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## RESEARCH ARTICLE

### Reliability Assessment of the Clinical and Radiographic Diagnosis of Furcation Involvement

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#### Abstract:

##### Aim:

The aim of the present study was to compare and assess the relationship and agreement between the clinical and radiographic detection of Furcation Involvement (FI) in the mandibular molars of patients with periodontitis.

##### Materials and Methods:

The sample size included 360 molars from 283 participants with a total of 180 molars involved with furcation clinically and 180 without. The inclusion criteria involved records of patients in the age range 35-76 years, diagnosed with generalized periodontitis, Stage II to IV, Grade B and C, and existing periapical radiographs/dental panoramic radiographs. The periodontal charts (Hamp's classification) and radiographs were used to evaluate furcation on the buccal and lingual sites of first and second mandibular molars.

##### Results:

Of the 360 molars, half of the molars (50%, n=180) had clinical FI. Of the clinical FI group, the majority (73%, n=131) demonstrated FI in the radiological assessment with the periapical radiographs. In the not-clinically detected FI group, just less than half (49%, n=89) demonstrated FI in the radiological assessment. The sensitivity of the radiographic detection of FI as a diagnostic marker was 50.6%, and the specificity was 72.8%. Of the 180 sites analyzed with FI clinically, a slight agreement was found between the clinical assessment and radiographic findings using the kappa analysis (k=0.18). The first mandibular molars showed a fair agreement (k= 0.21) compared to the second mandibular molars (k=0.15). In terms of the individual sites, the lingual sites (k=0.24) had a fair agreement compared to the buccal sites with a slight agreement. The Spearman Correlation analysis for the first mandibular molar showed a moderate positive correlation (r=0.4, p<0.001) compared to the second mandibular molar with no or negligible relationship (r=0.19, p<0.001). Comparatively, the DPT radiograph showed a weak correlation and poor agreement.

##### Conclusion:

Both diagnostic tools, intraoral radiography and clinical assessment should be used for diagnosing FI in mandibular molars.

**Keywords:** Furcation involvement , Radiographic furcation, Alveolar bone loss, Periodontitis, Furcation defects , Dental radiographs.

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## 1. INTRODUCTION

According to the American Academy of Periodontology, Furcation Involvement (FI) exists when periodontal disease has caused bone resorption into the bi- or trifurcation area of a multi-rooted tooth [1]. It is a clinical finding indicative of advanced periodontitis with a poor prognosis for the teeth involved [2, 3]. Due to the complex anatomical morphology in the area, it is difficult or impossible to debride with routine

periodontal instrumentation [4 - 6]. The management of a tooth with FI is currently a challenge that should be resolved. The main factors influencing the management decision include the tooth type, the degree of FI [7, 8] as well as the diagnosis and correct interpretation [8, 9].

Clinically, FI is measured with a Nabers periodontal probe and it is seen as a radiolucency with varying degrees of contrast in the inter radicular area in periapical (PA), dental panoramic (DPT) and, to some extent, in vertical bitewing radiographs [2, 10 - 13]. However, radiographs may over or underestimate the amount of bone loss due to projection errors

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and lack of three-dimensional information [14]. Several classification systems have been used to describe FI. Hamp's classification is a major classification system, classifying furcation based on the horizontal measurement of attachment loss at the furcation area as class I (Horizontal loss  $\leq 3$ mm), class II (Horizontal loss of support  $> 3$ mm) and class III (Horizontal through-and-through destruction).

According to literature, a few studies have been done to study the relationship between clinical and radiographic detection of FI, however, with inconclusive results [15 - 17] underpinning the need for new evidence. In addition, there is limited literature related to the agreement between the clinical and radiographic assessment of FI. The aim of the current study was to investigate the relationship and agreement between clinical and radiographic FI in teeth affected with periodontitis.

## 2. MATERIALS AND METHODS

A retrospective cross-sectional study was designed to determine the relationship and agreement between the clinical and radiographic assessment of FI. A consecutive sampling technique was used to extract computerized records of patients diagnosed with established periodontitis and FI in the College of Dentistry, King Saud Bin Abdul Aziz University for Health Sciences from January 2018 to July 2019.

A total sample of 360 mandibular molars (first and second) was recommended for this study. The calculation was based on the assumption that 65% of the molar teeth [18] with clinical furcation would be detected with the radiographs to achieve a power of 80% for detecting a difference in the proportion of 0.15 between the two groups with a two-sided p-value of 0.05. Our study received scientific and ethics approval from the Institutional Review Board at King Abdullah International Medical Research Centre (KAIMRC), Saudi Arabia (#SP19/449/R).

