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Comparative study of the prevalence of temporomandibular joint osteoarthritic changes in cone beam computed tomograms of patients with or without temporomandibular disorder

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Objectives. To compare the prevalence of temporomandibular joint (TMJ) osteoarthritic changes in cone beam computed tomography (CBCT) images of temporomandibular disorder (TMD) and non-TMD patients.

Study Design. A retrospective analysis of CBCT images of the joints of TMD and non-TMD patients was performed. The presence or absence of osteoarthritic changes (condylar erosion, osteophyte, subcortical cyst, or generalized sclerosis) in each TMJ was evaluated. The prevalence within the two study groups were compared by using Chi-square statistics.

Results. At least one type of osteoarthritic change was present in78.6% of joints in the TMD group and 79.7% in the non-TMD group. No significant difference was found in prevalence of osteoarthritic changes between the TMD and non-TMD groups in the overall study sample or within the subsets of gender and age in the groups.

Conclusions. The lack of a significant difference in prevalence of TMJ osteoarthritic changes in TMD and non-TMD patients highlights the equivocal relationship between osseous TMJ morphology and degenerative bone disease. (Oral Surg Oral Med Oral Pathol Oral Radiol 2015;120:78-85)

It is currently accepted that imaging of the temporomandibular joint (TMJ) should only be performed if imaging may have a diagnostic and therapeutic impact.[1] However, there is still no clear evidence indicating when patients with temporomandibular disorder (TMD) should undergo an imaging procedure. Therefore, clearly defined referral criteria based on scientific evidence for imaging of the TMJ are needed,[1] especially when it involves ionizing radiation.

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), provides a standardized approach to the diagnosis of TMDs.[2] In 2009, as part of the RDC/TMD Validation Project,[3] comprehensive TMJ diagnostic criteria were developed for image analysis. An osseous diagnosis of osteoarthritis of the TMJs was defined as the presence (in TMJ images) of TMJ deformation caused by subcortical cyst, surface erosion, osteophyte, or generalized sclerosis; and computed tomography (CT) was advocated as the imaging modality of choice for osseous tissues.[3] However, the clinical significance of such morphologic changes of the osseous component of the TMJs is questionable considering the conflicting findings about the relationship between the radiographic findings on CT or cone beam CT (CBCT) and the clinical signs and symptoms.[4,5] Furthermore, some authorities have highlighted the need for testing the hypothesis that patients with TMD who have TMJ-related pain and dysfunction with specific clinical symptoms do not differ from control patients with regard to the presence of specific imaging signs of TMJ osteoarthritis.[6]

Although there are numerous studies that have investigated osseous TMJ morphology in symptomatic patients, only one study has compared the prevalence of osteoarthritic changes in the CBCT images of symptomatic and asymptomatic patients, investigating only one type of osteoarthritic changes (surface erosion).[5] However, that study excluded symptomatic patients who were free of

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Statement of Clinical Relevance

The results of this study highlight the equivocal relationship between osseous temporomandibular joint (TMJ) morphology and degenerative bone disease and may aid in further assessment of the clinical significance of such morphologic changes and in the development of clearly defined criteria for TMJ imaging.

Table I. Causes of exclusion of patients

Cause of exclusion	*No. of patients excluded (No. of TMJs)*
No occlusal stops (including completely edentulous jaws)	22 (44)
History of orthodontic treatment	9 (18)
Craniofacial abnormalities	6 (12)
Full mouth rehabilitation	4 (8)
Trauma/maxillofacial surgery	3 (6)
Insufficient clinical information	3 (6)
Polyarthritic disorder (Sjogren syndrome)	2 (4)
Total	**49 (98)**

TMJ, temporomandibular joint.

Table II. Causes of exclusion of individual TMJs

Cause of exclusion	*No. of TMJs excluded*
Motion artifacts	75
Degraded image quality	2
TMJ ankylosis	1
Total	**78**

TMJ, temporomandibular joint.

radiographically detectable osteoarthritic changes. The exclusion of such an important patient cohort may have overestimated the prevalence of erosions in symptomatic patients compared with asymptomatic patients.

