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Correlation of clinical and radiographic severity of periodontitis with furcation involvement: Evaluation of periapical radiographs and Cone-beam Computed Tomography

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ABSTRACT

Objectives: To analyze the correlation of clinical and radiographic features in periodontitis with furcation involvement.

Materials and Methods: Cross-sectional analytic study of 30 mandibular molars from 13 patients (8 males and 5 females), who had periodontitis with furcation involvement, with purposive sampling. Clinical, periapical and CBCT examination were then carried out . Assessment for clinical dan CBCT based on modified Glickman classification. Correlation test was performed with *Kendall's Tau_b*.

Results: There was a significant difference between subjects of non CBCT group (clinical (p=0,01) and periapical (p=0,026)), with subjects examined by CBCT. However there was no difference between the clinical and periapical group. There is a correlation between furcation involvement on CBCT and periapical group (r=0,528; p=0,003).

Conclusion: There was no correlation between furcation involvement on clinical examination with periapical radiographs and CBCT. The correlation is only seen between periapical radiographs and CBCT.

Keywords: *Periodontitis with furcation involvement, clinical examination, periapical radiograph, CBCT*
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INTRODUCTION

Periodontal disease can cause attachment loss, alveolar bone loss and tooth mobility.[1] Based on Riskesdas 2018 in Indonesia, the prevalence of periodontitis in the 35-44 year age group reaches 77% while those over 65 years reach 66%. An almost similar thing was also shown based on gender, namely the prevalence of periodontitis between men and women was not much different, namely 73.2% and 74.7%.[2] Accurate diagnosis can be achieved by examining comprehensive periodontal condition. The "gold standard" for periodontal examination continues to develop. The information obtained is based on clinical and radiographic findings. This includes not only pocket depth, bleeding on probing, mobility, attachment loss, furcation involvement, but also bitewing and periapical radiographic examination.[3] Clinical examination using a periodontal probe has limitations. This is due to the various size and shape of the periodontal probe tip, pressure applied during probing, direction of penetration, gingival inflammation, and anatomical condition of the probed tooth.[1] Rost *et al*. showed that there were difficulties in measuring caused by factors such as patient discomfort during probing, probe angulation, and impaired visualization due to the presence of subgingival calculus and inflammation.[4] An accurate diagnosis of bone destruction is only possible by direct observation during a surgical procedure.[1]

Furcation involvement is a progressive stage of periodontitis. Furcation involvement generally occurs in mandibular molars and increases with age. Significant interdental bone loss may not be detected on periapical radiographs because the cortical density of intact buccal and lingual or palatal bone obscures the changes. Radiographic examination is very useful in establishing the diagnosis and treatment plan.[1] Conventional radiography has long been the radiographic examination of choice for the diagnosis of periodontal disease including evaluation of intra bony bone destruction and furcation involvement. Two dimension (2D) radiographic examinations are easy to obtain, fairly high resolution, and low cost with minimal radiation exposure.[3] However, 2D radiographic examinations have limitations. Two-dimensional radiographs were unable to demonstrate the internal morphology or depth of the crater destruction to the extent involve the facial and lingual surfaces. The radiographic appearance tends to underestimate the severity of bone destruction. Geometric limitations such as enlargement, distortion, and overlap of anatomical structures limits the accuracy of the two-dimensional image interpretation.[1] Cone beam

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computed tomography (CBCT) 3D radiographic examination may be an option when smaller dose examinations such as periapical and panoramic cannot provide the necessary diagnostic information for diagnosis and treatment planning.[5,6] In addition, when clinical examination raises hesitation, CBCT examination can add the diagnostic value.[1]

Cone beam computed tomography (CBCT) provides an accurate overview of the anatomical structures in 3D without overlapping. This allows for undistorted analysis and exact measurements of bone destruction even at the buccal and the lingual plates.[1] Several studies demonstrated that furcation bone defects are more accurately identified by CBCT than intraoral digital radiography.[7,8] CBCT examination in furcation involvement detection can be used to demonstrate an accurate mapping much more than the periapical radiograph. Limitations in performing a clinical examination are of particular concern in establishing the appropriate diagnosis and treatment plan. Therefore, a study was conducted regarding the correlation of clinical and radiographic severity of periodontitis with furcation involvement with periapical radiographs and CBCT.

