DANIEL BERRETTA MOREIRA ALVES

AVALIAÇÃO DA RADIOGRAFIA PANORÂMICA E TOMOGRAFIA COMPUTADORIZADA EM CISTOS E TUMORES ODONTOGÊNICOS.

EVALUATION OF PANORAMIC RADIOGRAPHY AND COMPUTED TOMOGRAPHY IN ODONTOGENIC CYSTS AND ODONTOGENIC TUMORS.

PIRACICABA
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Faculdade de Odontologia de Piracicaba

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Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do Título de Doutor em Estomatopatologia, na área de Patologia.

Thesis presentes to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Doctor in Estomatopathology, in Pathology area.

Orientador: Prof. Dr. Marcio Ajudarte Lopes

Este exemplar corresponde à versão final da tese defendida por Daniel Berretta Moreira Alves e orientada pelo Prof. Dr. Marcio Ajudarte Lopes.

Prof. Dr. Marcio Ajudarte Lopes

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RESUMO

A radiografia panorâmica (RP) é um importante exame de imagem que tem sido rotineiramente utilizado na prática odontológica por apresentar baixa exposição à radiação, facilidade de execução da técnica, tempo do exame reduzido, boa aceitação pelo paciente, acessibilidade e disponibilidade para a maioria dos cirurgiões dentistas. A tomografia computadorizada (TC) é uma importante ferramenta para o diagnóstico de lesões da região maxilofacial, proporcionado aos profissionais, acesso a uma imagem tridimensional, volumétrica e de ótima qualidade. O diagnóstico de cistos e tumores odontogênicos baseado nos achados de imagem pode ser muito dificil mesmo para um profissional treinado, devido a grande semelhança entre essas lesões. O objetivo deste estudo foi analisar e comparar a acurácia da radiografia panorâmica e da TC para o diagóstico de cistos e tumores odontogênicos. Foram avaliadas a radiografia panorâmica e TC de 25 casos de cistos e tumores odontogênicos provenientes da clínica de Estomatologia (OROCENTRO) da Faculdade de Odontologia de Piracicaba (FOP-UNICAMP), do Hospital AC Camargo e de uma clínica de radiologia odontológica privada. As análises foram realizadas por oito profissionais treinados (dois especialistas em radiologia odontológica, dois estomatologistas, dois patologistas orais e dois cirurgiões bucomaxilofacial) sem conhecimento sobre o diagnóstico histopatológico (padrão ouro) das lesões. Os avaliadores analisaram as imagens de radiografia panorâmica, descreveram as características da lesão através do questionário e sugeriram o diagnóstico. Quatro semanas após essa primeira etapa, os avaliadores analisaram as imagens de TC dos mesmos casos, fizeram uma nova descrição e a sugestão do diagnóstico. Para avaliar a taxa de acerto do diagnóstico entre os exames de RP e TC, foi utilizado o teste de sensibilidade, especificidade, acurácia e análise de variância para experimento inteiramente casualizado com um fator (One-way ANOVA) com modelo linear generalizado misto. Os resultados demonstraram superioridade estatisticamente significante ($p=0.0290$) da TC em relação a RP para o diagnóstico correto de cistos e tumores

odontogênicos. Ao avaliar as lesões separadamente, a TC apresentou diferença estatisticamente significativa (p=0.0024) para o diagnóstico correto do ameloblastoma. Em ambos os métodos, os resultados de sensibilidade foram baixos para o diagnóstico de ameloblastoma e tumor queratocisto odontogênico. Em conclusão, nosso estudo demonstrou que a tomografia computadorizada apresenta superioridade em relação à radiografia panorâmica para o diagnóstico de cistos e tumores odontogênicos, especialmente nos casos de ameloblastoma.

Palavras chave: Tomografia Computadorizada; Radiografia Panorâmica; Ameloblastoma; Cistos odontogênicos; Tumores odontogênicos.

ABSTRACT

Panoramic radiography (PR) is an important imaging test that is routinely used in dental practice because it exposes patients to low levels of radiation, is easy to operate, fast, has good patient acceptability, and is accessible and affordable for most dentists. Computed tomography (CT) is an important tool for the diagnosis of maxillofacial lesions, and provides professionals access to a three-dimensional, volumetric and high quality image. Even for trained professionals, correctly diagnosing odontogenic cysts and tumors based on imaging findings is difficult due to the similarity among these lesions. The aim of this study was to analyze and compare the accuracy of panoramic radiography and CT for the diagnosis of odontogenic cysts and tumors. This study evaluated the panoramic radiographs and CT scans of 25 cases of odontogenic cysts and tumors from the Oral Diagnosis Clinic (OROCENTRO), Piracicaba Dental School (FOP-UNICAMP), AC Camargo Hospital, and a private dental radiology clinic. Analyses were carried out by eight trained professionals (two experts in dental radiology, two oral medicines, two oral pathologists and two maxillofacial surgeons) without knowledge of the histopathological diagnosis (gold standard) of the lesions. The evaluators analyzed the panoramic radiograph images, described the features of the lesion using a questionnaire and suggested the diagnosis. Four weeks after this first stage, the evaluators analyzed the CT images of the same cases, described the images once more and suggested the diagnosis. To compare the accuracy rate of the diagnosis between PR and CT exams, the sensibility, specificity, accuracy and analysis of variance test were used for the completely randomized experiment with one factor (One-way ANOVA) with a mixed generalized linear model. The results showed statistically significant superiority ($p = 0.0290$) of CT compared with PR for the correct diagnosis of odontogenic cysts and tumors. When evaluating the lesions separately, the CT presented a statistically significant difference ($p=0.0024$) for the correct diagnosis of ameloblastoma. In conclusion, this study demonstrated that

CT is superior to PR for the diagnosis of odontogenic cysts and tumors, especially in cases of ameloblastoma.

Keywords: Computed tomography; Panoramic radiography; Ameloblastoma; Odontogenic cysts; Odontogenic tumors.

SUMÁRIO

DEDICATÓRIA

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“Os que se encantam com a prática sem a ciência são como os timoneiros que entram no navio sem timão nem bússola, nunca tendo certeza do seu destino”.

Leonardo da Vinci

INTRODUÇÃO

Com raras exceções, cistos intraósseos revestidos por epitélio são observados somente nos maxilares. Ainda que alguns cistos possam resultar da inclusão de epitélio na linha de fusão de processos embrionários, a maioria dos cistos dos ossos gnáticos é limitada por epitélio que se originam do epitélio odontogênico e por isso são denominados de cistos odontogênicos (Neville, 2004). Os tumores odontogênicos são derivados de elementos epiteliais, ectomesenquimais e mesenquimais de origem odontogênica e são encontrados exclusivamente na maxila, mandíbula e tecidos moles adjacentes, como gengiva e mucosa alveolar. A imagem radiográfica pode variar do radiolúcido ao radiopaco devido esses tumores apresentarem tanto tecidos moles quanto tecidos calcificados (WHO, 2005).

