ORIGINAL PAPER

JOINT SPACE MEASUREMENT IN CENTRIC OCCLUSION BETWEEN PANORAMIC TEMPOROMANDIBULAR JOINT RADIOGRAPHY AND CONE-BEAM COMPUTED TOMOGRAPHY: A COMPARISON IN PATIENTS WITH CLICKING DISORDERS

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ABSTRACT

Introduction: Patients with temporomandibular disorder (TMD) commonly experience clicking. Measuring the joint space between the condyle and glenoid fossa can assist a dentist in determining potential cause of this pathological anomaly. Initial examination of temporomandibular joint (TMJ) osseous structure can be performed with panoramic temporomandibular joint radiography (PanTMJ) that has a lower radiation and cost than cone-beam computed tomography (CBCT).

Objectives: The aim of this study was to quantitatively assess the difference in joint space measurement between PanTMJ and CBCT among patients with clicking in centric occlusion.

Material and methods: The study included thirty-four patients diagnosed with clicking in at least one of the TMJs. Patients underwent PanTMJ and CBCT in centric occlusion position, following clinical examination. Anterior joint space (AJS), superior joint space (SJS), and posterior joint space (PJS) were measured. Mann-Whitney test was applied to examine differences between PanTMJ and CBCT joint space measurements, while Wilcoxon test was used to compare differences between right and left joint space.

Results: The results showed significant differences ($p < 0.05$) in AJS, SJS, and PJS between PanTMJ and CBCT. The width of joint space in PanTMJ tended to be underestimated compared with that in CBCT. With the exception of AJS in Pan TMJ ($p < 0.05$), there was no statistically significant difference between the right and left condyle space in any radiography technique ($p > 0.05$).

Conclusions: The results of the current study show that joint space measurements on PanTMJ cannot be compared with those on CBCT.

Key words: cone-beam computed tomography, panoramic radiography, temporomandibular joint.

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INTRODUCTION

An ideal position of the condyle relative to the glenoid fossa at temporomandibular joint (TMJ) still raises many questions. The occlusion position of the teeth can affect TMJ and can be observed directly, but the position of the condyle to the fossa requires additional imaging examination [1]. Joint space is defined as the radiolucent area between the condyle mandible and temporal bone. The distance in this area can be used to determine the position

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of the condyle in the glenoid fossa. Joint space measurements can also assists dentists in determining the cause of pathological abnormalities in TMJ [2].

TMJ maneuvers for masticatory movements involve a combination of neurological and muscle control. Therefore, if there is a movement dysfunction, it will cause a temporomandibular disorder (TMD) [3]. TMJ dysfunction is one of the possible causes of TMD. However, since most patients do not experience pain, they neglect it. The clicking sound is a symptom of TMD, and about 70-80% of cases are caused by disc displacement. It is an abnormal position of the articular disc that is more anterior than the normal position when closing the mouth [4]. In patients with clicking disorders, the disc position is more anterior in closed mouth position. In contrast, the disc can still compensate for a typical open mouth position when patients open their mouths. It results in a 'click' sound [5].

The radiographic examination protocol for TMJ consist of an evaluation of hard tissue contours, position of the condyle-fossa, and analysis of the motion range of mouth opening and closing. Cone-beam computed tomography (CBCT) has a fundamental role in dentistry imaging and provides opportunities for the imaging of hard tissue components of TMJ [6, 7]. Quantitative studies on CBCT in various dentistry fields began in the 2000s, and have grown rapidly [7]. CBCT has several advantages, including presentation of 3D analysis and lower dose than in medical CT. It is possible to obtain reconstructed images of the TMJ structure parallel and perpendicular to the condyle, to precisely measure the condyle-fossa distance [2]. Several studies on condyle-fossa position were quantitatively assessed on CBCT in both normal and TMD participants [2, 8, 9]. Soni and Buch [3] analyzed the superior joint space between CBCT and panoramic radiograph in patients without TMJ disorders randomly selected from the radiology database.

