Original Research

Cone Beam CT Evaluation of the Bony Changes in the Temporomandibular Joint and the Association with the Clinical Symptoms of Temporomandibular Joint Disorders

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Abstract

Introduction: Temporomandibular joint (TMJ) disorders are among the most prevalent abnormalities of the jaw, which affect the masticatory system, including the muscles, TMJ, and tendons. Clinical examination alone cannot determine the cause of temporomandibular disorder (TMD). In most cases, the cause of TMD and a proper treatment plan are determined based on imaging modalities. The present study aimed to investigate the bone changes in the patients with TMD symptoms using cone beam computed tomography (CBCT). **Methods**: This retrospective, cross-sectional study was conducted through recording data on the pain caused by TMJ (upon touching, using the TMJ, and maximum mouth opening), clicking, and crepitus using a checklist of clinical symptoms. CBCT images were examined for the associated bone changes, including sclerosis, flattening, erosion, and osteophyte. Data analysis was performed in SPSS version 21 using Chi-square and logistic regression analysis. **Results**: In total, 160 joint images were examined, including 132 cases of flattening (82.5%), 45 cases of sclerosis (28.12%), 41 cases of osteophytes (25.62%), and 66 cases of erosion (41.25%). A significant association was observed between pain and flattening, and sclerosis and osteophytes. Moreover, a significant correlation was observed between flattening and clicking (P<0.05). **Conclusion**: According to the results, flattening was the most common bone change in the patients with TMD. In addition, sclerosis had the most significant association with pain, while sclerosis, osteophytes, and erosion were significantly correlated with joint crepitation.

Keywords: Temporomandibular Joint, Cone Beam CT, Bone Changes.

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Introduction

The temporomandibular joint (TMJ) is a complex joint in the body, which plays a key role in speaking and mastication (1). Temporomandibular disorder (TMD) refers to the disorders that affect the masticatory system, including the muscles, TMJ, and tendons (1). TMD is the most common abnormality of the jaw, and the clinical symptoms are reported in 28-86% of adults and adolescents (2-6). TMD is classically characterized clinical symptoms such as joint noises, pain, and limited or deviated mouth opening (7-9).

Clinical examination alone cannot determine the cause of TMD. In most cases, the cause and a proper treatment plan are determined based on imaging modalities. Some of the imperative techniques for the diagnosis of TMD include a series of clinical examinations, using the Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD), and TMJ imaging modalities (10).

Although several imaging techniques have been developed for the examination of TMJ bone changes, there is no general consensus on the best diagnostic imaging technique as a 'gold standard' for the tracking and identification of these lesions (11). The most common conventional imaging modalities in this regard are panoramic, submentovertex, transcranial, transpharyngeal, and lateral cephalometric techniques. However, their results often fail to match the clinical symptoms of the patients due to superimpositions and imaging limitations. New techniques, including computerized tomography (CT), magnetic resonance imaging (MRI), and cone beam computed tomography (CBCT) are increasingly used for the assessment of TMJ in order to eliminate the associated superimpositions and produce sectional images (9, 12).

CBCT scanners, which are designed for maxillofacial areas, could provide a spatial resolution of less than one millimeter within a shorter scanning time and low radiation dose compared to CT-scan. Therefore, they are applied in many dental clinics as an effective method for the diagnosis and evaluation of craniofacial problems (13). The application of CBCT has previously been investigated, and its diagnostic effects have also been confirmed for various dentistry purposes, such as endodontic therapy, oral and maxillofacial surgery (14), periodontology (15), restoration (16), and orthodontics.

Although the current literature is indicative of the efficiency of CBCT in evaluating the bone changes associated with TMJ (17), few studies have been focused on the use of this technique for the examination of TMD and its correlation with the bone changes caused by TMJ. The present study aimed to investigate the bone changes in sclerosis, osteophytes, and erosion in the patients with TMD symptoms using CBCT.

