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Correlation between Radiographic Findings, Clinical Findings and Joint Sounds of Temporomandibular Joint Osteoarthritis Patients

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Purpose: This study aims to evaluate the correlation between joint sounds and radiographic bone change patterns along with clinical symptoms of temporomandibular joint osteoarthritis (TMJ OA) patients.

Methods: The patients for this study were over 19 years of age, diagnosed tentatively with TMJ OA. The patients were examined with temporomandibular disorders analysis test and all three radiographs, including panoramic radiography, transcranial radiography, and cone beam computed tomography (CBCT). Information of the patients' age, pain status, joint sound and mouth opening range were collected. And bone change pattern was examined by reviewing panoramic radiography, transcranial radiography and CBCT images.

Results: The patients with crepitus had a higher average active mouth opening (AMO) range than patients without crepitus, and the group with bilateral crepitus had a higher average AMO range than the group with unilateral crepitus (p<0.001). And the patient with pain during mastication was increased in the group with clicking than the group without clicking, and the group with bilateral clicking showed a statistically significant increase in the patient with pain during mastication than the group with unilateral clicking (p<0.05). The analytical results of the relevance of crepitus showed a high correlation with bone change observed from each of the three radiographs. And the agreement in bone change findings from 3 groups of paired radiographs showed high agreement (p<0.001). Meanwhile, 77.2% of CBCT findings showed bone change of condyle without crepitus (p<0.001).

Conclusions: This study presented significant results in the evaluation of the correlation with crepitus and bone change of TMJ OA patients from panoramic radiography or transcranial projection. However, the accurate assessment is required through CBCT for the patient with complains of persistent pain, limitation of mouth opening, and occlusal change even if the crepitus does not exist.

Key Words: Clinical evaluation; Crepitus; Joint sound; Radiographic evaluation; Temporomandibular joint osteoarthritis

INTRODUCTION

The temporomandibular joint (TMJ) is one of the most complicated joints in the human body, which is composed of the mandibular condyle and temporal bone.[1] Past studies reported that 41% of the population have signs related to temporomandibular disorders (TMD) such as myofascial pain, TMJ internal derangement and TMJ degeneration.[2] One of the signs of TMD is TMJ osteoarthritis (TMJ OA),[1] which causes tissue degeneration due to the imbalance between the mechanical and biological synthesis and degradation of articular cartilage chondrocytes, extracellular matrix and subchondral bone.[3] It is most commonly caused by overload on the joint tissue. And the disease is induced

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when the articular surface is damaged by articular disc dislocation and retrodiscitis.[4)]

There are various symptoms for TMD such as pain during mouth opening and mastication, tenderness upon palpation on the TMJ and masticatory muscles, joint sound, and irregular mandibular movement. Joint sound is a common symptom observed on 25%-35% of asymptomatic persons, but the development of joint sounds are still in debate. It is generally described by articular disc displacement due to the extension or tear of ligaments,[5)] irregularity of the articular surface, articular disc-articular surface ankylosis, synovial degradation, and disc deformation.[6)] Clicking and crepitus are the most commonly used terms to express the various TMJ sounds. Clicking and reciprocal clicking, which occurs during both mouth opening and closing, are reported to be clinical symptoms of disc displacement with reduction and related to anterior disc displacement.[7)] Crepitus is generally known as a symptom of degenerative joint diseases,[8)] but other studies argue that a diagnosis cannot be concluded as OA with crepitus alone.[9)]

Diagnosis of TMJ OA is usually based on history taking and clinical examination. However, since there are no specific laboratory tests for the final diagnosis of TMJ OA, radiographic examinations such as panorama and conventional radiography are needed.[10)] Cone beam computed tomography (CBCT) is favored for it shows similar diagnostic efficiency to CT but with better accessibility and lower radiation exposure.[11)]

Many studies have been conducted to evaluate the relevance between the symptoms and signs of TMD and radiographic findings. While some studies[12)] report clinical symptoms such as pain and radiographs are highly associated, other studies were unable to find any relevance.[13)] Despite the functional, anatomical, and histological peculiarities of TMJ, more studies are needed in regard of the relevance between TMD and radiographs. Especially, there is an ongoing debate about the correlation between the diagnostic value of joint sounds and other clinical symptoms for TMJ OA, and more studies need to be conducted that analyzes joint sound and radiographic bone change patterns. Therefore, this study aims to evaluate the correlation between joint sounds and radiographic bone change patterns along with clinical symptoms of TMJ OA patients.