Panoramic radiography has the potential to detect abnormalities in TMJ, and this has been investigated in few studies on joint space. Also, panoramic is widely used to help diagnose TMJ abnormalities through joint space analysis due to its low cost and accessibility [3]. Although CBCT has several advantages, main drawbacks include its availability in major cities only, especially in Indonesia, and higher examination cost compared with panoramic radiograph.

OBJECTIVES

The current study aimed to investigate whether PanTMJ can be used as an alternative to CBCT to identify the position of the condyle-fossa from the measurements of anterior joint space (AJS), superior joint space (SJS), and posterior joint space (PJS) in patients with clicking disorders.

MATERIAL AND METHODS

SUBJECTS

Thirty-four patients with TMJ clicking from Universitas Gadjah Mada (Indonesia), aged 20-55 years, agreed to participate in the study and signed an informed consent. This study was approved by ethics' commission of the Faculty of Dentistry, Universitas Gadjah Mada Dental Hospital, with authorization number of 00612/KKEP/FKG-UGM/EC/2021. Inclusion criteria were a generally healthy condition and experiencing clicking either on one or both sides of TMJ, in accordance with the Research Diagnostic Criteria/TMD (RCD/TMD validated axis I TMJ diagnoses disc displacement with reduction) [10]. Patients with limited mouth opening and a history of mandibular fracture or tumors were excluded. History of predisposing factors that could cause clicking problems was reviewed on the basis of patient interview, orthodontic history, unilateral chewing, locking jaw, and chin support habits. A patient could have more than one predisposing factor or habit. A dentist carried out an examination of patient using bi-digital palpation method during open and closed mouth movements, and afterwards, PanTMJ and CBCT were performed.

RADIOGRAPHIC EXAMINATION

The same operator performed all radiographic examinations. PanTMJ was done using a Vatech PaX-I Insight (USA) panoramic machine with an exposure of 60-99 kV and 4-10 mA for 10.4 seconds, with patient positioned in centric occlusion. Radiograph results were four images of the right and left TMJ areas obtained during opening and closing of the mouth. CBCT machine used was an orthopantomograph (Instrumentarium Dental P 300, Tuusula, Finland), with an exposure factor of 57-90 kV, 4-16 mA for 10-20 seconds, and field of view size of 6 × 8 cm. Joint space measurement was conducted with EzDent-i (Vatech, Republic of Korea) for PanTMJ radiograph, and OnDemand3D™ Dental (Cybermed, Seul, Republic of Korea) for CBCT radiograph. Sagittal section was used for observation.

JOINT SPACE MEASUREMENTS

Joint space was measured in TMJ close position separated on the right and left sides of TMJ using AJS, SJS, and PJS parameters. These three parameters were calculated according to Ikeda and Kawamura's method [9]. Measurements were performed on PanTMJ and CBCT radiographs for each patient. In the axial view of the CBCT radiograph, the axis was first directed at the condyle with the widest medial–lateral diameter (Figure 1A). Measurements were obtained in the sagittal view, resulting

