

Accuracy of Panoramic Radiography for Degenerative Changes of the Temporomandibular Joint

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ABSTRACT

Background: Temporomandibular joint (TMJ) morphologies are complex, and changes in joint components have been studied extensively. TMJ conditions have many different etiologies, appearances, and relevant clinical significance. **Objective:** The objective of this study was to evaluate the concordance of the diagnosis of degenerative changes in the TMJ in panoramic radiographs. **Materials and Methods:** Cone beam computed tomography (CBCT) was used as a reference standard. Images of 84 patients (168 TMJs), 61 females (72.6%) and 23 males (27.4%) with an average age of 47.4 years, were evaluated by three radiologists who established the presence or absence of degenerative changes in the jaw heads. The data were collected and organized in a spreadsheet. Concordance between evaluators was analyzed using agreement percentages, statistical κ , and confidence intervals. In the analysis of compliance with CBCT, sensitivity, specificity, predictive positive and negative values, and probabilities of false positives and negatives were also calculated. All inferential tests were performed with a 5% significance level. **Results:** The percentage of agreement among raters in panoramic radiographs ranged from 66.7% to 82.9%, considered mild to moderate. Correlation between radiographic and tomographic images ranged from 45.5% to 64.9% in the inter-evaluator reviews, representing a very mild agreement. Sensitivity ranged from 28.6% to 58.7% and specificity from 66.7% to 100.0%. Positive predictive value ranged from 77.1% to 100.0%; the negative predictive value was lower, ranging from 32.2% to 54.8%. The probability of false negatives was higher than that of false positives, ranging from 45.2% to 67.8%. **Conclusion:** The rater did not reach acceptable diagnosis levels.

KEYWORDS: Cone beam computed tomography, panoramic radiography, temporomandibular joint disorders

Received : 06-10-19.
Accepted : 26-12-19.
Published : 11-02-20.

INTRODUCTION

Studies on the temporomandibular joint (TMJ) have been controversial, despite the historical evolution of research conducted showing a better understanding of the structure, physiology, and anatomy of this region. It is also an articulation that allows several operations, such as opening, closing, protrusion, retrusion of the mandible, and lateral, which is considered the most complete articulation.^[1,2]

The TMJ is also known for high adaptability and remodeling of the head mandible.^[3] Many conditions affect the jaw joints, such as erosion and osteophyte planing.^[4] These degenerative bone changes are significantly more frequent in the condyle than those in the articular eminence. They are challenging to detect

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How to cite this article: Oliveira SR, Oliveira RD, Rodrigues ED, Junqueira JC, Panzarella FK. Accuracy of panoramic radiography for degenerative changes of the temporomandibular joint. J Int Soc Prevent Communit Dent 2020;10:96-100.

Access this article online	
<p>Quick Response Code:</p> 	<p>Website: www.jispcd.org</p>
	<p>DOI: 10.4103/jispcd.JISPCD_411_19</p>

in conventional radiography due to the overlapping of anatomic structures.^[4,5] Clinical examination is critical in the evaluation of TMJ; however, it has its limitations. Thus, additional methods are necessary to obtain data that complement the clinical examination in the diagnosis and treatment of TMJ changes. It is in this context that tests are required through images, which provide important additional information for diagnosis.^[6-8]

Knowledge of the various imaging tests and a correct indication is key to diagnosing temporomandibular disorders (TMDs), especially in patients with large overlapping signs and symptoms. Researchers have evaluated the main diagnostic imaging tests of TMD, and have rationally discussed their suitability, advantages, and disadvantages. The authors concluded that the clinical findings might be of greater relevance, leading to diagnoses associated with TMD and determining the need for additional images instead of using panoramic images in all patients with facial pain and TMD.^[5,6,9]

Authors used computed tomography (CT) scanning as the gold standard and assessed the reliability and validity of panoramic radiography for detecting bone alterations TMJs.^[1,4,9] Similarly, the reliability and validity of panoramic radiography have been evaluated in assessing the morphology of the head jaw, by comparing the panoramic images of 40 individuals with TMJ disorder using magnetic resonance imaging (MRI) as the gold standard. The authors concluded that the panoramic radiographs are not a reliable method to accurately determine the shape of the condyle mandibular.^[1,2,6,10]

The diagnosis of a TMJ disorder is continuously evolving with the progress of imaging technology-based examinations. Many imaging modalities are currently used to evaluate the TMJ. MRI is commonly used to evaluate the TMJ, because of its superior contrast resolution and its ability to acquire dynamic images to demonstrate the functionality of the joint.^[6,9,11]

Considering that cone beam CT (CBCT) is the gold standard for visualizing bony structures of the TMJ and that the Panoramic radiograph (PR), in most cases, is the initial examination requested, this study aimed to evaluate the agreement and reproducibility of degenerative diagnostic changes of the TMJ with panoramic radiographs, using CT scans as reference.

MATERIALS AND METHODS

This study was approved by the ethics committee São Leopoldo Mandic College (reference number: CAAE 62613716.7.0000.5374), and all participants provided informed consent.