Therefore, this study aims to investigate the prevalence of TMJ osteoarthritic changes in sectional CBCT images of all TMD and non-TMD patients imaged within a certain period and to compare the prevalence between the two groups. The results of the study may help TMD investigators and clinicians more clearly assess the clinical significance of such morphologic changes and aid in the development of clearly defined, evidence-based referral criteria for imaging of the TMJs.

MATERIALS AND METHODS

The design of the present study is a retrospective comparative survey of CBCT images of patients attending the King Saud University College of Dentistry and who had undergone a CBCT examination (for any reason) in which the TMJs were visible. The study protocol was submitted for review by the Dental Ethics Review Board of the College of Dentistry Research Center and was granted approval (registration number NF 2228); the study is in compliance with the Helsinki Declaration. Analysis of CBCT data sets from the archives of the Radiology Department of the College of Dentistry was undertaken. The inclusion criteria were all the retrievable CBCT data sets acquired during a consecutive period (January 1, 2008 to November 9, 2010) and which included the TMJs within the field of view (FOV) of the CBCT volume. The patient' files were then reviewed, and patients whose files or CBCT images indicated the presence of any of the conditions listed in Table I or Table II were excluded from the study.

The patients were then classified as "TMD patient" or "non-TMD patient." A patient was classified as a "TMD patient" if the review of the patient's file indicated that he or she was referred for CBCT imaging of the TMJs, was undergoing TMJ therapy, was being followed up by a TMJ specialist, or had any signs, symptoms, or complaints related to the TMJs. The patient's gender and age at the time of CBCT imaging were also noted. Lack of mention in a patient's file of any one of the following led to inclusion of the patient within the asymptomatic group: TMD signs or symptoms; any therapy related to the TMJs; examination or follow-up by a TMJ specialist; or referral for CBCT imaging of the TMJs.

The full specifications of the CBCT device used to obtain the images, the reformatting software, and the viewing device and conditions have been described in a previous article.[7] The CBCT images were acquired with an Iluma device (Imtek Imaging, 3M company, St. Paul, MN) which utilized a large FOV flat panel detector 19 × 24 cm in size. The images had been acquired using 3.8 mA and 120 kVp with either the full FOV or with collimation to one-half its height. The scan time was either 39.9 seconds or 20 seconds. The reconstructed voxel size was 0.29 mm.

Two calibrated oral and maxillofacial radiologists with 8 and 12 years of experience, respectively, in TMJ imaging and interpretation, and 5 years of experience each in interpretation of CBCT images, performed the reformatting and interpretation of the TMJ sectional images. The CBCT data sets were processed with reformatting software (IlumaVision 3-D, Imtek Imaging, 3M company). Corrected sagittal and coronal images of each TMJ were obtained using the orthogonal reformatting module of the reformatting software. Images were viewed as 0.29-mm thick contiguous slices (thinnest slice thickness possible). The images were viewed on a liquid crystal display (LCD) monitor (Dell Ultrasharp 2408 WFP- 24" Widescreen Flat Panel Monitors) in a dimly lit room. All the slices were viewed throughout the entire thickness of the TMJ in both the sagittal and coronal planes. The examiners were permitted to adjust window level and width and magnification for optimal clarity.

The examiners evaluated the presence or absence of osteoarthritic changes in the condylar component of each TMJ. The criteria used for radiographic diagnosis of osteoarthritis were those defined by the RDC/TMD Validation Project,[3] that is, the presence of subcortical