MATERIALS AND METHODS

1. Study Subjects

In this study, the patients were enrolled who visited Chosun University Dental Hospital between the dates of January 1, 2012 and August 31, 2015 with a chief complaint of joint sounds and discomfort such as TMJ pain and mouth opening limitation. The patients for this study were over 19 years of age, diagnosed tentatively with TMJ OA, and examined with TMD analysis test and all three radiographs, including panoramic radiography, transcranial radiography, and CBCT. The inclusion criteria for this study was based on the Diagnostic Criteria for TMD (DC/TMD).[14)] Patients under the age of 19 were excluded to except juvenile idiopathic arthritis. And patients with a history of trauma or lower jaw surgery, congenital deformation, and systemic disease related to condyle absorption (rheumatoid arthritis, systemic sclerosis, lupus erythematosus, etc.) were also excluded.[15)]

A total of 191 patients, 38 males (19.9%) and 153 females (80.1%), with an average age of 41.4±17.7 were included for this study. For each age group, 6 patients (3.1%) were in the age of 19, 65 patients (34.0%) in the 20s, 32 patients (16.8%) in the 30s, 16 patients (8.4%) in the 40s, 34 patients (17.8%) in the 50s, 25 patients (13.1%) in the 60s, and 13 patients (6.8%) were over 70 years of age.

This study protocol was approved by the Chosun University Dental Hospital Institutional Review Board (CUDH IRB-1502-005).

2. Methods

Information on the patients' age, pain status, joint sound and mouth opening range were collected. And bone change pattern was examined by reviewing panoramic radiography, transcranial radiography, and CBCT images. The joint sound criterion may be met by the patient's report of any joint noise or by the examiner's detection of any joint noise with jaw movements during the clinical examination. Radiographic interpretation was based on the comprehensive findings of dental specialists of oral medicine and oral-maxillofacial radiology.

CB MercuRay (Hitachi, Tokyo, Japan) was used for CBCT. The patient was scanned on P-mode with the head kept stationary and the occlusal surface parallel to the floor. The scanning conditions of tube voltage, tube current, and exposure time were set at 120 kVp, 15 mA, and 9.8 sec, respectively. All scanned data were processed through CB Works (Hitachi) software and saved as 512 cross-sectional images that supports the Digital Imaging and Communications in Medicine (DICOM) 3.0 format.

3. Statistical Analysis

IBM SPSS Statistics ver. 20.0 software (IBM Co., Armonk, NY, USA) was used for statistical analysis. Cohen's kappa (κ) analysis was used to analyze the correlation of bone change on the radiograph and the agreement between the three radiographs according to joint sound. The correlation between the pain pattern and active mouth opening (AMO) range following joint sound was analyzed using Fisher's exact test and linear by linear association (trend test).

RESULTS

1. Pain Pattern according to Type of Joint Sound

Joint sound was observed in 180 patients (94.2%) and an increase in pain was observed during mastication (p=0.037). Out of the 49 patients (25.7%) with bilateral crepitus, 32 patients (16.8%) had pain during mastication and 35 patients (18.3%) had pain during mouth opening. Unilateral crepitus was found in 85 patients (44.5%), and among them, 61 patients (31.9%) had pain during mastication and 62 patients (32.5%) had pain during mouth opening. There was no statistical significance in the correlation between crepitus and pain during mastication (p=0.757) and mouth opening (p=0.053). Bilateral clicking was observed in 48 patients (25.1%) and 28 patients (14.7%) had pain during mastication and mouth opening. Unilateral clicking was found in 71 patients (37.2%) and among them, 48 patients (25.1%) had pain during mastication and 47 patients (24.6%) had pain during mouth opening. Pain during mastication increased more in the group with clicking than the group without clicking. Also, there was a statistically significant increase in the pain during mastication in the group with bilateral clicking than the group with unilateral clicking (p=0.023). Bilateral popping was observed in 6 patients (3.1%), and 5 patients (2.6%) had pain during mastication and mouth opening. Unilateral popping was found in 9 patients (4.7%) and among them, 5 patients (2.6%) had pain during mastication and 4 patients (2.1%) had pain during mouth opening. There was no statistical significance in the correlation between popping and pain during mastication