A etiologia dos cistos e tumores odontogênicos não é clara e o diagnóstico dessas lesões baseado somente nas imagens pode ser dificil devido a grande similaridade entre elas. A histopatologia continua sendo o padrão ouro para o diagnóstico dos cistos e tumores odontogênicos. Entretanto, as características clínicas associadas aos exames de imagem podem auxiliar no diagnóstico e definição de conduta dessas lesões. Por esse motivo, nos últimos anos temos visto uma crescente demanda no ensino de tomografia computadorizada para o diagnóstico de lesões odontogênicas para estudantes de graduação e pós-graduação em odontologia, sem saber ao certo, se essa experiência melhora a precisão do diagnóstico de cistos e tumores odontogênicos (Regezi, 2002; WHO, 2005; Ariji, *et al.* 2011; Felix, *et al.* 2014).

A radiografia panorâmica tem seu uso consagrado na prática odontológica. Entretanto, suas vantagens de baixo custo, baixa exposição à radiação e boa visualização geral das estruturas maxilofaciais são contrastadas com a impossibilidade de medidas vestibulo-linguais, resolução reduzida e elevado grau de ampliação e distorção, dificultando a avaliação do tamanho e bordas de lesões de origem odontogênica e não odontogênica, bem como a

extensão destas para estruturas anatômicas importantes ou tecidos moles (Alqerban *et al.* 2009; Bannemann, *et al.* 2012; Avril, *et al.* 2014).

Antes da tomografia computadorizada de feixe cônico (TCFC) ser introduzida na prática odontológica, as imagens multiplanares de cistos e tumores odontogênicos eram obtidas principalmente em tomógrafos computadorizados médicos (TCM) e ressonâncias magnéticas (RM), embora os custos e dimensões desses equipamentos inviabilizassem o seu uso exclusivo para a área odontológica. Desta forma, a TCFC se tornou mais popular, devido seu menor custo, dimensão menor e facilidade de operação do equipamento. Entretanto, o uso da TCM e RM ainda é necessário para avaliação de lesões em tecidos moles, extensão de tumores ósseos para partes moles e avaliação do disco da articulação temporomandibular (Ahmad, *et al*. 2012; Jaju e Jaju, 2014).

Não há como questionar a importância da imagem de TCFC para o planejamento cirúrgico de lesões ósseas dos maxilares. A possibilidade de avaliação da imagem em 3D permite a visualização da extensão real da lesão, da estrutura interna, assim como a sua mensuração em várias angulações e a escolha do melhor local de acesso para a biópsia e/ou intervenção cirúrgica reparadora. O diagnóstico por imagem preciso pode ser muito útil no planejamento e condução desses casos. Entretanto, é necessário cuidado para não superestimar os achados e conhecer melhor as características de imagem e variações de cada lesão, para aumentar a acurácia do diagnóstico de cistos e tumores odontogênicos com o seu uso (Ahmad, *et al*. 2012; MacDonald, *et al.* 2013).

Vale ressaltar que a análise de imagens de lesões ósseas dos maxilares pode ser muito subjetiva entre os profissionais que a avaliam. Além disso, o conhecimento prévio do diagnóstico pode mudar a percepção desses profissionais ao analisarem essas imagens (Raitz, *et al*. 2013). Ao mesmo tempo, o uso de imagens digitais auxiliado por ferramentas tecnológicas (brilho, contraste e mensurações) podem contribuir para aumentar a acurácia do diagnóstico por

imagem idependente da especialidade do profissional avaliador ou tipo de lesão analisada (Raitz, *et al.* 2006).

Devido o uso de radiação ionizante para obtenção da RP e TC, as pesquisas que comparam as vantagens e desvantagens de imagens em 2D e 3D se baseiam principalmente nos riscos e benefícios gerados para o paciente. Comparações entre as doses absorvidas pelo paciente durante o exame, qualidade de imagem (Schulze, *et al.* 2004; Liang *et al.* 2010; Suomalainen *et al.* 2009; Batista *et al.* 2012) e acurácia dos métodos de imagem norteiam a discussão nas diversas áreas da odontologia como: implantodontia, endodontia, cirurgia, ortodontia (Alqerban, *et al.* 2009; Dudic, *et al.* 2009; Fuster-Torres, *et al.* 2011; Patel, *et al*. 2012; Tsai, *et al*. 2012; Neves, *et al*. 2012; Kambungton, *et al.* 2012; de Silveira, *et al*. 2013; Lai, *et al.* 2013; Dave, *et al.* 2013) e em menor escala, na área de patologia oral (Cavalcanti e Antunes, 2002; Sogur, *et al.* 2009; Rosenberg, *et al.* 2010; Treister, *et al.* 2010; Ariji, *et al.* 2011; Gaia, *et al*. 2011; Suter, *et al.* 2011).

Schulze, et al. (2004) avaliaram a dose efetiva de radiação absorvida após diversos exames por imagem da face, convencionais (radiografia panorâmica, Waters modificado e póstero anterior de crânio) e computadorizados (TCFC e Tomografia Computadorizada Multislice). Os resultados demonstraram maiores valores de exposição na TC Multislice. A TCFC apresentou valores intermediários entre as radiografias convencionais e a TC Multislice. Os autores concluíram que a seleção do melhor método de imagem deve considerar a dose de exposição à radiação, qualidade de imagem e circunstâncias clínicas do paciente.

Segundo o Conselho da Associação Dental Americana sobre Assuntos Científicos (2012), o uso da TCFC deve ser racional e essa modalidade não substituirá os exames radiográficos convencionais. A indicação da TCFC deve ser baseada em critérios técnicos pelo profissional responsável, pensando nos potenciais benefícios ao paciente contra os riscos associados da exposição à radiação ionizante, respeitado o princípio ALARA (As Low As Reasonably

Achievable – tão baixo quanto razoavelmente exequível) para proteger pacientes e funcionários durante a aquisição da imagem.

A proposta desse trabalho se fundamenta em compreender de forma mais clara, a relação da TC e RP para o diagnóstico por imagem de cistos e tumores odontogênicos. Para isso, oito profissionais treinados, especialistas nas áreas que manejam pacientes com essas lesões (radiologia oral, estomatologia, patologia oral e cirurgia bucomaxilofacial) foram selecionados para avaliar as imagens de diferentes cistos e tumores odontogênicos. Os resultados dessas análises foram comparados com o resultado final do exame histopatológico (padrão ouro) e em seguida, realizada a análise estatística para comparação entre os métodos de imagens avaliados.

CAPÍTULO 1

Artigo submetido para publicação no periódico Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology.