MATERIALS AND METHODS

Research conducted in Radiology Clinic, Periodontics Clinic, and Integrated Clinic Rumah Sakit Khusus Gigi dan Mulut (RSKGM) Faculty of Dentistry, Universitas Indonesia with a time range from August 2022 to December 2022. Thirty mandibular molars from periodontitis patients with furcation involvement underwent clinical and radiographic examinations using periapical and CBCT. The inclusion criteria were the mandibular molars of periodontitis patients with suspected furcation involvement and had underwent scaling for periodontal treatment. Exclusion criteria were maxillary molars in periodontitis patients with furcation involvement, patients who had undergone periodontal treatment in addition to scaling, teeth with extensive caries, teeth with pulpoperiapical diseases, teeth with metal restorations and teeth after endodontic treatment.

Assessment of furcation involvement clinically performed using a Nabers probe with criteria based on modified Glickman classification, grade I is an incipient lesion with bone destruction less than 2 mm to the furcation; grade II is bone destruction of more than 2 mm to 6 mm to the furcation but most of the alveolar bone and periodontal ligament are intact; and grades III-IV are bone defects with through-and-through lesions between tooth furcation with or without gingival cover.[9]

Dental digital periapical radiograph examination was performed with a dental Carestream CS 2100 Intraoral X-Ray System, 60 kV, focal spot 0.7 mm. Furcation involvement radiographically on a periapical radiograph assessed by evaluated the presence or absence of triangular radiolucency in the furcation area and or the height of the bone below the furcation. Assessment criteria: 0 if there is no furcation involvement and the height of the bone is above the furcation and 1 if there is furcation involvement and the height of the bone is below the furcation.[9](Figure 1.)

CBCT examination was performed using a CBCT type CS new 9300 3D digital imaging system from Carestream Dental, 84 kVp, 5mA, 20s, 598mGy, voxel size 90 µm with a field of view 5x5, slice thickness 630 µm. Furcation involvement radiographically on CBCT assessed by measuring its depth from the axial aspect which shows the largest amount of bone loss in mm, and the assessment was classify based on the modified Glickman classification criteria, grade I if there is incipient lesions with less than 2 mm of bone destruction into the furcation; grade II is bone damage of more than 2 mm to 6 mm where part of the alveolar bone and periodontal ligament is still intact; and grade III is bone damage with through-and-through lesions between the tooth furcations.[9] Measurements were made by positioning a vertical line at the bifurcation on the sagittal aspect and then drawing a tangent line connecting the buccal or lingual aspect of the tooth root surface on the axial aspect. Then draw a straight line to the largest bone defect from the center of the tangent line at the bifurcation in mm. (Figure 2.) The measurements were performed by two observers from senior resident of dentomaxillofacial radiology with two observations at different times.

Furcation involvement assessment data from clinical, periapical and CBCT were analyzed statistically. The correlation between it was

Figure 1. Radiographic picture of the status of furcation involvement, (a) no furcation involvement; (b) has furcation involvement