Table 1. Pain pattern according to type of joint sound (n=191)

Variable	Pain during mastication		p-value	Pain during mouth opening		p-value
	No	Yes		No	Yes	
Joint sound			0.037*			0.344
None	0 (0.0)	11 (5.8)		2 (1.0)	9 (4.7)	
Exist	59 (30.9)	121 (63.4)		61 (31.9)	119 (62.3)	
Crepitus			0.757			0.053
None	18 (9.4)	39 (20.4)		26 (13.6)	31 (16.2)	
Unilateral	24 (12.6)	61 (31.9)		23 (12.0)	62 (32.5)	
Bilateral	17 (8.9)	32 (16.8)		14 (7.3)	35 (18.3)	
Click			0.023*			0.080
None	16 (8.4)	56 (29.3)		19 (9.9)	53 (27.7)	
Unilateral	23 (12.0)	48 (25.1)		24 (12.6)	47 (24.6)	
Bilateral	20 (10.5)	28 (14.7)		20 (10.5)	28 (14.7)	
Popping			1.000			1.000
None	54 (28.3)	122 (63.9)		57 (29.8)	119 (62.3)	
Unilateral	4 (2.1)	5 (2.6)		5 (2.6)	4 (2.1)	
Bilateral	1 (0.5)	5 (2.6)		1 (0.5)	5 (2.6)	

Values are presented as number (%).
*p<0.05 (p-value by trend test).

(p=1.000) and mouth opening (p=1.000; Table 1).

2. Correlation between Type of Joint Sound and AMO Range

The average AMO range was 32.8±9.0 mm in the group without any joint sounds and 41.2±8.5 mm in the group with joint sounds. And the average AMO range in patients without crepitus, with unilateral crepitus, and with bilateral crepitus were 38.9±10.2 mm, 41.2±8.4 mm, and 42.1±7.1 mm, respectively. Also, the average AMO range was 39.6±8.0 mm in patients without clicking, 41.1±9.8 mm in patients with unilateral clicking, and 42.0±7.9 mm in patients with bilateral clicking. And the average AMO range was 40.9±8.7 mm in patients without popping, 42.0±7.7 mm in patients with unilateral popping, and 35.2±9.2 mm in patients with bilateral popping. For the evaluation of the correlation between the type of joint sound and AMO range, AMO was converted to nominal variables divided into three groups: below 30 mm, 30-40 mm, and over 40 mm. Fisher's exact test was conducted by dividing a group without joint sounds and a group with more than one of the three joint sounds (crepitus, clicking, and popping) and mouth opening range increased in the group with joint sounds (p=0.006). Each joint sound was analyzed using linear by linear association. And the results showed that patients with crepitus had a higher average AMO range than patients without crepitus, and the group with bilateral crepitus had a higher average AMO range than the group with unilateral crepitus (p=0.002). There was no statistically significant correlation in the groups with clicking (p=0.284) or popping (p=0.264; Table 2).

3. Bone Change Findings for Each Radiography

From the observation results of bone change patterns for each radiography, bone change of both condyles was observed in 66 patients (34.6%) from panoramic radiography and transcranial radiography and 67 patients (35.1%) from CBCT. Bone change of the unilateral condyle was observed in 97 (50.8%), 96 (50.3%), and 110 (57.6%) patients from panoramic radiography, transcranial radiography, and CBCT, respectively. The number of patients without bone change was 28 patients (14.7%) for panoramic radiography,

Table 3. Bone change findings for each radiography (n=191)

Variable	Panoramic	Transcranial	CBCT
None	28 (14.7)	29 (15.2)	14 (7.3)
Unilateral side	97 (50.8)	96 (50.3)	110 (57.6)
Bilateral side	66 (34.6)	66 (34.6)	67 (35.1)

CBCT, cone beam computed tomography.
Values are presented as number (%).