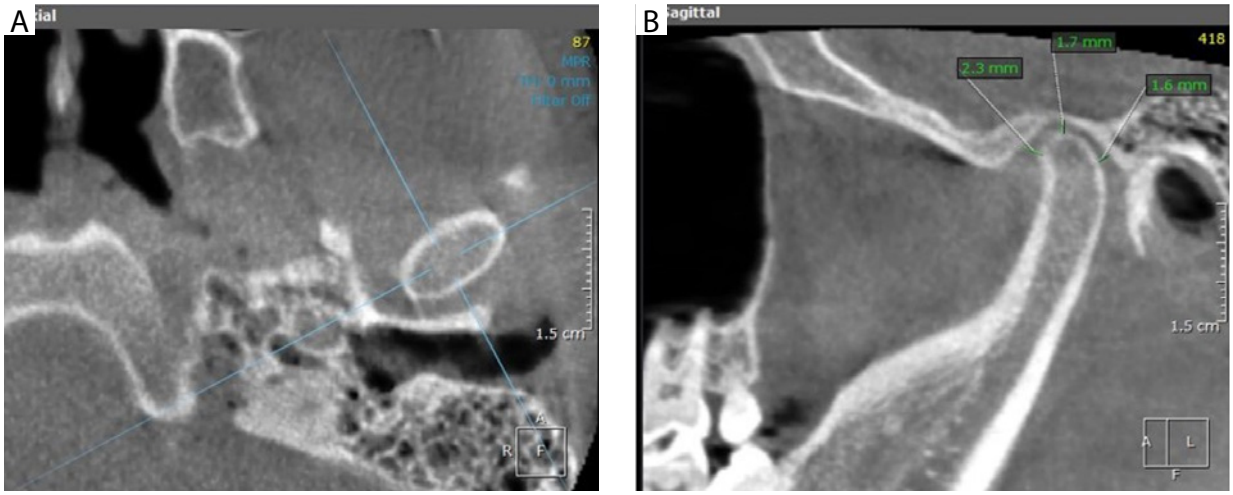

FIGURE 1. Axis placed in the middle of the condyle in cone-beam computed tomography image reconstruction for joint space measurement according to Ikeda and Kawamura's method [9]. **A**) Axial view with the widest medial-lateral diameter of condyle. **B**) Sagittal view

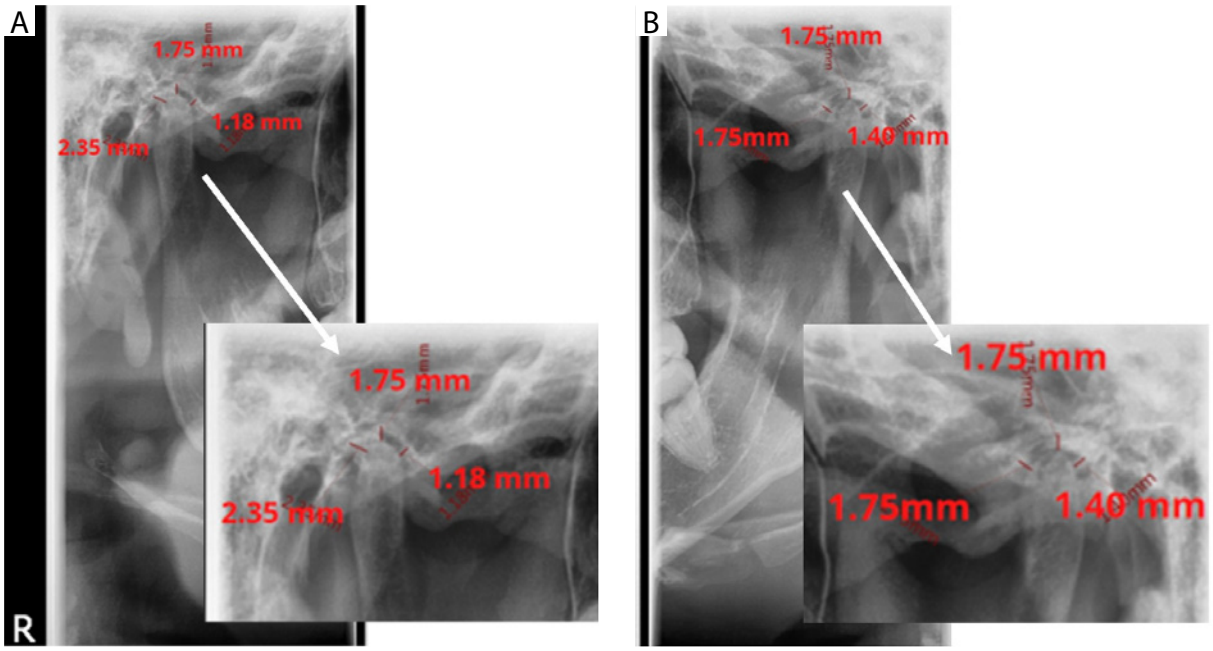

FIGURE 2. Measurement of joint space of the right and left side of PanTMJ radiograph according to Ikeda and Kawamura's method [9]. **A**) Right-close. **B**) Left-close