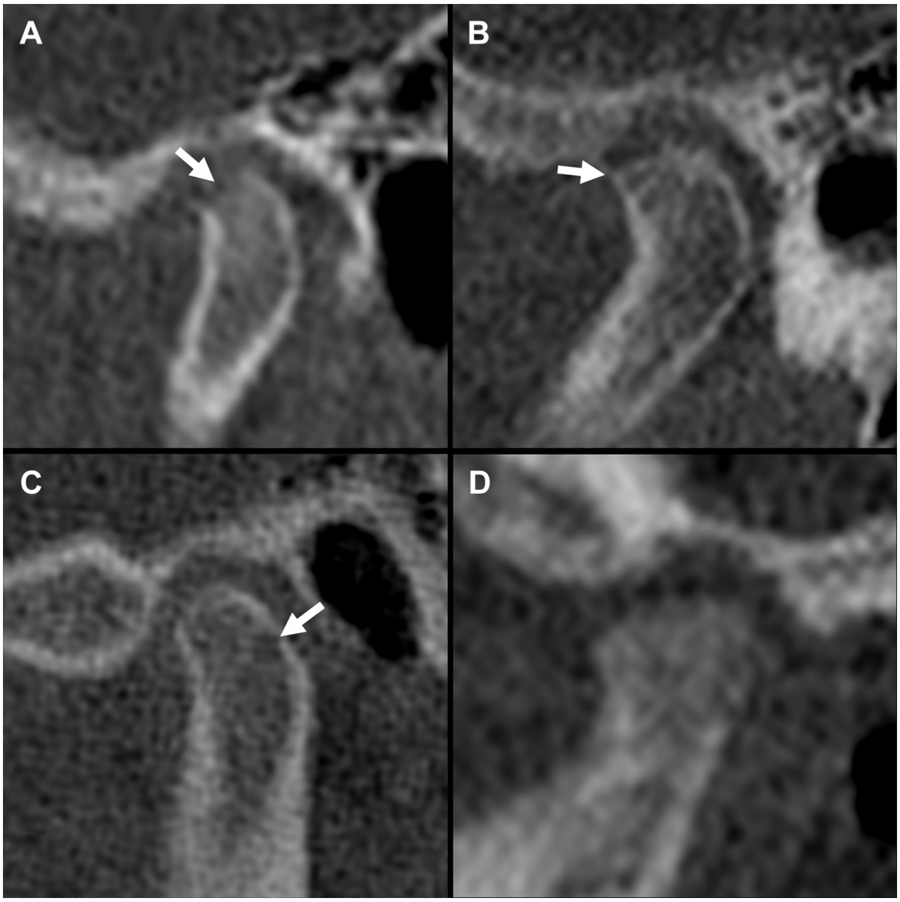

Fig. 1. Sample of condyles demonstrates osseous changes considered as osteoarthritic within the present study. A, Erosion (*arrow*). B, Osteophyte (*arrow*). C, Subcortical cyst (*arrow*). D, Generalized sclerosis.

Table III. Number of joints in each study group, with age and gender distribution

Age range (in years)	*Gender*	*Non-TMD group*	*TMD group*	*Total*
10−20	Female	17	8	25
	Male	4	4	8
21−30	Female	12	10	22
	Male	20	8	28
31−40	Female	10	6	16
	Male	13	2	15
41−50	Female	20	10	30
	Male	11	0	11
51−60	Female	10	6	16
	Male	8	2	10
61−70	Female	0	0	0
	Male	2	0	2
71−80	Female	0	0	0
	Male	1	0	1
Total		**128**	**56**	**184**

cyst, surface erosion, osteophyte, or generalized sclerosis. Erosion was defined as the absence of surface cortication along any area of the bone surface. Osteophytes were defined as marginal outgrowths of bone. Pseudo-osteophytes (angular shape of condyle resulting from flattening of an adjacent surface) were not considered osteophytes. Figure 1 demonstrates samples of osseous changes considered osteoarthritic within the present study.

The examiners interpreted the images independently of one another and evaluated each TMJ once. And in cases of disagreement, the examiners evaluated the images for a second time together, and a consensus was reached. When both examiners were unsure of the presence of a finding, the finding was considered to be not present. The examiners were blinded as to the patients' age and which group the patient belonged to ("TMD" or "non-TMD").

The prevalence of overall and individual osteoarthritic changes in the TMD and non-TMD groups were analyzed by descriptive statistics, and the prevalence within the two groups were compared by use of Chi-square statistics. When the expected frequency in at least one cell of the chi-square tables was less than 5, a corrected Chi-square test (Fisher exact test) was used. Significance level was set at $P = .05$.

