Analysis of Furca Lesions in Molars by Cone Beam Computerized Tomography

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Abstract

Furcation lesions are characterized by bone resorption and attachment loss into the interradicular space. Accurate diagnosis of periodontal disease affecting the furcation area requires periodontal examination and imaging. Cone beam computed tomography (CBCT) is capable of generating accurate and reliable submillimeter resolution images in all space dimensions and plays a role in the evaluation and treatment planning of molars with furcation (FL) damage. The objective of the research was to evaluate tomographic aspects of furcation lesions, measure attachment loss and rank the FL.

METHODOLOGY: retrospective observational cross-sectional study, CBCT scans were analyzed with a sample consisting of 560 teeth of patients of both sexes, aged between 30 and 70 years. Bone loss in height/width/depth of the interradicular area was analyzed, based on this measurement, it was classified into degrees I, II and III and its prevalence was evaluated according to its distribution by sex and age, and the most affected teeth.

RESULTS: FL grade II were the most observed in both upper and lower molars. The group of teeth most affected by FL were the upper molars, most frequently in females in group I (41-50 years), classified as grade II in buccal and distal furcations and grade I in mesial furcations. In lower molars, the highest frequency was FL grade II in females in groups 1 (30-40 years) and 2 (41-50 years) and, FL grade III in males in group III (51-70 years).

CONCLUSION: CBCT proved to be effective for the diagnosis of FL and may contribute to an accurate diagnosis and consequent better treatment plan.

INTRODUCTION

Furcation lesions are characterized by bone resorption and attachment loss in the interradicular area, which can conventional dental treatment difficult, mainly related to morphological, periodontal and endodontic aspects.

Some factors are associated with the etiology of furcation lesions, such as root anatomy (divergence, fusion, concavities), root trunk length, crown-root relationship, occlusal interference, age, parafunctional habits, smoking and endodontic and/or endoperiodontal lesions. Furcation involvements that affect both lower and upper molars are buccal furcations, and upper first molars are more frequently affected than lower molars, due to the length of the root trunk.

In the study by Jardini, Lima and Filho (2009), among the highest degrees of furcation injury, there’s a higher percentage of female individuals, adults (31 to 45 years old), and in individuals over 60 years old, there was a slight decrease in its prevalence. When they analyzed the predominance of furcation lesions for the molar groups, there wasn't significant difference in their values. The prevalence of this lesion in relation to the degree of involvement indicated that the
predominant degree was II and this was uniformly distributed in the groups. Grade III involvement is less common and shows similar to groups of teeth. According to Narjim, of the 2014 molars evaluated radiographically, 8.3% (167 teeth) showed involvement in the furcation area in grade II and/or III, and the frequency of involvement in the maxilla and mandible reached 11% and 5.5% of the cases, respectively.

Accurate diagnosis of periodontal disease affecting the furcation area requires periodontal and radiographic examination and must be determined before a prognosis can be established. The extent of the furcation lesion can be determined by evaluating numerous parameters such vertical bone loss and horizontal bone loss, the latter being the most used and classified according to the classification by Hamp et al (1975), divided into grades I, II and III. The buccal furcation of lower molars are the easiest to explore clinically and the most difficult type are the distal furcations.

Radiographic methods provide valuable information that complements the clinical examination but cannot replace it. Imaging diagnosis is a complement to establishing the correct definitive diagnosis, as the radiographic or related material allows a more complete evaluation of the bone structures of the teeth and, in general, of the periodontium. This may include periapical radiographs, panoramic radiography, conventional computed tomography (CT) and cone beam computed tomography (CBCT). Periapical radiographs are commonly used to complement clinical detection for furcation evaluation. However, these images are two-dimensional of a three-dimensional object, and may present overlapping and angulation problems, in addition to being considered of low sensitivity.

The cone-beam computed tomography (CBCT) is capable of generating accurate and reliable submillimeter resolution images in all spatial dimensions and plays a role in the evaluation and treatment planning of molars with furcation injuries. Although considered a valuable addition to furcation assessment, CBCT is not without its shortcomings. The production of beam hardening artifacts can compromise its diagnostic quality, especially in patients with extensive metal restorations, multiple endodontic treatment, orthodontic appliances or implant prostheses. CBCT is a powerful tool that allows the diagnosis of three-dimensional (3D) structures and is well documented as a tool for accurate quantification and localization of anatomical structures.

