, Shokri A, Hosseini Zarch SH, Bahraniy A, Ebrahimpour A, Alimohamadi SM (2019) Cone Beam CT Evaluation of the Bony Changes in the Temporomandibular Joint and the Association with the Clinical Symptoms of Temporomandibular Joint Disorders. J. Dent. Mater. Tech. 8
22. Bianchi J, Roberto Gonçalves J, Carlos de Oliveira Ruellas A, Vieira Pastana Bianchi J, Ashman LM, Yatabe M, et al (2021) Radiographic interpretation using high-resolution Cbct to diagnose degenerative temporomandibular joint disease. PLoS One 16 (8): e0255937.
23. Almpani K, Tran H, Ferri A, Hung M (2023) Assessment of condylar anatomy and degenerative changes in temporomandibular joint disorders–A scoping review. J Oral Biol Craniofacial Res 13 (6): 764–780.
24. Paknahad M, Khojastepour L, Tabatabaei S, Mahjoori-Ghasrodashti M (2023) Association between Condylar Bone Changes and Eichner Index in Patients with Temporomandibular Dysfunction: A Cone Beam Computed Tomography Study. J Dent 24 (1): 12.
25. Vasegh Z, Safi Y, Azar MS, Ahsaie MG, Arianezhad SM (2023) Assessment of bony changes in temporomandibular joint in patients using cone beam computed tomography–a cross sectional study. Head Face Med 19 (1): 47.
26. Semerci ZM, Günen Yılmaz S (2023) Evaluation of Rheumatic Diseases Affecting the Temporomandibular Joint: A Cone Beam Computed Tomography Study and Literature Review. 14 (1): 4.
27. Dolwick MF, Widmer CG (2020) Temporomandibular joint arthrocentesis: an evidence-based review. Front. Oral Maxillofac. Med. 2
28. Rytivaara R, Näpänkangas R, Kainulainen T, Sipola A, Kallio-Pulkkinen S, Raustia A, et al (2024) Thermographic findings related to facial pain–a survey of 40 subjects. 42 (1): 69–76.
29. Yousef M, Mowafey B, El-Shinnawi U Detection of osteoporosis using CBCT mandibular indices in Egyptian Females.
30. Park CS, Kang SR, Kim JE, Huh KH, Lee SS, Heo MS, et al (2023) Validation of bone mineral density measurement using quantitative CBCT image based on deep learning. Sci Rep 13 (1): 11921.
31. Noh KJ, Baik HS, Han SS, Jang W, Choi YJ (2021) Differences in mandibular condyle and glenoid fossa morphology in relation to vertical and sagittal skeletal patterns: A cone-beam computed tomography study. Korean J Orthod 51 (2): 126–134.
32. Khojastepour L, Haghnegahdar A, Eisazadeh M, Bahreini M (2019) Comparison between glenoid fossa roof thickness in TMD and non-TMD patients, a CBCT study. J Dent 20 (3): 165.
33. Görürgöz C, İçen M, Kurt M, Aksoy S, Bakirarar B, Rozylo-Kalinowska I, et al (2023) Degenerative changes of the mandibular condyle in relation to the temporomandibular joint space, gender and age: A multicenter CBCT study. Dent. Med. Probl. 60
34. Jeyasree RM, Theyagarajan R, Sekhar V, Navakumar M, Mani E, Santhamurthy C (2018) Evaluation of serum and salivary alkaline phosphatase levels in chronic periodontitis patients before and after nonsurgical periodontal therapy. J Indian Soc Periodontol 22 (6): 487–491. doi: 10.4103/jisp.jisp_133_18.
35. Tariq S, Tariq S, Lone KP, Khaliq S (2019) Alkaline phosphatase is a predictor of Bone Mineral Density in postmenopausal females. Pakistan J Med Sci 35 (3): 749–753. doi: 10.12669/pjms.35.3.188.
36. Cheng X, Zhao C (2023) The correlation between serum levels of alkaline phosphatase and bone mineral density in adults aged 20 to 59 years. Med (United States) 102 (32): E34755. doi: 10.1097/MD.0000000000034755.
37. Kuo TR, Chen CH (2017) Bone biomarker for the clinical assessment of osteoporosis: Recent developments and future perspectives. Biomark Res 5 (1): 1–9. doi: 10.1186/S40364-017-0097-4.
38. Shazam H, Shaikh F, Hussain Z (2020) Bone Turnover Markers in Chronic Periodontitis: A Literature Review. Cureus. doi: 10.7759/cureus.6699
39. Saha MK, Agrawal P, Saha SG, Vishwanathan V, Pathak V, Saiprasad SV, et al (2017) Evaluation of corelation between salivary calcium, alkaline phosphatase and osteoporosis- a prospective, comparative and observational study. J Clin Diagnostic Res 11 (3): ZC63–ZC66. doi: 10.7860/JCDR/2017/24960.9583.
40. Kerschan-Schindl K, Boschitsch E, Marculescu R, Gruber R, Pietschmann P (2020) Bone turnover markers in serum but not in saliva correlate with bone mineral density. Sci Rep 10 (1): 11550. doi: 10.1038/s41598-020-68442-z.