The inclusion criteria involved records of patients in the age range 35-76 years, diagnosed with generalized periodontitis, Stage II to IV, Grade B and C, with well aligned first and second molars exhibiting no spacing, crowding, anomalies or tilting. The exclusion criteria were records with undiagnostic and poor quality radiographs, radiographs performed at different dates, absence of at least one adjacent tooth, unsatisfactory positioning of the tooth in the dental arch, patients with intraoral conditions interfering with clinical recordings such as recent orthodontic treatment, gingival enlargement or limited mouth opening. A team of two calibrated assessors was established.

The clinical measurements of furcation for the first and second mandibular molars were taken from the periodontal chart of the patients in the SALUD software management system. The clinical measurements in the SALUD system were recorded with a Nabers probe and classified according to the Hamp's classification system: Class I  $\leq 3$ mm horizontal loss of periodontal tissue support, Class II  $> 3$  mm horizontal loss of periodontal tissue support, no through-and-through furcation and Class III through-and-through furcation (required to see the tip of the Nabers probe at the contralateral furcation opening) and additionally Class 0 = no horizontal loss of periodontal

tissue support (apart from the original scoring scale).

The radiographic assessment of the periodontitis sites was done with the records of PA radiographs taken using the paralleling technique with a sensor holder to ensure standardization. The parallel technique was done with a TrollByte Plus Sensor Holder (Planmecca, Helsinki, Finland), using a Planmecca ProSensor HD, size no.2 and a Planmecca ProX intraoral x-ray machine. The X-ray machine was set to 70 kV and 8 mA. The dental panoramic tomogram (Digital panoramic radiography) was done using a Planmecca ProMax 3D plus hybrid x-ray machine. All DICOM data was stored in the Planmecca Romexis software management system.

All the measurements were performed independently by two examiners. The radiographic presentation was categorized as the absence of bone loss, grey shade (varying degree of contrast) and complete radiolucency by two independent examiners, blinded to the clinical assessment findings. The clinical and radiographic data was collected, tabulated and statistically analysed using Statistical Package for Social Sciences (IBM-SPSS) program version 23. The statistical significance was set at  $p < 0.05$ .

Sensitivity, specificity, positive and negative predictive values were calculated with the McNemar  $\chi^2$  test with the evaluation of FI using clinical assessment with a Nabers probe as the gold standard. The kappa statistic (k) as a statistical measure of agreement was determined to indicate the agreement between results of Hamp's classification, Class I, II and III with radiographic categorization of absence of bone loss, grey shade and complete radiolucency respectively. The statistical analysis of the kappa statistics was also used to determine inter observer agreement. The Pearson's correlation test was used to correlate the measurements performed clinically and radiologically.

## 3. RESULTS

A total of 360 molars from 283 patients were evaluated. The majority (61%) were males and the age range was 35-76 years with a mean age of  $53 \pm 10.7$  years. Of the 360 molars, half of the molars (50%,  $n=180$ ) had clinical FI (Table 1).

**Table 1. Descriptive statistics.**

|  |   |
|--|---|
| <b>Gender</b>                            | Male: 173<br>Female: 110  |
| <b>Age (years)</b>                       | Mean $\pm$ Standard deviation = $53 \pm 10.7$<br>Minimum: 35<br>Maximum: 76                           |
| <b>Clinical involvement of furcation</b> | Yes: 180<br>No: 180<br>Mandibular 1 <sup>st</sup> molar: 181<br>Mandibular 2 <sup>nd</sup> molar: 179 |
| <b>Distribution of furcation</b>         | FI: 100 (56%)<br>FII: 65 (36%)<br>FIII: 15 (08%)  |

Of the clinical FI group, the majority (73%,  $n=131$ ) demonstrated FI in the radiological assessment with the PA

radiographs. In the not-clinically detected FI group, just less than half (49%, n=89) demonstrated FI in the radiological assessment of the PA radiographs (Table 2). The radiographic detection of furcation in PA radiographs as a diagnostic marker in this study had a sensitivity of 50.6% and a specificity of 72.8% with the clinical detection of furcation involvement as the gold standard for the purpose of analysis. Also, the positive predictive value of the radiographic presentation was 65% and the negative predictive value was 59.5%.