Therefore, the objective of this study was to evaluate the tomographic aspects of the FL, measure the attachment loss and classify them according to the degree of involvement.

METHODOLOGY

This is a cross-sectional observational retrospective study, in which, after approval by the Ethics Committee of the Federal University of Juiz de Fora (UFJF, Juiz de Fora, Minas Gerais, Brazil) (seem n° 3.949.888/ 2020). Cone beam computed tomography (CBCT), belonging to the file (database) of the Discipline of Dental Radiology, Faculty of Dentistry, Federal University of Juiz de Fora (FO/UFJF) (Minas
Gerais, Brazil). All images were acquired by the same CT scanner (I-Cat®, Imaging Sciences International, Hatfield, Pennsylvania, USA), with the following acquisition protocol: 120 kV, 8 mA, 26.9 s rotation time, slice thickness of 0.25 mm and a minimum FOV of 7 x 13 cm. The images were analyzed using the i-CAT Vision software (Imaging Sciences International, Hatfield, PA, USA). The sample will consist of exams with 560 teeth of patients of both genres, age between 30 and 70 years. Among the inclusion criteria, the following stand out: CT scans of diagnostic quality, with coverage of the all maxilla and mandible; patients diagnosed with periodontitis and who have at least 10 teeth present and one molar in each arch; teeth is showing levels of horizontal and/or vertical bone loss, and interradicular resorption with loss of attachment in molars. Teeth with fused roots, teeth with furcation caries, metallic crowns in the CBCT irradiation area, amalgam fillings close to the alveolar crest will be excluded; no pathology (cyst or tumor in the alveolar process), no mechanical damage (cracks or fractures in the alveolar process). Third molars will not be evaluated. Teeth with fused roots, teeth with furcation caries, metallic crowns in the CBCT irradiation area, amalgam fillings close to the alveolar crest will be excluded; no pathology (cyst or tumor in the alveolar process), no mechanical damage (cracks or fractures in the alveolar process). Showing levels of horizontal and/or vertical bone loss, and interradicular resorption with loss of insertion in molars.

For the analysis of the depth, height and width of the bone loss, axial, sagittal and coronal sections, respectively, of CBCT in the area of the furcation lesion were used. The depth of the lesion was measured in the axial section that shows the greatest amount of bone loss. In this section, lines were drawn tangent to the root surfaces. The distance from this line to the deepest point of bone loss was designated as the furcation bone loss depth (ZHANG et al., 2018). To assess bone loss in height, a line was drawn starting from the region interradicular to the depth of bone loss, as seen in the sagittal section. For width analysis, through the coronal section, a line was made from the bone level to the deepest point of bone loss in the buccolingual/palatal direction. The measurements taken were represented by the abbreviations POA (bone loss in height), POL (bone loss in width) and POP (bone loss in depth). (Fig. 1).

From the measurement of insertion loss in the furcation areas, these were classified according to the classification of Hamp et al (1975), in degrees I, II and III.

From the sample studied by CBCT, it is possible to obtain the prevalence of furcation lesions, their distribution by sex and age, as well as the determination of which teeth are most affected by furcation lesions.

This study was approved by the CEP of UFJF with the number CAAE: 27254719.5.0000.5147

**STATISTICAL ANALYSIS**

For the statistical analysis of the variables related to bone loss, the Kruskal-Wallis statistical test
was used, \( p \leq 0.05 \). And to compare the classification of furcation lesions according to the distribution of sex and age of the studied groups, the ANOVA test was used.

**RESULT**

A total of 1150 CT scans were analyzed to assess the degree of furcation involvement of upper and lower first and second molars. 504 exams were excluded, due to the age of the individuals (less than 30 years old – 32%), the presence of extensive metal restoration (16%), endodontic treatment (3.5%), exams with missing molars (15%), root caries (0.3%), edentulous (4.5%) and alterations in the tomographic beam.