COMPUTED TOMOGRAPHY OR PANORAMIC RADIOGRAPHY FOR DIAGNOSING ODONTOGENIC CYSTS AND ODONTOGENIC TUMORS: WHICH IS A MORE ACCURATE IMAGING DIAGNOSTIC TOOL?

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COMPUTED TOMOGRAPHY OR PANORAMIC RADIOGRAPHY FOR DIAGNOSING ODONTOGENIC CYSTS AND ODONTOGENIC TUMORS: WHICH IS A MORE ACCURATE IMAGING DIAGNOSTIC TOOL?

ABSTRACT

Objective: The aim of this study was to measure the accuracy of panoramic radiography (PR) and computed tomography (CT) for diagnosing odontogenic cysts and odontogenic tumors.

Study Design: Eight professionals from different fields analyzed the PR and CT images from 25 cases with odontogenic cysts and tumors. The data were assessed for their sensitivity, specificity and accuracy. One-way ANOVA (analysis of variance) for completely randomized experimental testing with a generalized linear mixed model was performed.

Results: The results showed the statistically significant superiority of CT compared to PR for correctly diagnosing odontogenic cysts and tumors ($p=0.0290$). When the lesions were evaluated separately, CT showed a statistically significant difference for diagnosing ameloblastoma ($p=0.0024$). However, PR and CT had low sensitivity scores for ameloblastoma (PR: 0.35 CT: 0.55) and keratocystic odontogenic tumors (PR: 0.44 CT: 0.26).

Conclusions: CT performed better than PR for diagnosing odontogenic cysts and tumors, especially for ameloblastoma.

Keywords: Ameloblastoma, Computed tomography; Panoramic radiograph; Odontogenic cysts; Odontogenic tumors.

INTRODUCTION

Gnathic bones are affected by a wide variety of tumors and cysts, which are usually derived from the participating components of odontogenesis. The etiology is unknown and the diagnosis can be challenging. Although histopathological evaluation is essential for diagnosing these lesions, the clinical characteristics and imaging exams are extremely important to the diagnosis and treatment planning. [1,2]

With the rapid development of technology, diagnostic imaging techniques have improved and become more sophisticated. Computed tomography (CT) provides accurate details of maxillofacial lesions and is particularly useful for their diagnosis and treatment planning. Panoramic radiography (PR) is routinely used in dental practice, and it has some advantages over CT. In general, patients are exposed to lower X-ray radiation; additionally, the assessment time is shorter, the technique is easier, there is greater patient acceptance, and the economic cost is lower. CT has increasingly become more common in dental practice, especially with the advent of cone beam computed tomography (CBCT). However, trained professionals must interpret the images. [3-12]. In addition, CT enables the observer to manipulate and reconstruct high-resolution images, providing more resources than other radiographic methods. [10,12] In dentistry, CT studies mainly focus on implantology, orthodontics, endodontics and surgery. [10, 13-22] Few studies have focused on the area of oral diagnosis. [12, 23-27] To date, the relationship between CT and PR for diagnosing odontogenic cysts and tumors is still unclear.

Previous studies have demonstrated that PR has a similar accuracy for measuring well-defined lesions located in the posterior region of the mandible compared with CT. PR is also considered a suitable method for evaluating odontogenic cystic lesions in the mandible. [28, 29] However, in the maxilla, it is difficult to assess lesions that are close to the maxillary sinus using a two-dimensional image. CT assesses the lesion's exact dimensions and its proximity to the adjacent anatomical structures. Therefore, the precise location for collecting a

biopsy can be chosen, the internal structure of the lesion can be more accurately evaluated and the bone cortical expansion can be determined. [29, 30]

The accuracy of CBCT has been tested to evaluate periapical lesions and presented with higher sensitivity for detecting periapical lesions than periapical X-rays.[31] However, CBCT did not perform better than histopathology for differentiating radicular cysts from periapical granulomas.[26] In addition, some studies have demonstrated the superiority of CBCT over PR for evaluating root resorption from orthodontic treatment. They suggest that PR may underestimate the presence of root resorption after orthodontic movement.[13] However, another study that compared periapical radiography with CBCT for detecting lesions on the dental root surface did not report a statistically significant difference between them.[32]

The purpose of this study was to compare the accuracy of CT and PR for diagnosing odontogenic cysts and tumors, using a group of professional experts in the management of patients with these lesions, by evaluating the images of different odontogenic cysts and tumors.

MATERIALS AND METHODS

After approval by the Research Ethics Committee, this study assessed PR and CT images from patients treated at the OROCENTRO, FOP-UNICAMP (Piracicaba, Brazil), AC Camargo Hospital (São Paulo, Brazil) and a private dental radiology practice (Belém, Brazil). Ninety-seven cases with radiographic characteristics of odontogenic cysts and odontogenic tumors were selected. However, odontogenic tumor cases were excluded when the histopathological diagnosis was inconclusive (nine cases).

Other cases were excluded due to the low quality of the PR or CT scan (17 cases) or when the patient's complete DICOM file or PR image could not be accessed (46 cases). Lesions that were classified as odontogenic cysts and tumors and whose diagnosis was confirmed with a histopathological report were included. The sample consisted of 25 cases for which PR and CT images had been generated for which the diagnosis had been confirmed through histopathological examination (Table 1). The sample consisted of 10 ameloblastomas (six females, four males; mean age 33.5 years; range 14-59), eight keratocystic odontogenic tumors (five females, three males, mean age 38.8, range: 14-81), two dentigerous cysts (two males; mean age 22.5 years; range: 10-35), two odontogenic myxomas (one male, one female; mean age 25 years; range: 18-32), one adenomatoid odontogenic tumor (male, 29 years), one glandular odontogenic cyst (male, 41 years) and one buccal bifurcation cyst (male, 9 years). The medical records were analyzed and data regarding the clinical and radiographic characteristics were collected.

PRs were carried out using analog and digital equipment. The analog tests were digitalized in a standard resolution of 600 dpi and 256 grayscale (8 bit) contrast resolution. PR images were then adjusted using the brightness and contrast tools of Adobe Photoshop® 6.0 (Adobe, San Jose, CA) software.