SELECTION AND CHARACTERIZATION OF THE PATIENTS

The patients were selected after bilateral TMJ region radiography and CBCT imaging results were confirmed. Inclusion criteria consisted of examinations of patients who sought the orofacial pain service of a higher education institution and initially performed a panoramic radiograph and then underwent CBCT for a definitive diagnosis. Patients were excluded if they were syndromic, underwent surgery in the region of interest, had fractures in the head of the mandible, or had examinations with poor-quality images, or those that did not include the area of TMJs.

Thus, 84 patients were selected. The tests were performed at the Dental School of Radiology Clinical São Leopoldo Mandic, São Paulo, Brazil, on a panoramic machine OP200 (Instrumentarium, Tuusula, Finland), using the manufacturer's recommendations, and scanner CAT Next Generation (Imaging Sciences International, Hatfield, Pennsylvania), according to the following parameters: 120 kVp; 5 mA; acquisition time, 40 s; reconstruction time, 62 s; voxel, 0.3 mm; and field of view, 23 × 17 cm.

EVALUATION OF IMAGES

Panoramic radiographs were evaluated by three experts in oral radiology, guided by the principal investigator (PI) to assess the presence or the absence of changes in the bone structure of the jaw heads. Thus, when there was no change in the TMJ, evaluators filled the number zero (0) in the sheet, and when they observed a change, the sheet was filled with the number one (1).

The CBCT images were evaluated by the PI, which were first demarcated along the axis of the condyle using axial section. Thereafter, the PI evaluated the bony structures of the condyle in all the reconstructions (axial, coronal, and sagittal). The values found were used as reference standards. The sheet was filled similarly to that for the panoramic radiographs, zero (0) for no change and one (1) for visible change.

The images were evaluated using the same software with which they were acquired. The panoramic radiographs were analyzed using the software CliniView (Instrumentarium), and CBCT images were analyzed using the XoranCAT software, version 3.1.62 (Xoran Technologies, Hatfield, Pennsylvania), using the LCD monitor 17 inch flat-screen, model 5000:1 (LG, Seoul, Korea) with a resolution of 1280 × 1024 pixels and maximum color quality (12 bits) in an environment with reduced light in the radiology clinic of St. Leopold of Dentistry Mandic. Images were evaluated in a quiet, darkened room at individual and at different times. The data were tabulated for statistical analysis.

STATISTICAL ANALYSIS

Concordance between evaluators was analyzed using agreement percentages, κ statistics, and confidence intervals [Table 1]. In the analysis of compliance with CBCT—“gold standard” imaging examination and excellent interobserver correlation for degenerative bone pathologies of TMJ—sensitivity, specificity, predictive positive and negative value, and the probabilities of false positives and negatives were also calculated. κ values were interpreted according to the criteria. All analyses were performed using the R* program (*R Core Team [2018]. A: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, <https://www.R-project.org/>). All data were analyzed using inferential tests with 5% significance level.

RESULTS

Of the 84 radiographic and tomographic examinations selected, 168 TMJ images were evaluated, and of these, 102 showed degenerative changes. In total, 72.6% of these images belonged to females, and the average age of these patients was 47.4 (standard deviation, 16.1 years; range, 18–73 years).

Analysis of the percentage of agreement between the three evaluators in panoramic radiographs to the right and left sides revealed that the values ranged from 66.7% to 82.9%. These percentages, according to Landis and Koch,^[12] show κ values between 0.30 and 0.50, which indicates mild to moderate concordance [Table 2].

When we analyzed the correlation between the evaluators, the diagnosis of TMDs in panoramic

radiographs and CT scans was 45.5%–64.9%. According to Landis and Koch,^[12] this variation corresponds to a κ value ranging from 0.12 to 0.31, which represents a very mild agreement. It was also observed that the sensitivity ranged from 28.6% to 58.7% and specificity from 66.7% to 100.0%. The positive predictive value ranged from 77.1% to 100.0% and the negative predictive value was lower, ranging from 32.2% to 54.8%. The probability of false negatives was higher than that of false positives, ranging from 45.2% to 67.8% [Table 3].

DISCUSSION

The panoramic imaging technique is unique in its projection geometry as it has a negative angle X-ray beam in most devices. Thus, bony structures in the TMJ region are not visualized well, and anatomical variations may be misdiagnosed as pathological changes.^[13] The image formed in this technique is directly affected by the patient's positioning within the shear layer; objects outside this layer present distortion.^[13,14]

CBCT, in turn, has the advantage of not duplicating structures and can offer a better diagnosis than panoramic X-ray, especially when considering TMJs and their complex morphology.^[1,2,5] Thus, this study aimed to evaluate the correlation between the diagnosis of degenerative changes in the TMJ using panoramic radiographs and CBCT; this was used as the “gold standard.”^[6,9,15] In this study, the κ values ranged from 0.30 to 0.50, representing a concordance of mild to moderate, which has been observed in previous studies.^[7,10,13]

In this study, high specificity was observed to range from 66.7% to 100.0%, and low sensitivity from 28.6% to 58.7%. In contrast to this study results, previous studies have shown a specificity and sensitivity of detection of 85% and 33%, respectively, in the panoramic radiographs of osteophytes.^[16-18] This variation should reflect the fact that in this study, differences were observed in degenerative bone changes. Thus, bone changes are suspected in the TMJ and panoramic radiographs show a negative result, CBCT should be performed.

