RADIOGRAPHIC EVALUATION OF PERIODONTAL OSSEOUS DEFECTS – *IN VITRO* STUDY

AVALIAÇÃO RADIOGRÁFICA DOS DEFEITOS ÓSSEOS PERIODONTAIS – ESTUDO "IN VITRO"

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SUMMARY

Introduction: Although the image diagnostic methods have been developed allowing an advanced of early detection of the diseases, the conventional radiographic exam continues to be an important tool to evaluate the periodontal condition. In the correlated literature few investigations exist on the specificity of the osseous defects radiographic image, highlighting the necessity of additional studies on the theme. **Objective:** To describe the radiographic aspects of periodontal bone defects, produced artificially in dry mandibles, and to emphasize the anatomic determinants that contribute to the formation of the different types of defects. **Method:** Eight periodontal bone defects types were produced in fourteen dry mandibles. Standardized digital photographs and conventional radiographs were obtained from each region, before and after the simulation of the referred defects. Soon afterwards, the radiographs were placed in a light box and evaluated by three examiners. **Results:** The bone defects showed distinct radiographics characteristics, allowing its identification, except for the one-, two-, three-walls infrabony defects. The radicular septum bone defect was the most difficult to be evaluated while the horizontal and vertical defects were the most easily interpreted. **Final considerations:** The interpretation of periodontal bone defects radiographics images is dependent to the resorption type is being evaluated. The description of the bone defect could be facilitated to those types that have the morphology with less overlap of the bone and dental structures.

UNITERMS: radiographic exam; periodontal lesions; radiographic interpretation.

RESUMO

Introdução: *Embora os métodos de diagnóstico por imagem tenham evoluído permitindo um avanço na detecção precoce das doenças, o exame radiográfico convencional ainda é uma ferramenta importante para a avaliação da condição periodontal. Na literatura correlata existem poucas investigações sobre a especificidade da imagem radiográfica dos defeitos ósseos, evidenciando-se a necessidade de estudos adicionais sobre a temática.* ***Objetivo:*** *Descrever os aspectos radiográficos de defeitos ósseos periodontais produzidos artificialmente em mandíbulas secas, ressaltando os determinantes anatômicos que contribuem na formação dos diferentes tipos de defeito.* ***Método:*** *Foram utilizadas quatorze mandíbulas*

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secas nas quais oito tipos de defeitos ósseos periodontais foram produzidos. Fotografias digitais e radiografias convencionais foram obtidas de forma padronizada de cada sítio, antes e após a confecção dos referidos defeitos. Em seguida, as radiografias foram dispostas em negatoscópio e avaliadas por três examinadores. ***Resultados:*** *Os defeitos ósseos apresentaram características radiográficas distintas, em grande parte, permitindo sua identificação, com exceção dos defeitos de uma, duas e três paredes ósseas. O defeito do septo radicular foi o mais difícil de interpretação enquanto que os defeitos horizontal e vertical foram mais facilmente interpretados.* ***Considerações finais:*** *A interpretação das imagens radiográficas de defeitos ósseos periodontais é dependente do tipo de reabsorção que está sendo avaliada. A descrição do defeito ósseo pode ser facilitada para aqueles tipos que apresentam a morfologia com menor superposição de estruturas óssea e dentária.*

UNITERMOS: *exame radiográfico; lesões periodontais; interpretação radiográfica.*

INTRODUCTION

The development of image diagnostic methods together with latest generation technologies has allowed the advance of early detection of diseases. In spite of this progress in science, the conventional radiographic exam continues to be an important tool to evaluate several systemic alterations. Periodontal disease, for example, is the second most prevalent clinical entity among oral disease, and is recognized as a serious public health problem. It is characterized by periods of activity followed by periods of quiescence. In view of these characteristics and the complexity of the disease, definition of the periodontal condition requires the association of clinical and radiographic exams to identify persons with the disease. In this context, the radiographic exam plays a decisive role in establishing the level of bone tissue, and in some situations, whether or not periodontitis is present.