Table 2. Correlation between type of joint sound and AMO range (n=191)

Variable	AMO (mm)	AMO (mm)			p-value
		Below 30	30-40	Over 40	
Joint sound					0.006*
None	32.8±9.0	4 (2.1)	4 (2.1)	3 (1.6)	
Exist	41.2±8.5	14 (7.3)	50 (26.2)	116 (60.7)	
Crepitus					0.002*
None	38.9±10.2	10 (5.2)	21 (11.0)	26 (13.6)	
Unilateral	41.2±8.4	6 (3.1)	21 (11.0)	58 (30.4)	
Bilateral	42.1±7.1	2 (1.0)	12 (6.3)	35 (18.3)	
Click					0.284
None	39.6±8.0	8 (4.2)	21 (11.0)	43 (22.5)	
Unilateral	41.1±9.8	8 (4.2)	19 (9.9)	44 (23.0)	
Bilateral	42.0±7.9	2 (1.0)	14 (7.3)	32 (16.8)	
Popping					0.264
None	40.9±8.7	16 (8.4)	49 (25.7)	111 (58.1)	
Unilateral	42.0±7.7	0 (0.0)	4 (2.1)	5 (2.6)	
Bilateral	35.2±9.2	2 (1.0)	1 (0.5)	3 (1.6)	

AMO, active mouth opening.
Values are presented as mean±standard deviation or number (%).
*p<0.05 (p-value by trend test and Fisher's exact test).

29 patients (15.2%) for transcranial radiography, and 14 patients (7.3%) for CBCT (Table 3).

4. Correlation of Radiographic Bone Change Pattern according to Type of Joint Sound

Based on the analytic results of the agreement by Cohen's kappa analysis, the kappa values for the relevance between the group without joint sounds and bone change patterns of the condyle observed from panoramic radiography and transcranial radiography were each κ=1.000 (p=0.001), and the kappa value for the relevance with bone change patterns observed from CBCT was κ=0.340 (p=0.013). The kappa value for the relevance between crepitus and bone change patterns of the condyle observed from panoramic radiography was κ=0.715 (p=0.000) as the kappa value for transcranial radiography was also κ=0.715 (p=0.000). And the kappa value for the relevance between crepitus and bone change from CBCT was κ=0.690 (p=0.000). The kappa values for the relevance between clicking and bone change patterns of the condyle observed from panoramic radiography, transcranial radiography, and CBCT were κ=0.540 (p=0.000), κ=0.533 (p=0.000), and κ=0.521 (p=0.000), respectively. The kappa value for the relevance between popping and bone change patterns of the condyle observed from panoramic radiography was κ=0.055 (p=0.000). Also, for transcranial radiography, the kappa value was κ=0.056 (p=0.000), and for CBCT, the kappa value was κ=0.065 (p=0.000; Table 4).

Table 4. Correlation of radiographic bone change pattern according to type of joint sound

Joint sound	Type of radiography	Kappa (κ)	p-value
None	Panoramic	1.000	0.001*
	Transcranial	1.000	0.001*
	CBCT	0.340	0.013*
Crepitus	Panoramic	0.715	0.000**
	Transcranial	0.715	0.000**
	CBCT	0.690	0.000**
Click	Panoramic	0.540	0.000**
	Transcranial	0.533	0.000**
	CBCT	0.521	0.000**
Popping	Panoramic	0.055	0.000**
	Transcranial	0.056	0.000**
	CBCT	0.065	0.000**

CBCT, cone beam computed tomography.
*p<0.05 (p-value by Cohen's kappa analysis), **p<0.001 (p-value by Cohen's kappa analysis).