**Table 2. Crosstabulation between clinical and radiographic assessment of Furcation.**

|  |     | Furcation Involvement Clinically |        | Total  |        |
|--|-----|----------------------------------|--------|--------|--------|
|  |     | No                               | Yes    |        |        |
| Furcation involvement in periapical radiograph | No  | Count                            | 91     | 49     | 140    |
|  |     | Column %                         | 50.6%  | 27.2%  | 38.9%  |
|  | Yes | Count                            | 89     | 131    | 220    |
|  |     | Column %                         | 49.4%  | 72.8%  | 61.1%  |
| Total  |     | Count                            | 180    | 180    | 360    |
|  |     | %                                | 100.0% | 100.0% | 100.0% |

The Spearman’s Correlation analysis determined the correlation between the clinical and PA radiographic detection of FI at all the measured sites. Statistical significance was set at  $p < 0.001$ . The Spearman Correlation analysis for the first mandibular molar showed a moderate positive correlation ( $r = 0.37$ ,  $p < 0.001$ ) compared to the second mandibular molar with no or a negligible relationship ( $r = 0.19$ ,  $p < 0.001$ ). Based on the findings for the DPT radiograph, no or a negligible correlation was shown between the grades of furcation and bone loss for the first and second mandibular molars (Table 3).

**Table 3. Correlation coefficients of clinical assessment of furcation with radiographic assessment for mandibular molars.**

| Comparison   | Tooth                | Correlation |
|--|----------------------|-------------|
| Clinical detection of FI with radiographic detection in periapical radiographs | General*             | 0.26        |
|  | Mandibular 1st molar | 0.37        |
|  | Mandibular 2nd molar | 0.19        |
| Clinical detection of FI with radiographic detection in panoramic radiographs  | General*             | 0.19        |
|  | Mandibular 1st molar | 0.17        |
|  | Mandibular 2nd molar | 0.17        |

\*Both mandibular molars.

Of the 180 sites with clinical FI, only a slight agreement was found between the clinically and radiographically detected FI with PA radiographs using the kappa analysis ( $k = 0.18$ ). The first mandibular molar had a fair agreement ( $k = 0.21$ ) compared to the second mandibular molar ( $k = 0.15$ ) (Table 4a). For the individual sites, the lingual sites ( $k = 0.24$ ) had a fair agreement compared to the buccal sites which showed only a slight agreement (Table 5). However, the DPT displayed only a slight agreement in general and also for the first and second mandibular molars individually between clinical and radiographic findings (Table 4a).

Inter-rater reliability was measured with the kappa statistic and was found to be excellent ( $k = 0.98$ ).

**Table 4a. Agreement (k) of FI Diagnosis Separately for Different Tooth Types by Radiography (I-O and DPT) and Diagnosis During clinical assessment of furcation.**

| Agreement Between FI diagnosed during clinical assessment and radiographically diagnosed FI       | Mandibular 1 <sup>st</sup> molar (n=89) | Mandibular 2 <sup>nd</sup> molar (n=91) | Both 1 <sup>st</sup> and 2 <sup>nd</sup> mandibular molars (n=180) |
|---|---|---|--|
| k: FI detected during clinical assessment and radiographically diagnosed FI using PA              | 0.21                                    | 0.15                                    | 0.18   |
| k: FI detected during clinical assessment and radiographically diagnosed FI using DPT radiographs | 0.12                                    | 0.13                                    | 0.12   |

**Table 4b. Crosstabulation: Hamps’ classification of FI \* Presentation of FI in PA radiograph.**

| * PA Crosstabulation   |           |                |  |                       |                       |
|--|-----------|----------------|--|-----------------------|-----------------------|
|  |           |                | Radiographic presentation of furcation involvement |                       |                       |
|  |           |                | No bone loss                                       | present of grey shade | complete radiolucency |
| Clinical assessment of furcation using Hamps’ classification | class I   | Count          | 35   | 65                    | 0                     |
|  |           | Expected Count | 26.7   | 73.3                  | 0                     |
|  | class II  | Count          | 10   | 42                    | 13                    |
|  |           | Expected Count | 17.3   | 37.9                  | 9.8                   |
|  | class III | Count          | 3  | 8                     | 4                     |
|  |           | Expected Count | 4.0  | 8.8                   | 2.3                   |
| Total  |           | Count          | 48   | 115                   | 17                    |
|  |           | Expected Count | 48.0   | 115.0                 | 17.0                  |

**Table 5. Site specific Agreement (k) of FI between Diagnosis Separately Radiography (I-O and DPT) and clinical assessment of furcation.**

| Kappa analysis                 | Value | Interpretation   |
|--------------------------------|-------|------------------|
| 1 <sup>st</sup> molar: Buccal  | 0.03  | Slight agreement |
| 1 <sup>st</sup> molar: Lingual | 0.24  | Fair agreement   |
| 2 <sup>nd</sup> molar: Buccal  | 0.07  | Slight agreement |
| 2 <sup>nd</sup> molar: Lingual | 0.16  | Slight agreement |

**4. DISCUSSION**

Radiographic assessments in conjunction with clinical probing have been the main diagnostic methods for detecting and characterizing FI [19]. Radiographs if taken properly can be used as a valuable supplementary tool in detecting FI. In the current study, a slight agreement between the clinical and PA radiographic detection of FI using the kappa analysis, ( $k = 0.18$ ) was found. The first mandibular molar, however, showed a fair

agreement ( $k=0.21$ ) compared to the second mandibular molar ( $k=0.15$ ). Site wise comparison revealed the lingual sites ( $k=0.24$ ) to have a fair agreement compared to the buccal sites which showed only slight agreement between clinical and radiographic detection of FI, possibly due to the increased thickness of the lingual bone requiring more bone destruction prior to clinical involvement.