Materials and Methods

This retrospective, cross-sectional study was conducted on the patients visiting the Department of Prosthetics and Radiology (TMJ clinic) of the School of Dentistry at Hamadan University of Medical Sciences, Iran. The research protocol was approved by the Ethics Committee of the university (ethics code: IR.UMSHA.REC.1394.324).

The inclusion criteria was the presence of at least one of the symptoms of TMJ, including pain in the TMJ region, restricted mouth opening, joint noises, TMJ reciprocal clicking in vertical opening and closing occurring at a minimum of a five-millimeter distance from the inter-incisal space when opening the mouth (repeated in two of three consecutive tests) (18), clicking during lateral or forward movements (repeated in two of three consecutive tests), crepitus in the TMJ region, and jaw movement deviation (19).

The exclusion criteria of the study were as follows: 1) patients with congenital craniofacial disorders; 2) history of TMJ treatment (e.g., surgery, laser therapy, anti-inflammatory medication, and corticosteroid therapy); 3) history of orthodontic treatments, systemic disorders involving the TMJ (e.g., rheumatoid arthritis, multiple myeloma, scleroderma, and gout) and 4) history of pyogenic arthritis (20, 21).

Initially, the patients presenting with the TMD symptoms were examined by a dental prosthodontist, and the clinical symptoms were recorded in a TMJ checklist. In addition, CBCT imaging was performed on the patients if necessary.

The patients were divided into two groups of normal and restricted based on the pain caused by TMJ, including pain upon touching, using the TMJ, and maximum mouth opening (35-50 mm) (22). Another factor based on which the patients were classified into the mentioned groups was joint noises, including short singular clicking and repetitive rough noises (e.g., crepitus), which were recorded in the checklist of the clinical symptoms (23).

CBCT was performed using a Promax device (PLANMECA, Helsinki, Finland) with the following parameters: KVP=84, general filtration=2.5 millimeters of aluminum, FOV=8×8 cm^2, matrix size=512×512 pix, scan time=25 seconds, exposure time=12 seconds, and slice thickness=0.5 millimeter. A thyroid shield and a lead apron were used for protection against the radiation of the scanning procedures. The obtained images were reconstructed in the ROMEXIS format and stored in the DICOM format.

The images were initially examined in the sagittal, coronal, and axial planes by two radiologists. The sagittal images of the TMJ portions (condyle, joint cavity, and joint prominence) were assessed in terms of the bone changes caused by the disorder, such as sclerosis, flattening, erosion, and osteophytes. Conventionally, for the mentioned cases to be considered as a change, they have to be observed in at least two consecutive cuts. Bone changes in joints include:

1. *Flattening (F)*, which is the loss of the uniform convexity or concavity of the joint surfaces;
2. *Sclerosis (SC)*, which is the thickening of the cortical bone on the joint surface;
3. *Osteophytes (OS)*, which is the localized bone prominence from the mineralized joint surface;
4. *Erosion (E)*, which is the localized cortical bone rarefaction from the joint surface;
5. *Concavity (Con)*, which is defined as the concavity of the bone contour with a dent;
6. *Subcortical cyst (Cyst)*, which is the round radiolucent area located either underneath the cortical bone or deeper into the bone in the trabeculae (24).

Data analysis was performed in SPSS version 21 (Microsoft, IL, USA) using Chi-square and logistic regression analysis at the significance level of 0.05.

Results

In total, 160 TMJ images obtained from 12 male patients (15%) and 68 female patients (85%) were investigated. The mean age of the patients was 33.38±8.05 years. The majority of the patients were within the age range of 26-35 years (41.3%). Table I shows the frequency of the bone changes in the subjects, including flattening, sclerosis, osteophytes, and erosion. The results of Chi-square regarding the association between the bone-joint changes in the TMJ and pain indicated that the sensation of pain had significant correlations with flattening (P=0.032), sclerosis (P=0.001), and osteophytes (P=0.007).