from the axial image reconstruction (Figure 1B). The first step of measurement was to determine the highest point of glenoid fossa (S) by drawing a horizontal line. From that point, a line was drawn anteriorly (A) and posteriorly (P), so that it was tangential to the most prominent point of the condyle. AJS, SJS, and PJS were further determined by drawing perpendicular lines from points A, S, and P towards the glenoid fossa. This measurement method was also applied to PanTMJ (Figures 2A and 2B). Observations were made twice in an interval of 1 month by an experienced oral radiologist. The mean measurements of two observations were analyzed statistically.

STATISTICAL ANALYSIS

The mean joint space measurements of AJS, SJS, and PJS between the right and left sides were calculated with Shapiro-Wilk normality test. Finally, Wilcoxon and Mann-Whitney tests were used because data were not normally distributed. Wilcoxon test was employed to compare values between the right and left sides in each radiograph technique. The mean total right and left joint space difference between PanTMJ and CBCT was investigated with Mann-Whitney test. Statistical analysis was conducted using GraphPad Prism software version 9.1.0

for Windows (GraphPad Software, San Diego, California USA, www.graphpad.com), with a p-value < 0.05.

RESULTS

AJS, SJS, and PJS were measured on the TMJ on the right and left sides of the subject in centric occlusion. Table 1 shows descriptive data on the number of subjects and clicking symptoms. The thirty-four participants included 3 men and 31 women, with an average age of 26 years. The clicking side was identified; the majority of participants (26 women and 3 males) experienced unilateral clicking. Medical histories of patients were examined to determine possible factors causing the clicking, as listed in Table 1. A subject may experience numerous probability factors. In 14 patients, orthodontic treatment history ranked first, followed by one-sided chewing tendencies in 13 subjects. Chin-supporting habits and a history of the locking jaw were identified in eight and two subjects, respectively.

Statistical test results of the difference in joint space measurements between PanTMJ and CBCT radiographs are presented in Table 2. Wilcoxon test showed no difference in joint space between the right and left sides in either radiographic techniques ($p > 0.05$), except for AJS in PanTMJ ($p < 0.05$). The total mean of the right and left joint space measurements for each parameter was compared between the two techniques. Significant differences ($p < 0.05$) in joint space at AJS, SJS, and PJS were found between PanTMJ and CBCT radiographs. The mean values of AJS (2.50 mm) and SJS (2.69 mm) in CBCT were higher than those in PanTMJ. By contrast, the mean PJS value (2.38 mm) was higher in PanTMJ than in CBCT.

DISCUSSION

The TMJ is a complex anatomical structure composed of bone and soft tissue, therefore requiring radiographic examination, such as plain radiographs and 3D techniques, i.e., CBCT [11]. Retro-discal tissue helps the disc stay in its position between the joint bone structures [5]. By measuring the anterior, superior, and posterior joint spaces, the ideal position of the mandi-

TABLE 1. Descriptive data on patients clicking side and habits that may influence clicking

Sex	*n*	Mean age (years)	Clicking		Possible predisposing factor			
			Unilateral	Bilateral	Orthodontic treatment history	One-sided chewing habit	Chin-supporting habits	Locking jaw
Female	31	26.1	26	5	13	12	8	2
Male	3	26.0	3	0	1	1	0	0

TABLE 2. Differences in anterior joint space (AJS), superior joint space (SJS), and posterior joint space (PJS) values between panoramic temporomandibular joint radiography (PanTMJ) and cone-beam computed tomography (CBCT) radiographs