CT scans were carried out using cone beam technology (10 cases, i-Cat 3D Dental Imaging System, 120 kV, 36 mA, 0.25-mm slice thickness; 11 cases, Sirona XG3D, 85 Kv, 5 mA, 0.16-mm slice thickness) and medical equipment with

spiral acquisition (four cases, Philips, 120 kV, 146 mA, 1.6-mm slice thickness). For visualization of DICOM files of scans, the RadiAnt™ Dicom Viewer, version 1.9.16 (64-bit) (Medixant, Poznan, Poland) software was used. The images were described using a questionnaire with 19 multiple choice questions, which included the following: the characteristics of the internal structure of the lesion, edges, relationship with adjacent teeth, root resorption, cortical expansion and destruction, and proximity to the mandibular canal. After describing the image, the evaluator suggested three hypotheses of diagnosis from a list provided by the authors, based on World Health Organization (WHO, 2005)[2], which included the following: ameloblastoma (Amelo); cementoblastoma; dentigerous cyst (DC); lateral periodontal cyst; glandular odontogenic cyst (GOC); buccal bifurcation cyst (BBC); ameloblastic fibroma; ameloblastic fibrodentinoma; ameloblastic fibro-odontoma; odontoma; odontoameloblastoma; odontogenic fibroma; odontogenic myxoma (Myx); keratocystic odontogenic tumor (KOT); squamous odontogenic tumor; calcifying epithelial odontogenic tumor; calcifying cystic odontogenic tumor; and adenomatoid odontogenic tumor (AOT).

The evaluators included eight specialized dentists; two are in dental radiology, two in oral medicine, two in oral pathology and two in oral and maxillofacial surgery. All of them were PhDs in their area of expertise, had at least five years of professional experience and lacked previous knowledge of the histological diagnosis of the lesions. The evaluators received information about patient's gender and age, and instructions on the questionnaire, images, and software to guarantee standardized assessments. First, the evaluators analyzed the PR images, described the features using the questionnaire and suggested three hypotheses for the diagnosis. Four weeks later, the same evaluators analyzed the CT images, performed a new evaluation and suggested three hypotheses for the diagnosis. When one of the evaluator's three suggestions corresponded to the histopathological diagnosis, the answer was considered correct. Conversely, when the three diagnostic hypotheses were different from the histopathological diagnosis, the answer was considered wrong. Professionals

received no information about the identity of the patients or the relationship between the PR and CT exams.

Statistical analysis:

To compare the rate of correct diagnosis between the PR and CT exams, the sensitivity, specificity, accuracy tests and one-way ANOVA (Analysis of Variance) for completely randomized designs with a generalized linear mixed model were used. The evaluator was the random factor and the examination was the fixed effect. All statistical tests were calculated using the SAS system (SAS Institute Inc. The SAS System, release 9.2. SAS Institute Inc., Cary: NC, 2010).

RESULTS

The sample consisted of 25 cases of odontogenic cysts and odontogenic tumors with a total of 200 PR evaluations (25 cases evaluated by eight experts) and 200 CT evaluations (25 cases evaluated by 8 experts). The total number of correct diagnoses (PR: 145 / 72.5%; CT: 163 / 81.5%) per examination method is summarized in Table 2. Table 3 shows a higher number of correct diagnoses made by CT compared to PR ($p = 0.0290$). Scores were higher for the diagnosis of ameloblastoma (PR: 60 / 75%; CT: 77 / 96.25%) using CT when compared with PR (Table 4; Figure 1). Analysis of variance showed that there was a statistically significant difference in the ameloblastoma cases ($p=0.0024$, Table 5).

There was no difference between the numbers of correct diagnoses when CT was compared with PR for dentigerous cysts ($p=0.5$), KOT ($p=0.8395$) or odontogenic myxoma ($p=1$). Figure 2 shows images of PR and CT observed in KOT cases. For AOT (Figure 3), there was a slight increase in the correct diagnoses for CT compared with PR, while for GOC and BBC, there was a decrease in the number of correct diagnoses from CT compared to PR. However, it was not possible to apply statistical test in these cases.

Table 6 summarizes the sensitivity, specificity and accuracy according to the type of lesion. The following results are worth highlighting: the CT diagnosis

of ameloblastoma had higher accuracy (PR: 0.65; CT: 0.68) and sensitivity (PR: 0.35, CT: 0.55) with lower specificity (PR: 0.85; CT: 0.76) than PR. Conversely, for KOT, the PR diagnosis was more accurate (PR: 0.70; CT: 0.66) and sensitive (PR: 0.44, CT: 0.26), but it was less specific (PR: 0.82; CT: 0.84), than CT. For the dentigerous cyst, the PR diagnosis was more accurate (PR: 0.91; CT: 0.86), sensitive (PR: 0.81; CT: 0.62) and specific (PR: 0.92; CT: 0.88) than CT. For the odontogenic myxoma, the results were the same for the accuracy (PR: 0.90; CT: 0.90), sensitivity (PR: 0.38, CT: 0.38) and specificity (PR: 0.94; CT: 0.94) for the two imaging methods. For the adenomatoid odontogenic tumor, CT had lower sensitivity (CT: 0.12) and PR had more specificity (PR: 0.98; CT: 0.95) and accuracy (PR: 0.94; CT: 0.92). For glandular odontogenic cyst, CT had higher specificity (PR: 0.96; CT: 0.98) and accuracy (PR: 0.94; CT: 0.96) with lower sensitivity (PR: 0.38, CT: 0.25). For the buccal bifurcation cyst, PR had higher sensitivity (PR: 0.75; CT: 0.62) with lower specificity (PR: 0.99; CT: 1) than CT, but both methods were equally accurate (PR: 0.98; CT: 0.98).

DISCUSSION

Due to the great variety of and similarity between benign lesions of gnathic bones, it is very difficult to make a diagnosis that is based only on a radiographic image, even for a trained professional. [33.34] This difficulty may explain the paucity of studies that assess the potential of PR and CT for diagnosing odontogenic lesions.

Tumors and cystic lesions with well-defined edges can easily be visualized using two-dimensional radiographs that are perpendicular to each other. However, with a CT, the three dimensions can be cross-sectionally evaluated. Therefore, the presence and extent of bone resorption, peripheral sclerosis, cortical expansion and perforation, external and internal calcifications and proximity to other vital anatomical structures can be assessed. [35-37] CT and PR use digital images and computers as tools for diagnosing lesions of the gnathic bones.

There was a statistically significant superiority (p=0.0290) of CT over PR for diagnosing odontogenic tumors and odontogenic cysts. Ariji, et al. (2011)[38] evaluated the ability to differentiate between KOT and ameloblastoma using PR and CT. The mean percent of correct diagnoses for both methods was 61.3%, which was lower than the present study (72.5% for PR and 82.5% for CT). Raitz, et al. (2006)[39] and Raitz, et al. (2012)[40] also obtained lower means of correct diagnosis than the present study when different groups of professionals evaluated the diagnosis of unilocular radiolucent lesions of the mandible using PR.