Our study revealed the sensitivity of the PA radiograph to identify a clinically detected furcation invasion as 50.6%, whereas the specificity was 72.8%, when clinical detection of furcation involvement was considered as the gold standard [10, 15]. This indicates that most clinically detected furcation invasions were not associated with radiographic detection, representing a high number of false negatives. The positive predictive value (65%) and the negative predictive value (59.5%) in this study also indicate the limited value that the radiographic assessment alone has for predicting the presence of furcation bone loss.

In cases where the PA radiographs did not identify FI, 27% were identified clinically, indicating an over-detection by clinical measurement (Table 4b). This is similar to the findings revealed by Zhang *et al.* [17] where one-quarter of the cases with FI were clinically detected and not on the intraoral radiographs. However, in the current study, in 49% of the cases that demonstrated bone loss on the PA radiograph, none was detected clinically, suggesting a clinical under-detection, higher than that reported by Zhang *et al.* [17] who reported 18.2% of radiographically detected FI, not detected clinically. The lack of consistency between the two methods could be attributed to measurement errors of both the techniques. Variations in clinical detection could be due to soft tissue inflammation, probing angulation and force as well as the inter-radicular bone and root morphology [9, 20]. Factors that may affect the photographic image include the thickness of the alveolar bone, variations in the horizontal angulation of the x-ray radiographic image as well as the tube head and exposure settings of the x-ray unit.

Our findings of correlation analysis ranged from 0.2 to 0.4 which are similar to the findings revealed by Zhang *et al.* [17]. They reported a poor correlation between the clinical assessment of FI and the detection of FI in PA radiographs. They also reported a slightly better correlation for the first mandibular molars ranging from 0.23 to 0.36 compared to the 2<sup>nd</sup> mandibular molars which is much closer to the findings from our study,  $r=0.4$ , (moderately positive) and 0.2 for the 1<sup>st</sup> and 2<sup>nd</sup> mandibular molars respectively. However, Zhang *et al.* assessed only the presence or absence of FI and bone loss whereas the current study focussed on the correlation between the categories of radiographic detection and clinical classification of FI. Comparatively, the DPT demonstrated a weak correlation between the two variables.

Our results are also in agreement with those of Ross *et al.* (1980) reporting a poor or lack of agreement between the clinical and radiographic findings. However, the statistical tests or results of the analysis were not described in the paper [18]. In contrast, a study by Gusmao *et al.* (2014) reported a significantly higher agreement of 0.65 using the Kappa analysis [15]. However, this study investigated only the

presence and absence of furcation clinically and radiographically and the majority of the cases were classified as grade II and III furcation, which were easily detectable in the radiographs. Moreover, this higher agreement could be attributed to the fact that the precision of conventional radiographs improves as the severity of the furcation involvement increases [19]. In addition, a single examiner was involved in the study by Gusmao *et al.* [15] compared to the current study with two examiners, blinded to the findings of the clinical records, and evidence of near perfect inter-rater reliability.

Limitations of the current study include a retrospective design; future prospective studies should be targeted to strengthen the evidence. The current study considered horizontal bone loss at the furcation areas based on Hamp's classification; thus, future studies should target the assessment of the vertical bone loss to gain a better understanding of the furcation status. Intra-surgical FI assessment should be implemented as the gold standard [17, 19, 21] to evaluate the accuracy of intraoral radiographics in the diagnosis of FI [22 - 24] owing to the errors that could result from measurements due to probing [9, 25].

## CONCLUSION

Our findings confirmed the necessity of supplementing clinical detection with intraoral radiographs for the diagnosis of FI, reflecting the consensus in the literature. Additional prospective studies should be conducted to support the findings and strengthen the evidence.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study received scientific and ethics approval from the Institutional Review Board at King Abdullah International Medical Research Centre (KAIMRC), Saudi Arabia (# SP19/449/R).

## HUMAN AND ANIMAL RIGHTS

Not applicable.

## CONSENT FOR PUBLICATION

Not applicable.

## AVAILABILITY OF DATA AND MATERIALS

The data sets analyzed during the current study are available from the corresponding author (Fathima F. Farook) on request.

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None.

## CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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