Although the importance of the periapical radiographic exam for assessing the periodontal condition is recognized, it has innumerable limitations: radiography identifies only the remaining periodontal bone tissue and not the amount lost, and these radiographically detected bone alterations are only observed after the loss of 30 to 50% of the mineral portion of the bone tissue (Aun et al.[1], 1993; Serson et al.[10], 1994). Furthermore, bone reabsorptions limited to the spongy portion are only perceived where there is cortical bone erosion or destruction (Cohen[2], 1992; Schwartz[9], 1992). In addition, radiographs tend to show less destruction that is present, and do not show the relation between soft and hard tissue. Another great limitation is that radiography does not show the internal morphology of the bone defect (Goaz et al.[6], 1994). On the other hand, image interpretation is prejudiced, since a periapical radiograph is a two-dimensional image, as it projects the tissues in only two dimensions (height and width) (Fuhrmann et al.[5], 1995; De Deus[3], 1992; Rosa et al.[8], 1994). Lastly, other limitations are the angulation of the radiation source during radiographic exposure, which may influence the shape and size of lesions (Mol et al. [7], 1993), as radiography also, does not identify the presence of predisposing factors or intensifiers of periodontal disease.

In spite of the innumerable limitations that may be presented on radiographic exam, the various benefits overcome these limiting factors. The low cost of the exam, ease of performing it, greater potency of the more up to date X-ray appliances allied to the greater sensitivity of radiographic films that generate less radiation to the individual, are among its advantages.

In view of this panorama, investigations must be made in this area with the purpose of extracting the maximum possible amount of information from this complementary tool, which makes it easier for the professional to make a diagnosis. It is from this viewpoint that the objective of this study was to describe the radiographic aspects of periodontal bone defects, produced artificially in dry mandibles, and to emphasize the anatomic determinants that contribute to the formation of the different types of defects.

MATERIALS AND METHODS

The research method used was divided into three parts. The first one involved attainment of initial radiographic and photographic images of areas selected for simulation of bone defects. The second one consisted in production of bone defects and after, attainment of radiographic exam and photographic took from areas. Finally, the radiographs and photographs made in these two stages were compared and evaluated for interpretation of observed radiographic features.

Firstly, the design for this research was submitted to and approved by the Research Ethics Committee of Feira de Santana State University, Bahia, Brazil (Protocol nº 004/2004).

In a similar way, fourteen dry mandibles made available by the Department of Morphological Sciences of Feira de Santana State University, and by the Human Anatomy Laboratory of the School of Agrarian and Health Sciences of the Metropolitan Union for Education and Culture (UNIME), were evaluated. They all contained at least one posterior tooth that presented clinically normal periodontal bone tissue. For each tooth, four sites could be utilized for producing the bone defects, on the mesial, distal, buccal and lingual surfaces.

Before producing the bone defect, initially, the mandibles were scaled to remove possible calculi present in the areas selected for the study. After this, they were photographed and radiographed in a standardized manner.

The *photographs* were taken using a digital still camera (Olympus ER 100S®), with a matrix of 1360 × 1024 pixels and resolution of 96 dpi, and the images were saved in jpg format. Both the buccal and the lingual surface of each study area were photographed.

Next, the *mandibles were radiographed* using radiographic film of size 2 (AGFA Dentus M2 Confort, Belgium), which was attached parallel to the lingual surface of the mandible using adhesive tape, at the sites selected. The lingual surface of the mandible was marked out, so that another sheet of film could be positioned there, for the radiograph to be repeated after creating the bone defects. A soft tissue simulator was utilized (4 cm^3 of water), and this was positioned in front of the mandible. The locating cylinder for the X-ray machine, operating at 70 kVp and 8 mA (Spectro 70×, Dabi Atlante S.A., Ribeirão Preto, Brazil), was positioned so as to have perpendicular incidence on this setup, with a focal distance of 20 cm. The exposure utilized was 0.4s. The film were processed using the temperature-time method, in a labyrinth-type darkened chamber, with a safety lamp (GBX-2, Kodak) and new processing solutions (Kodak Company, New York, USA). The radiographs were dried in a hot-air chamber (EMB, Brazil).

Eight types of periodontal bone defects were selected: interdental crater, horizontal, vertical, radicular septum on the buccal or lingual surface, radicular septum with apical extension on the buccal or lingual surface, one-wall, two-wall and three-wall infrabony defects. A minimum of five defects of each type were produced.

The bone defects were produced in a single session, by a single professional who is a specialist in periodontics. They were made using a slow-rotation micromotor (Kavo®) with nº 2 spherical and nº 56 cylinders burs, under the focused light of the dental equipment. The simulation of the defects was done in accordance with the following description:

Interdental crater:
(Figure 1a)
Depression in the bone crest between adjacent teeth, composed of buccal and lingual walls and two other walls created by the roots of the adjacent teeth.