Ariji, et al. (2011)[38] stated that CT increased the correct diagnosis of KOT when evaluated by oral radiology specialists. In the current study, CT was not superior to PR for diagnosing KOT. However, CT was statistically superior (p=0.0024) to PR for diagnosing (sensitivity and accuracy) ameloblastoma. This finding may be justified by the clinical characteristics of ameloblastoma (considerable buccal-lingual expansion[41-43]), which make it easily observable in a three-dimensional exam, such as CT. Felix, et al. (2014)[43] and Avril, et al. (2014)[37] found it difficult to distinguish between KOT and ameloblastoma using conventional radiographs and CT. Nuclear magnetic resonance (NMR) may be useful for these cases because it produces distinct images for these lesions due to the different composition of the intracystic contents of ameloblastoma and KOT. [44] However, NMR is expensive and mainly only available in hospitals and medical clinics; therefore, it is not usually found in standard dental practice. For diagnosing KOT, the panoramic radiograph presented with more sensitivity and accuracy than the CT. In our sample, two out of the eight analyzed cases presented with expansion and perforation of the buccal cortical and four presented with a retained tooth associated with the lesion (Figure 2). These characteristics may have contributed to the evaluators misdiagnosing ameloblastoma, dentigerous cyst and AOT, which present with similar characteristics from the CT. Meanwhile, only two cases had a classic presentation of KOT with characteristic growth along the medullary bone, little buccal-lingual cortical expansion and a scalloped shape of the tumor's margins.[28,33,42,43] Koçak-Berberoglu, et al. (2012)[30] concluded that CT is more

efficient than PR for diagnosing KOT. However, the authors came to this conclusion after analyzing four cases, three of which were in the maxilla, where the edges of the lesion are more diffuse, making it harder to evaluate because of the two-dimensionality of the panoramic radiograph. We evaluated eight cases, with only one in the maxilla, and the results are in line with those of Koçak-Berberoglu et al. (2012)[30], who argued that the PR provides more accurate information about mandibular KOT than for lesions in the maxilla.

In general, this study found that PR and CT scored low for sensitivity in the diagnosis of these lesions; i.e., there was a greater likelihood of a false negative result. However, the results of specificity for both methods showed a lower probability of a false positive result. The accuracy of the diagnostic imaging of these lesions is fundamental to choosing a better surgical approach.[34] However, the low sensitivity in the present study demonstrates the difficulty of making a diagnosis based solely on the images of odontogenic cysts and tumors. Therefore, professionals who treat patients with this type of lesion must be familiar with the characteristics of the image to define the procedure before reaching a final histopathological diagnosis. Conventional radiographs remain the first choice in the initial evaluation of lesions of the gnathic bones. CT can clearly show the delimitation of the lesion, and it is useful for choosing the best site for performing a biopsy; CT also enables accurate measurements for surgical planning, detailed images for postsurgical monitoring and the evaluation of possible recurrence. [34,35,37]

The diagnosis of DC using PR and CT showed good sensitivity, specificity and accuracy. PR produced superior results, which may be explained by the characteristic of an impacted tooth and the familiarity of evaluators with this type of lesion using PR. [34,42,45,46] Araki, et al. (2007)[47] considered CT to be superior to other imaging methods for diagnosing and detailing the internal structure and edges of odontogenic myxoma. Unlike the results in that study, we observed equal sensitivity, specificity and accuracy between PR and CT. There was low sensitivity (0.38) with high accuracy (0.90). Due to the characteristics of odontogenic myxoma

(more diffuse edges, thinner septa and less expansion of the cortical when compared to ameloblastoma[46]) the level of accurate diagnosis of this type of lesion is the same for both CT and PR.

AOT, GOC and BBC cases presented with high accuracy and specificity levels and low sensitivity levels. Furthermore, there was an increase in the correct AOT diagnosis from CT. These findings can be explained by the difficulty of identifying the presence of calcification within the lesion using PR, while CT clearly shows the presence of calcified material (Figure 3). However, the cases of GOC and BBC had more correct diagnoses with PR. Due to its mandibular location and buccal-lingual bone expansion, GOC was consistently misclassified as ameloblastoma with CT, and the latter lesion is more common and has similar characteristics[2]. Because of its rarity and bilateral presentation[48], the BBC case was misinterpreted as KOT from CT, which may manifest as multiple lesions when associated with Gorlin syndrome, and was also misinterpreted as dentigerous cyst, which is usually associated with one unerupted tooth that may present with more than one concomitant lesion[45,46]. However, AOT, GOC and BBC were only assessed in a single case per lesion, and further studies with a larger sample are needed for a more consistent analysis of these lesions.

In conclusion, the current study demonstrated the superiority of CT compared with PR for diagnosing odontogenic cysts and odontogenic tumors, especially for ameloblastomas. However, due to the low sensitivity of both methods, a definitive diagnosis of these lesions can only be made when the clinical and radiographical characteristics are combined with the histopathological results.

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TABLES

Table 1: Distribution of the 25 cases according to the diagnosis and location.

Diagnosis	Location (n)	n (%)
Ameloblastoma	Maxilla (1), Mandible (9)	10 (40)
Keratocystic odontogenic tumor	Maxilla (1), Mandible (7)	8 (32)
Dentigerous cyst	Mandible (2)	2 (8)
Odontogenic myxoma	Maxilla (1), Mandible (1)	2 (8)
Adenomatoid odontogenic tumor	Mandible (1)	1 (4)
Glandular odontogenic cyst	Mandible (1)	1 (4)
Buccal bifurcation cyst	Mandible (1)	1 (4)

Table 2: Total number of correct diagnosis per examination.

Exam	Incorrect diagnosis (%)	Correct diagnosis (%)	Total[a] (%)
Panoramic radiography	55 (27.5)	145 (72.5)	200 (100)
Computed tomography	37 (18.5)	163 (81.5)	200 (100)

[a] 200 evaluations (25 cases evaluated by 8 specialists)

Table 3: Variable analysis of total number of correct diagnosis per examination.

Exam	Total[a]	Mean	Std Dev	Upper 95% CL for Mean	Lower 95% CL for Mean
Panoramic radiograph p = 0.0290[b]	200	0.730	0.456	0.794	0.666
Computed tomography	200	0.820	0.398	0.875	0.765

[a] 200 evaluations (25 cases evaluated by 8 specialists); [b] $p < 0.05$; Std Dev. Standard deviation

Table 4: Total Number of Correct Diagnosis per Lesion

Diagnosis	Panoramic radiography			Computed tomography		
	Correct diagnosis	Wrong diagnosis	Total	Correct diagnosis	Wrong diagnosis	Total
Amelo	60 (75)	20 (25)	80 (100)	77 (96.25)	3 (3.75)	80 (100)
KOT	49 (76.6)	15 (23.4)	64 (100)	47 (73.4)	17 (26.6)	64 (100)
DC	13 (81.25)	3 (18.75)	16 (100)	16 (100)	0 (0)	16 (100)
Myx	10 (62.5)	6 (37.5)	16 (100)	10 (62.5)	6 (37.5)	16 (100)
AOT	0 (0)	8 (100)	8 (100)	2 (25)	6 (75)	8 (100)
GOC	7 (87.5)	1 (12.5)	8 (100)	6 (75)	2 (25)	8 (100)
BBC	6 (75)	2 (25)	8 (100)	5 (62.5)	3 (37.5)	8 (100)
Total	145 (72.5)	55 (27.5)	200 (100)	163 (81.5)	37 (18.5)	200 (100)

Amelo: Ameloblastoma; KOT: Keratocystic Odontogenic Tumor; DC: Dentigerous Cyst; Myx: Odontogenic Myxoma; AOT: Adenomatoid Odontogenic Tumor; GOC: Glandular Odontogenic Cyst; BBC: Buccal Bifurcation Cyst.