Table IV. Number of joints with detected osteoarthritic changes in each study group

	Non-TMD group (%)	*TMD group (%)*	P *value*
Combined changes			
Absent (38)	26 (68.4)	12 (31.6)	.846*
Present (146)	102 (69.9)	44 (30.1)	
Erosion			
Absent (60)	39 (65)	21 (35)	.349*
Present (124)	89 (71.8)	35 (28.2)	
Osteophyte			
Absent (90)	64 (71.1)	26 (28.9)	.656*
Present (94)	64 (68.1)	30 (31.9)	
Generalized sclerosis			
Absent (171)	117 (68.4)	54 (31.6)	.183†
Present (13)	11 (84.6)	2 (15.4)	
Subcortical cyst			
Absent (175)	121 (69.1)	54 (30.9)	.448†
Present (9)	7 (77.8)	2 (22.2)	

*Chi-square statistic.
†Fisher exact test.

RESULTS

The CBCT data sets of 180 patients were obtained (360 individual TMJs). Based on the exclusion criteria, a total of 176 joints were excluded. Tables I and II demonstrate the number of excluded patients and joints, respectively, and the causes for their exclusion. A total number of 184 joints were, thus, included in the study. Of the included joints, 56 were classified within the TMD group, and 128 within the non-TMD group. Table III demonstrates the distribution of the joints, according to study group (TMD group or non-TMD group), age range, and gender.

The prevalence of osteoarthritic changes within the TMD and non-TMD groups is shown in Table IV. The percentage of joints with at least one type of osteoarthritic change was 78.6% in the TMD group and 79.7% in the non-TMD group. No significant difference was found in the prevalence of overall or individual osteoarthritic changes between the two groups.

Table V demonstrates the number of joints with osteoarthritic changes in each study group cross-tabulated with age range. An insufficient number of patients were available for analysis for the following subsets: patients in their seventh and eighth decades; patients with subcortical cysts and were in their fourth and sixth decades; and patients with generalized sclerosis and in their sixth decade. For all other findings and age ranges included in the study, no significant difference was found within the various age groups in the prevalence of combined osteoarthritic changes or individual osteoarthritic changes between the TMD and non-TMD groups.

Table VI demonstrates the number of joints with osteoarthritic changes in each study group cross-tabulated with gender. Within the female and male subsets, no significant difference was found in the prevalence of combined osteoarthritic changes or individual osteoarthritic changes between the TMD and non-TMD groups.

DISCUSSION

In the present study, the pool of CBCT images of the TMD and non-TMD patients was used as a sample of convenience. The TMJs were visible in a large proportion of the CBCT examinations in the older CBCT archives because during that period the only available option for CBCT imaging in the College of Dentistry was use of a large FOV or collimation to one-half the height of the large FOV; both FOV options included the TMJs.

Use of such a sample of convenience for the non-TMD group is one of the limitations of the present study. Random selection of symptomatic and asymptomatic patients from the general population may have provided samples more representative of the general population. However, we considered exposing such asymptomatic patients to the ionizing radiation of the CBCT examination purely for research purposes to be unethical. Thus patients who underwent CBCT for other reasons were used instead, and the exclusion criteria used were an attempt to minimize the presence of possible confounding factors that may possibly affect TMJ morphology.

The retrospective design is another limitation of the present study. Because of the retrospective design of the study, it was not possible to evaluate the clinical status of the TMJ at the time of image acquisition in a standardized manner. The present results, nonetheless, may provide insight into the morphology of TMJs of patients without TMD, which may provide an impetus for further research.

The criteria used in the present study for radiographic identification of osteoarthritic changes were those defined by the RDC/TMD Validation Project[3] for osteoarthritis, which were further validated by Palconet et al. and advocated as the criteria of choice because they are based on the RDC/TMD.[4] The authors of the RDC/TMD Validation Project stated that the term "degenerative joint disease" may be better than "osteoarthritis" but that "osteoarthritis" might be the best term to use for the interpretation of radiographs and images when no clinical information is available.[3] However, we find it difficult to reconcile the term "osteoarthritis," which is an age-related degenerative process,[8] with the presence of the aforementioned osseous findings in young patients in their second and third decades of life. Therefore, in the present study, we have chosen to refer to such osseous findings as "osteoarthritic changes," rather than "osteoarthritis."

