Revista da Faculdade de Odontologia de Porto Alegre
V. 63, n. 1 (2022) - Artigos Originais
DOI: 10.22456/2177-0018.117538

Can the method of CBCT interpretation influence endodontic diagnosis?

O método de interpretação da tcfc pode influenciar o diagnóstico endodôntico?

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RESUMO

Objetivo: Este estudo avaliou a influência do método de visualização e análise do exame de tomografia computadorizada de feixe cônico (TCFC) no diagnóstico de afecções endodônticas. **Materiais e métodos:** Vinte casos clínicos contendo doze diferentes afecções endodônticas foram analisados por dois especialistas em radiologia odontológica e um especialista em endodontia. Inicialmente, os avaliadores visualizaram os casos em Portable Document Format (PDF) contendo uma seleção de imagens digitais e, por consenso, descreveram suas hipóteses diagnósticas para cada caso. Após uma semana, os avaliadores reavaliaram os casos, desta vez utilizando reconstrução multiplanar em um visualizador de imagens no formato Digital Imaging and Communications in Medicine (DICOM). Novamente, por consenso, eles indicaram suas hipóteses diagnósticas. **Resultados:** Em 10% dos casos, houve discrepância entre os diagnósticos realizados utilizando as seleções de imagens digitais em PDF e utilizando a reconstrução multiplanar. A visualização das imagens em PDF obteve sensibilidade de 0.714, especificidade de 0.966, e acurácia de 90%. **Discussão:** Na maioria destes casos, as afecções endodônticas identificadas utilizando o visualizador de imagens DICOM (reconstrução multiplanar) não foram detectadas quando visualizados os PDF de imagens pré-selecionadas. **Conclusão:** Embora mais estudos sejam necessários, os autores reiteram que a utilização de reconstruções multiplanares sempre são preferíveis comparadas à outras formas de análise da TCFC, para que se atinja o máximo potencial diagnóstico do exame de imagem.

Palavras-chave: Tomografia computadorizada de feixe cônico. Diagnóstico. Endodontia.

ABSTRACT

Aim: This study evaluated the influence of the method used for visualization and analysis of cone-beam computed tomography (CBCT) on the diagnosis of endodontic conditions. **Materials and methods:** Twenty clinical cases containing twelve different endodontic conditions were analyzed by two specialists in dental radiology and one specialist in endodontics. Initially, the evaluators viewed the cases in Portable Document Format (PDF) containing a selection of digital images and, by consensus, described their diagnostic hypotheses for each case. One week later, the evaluators reassessed the cases, this time using multiplanar reconstructions with a Digital Imaging and Communications in Medicine (DICOM) format image viewer. Once more, by consensus, they recorded their diagnostic hypotheses. **Results:** In 10% of the cases there was a discrepancy between the diagnoses made using preselected digital images in PDFs and by viewing multiplanar reconstructions. The visualization of the PDF images obtained a sensitivity of 0.714, specificity of 0.966, and 90% accuracy. **Discussion:** In the majority of these cases, endodontic conditions identified using the DICOM image viewer (multiplanar reconstruction) were not detected using the PDFs of preselected images. **Conclusion:** Although more studies are needed, the authors reiterate that using multiplanar reconstructions should always be preferred to other forms of analysis for CBCT, so that the maximum diagnostic potential of the imaging exam can be achieved.

Keywords: Cone-beam computed tomography. Diagnosis. Endodontics.

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Data de envio: 09/08/2021 | **Data de aceite:** 18/11/2021

Introduction

Many professionals have adopted cone-beam computed tomography (CBCT) to improve visualization and understanding in complex clinical situations, in response to increasing demand for safer and more predictable treatments[1,2]. Among other advantages, CBCT imaging eliminates distortions, magnification, and artifacts usually associated with conventional radiographs, in addition to exposing patients to a relatively low dose of radiation compared to medical-grade computed tomography[3,4]. These examinations can be essential for diagnosis, treatment decision-making, planning, and monitoring of endodontic conditions[5]. However, although multiplanar reconstruction is considered the most significant advantage of CBCT, it has been observed that these examinations are often analyzed using preselected digital images stored in PDF files, rather than by viewing multiplanar reconstructions using visualization software. The preference for this method of analysis can perhaps be explained by issues such as practicality, reduced demand on professionals' clinical time, or even a lack of training in use of visualization software[6].

Imaging studies can be analyzed using PDFs of selected digital images either on printed films or displayed on the computer screen in digital format. In both cases, results are dependent on the sections (slices) chosen at the time the set of images is compiled. Once acquired, the images are static and cannot be changed[7]. In contrast, when evaluating images using multiplanar reconstruction software, the professional is not restricted to viewing the slices selected for the PDFs and therefore has greater freedom and autonomy to interpret the full imaging study[8,9].