Table 5: Variable analysis of the total number of correct diagnosis per lesion.

Diagnosis	Exame	Total	Mean	Std Dev	Upper 95% CL for Mean	Lower 95% CL for Mean
Amelo (p = 0.0024)	RP	80	0.750	0.436	0.847	0.653
	TC	80	0.963	0.191	1.005	0.920
KOT (p = 0.8395)	RP	64	0.766	0.427	0.872	0.659
	TC	64	0.750	0.471	0.868	0.632
DC (p = 0.5)	RP	16	0.875	0.500	1.141	0.609
	TC	16	1.000	0.000	.	.
Myx (p = 1.0)	RP	16	0.625	0.500	0.891	0.359
	TC	16	0.625	0.500	0.891	0.359
AOT	RP	8	0.000	0.000	.	.
	TC	8	0.250	0.463	0.637	-0.137
GOC	RP	8	0.875	0.354	1.171	0.579
	TC	8	0.750	0.463	1.137	0.363
BBC	RP	8	0.750	0.463	1.137	0.363
	TC	8	0.625	0.518	1.058	0.192

RP: Panoramic Radiography; CT: Computed Tomography; Amelo: Ameloblastoma; KOT: Keratocystic Odontogenic Tumor; DC: Dentigerous Cyst; Myx: Odontogenic Myxoma; AOT: Adenomatoid Odontogenic Tumor; GOC: Glandular Odontogenic Cyst; BBC: Buccal Bifurcation Cyst; $p < 0.05$

Table 6: Sensitivity, specificity and accuracy of the image exam according to the diagnosis.

Diagnosis	Exam	Sensitivity	Specificity	Accuracy
Ameloblastoma	PR	0.35	0.85	0.65
	TC	0.55	0.76	0.68
Keratocystic Odontogenic Tumor	PR	0.44	0.82	0.70
	TC	0.26	0.84	0.66
Dentigerous Cyst	PR	0.81	0.92	0.91
	TC	0.62	0.88	0.86
Odontogenic Myxoma	PR	0.38	0.94	0.90
	TC	0.38	0.94	0.90
Adenomatoid Odontogenic Tumor	PR	0	0.98	0.94
	TC	0.12	0.95	0.92
Glandular Odontogenic Cyst	PR	0.38	0.96	0.94
	TC	0.25	0.98	0.96
Buccal Bifurcation Cyst	PR	0.75	0.99	0.98
	TC	0.62	1	0.98

PR: Panoramic Radiography; CT: Computed Tomography

FIGURES AND LEGENDS:

Figure 1: Ameloblastoma A) PR: Radiolucent lesion involving the body of the mandible on the right side associated with the presence of calcified material. Only one of the evaluators (1/8) made the correct diagnosis of ameloblastoma with this image. B-C) CT: Sagittal and axial sections, respectively, showing an expansive lesion with rupture of the cortical bone. All evaluators (8/8) made a correct diagnosis of ameloblastoma with CT images.