Table 1: Interpretation of κ values by Landis and Koch^[12]

κ values	Interpretation
<0	Agreement poor
0–0.19	A slight concordance
0.20–0.39	Agreement light
0.40–0.59	Moderate agreement
0.60–0.79	Substantial agreement
0.80–1.00	Almost perfect agreement

Table 2: Percentages of agreement, κ , and confidence intervals between evaluators who diagnosed temporomandibular disorders in panoramic radiographs for the right and left sides

Side	Appraisers	Percentages of agreement	κ	Statistical confidence interval κ
Right	1–2	71.4	0.40	0.22–0.58
	1–3	73.2	0.43	0.26–0.60
	2–3	82.9	0.50	0.28–0.73
Left	1–2	66.7	0.30	0.10–0.49
	1–3	70.7	0.35	0.17–0.54
	2–3	79.3	0.41	0.18–0.64

Table 3: Analysis of concordance between evaluators who diagnosed temporomandibular disorders in panoramic radiographs and computed tomography scans

Side	Av	Specificity	Sensitivity	PPV	VPN	FPP	FNP	Percentage of agreement	κ	κ statistics IC
Right	1	66.7%	51.8%	80.6%	34.2%	19.4%	65.8%	55.8	0.14	-0.04 to -0.33
	2	90.5%	28.6%	88.9%	32.2%	11.1%	67.8%	45.5	0.12	0.00 to 0.24
	3	95.2%	29.6%	94.1%	34.5%	5.9%	65.5%	48.0	0.16	0.05 to 0.28
Left	1	74.2%	58.7%	77.1%	54.8%	22.9%	45.2%	64.9	0.31	0.11 to 0.51
	2	87.1%	37.0%	81.0%	48.2%	19.0%	51.8%	57.1	0.21	0.04 to 0.38
	3	100.0%	31.8%	100.0%	50.8%	0.0%	49.2%	60.0	0.28	0.14 to 0.42

Av = appraisers, PPV = positive predictive value, NPV = negative predictive value, FPP = false-positive probability, FNP = false-negative probability, IC = confidence interval

Other studies have found that the smaller the change, the lower is the detection probability of these changes, due to overlap and oblique images of TMJs in panoramic radiographs.^[15-17]

In our study, we found that the correlation values between panoramic radiographs and CBCT that were used as a benchmark ranged from 45.5% to 64.9%. These values corroborate the statements of the studies that panoramic radiography is not the test of choice for TMJ evaluations as it may underestimate the findings.^[1,2,5,16,17]

As found in other studies that have used panoramic radiographs for evaluating TMJs, the diagnosis of TMJ changes is best made using three-dimensional (3D) tests such as CBCT. It is worth noting that the use of panoramic radiography at initial diagnosis may often be valid in cases of gross TMJ changes, as it is considered to be one of the routine tests requested by clinicians and may show changes without a clinical report; however, 3D images are still required for confirmation.^[1,2,4,6,9,11,16]

A recent study assessed the reliability and reproducibility of individual evaluations of radiologists and orthodontists maturation of the sutures for the diagnostic application using CBCT for diagnostic application. Reliability and reproducibility of these evaluations had acceptable levels, but the concordance rate was not high enough for routine clinical application. Thus, the authors concluded that further studies should be performed despite the results obtained.^[16,17]

Barbosa *et al.*^[18] addressed a simple but important issue: how many observers are needed for medical imaging studies? They claimed that the imaging techniques are not diagnostic, but only aid professionals in establishing a diagnosis. However, each radiologist has different cognitive, visual, and perceptual skills; hence, the appropriate number of professionals to be included in the study depends on its objectives.

Further studies may be conducted to understand the influences of previous experience of the examiners in

radiographic and tomographic diagnosis to corroborate the results of this study.

CONCLUSION

On the basis of applied methodology, it was concluded that the correlation between assessors did not achieve acceptable levels of diagnosis and therefore the panoramic radiograph should not be indicated for the diagnosis of degenerative changes in TMJ.

ACKNOWLEDGEMENTS

We would like to thank the graduates of the São Leopoldo Mandic School of Dentistry for participating in the sample selection. All authors approved the submission of the manuscript and Professor Rudyard dos Santos Oliveira as its corresponding author.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHOR CONTRIBUTIONS

All authors were involved in the study design, data collection, data acquisition and analysis, data interpretation, writing of the manuscript and all authors approved the final version of the manuscript for publication.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

This study was approved by the local ethics committee São Leopoldo Mandic College (reference number: CAAE 62613716.7.0000.5374) on 01/23/2018.

PATIENT DECLARATION OF CONSENT

All participants sign the free and informed consent form when performing the image exam.

DATA AVAILABILITY DECLARATION

The data set used in this study is available on request from the corresponding author's email (dr.rudyardoliveira@gmail.com).

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