A total of 646 teeth were selected, referring to examinations of females (322 females – 49.8%) and males (324 males – 50.2%). The mean age was 43 years (SD ± 8.97). The sample consisted of upper first and second molars, lower first and second molars. Being included in the study 646 teeth (56%) and 504 excluded (54%). Of the samples that showed LF, 226 were from lower molars (45%) to 274 from upper molars (55%). And 146 molars (upper and lower) did not present any degree of LF (26% of the total evaluated teeth).

From the samples with identified LF, a mean age of 45 years (SD ± 9.36) was obtained for upper molars and, for lower molars, a mean age of 43 years (SD ± 8.95).

In the study of upper molars, LF was found in 165 women (60%) and 109 men (40%). In the lower molars, they affected 99 (44%) women and 127 (56%) men.

In the study of mandibular molars, 146 teeth were 1st molars (65%) and 80 teeth were 2nd molars (35%). The mean bone loss in height (POA) was 4.6mm (SD ± 21.6). In cases of bone loss in width (POL), an average of 2.80 mm (SD ± 0.80) was obtained. In the calculation for bone loss in depth (POP) - buccolingually - it was

4.73mm (SD ± 2.86) and, in the lingual-buccal direction, an average of 1.71mm (SD ± 3.50). In 48 samples, LF were found on the lingual side (21%) and 178 on the buccal surface of the lower molars (79%).

In the mandibular first molars, 33 teeth were found with FL grade I (23%), 75 teeth with grade II (51%) and 38 teeth with grade III (26%). In the mandibular second molars, 29 teeth were observed with LF grade I (36%), 31 teeth with grade II (39%) and 20 teeth with grade III (25%). Showing, for both, a higher frequency of LF grade II.

In the study of upper molars, 194 were upper 1st molars (71%) and 80 were upper 2nd molars (29%). The mean bone loss in height (POA) was 3.52 mm (SD ± 0.92). For bone loss in width (POL), distobuccal root, a mean of 3.70mm (SD ± 0.82) was obtained, and for the mesiobuccal root, a mean of 3.01mm (SD ± 0.69). In the calculation of bone loss in depth (POP) – buccopalatal direction, the average was 4.98mm (SD ± 1.30).
In the evaluation of the distal furcations, grade I FL was found in 68 teeth (35%), 92 teeth in grade II (47%) and 34 in grade III (18%). In the mesial furcations, 106 teeth (55%) were found with FL grade I, 75 teeth with FL grade II (38%) and 13 teeth with FL grade III (7%). In the buccal furcations, 52 (27%) teeth were grade I LF, 103 (53%) teeth were grade II FL and 39 (20%) were grade III.

In the upper second molars, in the evaluation of the distal furcations, 27 teeth presented LF to grade I (34%), 38 with LF grade II (47.5%) and 15 teeth with LF grade III (18.5%). In the buccal mesial furcations, 44 teeth presented LF grade I (55%), 31 with LF grade II (39%) and 5 with LF grade III (6%). In the buccal furcations, they were found in 41 teeth with grade I FL (51%), 20 teeth with grade II (25%) and 19 teeth with grade III (24%).

In upper molars, a higher prevalence of FL grade II was observed in the distal furcations and of grade I in the mesial furcations.

Based on the results, in the lower molars, the occurrence of FL grade I didn't show statistically significant difference between the analyzed groups. In the buccal furcations, there was a higher frequency of FL grade II in groups 1 and 2, females, but with no statistically significant difference between them. In grade III FL, a prevalence was found in female group III, with a statistically significant difference between groups 1–3 (p: 0.001) and 2–3 (p:0.003), as shown in Table 1.

For the upper molars, the mesial furcation was grade I regardless of the age group, female, without showing statistically significant difference between the groups. For distal furcation, the prevalence was grade II (p:0.002) in all female groups, no statistically significant difference between groups 1 and 2 and groups 2 and 3. In comparison of groups 1 and 3, there was statistically significant difference (p:0.001). For the buccal furcation, grade I was observed for groups 1 (30–40 years) and 2 (41–50 years) with no statistically significant difference (p > 0.005), grade II for group 3 (51–70 years) with a statistically significant difference between groups 1–3 (p:0.002) and 2–3 (p:0.001), as shown in Table 2.
Table 1
Lower molar (FREQUENCY)

<table>
<thead>
<tr>
<th>FURCA</th>
<th>GENDER</th>
<th>DEGREE</th>
<th>COMPARISON BETWEEN GROUPS</th>
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<td>L-V</td>
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The table above shows that for grade II FL, the highest frequency was female, with no statistically significant difference (*) between groups, and for grade III, it was female, with statistically significant difference between groups 1–3 and 2–3.