5. Agreement of Bone Change Findings for Each Radiography

The agreement of bone change findings for each radiography was analyzed using Cohen's kappa analysis. The kappa value between panoramic radiography and transcranial radiography, panoramic radiography and CBCT, and transcranial radiography and CBCT was κ=0.971 (p=0.000), κ=0.884 (p=0.000), and κ=0.870 (p=0.000), respectively (Table 5).

Table 5. Agreement of bone change findings for each radiography

Variable	Kappa (κ)	p-value
Panoramic/transcranial	0.971	0.000**
Panoramic/CBCT	0.884	0.000**
CBCT/transcranial	0.870	0.000**

CBCT, cone beam computed tomography.
**p<0.001 (p-value by Cohen's kappa analysis).

6. Agreement of Crepitus Pattern to the Bone Change Pattern on Each Radiography

The accordance rate of the observed bone changes on both condyles from the panoramic radiography was 100.0% when crepitus was present bilaterally. Of the cases, 93.2% showed bone changes on the right condyle of the panoramic radiography within the existence of crepitus on the right. Of the accordance rate, 92.7% showed bone changes on the left condyle of the panoramic radiography within the existance of crepitus on the left. In the absence of crepitus, 38.6% did not observed bone change on condyle from panoramic examination. Cohen's kappa analysis of the agreement between the crepitus pattern and bone change pattern on panoramic radiography showed that the agreement was κ=0.715, which was statistically significant at p<0.0001 level.

The accordance rate of the observed bone change on both condyles from the transcracranial radiography was 100% when crepitus was present bilaterally. Of the cases, 88.6% showed bone changes on the right condyle of the transcranial radiography within the existence of crepitus on the right. Of the accordance rate, 95.1% showed bone changes on the left condyle of the transcranial radiography within the existence of crepitus on the left. In the absence of crepitus, transcranial radiography showed 40.4% of cases

Table 6. Agreement of crepitus pattern to the bone change pattern on each radiography (n=191)

Variable	Crepitus				Kappa (κ)	p-value
	Both	Rt.	Lt.	None		
Panorama					0.715	0.000**
Both	49 (100.0)	0 (0.0)	0 (0.0)	17 (29.8)		
Rt.	0 (0.0)	41 (93.2)	0 (0.0)	10 (17.5)		
Lt.	0 (0.0)	0 (0.0)	38 (92.7)	8 (14.0)		
None	0 (0.0)	3 (6.8)	3 (7.3)	22 (38.6)		
Transcranial					0.715	0.000**
Both	49 (100.0)	0 (0.0)	0 (0.0)	17 (29.8)		
Rt.	0 (0.0)	39 (88.6)	0 (0.0)	10 (17.5)		
Lt.	0 (0.0)	1 (2.3)	39 (95.1)	7 (12.3)		
None	0 (0.0)	4 (9.1)	2 (4.9)	23 (40.4)		
CBCT					0.690	0.000**
Both	49 (100.0)	0 (0.0)	0 (0.0)	18 (31.6)		
Rt.	0 (0.0)	44 (100.0)	0 (0.0)	15 (26.3)		
Lt.	0 (0.0)	0 (0.0)	40 (97.6)	11 (19.3)		
None	0 (0.0)	0 (0.0)	1 (2.4)	13 (22.8)		

CBCT, cone beam computed tomography; Rt., right; Lt., left.
Values are presented as number (%).
**p<0.001 (p-value by Cohen's kappa analysis).

in which conlylar bone change was not observed. Cohen's kappa analysis showed the agreement between the crepitus pattern and bone change paterrn on transcranial radiography showed that the agreement was κ=0.715, which was statistically significant at p<0.0001 level.

The accordance rate of bone change on both condyles with bilateral crepitus was 100% from the CBCT. Of the cases, 100% showed bone changes on the right condyle of CBCT within the existence of crepitus on the right. Of the accordance rate, 97.6% showed bone changes on the left condyle of the CBCT within the existence of crepitus on the left. In the absence of crepitus, CBCT showed 22.8% of cases in which conlylar bone change was not observed. Cohen's kappa analysis showed the agreement between the crepitus pattern and bone change paterrn on CBCT showed that the agreement was κ=0.690, which was statistically significant at p<0.0001 level (Table 6).