If CBCT imaging is conducted at a dental radiology clinic, the images will be analyzed by a radiology specialist who performs the multiplanar scanning. However, CBCT equipment is becoming less expensive on the market and increasing numbers of general dental clinics are purchasing scanners and performing these examinations on their own premises. In this scenario, it is often the same professional who orders the images who interprets them, usually centered on the patient's primary complaint and using preselected two-dimensional images. Moreover, many dental radiology specialists work remotely; i.e., they are sent digital images over the internet and are tasked with diagnosing what the images show[10,11]. Nonetheless, because of the technical difficulty caused by the size of DICOM files, the capacity of internet networks and computers, data transfer times, and even radiology clinics' rules, many specialists end up basing their reports on PDFs of preselected digital images. It is against this background that the present study investigated the impact of the method used to view tomographic images on diagnosis of different endodontic conditions.

Materials and methods

Sample selection and cases

This study was conducted by analyzing a subset of the clinical cases used in a previous article "Can Cone-beam Computed Tomography Change Endodontists' Level of Confidence in Diagnosis and Treatment Planning? A Before and After Study"[12]. For that article, two questionnaires were constructed using the Google Docs platform (Google, Mountain View, United States of America) showing images from twenty clinical cases of different degrees of complexity, classified according to the American Association of Endodontists (A.A.E.) evaluation criteria. This was a convenience sample of cases from the archives of a private dental radiology clinic, containing both preselected digital images in PDFs and also de DICOM files for the multiplanar reconstruction. The endodontic conditions present in the cases were as follows: mineralization of the pulp chamber; root canal mineralization; partially treated root

canal; undetected or untreated root canal; accessory root canal; root laceration; external root resorption; chronic apical periodontitis; endoperiodontal lesion; dental fracture; and root perforation.

Image evaluation

The CBCT studies were analyzed, in consensus, by two oral and maxillofacial (OMF) radiologists (M.B.V. and N.A.A.), and one endodontist (F.M.). Initially, the cases were assessed on the basis of a fictitious clinical history, periapical radiograph, and PDFs containing preselected digital images. The evaluators described their diagnostic hypotheses for each case. One week later, the evaluators analyzed the same cases, but in a different order, this time using the fictitious clinical history, periapical radiograph, and tomographic volume rendering (RadiAnt DICOM Viewer, Medixant, Poznan, Poland) software. Once again, they noted their diagnostic hypotheses for each case. This second analysis was defined as the gold standard for data analysis.

Data analysis

A database was created to store the examiners' answers on the Google Sheets platform (Google, Mountain View, United States of America). This database was used to compare the diagnoses for each case and identify discrepancies between diagnoses made using preselected digital images in PDFs and multiplanar reconstruction methods. The answers database was constructed with 240 fields coded true or false, one for each possible diagnosis, since 20 clinical cases were analyzed and 12 different endodontic conditions were included. Results were expressed in percentages. Afterwards, the sensitivity, specificity and accuracy values were calculated using an online Diagnostic Test Calculator[13].

Results

All of the answers were analyzed and disagreement between the result obtained by analysis of PDFs of preselected digital images and multiplanar reconstruction methods was detected in 24 (24/240) of them, equating to 10% of the responses. In the majority (75% or 18/24) of these cases, endodontic conditions were only identified by analysis of multiplanar reconstruction. Six of these cases (25%) were considered false positives, where the conditions were identified using the PDFs, but were not actually present in the cases (4: external root resorption; 1: partially treated canal; 1: apical periodontitis). The analysis using the PDFs containing preselected digital images obtained a sensitivity of 0.714, specificity of 0.966, and 90% accuracy.

The accessory canal was the condition with the highest percentage difference (100%), since only one case of this condition was included in the sample and this case was only identified using the multiplanar reconstruction. There was a 66.6% difference in identification of root canal mineralization, where only 2 of the total of 6 cases were identified using PDFs of digital images. There was a 57.1% difference in identification of root perforation, where only 3 of the total 7 cases were identified using PDFs. Fifty percent (1/2) of the cases of endoperiodontal lesion were identified with the PDFs. There was a 33.3% difference in identification of undetected or untreated root canal (2/3 identified with the PDFs) and external root resorption (8/12 identified with the PDFs). There was a 25% difference in identification of root dilacerations, where three out of the four root lacerations cases were identified using the PDFs. A difference of 16.6% was identified regarding partially treated root canal, where 5 out of 6 cases were identified using the PDFs. Only one out of 19 cases of apical periodontitis was not identified in the PDFs, resulting

in a difference of 5.3%. With regard to the other conditions present in cases not mentioned above (pulp chamber mineralization and fracture), there were no discrepancies between the diagnoses made using PDFs of digital images and multiplanar reconstructions.