Contrary to the association between TMJ pain and the mentioned parameters, the correlation between pain and erosion was not considered significant based on the Chi-square test. In addition, the results of Chi-square showed no significant association between the restricted movement of the TMJ and its bone changes (flattening, sclerosis, osteophytes, and erosion) (P>0.05) (Table II).

Logistic regression analysis was used to examine the simultaneous effects of the variables on each other. According to the obtained results, sclerosis was the only variable that could affect TMJ pain with a statistically significant difference (P=0.004) (Table III). Based on the regression model, the following equation could be used to predict the possibility of the occurrence of pain:

$$p\,(pain = yes) = \frac{\exp(0.405 - 0.640\, flattening - 1.323\, sclerosis + 0.375\, erosion)}{1 + \exp(0.405 - 0.640\, flattening - 1.323\, sclerosis + 0.375\, erosion)}$$

It could be stated that the possibility of pain in the patients with a history of sclerosis was 0.266 compared to someone who has no sclerosis.

According to the results of Chi-square, the only significant association was observed between flattening and clicking (P=0.023), and the three other variables had no correlations with clicking (P>0.05) (Table IV). Moreover, our findings indicated that crepitation had significant associations with sclerosis (P=0.001), osteophytes (P=0.009), and erosion (P<0.000). However, no significant correlation was denoted between crepitation and flattening (P>0.005) (Table IV).

Table I. Frequency of Various Bone Changes Observed in Patients

Bone Change	Observed Cases N (%)	Non-Observed Cases N (%)	Total
Flattening	132 (82.5)	28 (17.5)	160 (100)
Sclerosis	45 (28.12)	115 (81.87)	160 (100)
Osteophytes	41 (25.62)	119 (74.37)	160 (100)
Erosion	66 (41.25)	94 (58.75)	160 (100)
Total	92 (57.5)	68 (42.5)	160 (100)

Table II. Contingency Tables Regarding Associations between Pain and Restricted Movement with Bone Changes (Flattening, Sclerosis, Osteophytes, and Erosion)

Bone Change		Pain			P-value	Restricted Movement			P-value
		Yes (%)	No (%)	Total		Yes (%)	No (%)	Total	
Flattening	Yes (%)	81 (50.62)	51 (31.87)	132 (82.5)	0.030	60 (37.5)	72 (45)	132 (82.5)	0.233
	No (%)	11 (6.875)	17 (10.62)	28 (17.5)		10 (6.25)	18 (11.25)	28 (17.5)	
	Total	92 (57.5)	68 (42.5)	160 (100)		70 (43.75)	90 (56.25)	160 (100)	
Sclerosis	Yes (%)	35 (21.87)	10 (6.25)	45 (28.12)	0.001	24 (15)	21 (13.12)	45 (28.12)	0.126
	No (%)	57 (35.62)	58 (36.2)	115 (71.87)		46 (28,75)	69 (43.12)	115 (71.87)	
	Total	92 (57.5)	68 (42.5)	160 (100)		70 (43.75)	90 (56.25)	160 (100)	
Osteophytes	Yes (%)	31 (19.37)	10 (6.25)	41 (25.62)	0.007	20 (12.5)	21 (13.12)	41 (25.62)	0.452
	No (%)	61 (38.12)	58 (36.2)	119 (74.37)		50 (31.25)	69 (43.12)	119 (74.37)	
	Total	92 (57.5)	68 (42.5)	160 (100)		70 (43.75)	90 (56.25)	160 (100)	
Erosion	Yes (%)	40 (25)	26 (16.25)	66 (41.25)	0.308	34 (21.25)	32 (20)	66 (41.25)	0.097
	No (%)	52 (32.5)	42 (26.25)	94 (58.75)		36 (22.5)	58 (36.25)	94 (58.75)	
	Total	92 (57.5)	72 (42.5)	160 (100)		70 (43.75)	90 (56.25)	160 (100)	