Table 2
Upper molar

<table>
<thead>
<tr>
<th>FURCA</th>
<th>GENDER</th>
<th>DEGREE</th>
<th>COMPARISON BETWEEN GROUPS</th>
</tr>
</thead>
<tbody>
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<td>M</td>
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<td>1-3</td>
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The table above shows that, for furcation M, the frequency was for LF grade I, with no statistically significant difference (*) between the studied groups. For furca D, the highest frequency was LF grade II for females, with no statistical difference between groups 1–2, 2–3, but with a statistical difference for group 1–3. In furcation V, higher frequency of grade II, with statistical difference only in group 1–3. Group 1 (30–40 years), group 2 (41–50 years) group 3 (51–60 years).

DISCUSSION

CBCT of periodontal bone lesions offers highly informative value in diagnosing the presence and extent of FL. The spatial representation of the three planes plays a significant role as treatment decisions and long-term prognosis depend on it. And, in this study, it was possible to observe the lesion in all extensions, agreeing on its efficiency and sensitivity (16 17).
However, there was limitation of measurements when there were extensive metal restorations, multiple endodontic treatment, orthodontic or prosthesis on implant due to the production of artifacts in the root region, making measurements difficult, these limitations are accordance with the studies by Zhang\textsuperscript{7}, Quião\textsuperscript{18} and Walter\textsuperscript{19}.

When the prevalence of FL in imaging exams was compared in relation to the clinical, studies showed that the radiographic exam differs from the clinical exam, since it is the formation of a two-dimensional image in a three-dimensional plane, making the diagnosis more difficult. Jardini\textsuperscript{10}, Corbet\textsuperscript{14} and Weiger\textsuperscript{22} made the clinical and radiographic comparison, and demonstrated a statistically significant difference using the classification of Hamp et.al (1975). These findings were corroborated by the study Araújo\textsuperscript{30} who reported a statistical difference in the presence of FL when comparing the clinical and radiographic examination, having the same patient with the clinical and radiographic analysis. The data obtained by the exams detected an involvement of the furcation region in 31\% and 29\%, clinically and radiographically, respectively, is showing that the radiographic exam may underestimate the presence of FL. In our study, there was an accurate diagnosis of FL by CBCT analysis, which agreed with the study of Zhang\textsuperscript{7} and Quião\textsuperscript{19} who also demonstrated diagnostic accuracy using CBCT. They proved the efficiency in the compatibility of the analysis since it makes a representation of a three-dimensional plane with its millimeter measurements of the studied structure.

A statistically significant higher prevalence of FL was observed in this study in upper molars when compared to lower molars, the same finding of the clinical study by Susin\textsuperscript{23}. In the study by Wang\textsuperscript{24}, a greater occurrence of FL was observed in lower molars, which, for the authors, was due to greater difficulty in cleaning, greater accumulation of bacterial plaque and, when periodontal therapy is necessary, be a factor of lower biological response. In the study by Graetz\textsuperscript{21}, they also evaluated the frequency of FL in molars and observed that in 60.9\% it was in upper molars and 48.7\% in lower molars. Aligning with the present study, where the highest frequency of FL was upper molars, with a statistically significant difference in relation to the lowers. Moreira\textsuperscript{25} in a study evaluating 2421 molars also observed a higher occurrence of FL in the maxilla than in the mandible (33.1\% and 19.1\% respectively).

In upper molars, the occurrence of FL was higher in distal furcations, in agreement with the studies by Quião\textsuperscript{18} and Zhang\textsuperscript{7}, justified the fact due to the anatomy of the roots, in upper molars, have a trunk shorter root in relation to the mandible, being more susceptible to injury. Moreira\textsuperscript{25} also reported a higher occurrence in distal furcations, with a percentage of 25.7\%.