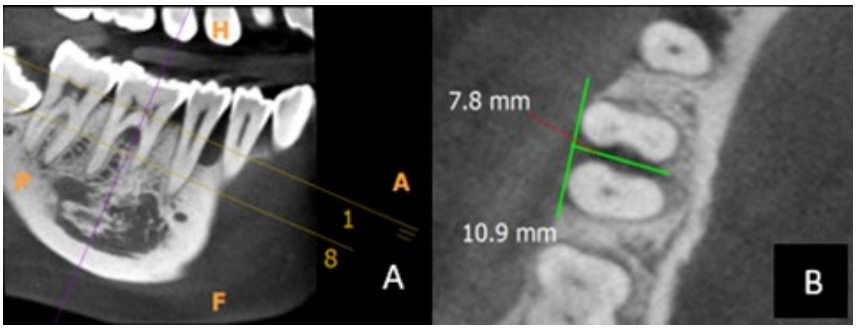

Figure 2. Measurement of furcation involvement. (A) Sagittal aspect, determining the position of the vertical line at the bifurcation. (B) Axial aspect, measurement of bone destruction at the bifurcation

performed with *Kendall's Tau_b* test. Statistical differences with a p value <0.05 were considered significant. The study was conducted after obtaining permission from the Research Ethics Commission at the Faculty of Dentistry and the Research Ethics Commission for Dental and Oral Hospitals, Faculty of Dentistry, University of Indonesia. Each research subject was given written informed consent.

RESULTS

The sample is primary data totaling 30 samples from 13 patients that are included in the inclusion criteria. The sample consisted of 8 man (61.5%) and 5 women (38.5%). The sample age range in this study ranged from 36 to 69 years. The comparative tests on clinical, periapical radiographic and CBCT data on furcation involvement (Table 1) showed that there was a significant difference between the three measurements in assessing furcation involvement (p=0.019). Based on the results of clinical examination, the average furcation involvement was 1.23 ± 0.935, while for periapical radiographs it was 1.77 ± 0.430 and for CBCT 1.97 ± 0.765.

To evaluate more details between the variables, further comparative tests were performed between the two groups (Table 2, 3 and 4). Furcation involvement in Tables 2, 3 and 4 is categorized into

Table 1. Comparative test of clinical furcation involvement, periapical radiographs and CBCT

Measurement	Furcation Involvement		Total	*p-values*
	No	There is		
Clinical	9 (30%)	21 (70%)	30	0.019*
Periapical Radiograph	8 (26.7%)	22 (73.3%)		
CBCT	1 (3.3%)	29 (96.7%)		

*Pearson Chi-square

Table 2. Comparative test of clinical furcation involvement and periapical radiographs

Measurement	Furcation Involvement		Total	*p-values*
	No	There is		
Clinical	9 (30%)	21 (70%)	30	1,000*
Periapical Radiograph	8 (26.7%)	22 (73.3%)		

*Continuity Correction

Table 3. Comparative test of clinical furcation involvement and CBCT

Furcation Involvement		CBCT				Total	*p-values*
		Absent	Grade 1	Grade 2	Grade 3		
Clinical	**Absent**	0	4 (13.3%)	2 (6.7%)	3 (10%)	9 (30%)	0.010*
	Grade 1	1 (3.3%)	1 (3.3%)	3 (10%)	1 (3.3%)	6 (20%)	
	Grade 2	0	1 (3.3%)	10 (33.3%)	3 (10%)	14 (46.7%)	
	Grade 3	0	0	1 (3.3%)	0	1 (3.3%)	
	Total	1 (3.3%)	6 (20%)	16 (53.3%)	7 (23.3%)	30 (100%)	

*Fisher's Exact Test

Table 4. Comparative test of furcation involvement on periapical radiographs and CBCT

Measurement	Furcation Involvement		Total	*p-values*
	No	There is		
Periapical Radiograph	8 (26.7%)	22 (73.3%)	30	0.026*
CBCT	1 (3.3%)	29 (96.7%)		

*Fisher's Exact Test

Table 5. Correlation test of furcation involvement based on clinical examination and periapical radiographs on CBCT

Furcation Involvement		CBCT	
		Correlation (r)	*p-value*
Examination	**Clinical**	0.140	0.396
	Periapical	0.528	0.003*

*Significant correlation

two, there are present and absent, while in Table 3 the category is classified based on modified Glickman classification criteria. There was a statistically significant difference between clinical measurements of furcation involvement and CBCT (p=0.010) and between periapical radiographs and CBCT (p=0.026). There was no statistically significant difference for clinical and periapical radiographic measurements of furcation involvement (p=1.000). In order to assess the relationship between furcation involvement based on the clinical examination with periapical radiographic examination and CBCT correlation, *Kendall's Tau_b* test was performed.