DISCUSSION

OA of the TMJ is degenerative disease that causes destruction of joint tissues of the condyle and articular fossa due to increased load and stimulation.[16] It is defined by the gradual decrease of the articular cartilage related to subchondral bone hypertrophy, and the bone undergoes reactive hyperplasia that forms peripheral osteophytes.[17] The symptoms of TMJ OA include pain on palpation, functional pain, joint sound, masticatory muscle pain, and mandibular movement limitation, and the pain tend to increase in the afternoon.[18] And grinding and crepitus are common,[19] especially for joint sounds, accompanied with or without clicking.[20] In cases of severe bone loss, the strong contact between molars can create a fulcrum effect, causing the rotation of the mandible and induce anterior open bite.[21] Early stages of OA is clinically and radiographically difficult to differentially diagnose with other TMD symptoms and in late stages of OA, ankylosis or joint instability can occur and an increased bone change pattern are observed on the radiographs.[22]

Because of the various clinical symptoms of TMJ OA, many studies have been conducted to evaluate the relevance between the symptoms and OA, but the results are still in debate. According to the study by Wiese et al.,[23] the correlation between pain and bone change pattern observed from TMJ tomography was uncertain. And there was no statistical significance in the relevance of TMJ OA and clinical symptoms such as joint sound (clicking, crepitus), tenderness on palpation, and mouth opening range.[24]

Based on the analytical results of joint sounds and pain patterns (Table 1), the patients suffering from pain during mastication was increased in the group with joint sounds than the group without joint sounds (p=0.037). Also, the patient with pain during mastication was increased in the group with clicking than the group without clicking, and the group with bilateral clicking showed a statistically significant increase in the patient with pain during mastication than the group with unilateral clicking (p=0.023). However, this study was limited to patients who visited the dental hospital rather than to randomly selected patients, thus, further research needs to be conducted with general population. Moreover, additional research is needed to clarity the cause and pattern of pain and the pain area.

Meanwhile, an interesting result was drawn from this study for joint sounds and AMO range (Table 2). The AMO range was converted to a nominal variable divided into three groups (below 30 mm, 30-40 mm, over 40 mm), and then Fisher's exact test was conducted by dividing it into a group without joint sounds and a group with at least one joint sound out of the three (crepitus, clicking, popping). The results showed a statistically significant increase in AMO range for the group with joint sounds (p=0.006). Also, from the analytical results by linear by linear association, patients with crepitus showed a higher AMO than patients without crepitus (38.9±10.2 mm), and the group with bilateral crepitus (42.1±7.1 mm) had a higher AMO than the group with unilateral crepitus (41.2±8.4 mm) ($p<0.05$). In other words, an increase in mouth opening range was observed as the developmental pattern of crepitus increases. This observation may be affected by the inclusion of patients accompanied by disc displacement without reduction in TMJ OA patients without joint sounds. And the presence of crepitus is thought to be a result of the possible sliding movement of the condyle.

According to the study by Gray[25] TMJ OA occurs more commonly on one side than both sides. Also, for bilateral OA, it is common for one side to manifest more severe symptoms than the other and that the length difference of the mandibular ramus or parafunctional habits such as unilateral mastication are related to this phenomenon.[26] These findings coincide with the study results, as bone change of the condyle was observed on both sides in 66 patients (34.6%) each from panoramic radiography and transcranial radiography, and in 67 patients (35.1%) from CBCT. Bone change on only one side of the condyle was observed in 97 patients (50.8%) from panoramic radiography, 96 patients (50.3%) from transcranial radiography, and 110 patients (57.6%) from CBCT, having more unilateral TMJ OA patients than bilateral TMJ OA patients (Table 3).