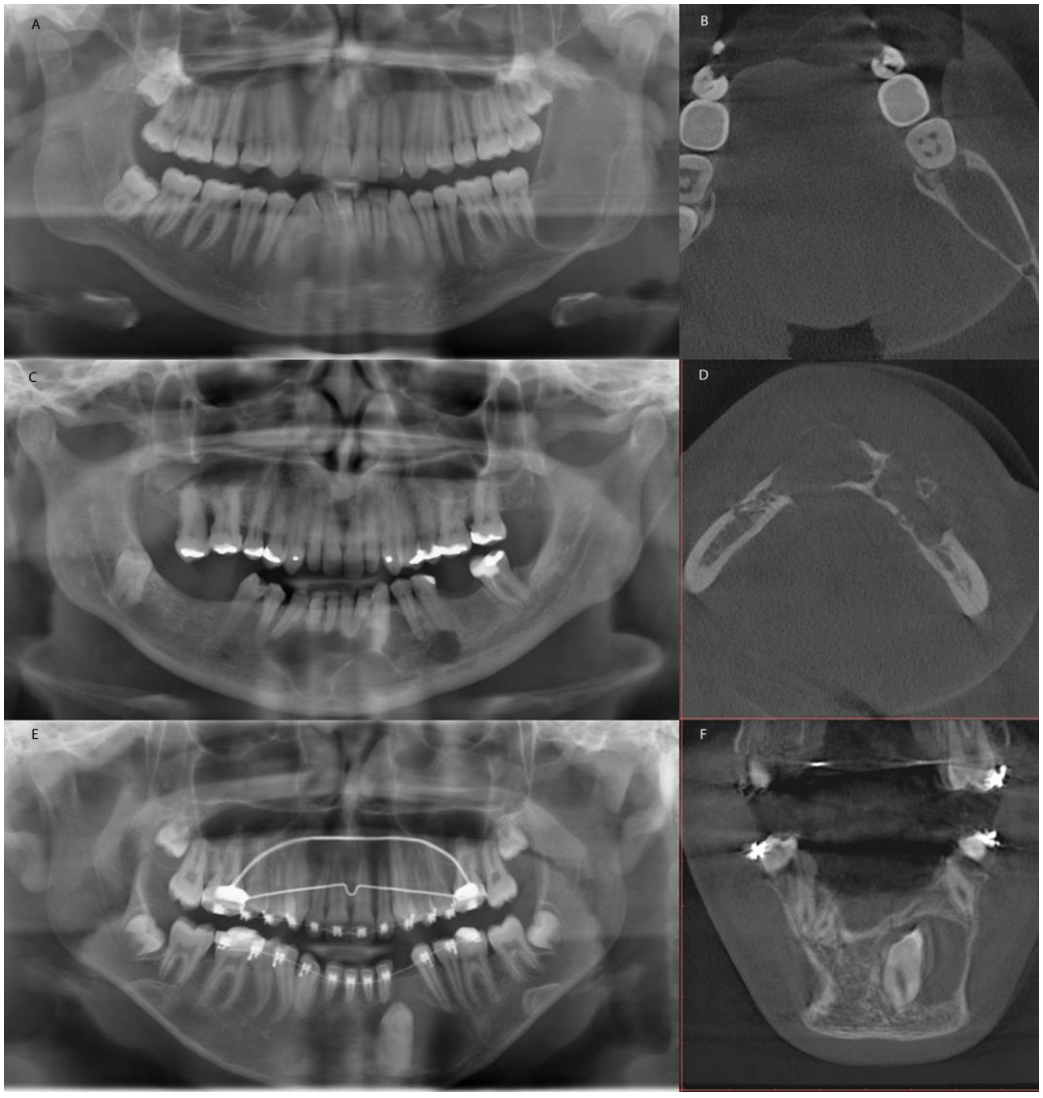

Figure 2: Keratocyst odontogenic tumor. A) PR: Radiolucent lesion on the left mandible, showing the characteristic scalloped KOT. B) CT: Axial image with little expansion and linguo-buccal growth through the bone marrow. All evaluators (8/8) made a correct diagnosis of KOT with PR and CT images. C) PR: Radiolucent lesion involving the anterior mandible with scalloped borders and bone septa inside. Six evaluators (6/8) made a correct diagnosis of KOT with PR image. D) CT: Axial section demonstrating bone expansion and rupture of the buccal and lingual cortical of the lesion. Five evaluators (5/8) made a correct diagnosis of KOT with the CT images. E-F) Lesion involving an impacted left mandibular canine. Two evaluators (2/8) made a correct diagnosis of KOT with CT images.

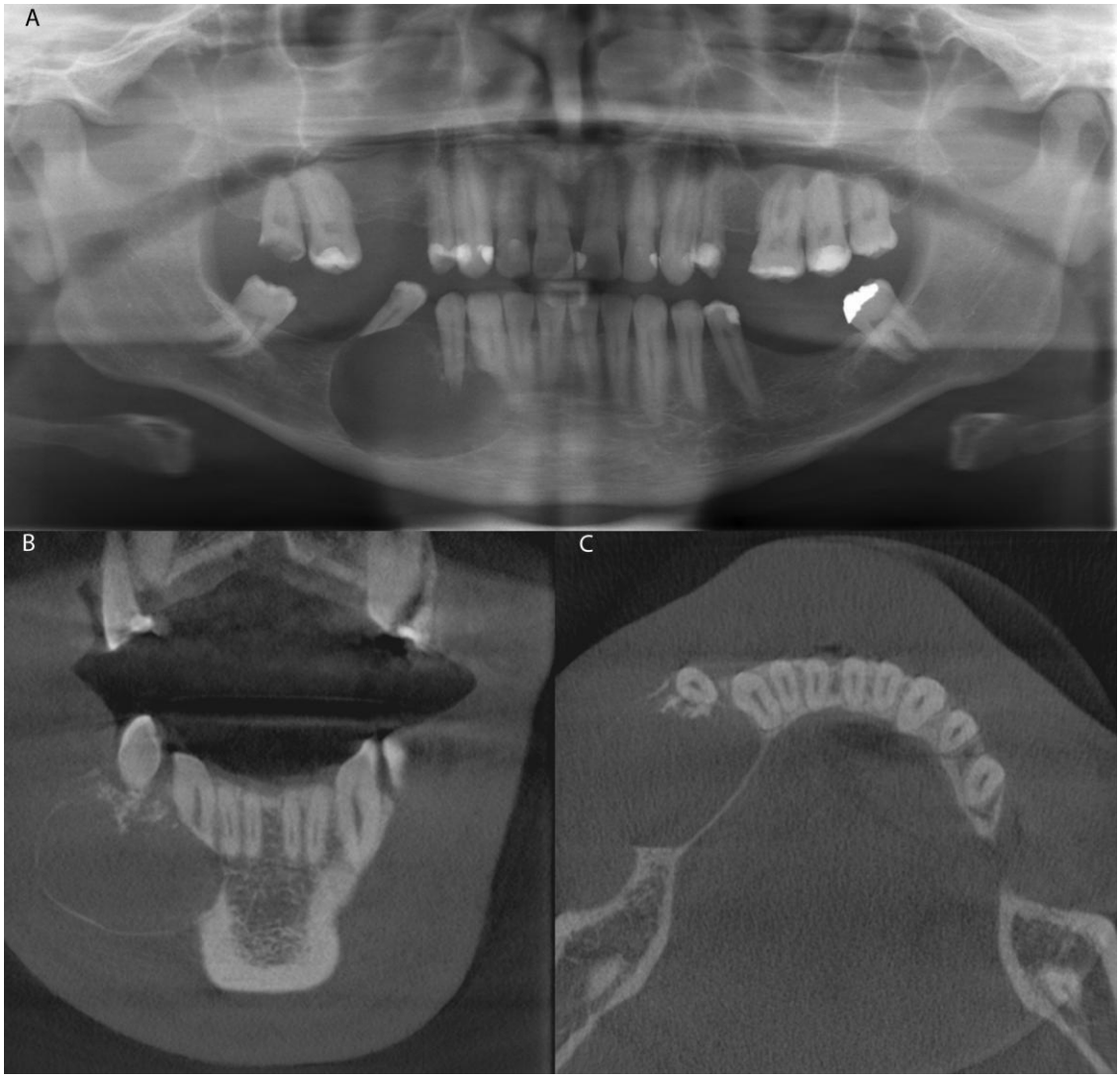

Figure 3: Adenomatoid Odontogenic Tumor. A) PR: Radiolucent image of the right mandibular body region, causing displacement and resorption of the root of the canine and second premolar. Note the presence of a discrete radiopaque image adjacent to the root of the first premolar. None evaluator (0/8) made a correct diagnosis of AOT with RP image. B-C) CT: Coronal and axial sections, respectively, showing the presence of a lesion with obvious areas of calcification associated with the first premolar. Two evaluators (2/8) made a correct diagnosis of AOT with CT images.

CONCLUSÃO

1 – A tomografia computadorizada apresentou uma taxa de acerto significativamente maior que a radiografia panorâmica para avaliação dos casos de ameloblastoma.

2 – Nos casos de tumor queratocisto odontogênico, cisto dentígero e mixoma odontogênico, não houve diferença estatisticamente siginificante entre o número de acertos na radiografia panorâmica e tomografia computadorizada.

3 – A radiografia panorâmica e a tomografia computadorizada demonstraram baixa sensibilidade para a interpretação do tumor queratocisto odontogênico (RP: 0.44; TC: 0.26) e do ameloblastoma (RP: 0.35; TC: 0.55).

4 – Conhecer melhor as características de imagem destas lesões, especialmente na TC, pode contribuir para a escolha da melhor conduta nos casos de cistos e tumores odontogênicos.