Correlation test results in Table 5 shows that there is no statistically significant relationship between furcation involvement on CBCT examination and furcation involvement on clinical examination (p>0.05), whereas on periapical radiographic examination it shows a statistically significant relationship (r=0.528; p=0.003). The correlation coefficient showed a strong positive relationship, which means an increase in furcation involvement on periapical radiographic examination was followed by an increase in CBCT furcation involvement.

DISCUSSION

Cone beam computed tomography (CBCT) examination in periodontitis patients with furcation involvement in this study was used as the "gold standard" in consideration of previous studies which showed that there were no significant differences in the results of intraoperative examination which is the "gold standard" in measuring pocket depth and furcation involvement with CBCT.[10,11,12,13] In this study, the results of a comparative test of furcation involvement based on clinical examination, periapical radiographs and CBCT showed statistically significant differences (p=0.019), which means that there was a discrepancy between the results of clinical examinations, periapical radiographs and CBCT. It was shown that of the 9 (30%) samples that had furcation involvement clinically only 1 (3.3%) was confirmed on CBCT. In a further comparative test between two variables, a significant difference was shown between clinical examination with periapical radiographs and CBCT.

The results of the comparative test showed that there was a statistically significant difference (p=0.010) between furcation involvement in CBCT and clinical examination and with periapical radiographs (p=0.026), while between clinical examination and periapical radiographs there was no statistically significant difference (p=1.000). In this study, there were 3 (10%) samples with grade 3 which were not clinically detected. In addition, out of a total of 7 (23.3%) samples with grade 3 on CBCT, only 1 (3.3%) sample was detected clinically and after being measured with CBCT it was only grade 2. In contrast, there were 1 (3.3%) of samples clinically detectable with grade 1 but no furcation involvement on CBCT. Nonetheless, there is concordance in detecting furcation involvement at grade 2 in 10 (33.3%) samples between clinical examination and CBCT so that clinical examination is still appropriate in detecting grade 2 furcation involvement.

The difference in the results could be due to differences in the anatomy of the tooth furcation and the accessibility of the furcation area during clinical examination.[10] The results of this study are in line Pajnigara *et al*. who stated that there was an underestimation of furcation depth measurement on clinical examination compared to CBCT.[14] The accessibility of the mandibular molars was not guarantee that they will be evaluated more easily than the maxillary molars. Cimbaljevic *et al*. showed that the lowest agreement between clinical and CBCT measurements was on the buccal side of the mandibular molars, 63.3% of cases were only detected by CBCT and not detected clinically, while the highest agreement was seen on the distopalatal side of the maxillary which had quite difficult access.[15] Zhang *et al*. showed similar results that there was clinical involvement of the furcation of 18.7% while on CBCT it was not detected, which means there was overdetection on clinical examination.

In contrast was seen in the CBCT examination which showed that 26.7% had bone loss, while on clinical examination it was not detected, which means that there was underdetection on clinical examination.[9] These results are similar to Pajnigara *et al*. which showed that there was a significant difference between clinical examination with intraoperative and CBCT. It appears that the results of clinical measurements underestimate the results of intraoperative examinations and CBCT.[14] Similar with the study, Farook *et al*. showed that there was overdetection on clinical examination compared to periapical radiographs and also underdetection with 49 cases having furcation involvement on periapical radiographs that was not detected clinically.[16]