The degeneration of the mandibular condyle can be divided into 4 classifications: sclerosis, erosion, flattening, and osteophyte, based on morphological change and cortical delineation. Sclerosis is commonly observed in early stages, while erosion or osteophyte formation is found in late stages. As this study only assessed the presence of bone change without classifying change patterns, further studies of a more subdivided evaluation of bone change patterns may be needed.

Crepitus is mentioned in various studies, while several studies report that crepitus has low sensitivity for diagnosis, other studies report that from the clinical symptoms such as pain on palpation, joint sound, subjective pain, only joint sound is related to the degenerative bone change of the condyle observed from radiographs (panoramic radiography, TMJ tomogram, transcranial radiography).[3] Although the usefulness of crepitus for TMJ OA diagnosis is still in debate, according to the DC/TMD, crepitus is an important criteria which is advised for definite diagnosis with CBCT.[14] While chronic OA can be observed through T1- and T2-weighted magnetic resonance images (MRI),[27] according to the study by Kye et al.,[28] there is a significant correlation between crepitus and osteophytes observed from MRI. Also, condyle-disc deformity can occur without pain, and crepitus is an important clinical symptom in condyle-disc degeneration. From the analytical results of bone change patterns of the mandibular condyle observed from radiographs (panoramic radiography, transcranial radiography, CBCT), according to joint sounds, using Cohen's kappa analysis, a high correlation was shown from the group without joint sounds and from panoramic radiography and transcranial radiography. And the analytical results of the relevance of crepitus showed a high correlation with bone change observed from each of the three radiographs (Table 4). In this regard, crepitus is an important symptom and highly significant than other clinical symptoms in the correlation with bone change patterns observed from radiographs.

In this study, based on the analytical results by Cohen's kappa analysis of the agreement in bone change findings from 3 groups of paired radiographs (panoramic radiography/transcranial radiography, panoramic radiography/CBCT, transcranial radiography/CBCT) (Table 5), all 3 groups showed high agreement. Thus, unlike previous studies, panoramic and transcranial radiography can also be useful in the observation of bone change patterns of the mandibular condyle. However, since the radiographic interpretations were decided through a simple discussion without considering inter-examiner reliability and intra-examiner reliability, further studies may be needed to compensate in this regard. Also, while panoramic radiography is useful to observe the medial surface of the condyle and transcranial radiography is useful to observe the lateral surface of the condyle, in this study, the agreement between the two radiographs was high (Table 5). This result may present the possibility that bone change of the mandibular condyle in some TMJ OA patients does not progress only on one side of the medial or lateral surface but comprehensively around the condyle. Thus, it may be more efficient to use both types of radiographs for the evaluation of TMJ OA.

Meanwhile, 77.2% of CBCT findings showed bone change of condyle without crepitus (Table 6). Considering this point, an additional evaluation of CBCT may be necessary in the patient with persistent pain or restriction of mouth opening even though the crepitus aspect is not clearly observed.

As advised from RDC/TMD[29] and DC/TMD,[14] CBCT is more useful and valuable for the diagnosis of bone change patterns. But this study presented significant results (Tables 4-6) in the evaluation of the correlation with crepitus and bone change of OA patients from panoramic radiography or transcranial projection. According to a study comparing the accuracy of TMJ observation with CBCT, panoramic radiography showed accuracy of 90.64% and transcranial projection showed accuracy of 86.97%.[30] Since most TMD patients do not scan CBCT for initial examination, panoramic radiography and transcranial projection may be helpful in the diagnosis of TMJ OA through careful observation.

In conclusion, in the case of the early stage TMJ OA, there is a possibility that bone change is not observed on the radiography, and there is also a case where the TMJ OA proceeds without clinical symptoms such as crepitus. Therefore, a more accurate assessment is required through CBCT for the patient with complains of persistent pain, limitation of mouth opening, and occlusal change even if the crepitus does not exist. In addition, when crepitus is present in the absence of any particular discomfort of the patient, and bone change pattern is clearly observed in the panoramic radiography and transcranial radiography, the bone may actually be remodeling, resulting in a clinically stable arthrosis. Thus, the diagnosis should be made considering the various test results in a comprehensive manner.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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