Regarding age, in this study there was higher prevalence of FL in female individuals aged 41 to 50 years, in agreement with the study by Frutos\textsuperscript{26} and Patil\textsuperscript{27}, justified this occurrence to the alteration hormone, such as menopause, where the woman's more susceptible to periodontal diseases. This higher prevalence was also reported by Susin\textsuperscript{23} was related woman to a higher anxiety index in this age group, as consequence, cigarette use, increasing the risk of periodontal disease. In the evaluation of male
individuals, this study showed a higher prevalence of FL in the 51–60 age group, which corroborates the analysis by Moreira\textsuperscript{25} that also reported a higher occurrence in the 55–64 age group.

In the upper molars, the buccal and distal furcations were the most diagnosed with grade II and the mesial furcations with grade I in the group of women aged between 41 and 50 years, similar findings described by Susin\textsuperscript{23}, where a bone loss greater than 3 mm in the distal furcation, found in women aged 40–49 years.

In the lower molars, the highest frequency was FL grade II in female individuals, with LF grade III, it was more found in males aged over 50 years. In agreement with the study by Rodrigues\textsuperscript{28}, which presented a comparison of the frequency of FL in relation to age and gender, and showed higher prevalence with a statistical difference in men of higher age, influenced by the use of systemic medication, the loss of adjacent teeth and difficulty in cleaning, accelerating bone resorption in the region, mainly in the interradicular space.

Jardini\textsuperscript{10} evaluated the frequency of FL according to age (groups from 31 to 45 and 41 to 60), sex and smoking habit in 205 patients, and didn't report statistical differences in the occurrence of FL for the gender and age in all analyzed groups. In the work presented, there was statistical difference in relation to sex and age, with a higher prevalence in women aged 41–50 years, aligning these results with the study by Susin\textsuperscript{23}.

The present study suggests a greater use of CBCT for the diagnosis of FL because it is more accurate than conventional radiographic examinations and clinical examinations, contributing to better determine the prognosis and better treatment planning for these lesions.

**CONCLUSION**

**Based on the study, it can be concluded that:**

The CBCT exam is effective method for the evaluation, diagnosis and classification of FL, however with limitations.

The occurrence of LF was statistically significantly higher in upper molars when compared to lowers.

In maxillary molars, the distal furcation was the most involved.

The presence of FL occurred more frequently in females aged 41–50 years and in males, in the 51–60 age group.

**Declarations**

**Ethics approval**
This study was approved by the Ethics Committee of the Federal University of Juiz de Fora with CAAE identifier: 27254719.5.0000.5147. With consent for the collection of data provided by the Institution as well as for publication.

**Competitive Interests**

This study was of interest to contribute to better treatment planning

**Author contributions**

FAABELLA, M.E.V participated in the textual correction; PEREIRA, J.J contribuiu para análise estatística and SOUZA, R.J.S participated in the collection and interpretation of data, in addition to the textual construction

**Financing**

No funding received

**Availability of data and materials**

Images collected from Cone Beam Computed Tomography (CBCT) were analyzed, belonging to the archive (database) of the Discipline of Dental Radiology, Faculty of Dentistry, Federal University of Juiz de Fora (FO/UFJF) (Minas Gerais, Brazil).

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Figures

Figure 1
A - Schematic diagram illustrating the measurement of furcation bone loss of a maxillary first molar. The dotted line represents the tangent line connecting two adjacent root surfaces. The arrows represent the distances from the center of the tangent line to the deepest point of bone loss on the different surfaces. The red, green, and blue arrows denote furcation bone loss on the buccal, mesial palatal, and distal surface of the molar, respectively. MB (buccal root - mesial); DB (buccal root - distal); and P (palatine root).

C - Schematic diagram illustrating the measurement of furcation bone loss of a lower first molar. The dotted line represents the tangent line connecting the buccal or lingual surfaces of the two roots, respectively. The red and green arrows indicate furcation bone loss on the buccal and lingual surface of the molar, respectively. M (mesial root); and D (distal root).