Similar to the RDC/TMD Validation Project,[3] the osteoarthritic changes considered in the present study

Table V. Number of joints with osteoarthritic changes in each study group cross-tabulated with age group

	Combined changes			*Erosion*			*Osteophyte*			*Generalized sclerosis*			*Subcortical cyst*		
	Known disease status			*Known disease status*			*Known disease status*			*Known disease status*			*Known disease status*		
Age	*Non-TMD*	*TMD*	P *value*	*Non-TMD*	*TMD*	P *value*	*Non-TMD*	*TMD*	P *value*	*Non-TMD*	*TMD*	P *value*	*Non-TMD*	*TMD*	P *value*
10−20															
Absent	2	3	.328*	2	5	.071*	12	8	.719*	18	12	.284*	19	12	.523*
Present	19	9		19	7		9	4		3	0		2	0	
20−30															
Absent	5	3	.609*	7	7	.169†	18	6	.103†	26	17	.398*	31	16	.291*
Present	27	15		25	11		14	12		6	1		1	2	
30−40															
Absent	7	1	.642*	8	2	.483*	11	1	.108*	23	7	.258*	23	8	—‡
Present	16	7		15	6		12	7		0	1		0	0	
40−50															
Absent	4	1	.647*	11	2	.458*	10	6	.150*	29	10	.567*	29	10	.567*
Present	27	9		20	8		21	4		2	0		2	0	
50−60															
Absent	8	4	.563*	11	5	.648*	12	5	.587*	18	8	—‡	18	8	—‡
Present	10	4		7	3		6	3		0	0		0	0	
60−70															
Absent	0	0	—‡	0	0	—‡	0	0	—‡	2	0	—‡	0	0	—‡
Present	2	0		2	0		2	0		0	0		2	0	
70−80															
Absent	0	0	—‡	0	0	—‡	0	0	—‡	2	0	—‡	1	0	—‡
Present	1	0		1	0		0	0		0	0		0	0	

*Fisher exact test.
†Chi-square statistic.
‡Insufficient sample number.

Table VI. Number of joints with osteoarthritic changes in each study group cross-tabulated with gender

Gender	Combined changes – Known disease status: Non- TMD	Combined changes: TMD	P value	Erosion – Known disease status: Non- TMD	Erosion: TMD	P value	Osteophyte – Known disease status: Non- TMD	Osteophyte: TMD	P value	Generalized sclerosis – Known disease status: Non- TMD	Generalized sclerosis: TMD	P value	Subcortical cyst – Known disease status: Non- TMD	Subcortical cyst: TMD	P value
Male															
Absent	11	3	.621*	16	7	.230*	25	5	.421†	50	16	.191*	55	14	.602*
Present	48	13		43	9		34	11		9	0		4	2	
Female															
Absent	15	9	.554*	23	14	.859†	39	21	.684†	67	38	.623*	66	40	.297*
Present	54	31		46	26		30	19		2	2		3	0	

*Fisher exact test.
†Chi-square statistic.

were only those detected within the condylar component because of the reportedly lower prevalence of such findings in the temporal component,[9,10] and no attempts were made to designate the extent of the osseous changes because such designations may be highly subjective, difficult to standardize, and reduce reliability.[3]

The diagnostic efficacy of CBCT in the detection of morphologic changes of the osseous components of the TMJs has been found to be very high,[11,12] with interactive viewing of CBCT images reportedly being more accurate than viewing of static images.[13] Thus, the examiners in the present study were permitted to view the images interactively, adjusting window and zoom level, as necessary, to improve the clarity of the osseous structures. The intraobserver and interobserver reliability of detection of TMJ erosions on CBCT images have both been found to range from 0.65 to 0.81,[11] which is good but not excellent. Thus, in the present study, consensus of the examiners was required for determination of presence or absence of osteoarthritic changes.