Horizontal bone defect:
(Figure 1b)
Bone loss perpendicular to the long axis of the tooth, along the whole length of the alveolar bone crest, with occurrence of reabsorption of the buccal and lingual cortical laminae, including the interdental bone.

Vertical bone defect:
(Figure 1c)
Located in the interdental bone and defined by oblique or angular orientation of the bone reabsorption in relation to the long axis of the tooth, with apical direction.

Radicular septum bone defect:
(Figure 1d)
Non-uniform radicular septum reabsorption. It compromises both the alveolar bone cortex as the trabecular bone, on the lingual or buccal surface, leaving a portion of the tooth root exposed to the periodontal pocket.

Radicular septum bone defect with apical extension:
(Figure 1e)
Progression of a radicular septum bone defect. Characterized by reabsorption of the radicular septum, extending towards the apex of the tooth. May also occur both on the lingual surface and on the buccal surface.

Three-wallinfrabony defect:
(Figure 1f)
Defect limited by three osseous walls and the tooth surface. In this case, the bone defect is surrounded by the buccal and lingual laminae, and by the remaining interdental bone septum from the roots of the non-involved adjacent tooth, after the destruction of the distal or mesial portion of the interdental bone.

Two-wall infrabony defect:
(Figure 1g)
Defect limited by two osseous walls and the tooth surface. Formed when the mesial or distal portion of the interdental bone septum is reabsorbed, or likewise one of the buccal or lingual cortical laminae.

One-wall infrabony defect:
(Figure 1h)
Defect limited by one osseous wall and the tooth surface. Formed when the mesial or distal portion of the interdental bone septum is reabsorbed, or likewise the two buccal or lingual cortical laminae.