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ANEXO 1 – CERTIFICADO DO COMITÊ DE ÉTICA EM PESQUISA

COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa **"Comparação entre radiografia panorâmica e tomografia computadorizada de feixe cônico para o diagnóstico de cistos e tumores odontogênicos"**, protocolo nº 043/2012, dos pesquisadores Daniel Berretta Moreira Alves, Leonardo Berretta Moreira Alves e Marcio Ajudarte Lopes, satisfaz as exigências do Conselho Nacional de Saúde - Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 17/09/2012.

The Ethics Committee in Research of the Piracicaba Dental School - University of Campinas, certify that the project **"Panoramic radiography and cone beam computed tomography comparison for the diagnosis of odontogenic cysts and tumors"**, register number 043/2012, of Daniel Berretta Moreira Alves, Leonardo Berretta Moreira Alves and Marcio Ajudarte Lopes, comply with the recommendations of the National Health Council - Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee on Sep 17, 2012.

Profa. Dra. Lívia Maria Andaló Tenuta
Secretária
CEP/FOP/UNICAMP

Prof. Dr. Jacks Jorge Junior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.
Notice: The title of the project appears as provided by the authors, without editing.

ANEXO 2 – FORMULÁRIO PARA AVALIAÇÃO DOS CISTOS E TUMORES ODONTOGÊNICOS.

AVALIAÇÃO DA RADIOGRAFIA PANORÂMICA E TOMOGRAFIA COMPUTADORIZADA EM CISTOS E TUMORES ODONTOGÊNICOS

N° DO CASO: _____

- ☐ **RADIOGRAFIA PANORÂMICA**
- ☐ **TOMOGRAFIA COMPUTADORIZADA**

FORMAÇÃO DO AVALIADOR:

- ☐ RADIOLOGISTA ORAL
- ☐ PATOLOGISTA ORAL
- ☐ ESTOMATOLOGISTA
- ☐ CIRURGIÃO BUCOMAXILOFACIAL

1 – LOCALIZAÇÃO DA LESÃO:

- ☐ MANDÍBULA
- ☐ MAXILA
- ☐ AMBOS OS ARCOS

2 - REGIÃO DO CENTRO DA LESÃO:

- ☐ INCISIVOS
- ☐ RAMO ASCENDENTE
- ☐ CANINO
- ☐ ATM
- ☐ PRÉ-MOLARES
- ☐ SEIO MAXILAR
- ☐ MOLARES

3 - NÚMERO DE LESÕES:

- ☐ UMA
- ☐ TRÊS OU MAIS
- ☐ DUAS
- ☐ GENERALIZADO

4 - TAMANHO DA LESÃO:

- ☐ MENOR QUE 2 cm
- ☐ MAIOR QUE 3 cm
- ☐ ENTRE 2 E 3 cm
- ☐ NÃO É POSSIVEL PRECISAR

5 - ORIGEM DA LESÃO:

- ☐ CENTRAL
- ☐ PERIFÉRICA
- ☐ NÃO É POSSÍVEL PRECISAR

6 - ESTRUTURA INTERNA

- ☐ RADIOLÚCIDA / HIPODENSA
- ☐ RADIOPACA / HIPERDENSA
- ☐ RADIOLÚCIDA E RADIOPACA / HIPODENSA E HIPERDENSA (PREDOMINANTEMENTE RADIOPACO / HIPERDENSA)

☐ RADIOLÚCIDA E RADIOPACA / HIPODENSA E HIPERDENSA (PREDOMINANTEMENTE RADIOLÚCIDO / HIPODENSA)

☐ NÃO É POSSÍVEL PRECISAR

7 – PRESENÇA DE CALCIFICAÇÃO NO INTERIOR DA LESÃO:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

8 – DENSIDADE DA CALCIFICAÇÃO COMPATÍVEL COM:

☐ DENTE ☐ OSSO ☐ NÃO É POSSÍVEL PRECISAR

9 - BORDAS DA LESÃO:

☐ BEM DEFINIDA COM ESCLEROSE ☐ MAL DEFINIDA SEM ESCLEROSE

☐ DEFINIDA SEM ESCLEROSE ☐ NÃO É POSSÍVEL PRECISAR

10 - ASPECTO DA LESÃO:

☐ UNILOCULAR ☐ NÃO LOCULADA

☐ UNILOCULAR SEPTADA ☐ NÃO É POSSÍVEL PRECISAR

☐ MULTILOCULAR

11 - RELAÇÃO DA LESÃO COM OS DENTES:

☐ ASSOCIADO À COROA ☐ ASSOCIADO AO ÁPICE DENTAL ☐ DENTE NÃO ASSOCIADO

☐ ASSOCIADO À RAIZ ☐ REGIÃO DE DENTE AUSENTE

12 - LESÃO ENVOLVE UM OU MAIS DENTES:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

13 - CAUSA REABSORÇÃO RADICULAR:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

14 - CAUSA DESLOCAMENTO OU IMPACÇÃO DENTÁRIA:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

15 - CAUSA EXPANSÃO ÓSSEA:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

16 - CAUSA DESTRUIÇÃO DAS CORTICAIS ÓSSEAS:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

17 – CAUSA INVASÃO DE TECIDOS ADJACENTES:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

QUAIS? _____

SOMENTE PARA LESÕES MANDIBULARES:

18 – CAUSA DESLOCAMENTO DO CANAL MANDIBULAR:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

19 – ENVOLVE O CANAL MANDIBULAR:

☐ SIM ☐ NÃO ☐ NÃO É POSSÍVEL PRECISAR

20 – HIPÓTESE DIAGNÓSTICA

1ª OPÇÃO: _____

2ª OPÇÃO: _____

3ª OPÇÃO: _____

OPÇÕES PARA O DIAGNÓSTICO DE CISTOS E TUMORES ODONTOGÊNICOS

AMELOBLASTOMA

CEMENTOBLASTOMA

CISTO DENTÍGERO

CISTO PERIODONTAL LATERAL

CISTO ODONTOGÊNICO GLANDULAR

CISTO DA BIFURCAÇÃO VESTIBULAR

FIBROMA AMELOBLÁSTICO

FIBRODENTINOMA AMELOBLÁSTICO

FIBRO ODONTOMA AMELOBLÁSTICO

FIBROMA ODONTOGÊNICO

MIXOMA ODNTOGÊNICO

ODONTOMA

ODONTOAMELOBLASTOMA

TUMOR ODONTOGÊNICO ESCAMOSO

TUMOR ODONTOGÊNICO EPITELIAL CALCIFICANTE

TUMOR ODONTOGÊNICO ADENOMATOIDE

TUMOR QUERATOCISTO ODONTOGÊNICO

TUMOR ODONTOGÊNICO CÍSTICO CALCIFICANTE

OBSERVAÇÕES:

_____
_____
_____
_____
_____
_____