Joint space ($n = 34$)	PanTMJ			CBCT			p-value††
	Mean (SD)	Median (Min-Max)	p-value†	Mean (SD)	Median (Min-Max)	p-value†	
AJS							
Right	NA	1.54 (0.72-3.70)	0.000*	NA	2.22 (1.50-4.10)	0.300	0.00*
Left	NA	2.03 (1.30-7.79)		NA	2.65 (1.50-4.80)		
Total	1.96 (0.75)	1.80 (1.24-5.74)	NA	2.50 (0.56)	2.42 (1.60-3.60)	NA	
SJS							
Right	NA	2.16 (0.99-4.19)	0.750	NA	2.50 (1.30-4.40)	0.260	0.028*
Left	NA	2.17 (0.91-4.34)		NA	2.57 (1.40-4.70)		
Total	2.33 (0.57)	2.21 (1.33-3.70)	NA	2.69 (0.69)	2.57 (1.60-4.50)	NA	
PJS							
Right	NA	2.33 (1.57-4.61)	0.340	NA	2.10 (0.90-3.80)	0.680	0.041*
Left	NA	2.04 (1.08-5.72)		NA	2.00 (1.00-4.10)		
Total	2.38 (0.67)	2.22 (1.47-4.68)	NA	2.12 (0.67)	2.10 (0.95-3.95)	NA	

SD – standard deviation, NA – not applicable
**Significant p-value < 0.05. †Wilcoxon test. ††Mann-Whitney test*

bular condyle adjacent to the glenoid fossa can be determined [3, 9]. Panoramic radiography is the basis of dental radiology examination, and CBCT can be used in complex cases; both are options for evaluating osseous structures in the TMJ area [5, 12]. In this study, the measurements of the three joint spaces were compared between PanTMJ and CBCT.

Condyle position related to the fossa can be observed from a central sagittal view to find the possibility of dislocation as well as developmental abnormalities and pathological changes. The coronal view can be used to observe the condition of the medial and lateral condyle surface, whereas the sagittal view shows the anterior and posterior surfaces [13]. In this study, the joint space measurement in the sagittal view was conducted by first positioning of the axis in the axial view in the center, parallel to the condyle, and then measuring the distance in the sagittal view. However, the study did not include the coronal view because its direction could not be compared with PanTMJ.

Clicking is the most common symptom in patients with TMDs compared with other symptoms, such as jaw deviation, attrition, and limited mouth opening [14]. Therefore, determining the position of the condyle on TMJ is important. The current study examined the potential of panoramic examination as an initial screening method to determine the position of TMJ, provide an overview of the TMJ area and its surrounding structures, and compare it with CBCT. Slightly open mouth condition and edge-to-edge position during exposure cast doubt on whether panoramic radiography can provide information about the condyle position [5]. In the present study, this situation was overcome by asking the patient to maintain centric occlusion while being exposed to PanTMJ radiographs in the closed position, and sustain the maximum opening of the mouth.

Descriptive data from interviews with the patients were collected to identify possible clicking causes. Many patients had a history of orthodontic treatment and unilateral chewing habits. Abdullah and Hamed [15] investigated the relationship between para-function habit and TMJ clicking, and found that TMJ clicking was not associated with malocclusion classification, crossbite, and unilateral chewing. Meanwhile, Ved *et al.* [16] reported that unilateral chewing remarkably affected TMD development and clicking was one of the TMD symptoms.

The condyle-fossa position in patients clicking disorder was evaluated by PanTMJ and CBCT using the joint space parameters of anterior, superior, and posterior sides. Al-Rawi *et al.* [8] and Mazzetto *et al.* [17] compared the condyle position between men and women on the basis of CBCT measurements, and found that the joint space size of men tended to be larger than that of women. By contrast, the current study did not classify the participants according to gender, because the number did not balance between men and women.