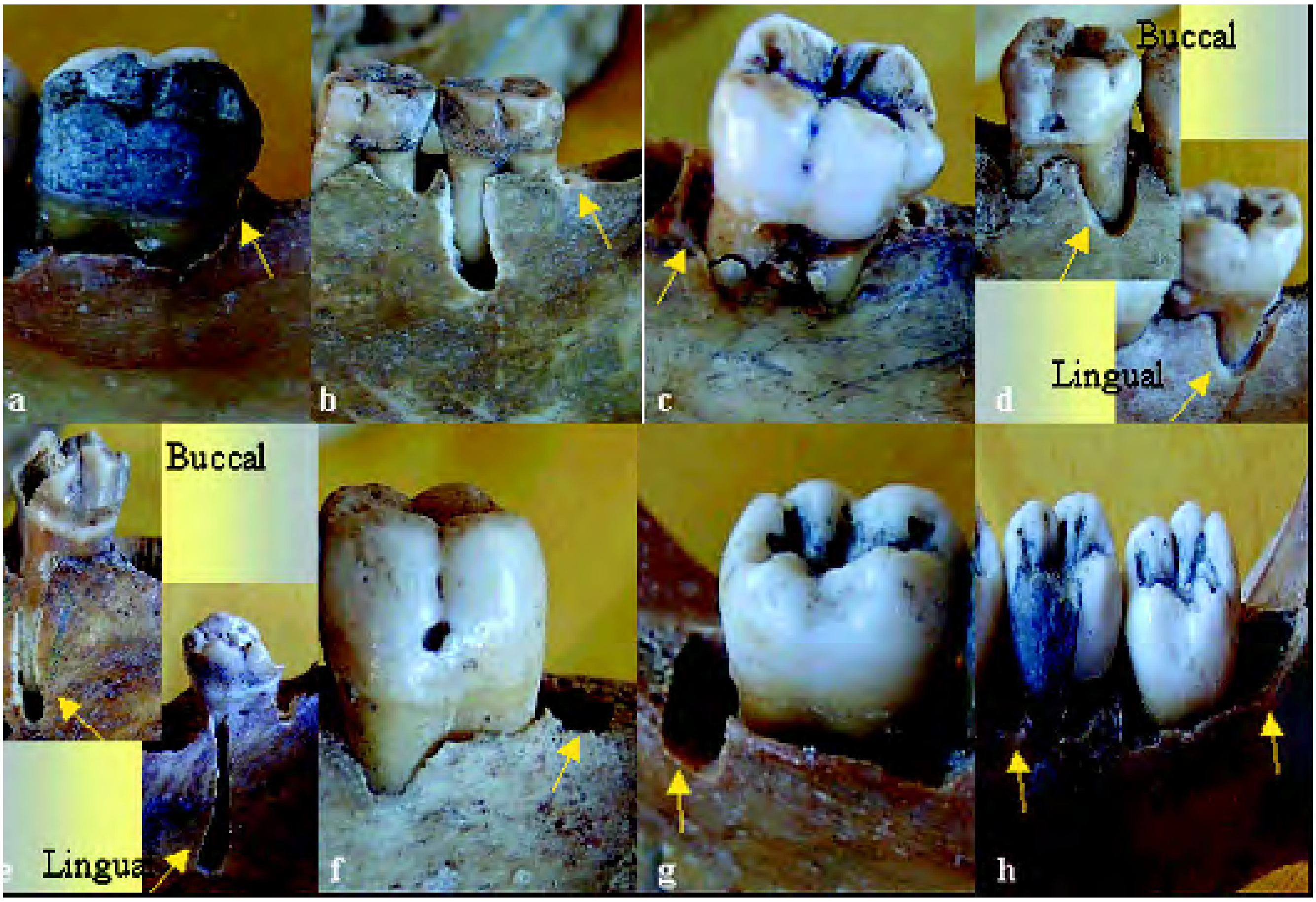


Figure 1 – Photographs of eight types of periodontal bone defects: a - interdental crater, b - horizontal, c - vertical, d - radicular septum on the buccal or lingual surface, e - radicular septum with apical extension on the buccal or lingual surface, f - three-wall infrabony defects, g - two-wall infrabony defects and h - one-wall infrabony defects.

After producing the periodontal bone defects, once more *the areas selected on mandibles were photographed and radiographed*, in accordance with the previous description (Figure 1).

For comparison and analysis of radiographic exams, the radiographs were arranged and identified in accordance with images obtained before and after producing the bone defects.

Next, a presentation in *PowerPoint* (Microsoft Office®) was created in which the corresponding digitalized photographs, obtained before and after producing the bone defects, were sequentially arranged for comparison. The images were analyzed by three professionals: two radiologists and one specialist in periodontics and radiology. These examiners described characteristic radiographic features of each type of bone defect, on a specific form. In the event of disagreement, the feature cited by the majority would prevail. The *radiographic interpretation* was made in adequate environment, using 2.0× magnifying glass, in a light box, and with use of millimeter ruler. Black card papers positioned as masks over the radiographs were used. The file of digitalized photographs was displayed on a 17” super VGA flat-screen monitor.

RESULTS

The interpretation and comparison of radiographic images observed by examiners before and after the simulation of eight types of periodontal bone defects, after compiling the described data, created the analysis showed in Chart 1.