According to Mark *et al*., buccal and lingual bone defects and maxillary molar trifurcation were detected more precisely by CBCT than by 2D direct digital radiography (DDR) images. Mark *et al*., showed that crater-shaped bone destruction with furcation involvement was detected and diagnosed in 100% using CBCT, whereas only 71% of crater bone destruction and 56% of furcation involvement were detected with DDR.[17] Braun *et al*. showed different results, that intraoral radiographs could detect a higher intra bony defect of 82.7% and furcation involvement of 75.6% compared to CBCT which reached 99.7% and 94.8%.[7]

In present study, the average furcation involvement was 1.77 ± 0.430 on periapical radiographs and 1.97 ± 0.765 on CBCT, whereas clinically it was only 1.23 ± 0.935. The highest frequency of furcation involvement was grade 2 both clinically and CBCT. CBCT provides more accurate picture of furcation bone destruction compared to intraoral digital radiographs.[7] According to Braun *et al*., conventional radiographs show an accuracy of only 27% and are mostly related to grade 3 furcation involvement. This shows a 29% overestimation of conventional radiographs and a 44% underestimation of the grade of furcation involvement. Generally, overestimation occurs in grade 1 furcation involvement and underestimation in grade 2. The treatment plan based on CBCT examination is more invasive in 41% of cases and non-invasive in 18% compared to conventional.[7] The appropriate treatment plan is determined based on the results of the examination obtained so the treatment approach is more relevant and appropriate and shows a high success rate.[18]

On the correlation test between clinical and radiographic furcation involvement both periapically and CBCT, indicates that there is no correlation between them. This means that clinically the results of furcation involvement examination are not in line with the appearance in radiograph, both periapical and CBCT. A strong positive correlation was showed in the results of furcation involvement examination on periapical radiographs with CBCT (r=0.528; p=0.003), which means that increased furcation involvement on periapical radiographs will be followed by increased furcation involvement on CBCT. Thus, furcation involvement seen on periapical radiographs will give a similar appearance to the CBCT findings. Unlike Zhang *et al*. study which states that there is a correlation between clinical examination and intraoral radiographs and CBCT, as well as intraoral and CBCT. The correlation between clinical examination and CBCT was 0.264-0.372 (p<0.001), and 0.230-0.362 (p<0.001) for periapical radiographs which means there was a moderate correlation.[9] Like Zhang *et al*., Farook *et al*. showed a correlation between clinical examination and periapical radiographs, both in mandibular first molars (r=0.37; p<0.001), and mandibular second molars (r=0.19; p<0.001).[15] In present study, there was no correlation between furcation involvement on clinical examination and periapical radiographs or CBCT. The strong positive correlation is only between periapical radiographs and CBCT.

The difference in the results of this study with Zhang *et al*. possibly because measurements in Zhang *et al*. were made separately for the lingual and buccal furcations, whereas in present study they were not separated either clinically or CBCT. This correlation makes CBCT the appropiate choice of re-entry surgery for bone formation evaluation in post-regenerative surgery, because it is non-invasive.[19] Although it is very helpful in the diagnosis of periodontal disease, the determination of CBCT examination needs to be considered with the guideline, that CBCT can be performed if conventional clinical and radiographic examinations do not provide adequate information for treatment planning.[5,20] In addition, the high benefits of CBCT examination but the ALARA (As Low As Reasonably Achievable) principle should be considered, and each patient should be evaluated individually based on their specific and situational treatment needs.[21]

CONCLUSION

In this study, there was a correlation between furcation involvement on periapical radiographs with CBCT, and no correlation with clinical examination. Positive correlation between periapical radiographs with CBCT showed that the furcation involvement on periapical radiographs will be followed by furcation involvement on CBCT. The high accuracy of CBCT examination in detecting furcation involvement, can be recommended as one of the follow-up radiographic examinations to evaluate advanced or complex periodontal disease with furcation involvement.

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FOOTNOTES

All authors have no potential conflict of interest to declare for this article. All procedures conducted were in accordance with the ethical standards.

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