Table 1 lists the endodontic conditions assessed in the present study and the discrepancies between the diagnoses using multiplanar reconstruction and using the PDFs.

Table 1: Comparison of the number of cases diagnosed using multiplanar reconstruction and using PDFs.

Endodontic condition	Number of cases diagnosed using multiplanar reconstruction	Number of cases diagnosed using PDFs	Percentage of difference in identification
Accessory root canal	1	0	100%
Root canal mineralization	6	2	66%
Root perforation	3	7	57.1%
Endoperiodontal lesion	1	2	50%
Undetected or untreated root canal	2	3	33.3%
External root resorption	8	12	33.3%
Root laceration	3	4	25%
Partially treated root canal	5	6	16.6%
Chronic apical periodontitis	18	19	5.3%
Mineralization of the pulp chamber	1	1	0%
Dental fracture	2	2	0%

Discussion

Scarfe *et al.*[14] state that "as CBCT image-capture is inherently digital, image visualization should be by digital display." Also, unlike other dental radiographic procedures, CBCT acquisition is volumetric and captures 3D information. Therefore, to enable visualization of all of the digital information within the volume imaged, interpretation should not be based on PDFs of digital images, but conducted using software-assisted volumetric review.

Different methods of interpretation of an imaging exam can change the results, often influencing diagnosis, management, and treatment planning. Opting for a static method that may be considered more practical, such as PDFs of digital images, may have consequences that reduce the examination's accuracy as a form of diagnosis. It is important to emphasize that having exposed a patient to ionizing radiation, we have a duty to analyze the full findings of the examination to make the most of its benefits[15]. When an imaging exam is analyzed more thoroughly, there is a greater likelihood of detecting incidental findings, as was reported in a

study in which incidental findings were identified in 92.8% of CBCT studies, including findings involving the airways, impacted teeth, temporomandibular joint, endodontic lesions, and others[16]. Analysis of PDFs of digital images may fail to identify these conditions, since they could be located between the slices selected and therefore not be included in the final set of images.

Consideration should be given to the preferences of the professionals involved, in terms of their self-confidence with relation to analysis of imaging studies, since sometimes professionals who are specialists in a different area (endodontics, for example) would rather call on the support of an OMF radiologist. In a study by Beacham *et al.*[17], in which endodontists and second-year specialization students analyzed CBCT studies and answered whether they thought it was necessary to refer the examination to a radiology specialist, students of endodontics referred to the radiologist in 49.8% of cases, while specialists did so in 38.9% of cases. Interrelation between different areas of dentistry should be encouraged, since combining different professionals' points of view should enable a more comprehensive process of diagnosis and treatment planning and ensure that the best possible use is made of the imaging exam.

It is important to emphasize that, in cases in which the OMF radiologist makes the diagnosis and prepares the radiography report, the specialist who ordered the examination often does not verify or cross-check these data. Silveira *et al.*[18] reported that orthodontists only stated that they cross-checked the cephalometry performed by radiology clinics in 19.2% of cases. It is necessary to verify radiographic examinations because significant discrepancies can lead to changes in conduct and treatment, such as unnecessary extractions[19]. Some dentists consider the PDFs of digital images a more simplistic option compared to multiplanar reconstruction (which requires a computer, software, and time). This choice is mainly due to resistance to using the software and the idea that multiplanar reconstruction would demand increased clinical time. In Brazil, it is uncommon for small clinics to have the equipment needed to conduct tomographic examinations at their own premises. Thus, the tendency for professionals to be unfamiliar with interpreting examinations using dedicated software could be greater than in other countries where tomography is more accessible and more likely to be part of routine clinical practice. Professionals' habits influence their conduct when interpreting imaging exams. Each professional acquires preferences depending on their academic background, professional trajectory, confidence, and habits. Using PDFs of digital images may be a popular choice among professionals qualified in areas other than radiology, because of their practicality and easy access. Still, even though the PDF visualization may be a recurrent habit, the increasing in CBCT requests, along with its importance within some specialties, e.g. Endodontics, has led professionals into trying to make the most of the exam, through a more detailed evaluation of the images through analyzing multiplanar reconstructions (volume).

Conclusion

This study concluded that analyzing the CBCT in the form of preselected slices obtained an accuracy of 90%, reducing the examination's diagnostic capacity for endodontic disorders when compared to the multiplanar reconstruction. Although that could be considered a high accuracy, the authors reiterate that volumetric rendering should always be preferred to other forms of analysis so that the maximum potential of the imaging exam can be achieved.

Funding

This study was financed in part by PROBIC FAPERGS UFRGS – Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul.

Conflict of interests

The authors declare that they have no conflict of interest.

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