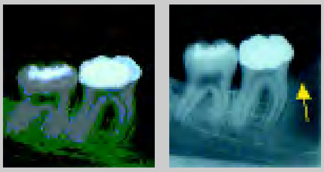
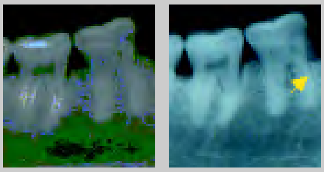
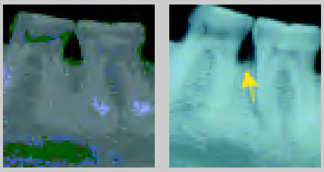
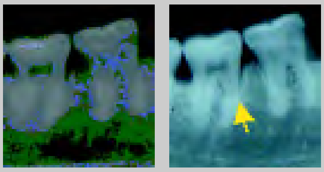
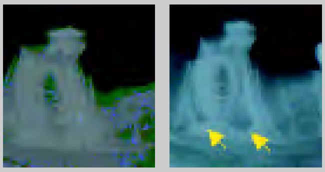
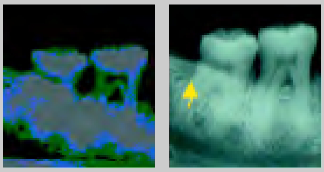
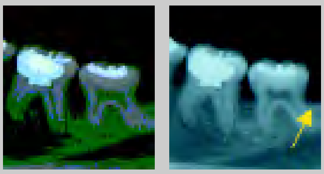
Bone Defect	Result
Interdental crater  *Before* *After*	Partial disappearance of the radiopacity of the ABC and subtle alteration in the trabecular bone texture in the region of the defect were observed. In the other hand, by tracing out two imaginary lines, between the CEJs of the adjacent teeth and over the alveolar bone crest, it was seen that the distance between them remained within normal values (up to 2 mm).
Horizontal bone defect  *Before* *After*	By tracing out two imaginary lines, between the CEJs of the adjacent teeth and over the alveolar bone crest, it was observed that the distance between them was greater than 2 mm. In addition to this, it was noted that the radiopacity of the alveolar bone crest had disappeared.
Vertical bone defect  *Before* *After*	By tracing out two imaginary lines, between the CEJs of the adjacent teeth and over the alveolar bone crest, it was observed that there was an intersection between them. It was also observed that the radiopacity of the ABC and the lamina dura in the area close to the defect had disappeared.
Radicular septum bone defect  *Before* *After*	Subtle alteration of the trabecular bone texture in the region of the defect was observed.
Radicular septum bone defect with apical extension  *Before* *After*	There was subtle alteration of the trabecular bone texture in the region of the defect that extended to the periapical region, suggesting a radiolucent image of the periapical lesion.
Three-wall infrabony defect  *Before* *After*	Almost complete disappearance of the radiopacity of the ABC of the interdental septum was observed, along with partial disappearance of the lamina dura and alteration of the trabecular bone texture in the region of the defect.
Two-wall infrabony defect  *Before* *After*	There was almost complete disappearance of the radiopacity of the ABC of the interdental septum, along with partial disappearance of the lamina dura and alteration of the trabecular bone texture in the region of the defect.
One-wall infrabony defect  *Before* *After*	Almost complete disappearance of the radiopacity of the ABC of the interdental septum was observed, along with partial disappearance of the lamina dura and alteration of the trabecular bone texture in the region of the defect.

Chart 1 – Radiographics before and after the simulation of bone defects. Descriptive analisys of radiographics images of periodontal bone defects.

DISCUSSION

The results of the descriptive analysis of the periodontal bone defects simulated in this investigation made it evident that horizontal and vertical defects were the most easily identified and interpreted, with distinct radiographic aspects. The other six types of periodontal bone defects investigated presented the following degree of being difficult to identify, ranked in ascending order: interdental crater, of one-, two- or three-walls infrabony defects, radicular septum bone defect with apical extension, and finally, radicular septum bone defect.

The differences presented for identifying and interpreting the different types of bone defects depend on the type of bone reabsorption that is being assessed, as a result of each individual's structural determinants, in each region of the mouth, and more specifically, of each tooth site. In addition to these aspects, there are other important factors that determine the different types of bone defects, such as: the shape of the alveolar bone crest, the thickness of the interdental and radicular bone septum, the position and caliber of the arteries in the bone septum, the place where the tooth erupted in the dental arch and the presence of bone dehiscence and fenestration (Freitas et al.[4], 1998).

With regard to *horizontal defect*, characterized by linear bone reabsorption in relation to the long axis of the adjacent tooth unit, generally speaking, it occurs in a thin interdental bone septum, in the buccal-lingual direction, and is of a homogenous pattern as regards size and number of medullar spaces. This type of structural determinant enables a uniform reabsorption in the apical occlusal direction, leading to greater distancing from the ABC to CEJ than the limit accepted as normal (up to 2 mm). Whereas, the *vertical defect*, characterized by oblique bone reabsorption in relation to the long axis of the adjacent tooth unit, generally speaking, also occurs in a thin interdental bone septum, in the vestibular-lingual direction, but is of a heterogeneous pattern as regards size and number of medullar spaces. From this perspective, in one of the extremities of the interdental bone septum, in the mesio distal direction, there is spongy bone tissue with fewer medullar spaces of larger size. Whereas, at the other extremity, there is tissue formed by a greater number of medullar spaces of smaller size. This structural determinant of the interdental septum enables faster bone reabsorption at the first extremity, when the septum is affected by an inflammatory process, causing an oblique bone defect in relation to the long axis of the tooth.