Table III. Estimation of Parameters in Logistic Regression Model

Variables	Coefficient (B)	OR=Exp (B)	SE	P-value
Constant	0.405	1.5	0.398	0.308
Flattening	-0.640	0.527	0.445	0.150
Sclerosis	-1.323	0.266	0.455	0.004
Erosion	0.375	1.455	0.398	0.327

Table IV. Contingency Tables Regarding Associations between Clicking and Crepitus with Bone Changes (Flattening, Sclerosis, Osteophytes, and Erosion)

Bone Change		Clicking			P-value	Crepitus			P-value
		Yes (%)	No (%)	Total		Yes (%)	No (%)	Total	
Flattening	Yes (%)	0.023	68 (42.5)	132 (82.5)	0.023	22 (13.75)	110 (68.75)	132 (82.5)	0.999
	No (%)	7 (4.37)	21 (13.12)	28 (17.5)		4 (2.5)	24 (15)	28 (17.5)	
	Total	71 (44.37)	89 (55.62)	160 (100)		26 (16.25)	134 (83.75)	160 (100)	
Sclerosis	Yes (%)	0.732	26 (16.25)	45 (28.12)	0.732	14 (8.75)	31 (19.37)	45 (28.12)	0.001
	No (%)	52 (32.5)	63 (39.37)	115 (71.87)		12 (7.5)	103 (64.37)	115 (71.87)	
	Total	71 (44.37)	89 (55.62)	160 (100)		26 (16.25)	134 (83.75)	160 (100)	
Osteophytes	Yes (%)	0.424	25 (55.62)	41 (25(62)	0.424	12 (7.5)	29 (18.12)	41 (25.62)	0.009
	No (%)	55 (34.37)	64 (40)	119 (71.87)		14 (8.75)	105 (65.62)	119 (74.37)	
	Total	71 (44.37)	89 (55.62)	160 (100)		26 (16.25)	134 (83.75)	160 (100)	
Erosion	Yes (%)	0.087	42 (26.25)	66 (41.25)	0.087	20 (12.5)	46 (28.75)	66 (41.25)	<0.001
	No (%)	47 (29.37)	47 (29.37)	94 (58.75)		6 (3.75)	88 (55)	94 (58.75)	
	Total	71 (44.37)	89 (55.65)	160 (100)		26 (16.25)	134 (83.75)	160 (100)	

Discussion

The present study aimed to examine 160 TMJ images obtained from 80 patients presenting with the symptoms of TMD based on CBCT and assess the bone changes and condylar bone lesions (flattening, sclerosis, erosion, and osteophytes) in each joint, as well as their correlations with the clinical symptoms, such as pain, restricted movement, and joint noises.

The CBCT technique was used in the current research considering its image reconstruction capability in three planes, resolution of less than one millimeter, and ability to display the minor initial changes in the TMJ (21, 25). In line with our findings, Honey, Alkhader, and Peck (26-28) also reported that CBCT is the preferred technique for the examination of condylar bone changes in the patients with TMD owing to its low radiation dose, cost-efficiency, less required time compared to CT, high image quality, possibility of examining primary condylar bone changes in three planes compared to panoramic radiography and cephalometry, higher sensitivity, and ability to display minor bone changes more accurately compared to modified linear tomography and MRI (29).

In the present study, 85% of the patients with TMJ dysfunction were female. The previous studies by Pedronil (30), Carlsson (31), and Huber (32) have also suggested that the prevalence of these disorders is higher in women compared to men. The higher prevalence of TMJ disorders in women could have various reasons. One of the reasons is that women tend to experience higher stress levels throughout their life, and stress is considered to be a major cause of TMD. Furthermore, women are more sensitive to the issues in their environment (33). On the other hand, hormonal factors could contribute to these disorders (34), and the previous studies conducted on rats have suggested that the differences in the hormonal receptors in the joints of women could potentially lead to TMD (35).