In this study, AJS and SJS were greater than PJS on the CBCT measurements. Conversely, AJS was smaller than SJS and PJS on PanTMJ. This finding was consistent with a previous study using CBCT, in which patients with TMD tended to have a posterior condyle position [17]. Anterior disc displacement condition may explain the narrow posterior space. However, the current results differ from those of Al-Rawi *et al.* [8], who also investigated the condyle position in patients with TMD and found that AJS was smaller than PJS, because the edge-to-edge occlusion during CBCT prompted the condyle to move anteriorly and cause a narrow anterior space [8]. In a research by Ikeda and Kawamura [9] on condyle position in asymptomatic subjects by depicting the morphology and position of the articular disc on MRI, AJS was smaller than SJS and PJS. The posterior position of the thickest disc band was at 12 o'clock; therefore, the superior space was wide.

The results of three joint space measurements differed between PanTMJ and CBCT radiographs. AJS and SJS measurement results tended to be larger on CBCT than on PanTMJ, except for higher PJS on PanTMJ than on CBCT. Therefore, the joint space measurement on PanTMJ was underestimated compared with that on CBCT. In a study conducted by Dalili *et al.* [2] using CBCT among class I angle malocclusion subjects without a history of TMJ disease, the patients had a joint space size close to the current panoramic measurements for clicking subjects. This finding indicated that the joint space measurement results on the panoramic view cannot reflect the condyle position associated with clicking conditions that lead to disc displacement. The posterior-superior condyle position is more frequently seen in patients with anterior disc displacement than in patients with normal TMJ conditions [18]. In the current research, AJS on PanTMJ was smaller than SJS and PJS. These results were in agreement with a descriptive study conducted by Putri *et al.* [19] among patients with clicking.

PJS measurements in PanTMJ were greater than those in CBCT. A possible reason is that in the measurement of the posterior region, the glenoid fossa is superimposed in the skull base. Hence, the point of PJS measurement with the fossa is difficult to determine. The TMJ glenoid fossa area appears as a soap bubble or multi-ocular radiolucency due to superimposition with mastoid air cells extending from the temporal bone to zygomaticotemporal suture [5]. The superimposition and distortion of anatomical structures around the TMJ area indicate the need for an advanced radiographic examination, so that the TMJ position and structure can be observed in detail [5]. Soni and Bunch [3] examined the validity of SJS panoramic and CBCT measurements, and showed that precise joint space measurements on panoramic radiograph cannot be carried out because data from each technique have high variations. Panoramic radiograph can still be used for an initial patient evaluation. However, geometric distortion and magnification may appear when positioning patient's head and exposure is not handled by an experienced radiographer [12, 20]. Panoramic radiographs can

only be used to evaluate changes in the condyle and fossa at a severe level. Further examination of the TMJ articular surface can use CBCT for hard tissue and MRI for soft tissue evaluation [11].

CBCT is a radiographic technique for the dental area with lower dose and higher contrast than multislice computerized tomography. However, CBCT has a higher dose and examination cost than conventional dental radiographic techniques. Routine CBCT examination of the TMJ area is not recommended if it does not have an impact on treatment decisions. Nevertheless, CBCT has proven to be accurate in detecting abnormalities on the TMJ osseous structure [11].

The present study has some limitations. The clicking complaint was not confirmed by MRI examination to determine the disc position. Clicking was only observed by clinical examination based on TMJ axis I research diagnostic criteria. In addition, grouping based on gender was not conducted, and the difference in joint space between men and women has not been analyzed. The use of a single observer is another limitation of this study. This is anticipated by an average of the joint space measurements that were carried out twice at one-month intervals. In the future, research can be carried out to prove the potential of panoramic radiograph as an alternative to CBCT for the initial examination of TMJ abnormalities by observing the morphology of the condyles.

CONCLUSIONS

All measured joint space parameters differed between PanTMJ and CBCT among patients with clicking symptoms. PanTMJ must be considered in identifying the condyle's position related to the glenoid fossa. However, for the condyle-fossa space, CBCT may be the most reliable method for accurate examination because it provides a multiplanar view.

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CONFLICT OF INTERESTS

The authors declare no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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