The *interdental crater defect*, characterized by destruction of the bone crest throughout its entire mesio distal extent, and by the advance of the destructive process in the spongy bone, occurs in a interdental bone septum of medium thickness, in the vestibular-lingual direction, which enables a homogenous pattern as regards size and number of medullar spaces in its coronal third. That is, a spongy bone tissue with fewer medullar spaces of larger size. In addition to this, the external buccal and lingual corticals of this septum must be sufficiently thick to bear the destructive inflammatory process, without them being reabsorbed, enabling the formation of a defect in the shape of a crater. In addition to these characteristics, a high caliber artery in a position to the center of the bone septum may also facilitate the development of the type of defect in question.

Whereas *one-, two- or three-wall infrabony defects* present very similar radiographic aspects among them. Superimposition of the remaining bone structure made it difficult to define the specific type of alteration. The one-wall infrabony defect was the most easily detected because there is no external cortical bone. Similarly, there are structural determinants for these defects, which define the appearance of one or other type of reabsorption. Generally speaking, they occur in a thick interdental bone septum, in the buccal-lingual direction, but have a heterogeneous pattern as regards size and number of medullar spaces. At one of the extremities of the interdental bone septum, in the mesiodistal direction, there is spongy bone tissue with fewer medullar spaces of larger size, and a contrary disposition occurs at the opposite extremity. This structural determinant of the interdental septum enables faster bone reabsorption at the first extremity, when the septum is affected by an inflammatory process, contrary to the opposite situation in which the larger number of bony trabeculae makes the destruction of bone tissue difficult by a lower rate of progression. In this case, as the bone septum is thick, the peripheral portions at the center of the destructive process are not completely compromised, enabling a bone defect with remaining walls. Depending on the number of these walls, different types of bone defects may appear. The smaller the number of existent walls and the greater the advance of the destructive process in the spongy bone tissue, the easier it will be to identify and interpret the type of defect. In addition, a high caliber artery in a position lateral to the bone septum may also favor the development of the type of defect in question. Furthermore, these reabsorptions occur on flat alveolar bone crests.

One type of bone alteration frequently found clinically during surgical access to periodontal lesions, the *radicular septum bone defect with apical extension*, was also created in this investigation. This is characterized by the advance of the destructive bone process to the areas around the tooth apex. Initially, this type of bone defect occurs in a thin radicular septum, basically composed of external corticals and hard lamina. The non-existence of spongy bone between them is due to the non-centralized position of the tooth in the arch, being located more towards the buccal or lingual faces. Moreover, the presence of bone fenestration or dehiscence also makes it easier for this defect to occur. When the inflammatory process progresses up to the apical third of the tooth root, the result is the appearance of a *radicular septum bone defect*. The image of this type of defect is the product of superimposition of the tooth and remaining bone structure. Normally, the radicular bone septum is thicker than the root structure and is presented superimposed on it. Consequently, the radiographic image of this bone defect is almost impossible to see. If the region beyond the tooth apex is formed by a spongy bone tissue with smaller medullar spaces of a larger size, and the inflammatory process reaches this area and spreads to the periapical region, the rate of destruction will be faster and then a *radicular septum bone defect with apical extension* will be established. As a result of image superimposition, the radiographic aspect seen is suggestive of periapical lesion. Photographic comparison of the defect with a radiographic image made it easier to interpret during the research. Its assessment in vivo, however, requires the use of complementary exams, such as the pulp sensitivity test, which would define whether or not there is pulp necrosis, and would final suggest the real type of lesion.

Although the bone defects in this study were created in previously determined areas, it is worth emphasizing that: provided that the necessary conditions of tissue thickness, bone quality, vascularization, among other factors exist, bone reabsorptions similar to those studied here may occur in any other region or bone septum, both in the maxilla and the mandible.

CONCLUSIONS

Knowledge of these anatomic factors facilitates comprehension of the mechanisms through which periodontal disease progresses. Moreover, it facilitates the radiographic interpretation of periodontal support structures through the use of this knowledge during evaluation of the periapical radiographs. The type of surgical procedure is determined by means of prior evaluation of the clinical indicators, in association with features viewed radiographically. The possibility, prior to surgical therapy, of defining the type of bone defect that exists, may dictate which periodontal surgical procedure is utilized. Therefore, many further advances in this field of research can be achieved, with verification of the incipient radiographic features of periodontal alterations. This type of *in vitro* investigation makes knowledge of bone alterations more accessible, since *in vivo* studies on this subject are increasingly rare, considering the ethical commitment involved in research.

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