The majority of the patients in the current research were aged less than 45 years. As argued in previous studies, the prevalence of TMJ disorders is higher in this age group (18). For instance, Alexio has claimed that the clinical symptoms, frequency, and severity of radiographic mandibular condyle abnormalities increase with the age of less than 40 years (21). Similarly, Ganguly has stated that at a cellular level, aging causes functional defects due to the complex process of various accumulated injuries, thereby increasing the senescent cells and decreasing resistance to oxidative damage. Therefore, it could be inferred that although the remodeling strength of joint surfaces lasts beyond the growth age, resistance to damage reduces with age, giving rise to more frequent and severe symptoms (36).

In the present study, flattening was observed in 132 (82.5%) out of 160 examined patients and considered to be the most prevalent lesion. The other lesions included sclerosis (n=45; 28.125%), osteophytes (n=41; 25.625%), and erosion (n=66; 41.25%). As such, osteophytes had the lowest prevalence compared to the other parameters. This is consistent with the study by Wiese et al. (37) in Denmark, which reported flattening, osteophytes, sclerosis, and erosion as the most common bone changes in order of prevalence. Meanwhile, sclerosis was reported to be the most common bone change in the research by Nah et al.(38), while the most common TMDs were erosion and sclerosis in the study by Cho et al. (39) and erosion in the study by Kilicl et al. (40), which is inconsistent with the current research.

In general, it seems that the prevalence of bone changes does not follow a particular pattern, and the results largely depend on the study population. Mean age of the patients, duration of symptom onset, severity of the symptoms, and the presence or absence of parafunctional habits and malocclusion may be involved in the development of various bone changes. For instance, the findings of Krisjane (20) have indicated that TMJ-OA views, such as joint surface flattening and subchondral sclerosis, are more prevalent in malocclusions compared to the patients with class I occlusion.

In line with the results of the present study, a positive correlation was observed between pain and condylar bone changes in the studies by Pedroni (30), Kurita (41), Cevidanes (42), and Imani Moghaddam (43). The findings of Cevidanes (42) showed that the severity and duration of pain increase with the progress of condylar atrophy. Therefore, it could be argued that the progress of osteoarthritis (TMJ-OA) and accumulation of inflammatory factors in the joint may cause pain and bone changes. In addition, TMJ-OA is rarely observed without masticatory muscle myalgia. The presence and level of masticatory muscle myalgia could affect the expression of pain in different individuals.

In the current research, none of the TMJ bone changes had a significant correlation with restricted TMJ movement, which is in congruence with the results obtained by Dworkin (44). On the other hand, a significant correlation was observed between erosion and restricted oral movement in the study by Cho (39). Kilic (40) reported that flattening and sclerosis had significant associations with TMJ functioning, which is inconsistent with our findings.

In TMD, the physiological functioning of the body is adjusted to changes, reducing the symptoms. Therefore, one of the main reasons for the conflicting results in the literature could be the differences in the time since the onset of the symptoms, as well as the age range the muscular problems in the patients. Therefore, it is recommended that further investigation be conducted in this regard in order to examine the clinical symptoms and images of age-matched patients and determine the exact duration of the symptoms since the onset.

In the present study, flattening was the only bone change observed in the TMJ that had a significant correlation with clicking, which is in line with the results obtained by Alsawaf (45). The clicking sound is often heard when the disc returns to normal position in anterior disc displacement, which is a characteristic of the early stages of internal TMJ dysfunction, while flattening is a characteristic of the early stages of condyle bone changes. These damages are concurrent in the early stages, and severer changes and symptoms occur as the disease progresses.

Conclusion

According to the results, flattening was the most common bone change in the patients with TMD. A correlation was observed between almost all the types of bone changes and pain. However, restricted movement in the TMJ had no association with bone changes. Flattening was observed to be the only bone change to have a correlation with clicking. In addition, sclerosis, osteophytes, and erosion had significant associations with crepitation.

Conflicts of Interest

None declared.

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