To our knowledge, the present study is the only study that attempts to compare the prevalence of TMJ osteoarthritic changes in sectional CBCT images of TMD and non-TMD patients. Previous studies[5,14,15] have compared osseous morphology of symptomatic and asymptomatic joints but have used different imaging techniques and diagnostic criteria. The present study's findings are in agreement with those of Mupparapu et al.[14] and Emshoff et al.,[15] who found no significant difference between the morphology of symptomatic and asymptomatic joints, even though their studies used conventional tomography and magnetic resonance imaging, respectively, and investigated different osseous changes (including surface flattening) from those in the present study.

The results of the present study, on the other hand, are in conflict with those of Cevidanes et al.,[5] who found profound differences in condylar erosive changes between the condyles of asymptomatic patients and those classified radiographically as osteoarthritic, and they reported that the extent of the resorptive changes paralleled pain severity and duration. The contrasting results of the study by Cevidanes et al.[5] and those of the present study may be explained by different patient inclusion and exclusion criteria and imaging parameters. In the former study, the inclusion criteria for symptomatic patients stipulated that all cases meet the radiographic diagnosis criteria for osteoarthritis. Thus, patients without osteoarthritic changes were excluded from the study group but not from the control group, increasing the difference in recorded prevalence of erosion between symptomatic and asymptomatic patients. Furthermore, the exclusion criteria applied to the control group in the former study were not applied to the study group, which may have possibly led to a further imbalance in the results between the two groups.

On the other hand, in the former study a clinical examination was performed on patients with TMJ pain, and the control group denied any symptoms; so the grouping of patients into symptomatic and asymptomatic groups used in that study may have been more representative of the clinical status of the TMJs compared with the grouping used in the present study.

The CBCT reconstruction parameters and viewing modality are other possible explanations for the differences in the results of the study by Cevidanes et al.[5] and those of the present study. For the CBCT voxel volume used in the former study was more than four times that used in the present study, and the former study used image segmentation of volume-rendered images to detect the surface erosions. These two factors may possibly have limited the visualization of erosive changes in the former study to only gross or marked erosions.[16-20] Therefore, it is conceivable that the differences in the results of the study by Cevidanes et al.[5] and those of the present study may also be influenced by the fact that only marked changes were visible in their images, whereas small detailed findings were detected in the sectional images in the present study. It is also conceivable that differences in the results may be caused by use of different CBCT devices.[21]

The findings of the present study are compatible with the findings of studies that have found no relationship between the presence of abnormal TMJ clinical signs and symptoms and osteoarthritic changes in CBCT images.[4] Regarding the prevalence of osteoarthritic changes detected on the CBCT images of TMD patients, the prevalence rates of erosions and osteophytes in the present study are comparable with the findings of Alexiou et al.[22] but higher than those reported by Alkhader et al.[23] A possible cause for the higher rates in the present study may be the use of thinner image slices, which may have allowed the visualization of smaller areas of osseous changes.

By demonstrating a similar prevalence of osteoarthritic changes in TMD and non-TMD patients, the results of the present study highlight the equivocal relationship between osseous TMJ morphology and degenerative bone disease. However, based on the findings of previous studies, it is possible that the extent of the degenerative changes may possibly be correlated with TMD signs or symptoms. Therefore, further prospective studies are recommended to compare the prevalence of TMJ degenerative changes in CBCT sectional images of symptomatic and asymptomatic patients, in which a standardized clinical examination of the TMJs of each patient undergoing a CBCT examination is performed based on the RDC/TMD criteria to more accurately categorize symptomatic and asymptomatic patients, and in which the extent of the osteoarthritic changes are objectively categorized and correlated with TMD signs and symptoms. Objective categorization of the extent of the degenerative changes may be attempted with use of standardized CBCT voxel size and slice thickness, and categorization based on number of image sections in which the degenerative changes are visible.

CONCLUSIONS

Within the limitations of the study, no significant difference in the prevalence of TMJ osteoarthritic changes was detected in the CBCT images of TMD and non-TMD patients. The results thus highlight the equivocal relationship between osseous TMJ morphology and degenerative bone disease.

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