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Jéssica Lopes Trindade

CONHECIMENTO E PERCEPÇÃO DOS ENDODONTISTAS SOBRE TOMOGRAFIA COMPUTADORIZADA DE FEIXE CÔNICO E IMPACTO DO EXAME EM CASOS ENDODÔNTICOS

Santa Maria, RS
2023

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Tese apresentada ao Curso de Doutorado do Programa de Pós-Graduação em Ciências Odontológicas da Universidade Federal de Santa Maria (UFSM, RS), como requisito parcial para a obtenção do título de **Doutora em Ciências Odontológicas com Ênfase em Endodontia**.

Orientador: Prof. Dr. Carlos Alexandre Souza Bier

Coorientadora: Profª Drª Gabriela Salatino Liedke

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2023

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Jéssica Lopes Trindade

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Aprovada em 01 de dezembro de 2023:

_____

Carlos Alexandre Souza Bier, Dr. (UFSM)
(Presidente da Banca/Orientador)

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Gabriela Salatino Liedke, Dra. (UFSM)
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Camilla dos Santos Tibúrcio Machado, Dra. (APCD/São José dos Campos)

Santa Maria, RS
2023

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RESUMO

CONHECIMENTO E PERCEPÇÃO DOS ENDODONTISTAS SOBRE TOMOGRAFIA COMPUTADORIZADA DE FEIXE CÔNICO E IMPACTO DO EXAME EM CASOS ENDODÔNTICOS

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ORIENTADOR: Carlos Alexandre Souza Bier
COORIENTADORA: Gabriela Salatino Liedke

O objetivo desse trabalho foi avaliar o conhecimento dos endodontistas brasileiros sobre tomografia computadorizada de feixe cônico ou *cone beam* (TCFC ou TCCB), bem como sua utilização clínica. Além disso, foi realizada uma análise sobre o impacto do exame no diagnóstico, tomada de decisão clínica e nível de confiança em casos clínicos endodônticos. Este estudo foi desenvolvido em duas partes: I, um estudo observacional transversal e II, uma revisão sistemática de literatura. A coleta de dados ocorreu por meio de um questionário eletrônico de 24 perguntas, abrangendo informações demográficas, aprendizado da TCFC, utilização clínica da TCFC e o impacto percebido da TCFC. A análise dos dados foi realizada por meio de estatística descritiva e regressão logística; os resultados foram apresentados como Odds Ratios (OR) com intervalos de confiança (IC) de 95% e valores de p. Resultados: A amostra foi composta por 300 endodontistas, dos quais 79,3% relataram ter recebido algum tipo de educação em TCFC. Houve associação significativa entre a utilização do exame de TCFC e o aprendizado ($p<0,001$). A análise de regressão logística revelou que os endodontistas que relataram confiar apenas no laudo do radiologista do exame de TCFC tiveram menores chances de perceber o impacto do exame no diagnóstico (OR 0,17; IC 0,44-0,73) e no nível de confiança (OR 0,18; IC 0,04). -0,84). Endodontistas com menor tempo de pós-graduação também tiveram menor chance de percepção do impacto do exame no nível de confiança (OR 0,18; IC 0,03-0,95). Endodontistas brasileiros que relataram mais conhecimento sobre TCFC têm maior probabilidade de utilizar o exame. No estudo II, foi realizada uma busca sistemática nas bases de dados PubMed/MEDLINE, Cochrane-CENTRAL, EMBASE, Scopus, LILACS e Web of Science, bem como na literatura cinzenta (PROSPERO, Google Scholar e DANS EASY Archive). Foram lidas na íntegra 30 publicações e 24 preencheram os critérios de inclusão. Foram avaliadas informações sobre mudanças no diagnóstico, planejamento de tratamento e nível de confiança após TCFC. A qualidade metodológica dos estudos incluídos foi avaliada pelo QUADAS-2. Foram incluídos 24 estudos, com um total de 1.144 dentes avaliados. Nove estudos foram classificados como de baixo risco de viés. A maioria dos estudos focou em mudanças no planejamento do tratamento (n=10) ou no diagnóstico (n=5). A TCFC levou a alterações diagnósticas na maioria dos casos de tratamento endodôntico primário (n=6); estudos que avaliaram trauma dentário mostraram a melhora mais significativa. A TCFC impacta o diagnóstico, o planejamento do tratamento e a confiança profissional em casos de tratamentos endodônticos complexos, muitas vezes levando a tratamentos mais invasivos.

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

ABSTRACT

ENDODONISTS' KNOWLEDGE AND PERCEPTION ABOUT CONE BEAM COMPUTERIZED TOMOGRAPHY AND THE IMPACT OF THE EXAM IN ENDODONTIC CASES

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ADVISOR: Carlos Alexandre Souza Bier
CO-ADVISOR: Gabriela Salatino Liedke

The objective of this work was to evaluate the knowledge of Brazilian endodontists about cone beam computed tomography (CBCT or CBCT), as well as its clinical use. Furthermore, an analysis was carried out on the impact of the exam on diagnosis, clinical decision-making and level of confidence in endodontic clinical cases. This study was developed in two parts: I, a cross-sectional observational study and II, a systematic literature review. Data collection occurred through a 24-question electronic questionnaire, covering demographic information, CBCT learning, clinical use of CBCT, and the perceived impact of CBCT. Data analysis was performed using descriptive statistics and logistic regression; results were presented as Odds Ratios (OR) with 95% confidence intervals (CI) and p-values. Results: The sample consisted of 300 endodontists, of whom 79.3% reported having received some type of education in CBCT. There was a significant association between the use of the CBCT exam and learning ($p<0.001$). Logistic regression analysis revealed that endodontists who reported relying only on the radiologist's report of the CBCT exam were less likely to perceive the impact of the exam on diagnosis (OR 0.17; CI 0.44-0.73) and on the level of trust (OR 0.18; CI 0.04). -0.84). Endodontists with less postgraduate experience also had a lower chance of perceiving the impact of the exam on their level of confidence (OR 0.18; CI 0.03-0.95). Brazilian endodontists who reported more learning about CBCT are more likely to use the exam. In study II, a systematic search was carried out in the PubMed/MEDLINE, Cochrane-CENTRAL, EMBASE, Scopus, LILACS and Web of Science databases, as well as in the gray literature (PROSPERO, Google Scholar and DANS EASY Archive). 30 publications were read in full and 24 met the inclusion criteria. Information on changes in diagnosis, treatment planning and level of confidence after CBCT was assessed. The methodological quality of the included studies was assessed by QUADAS-2. 24 studies were included, with a total of 1,144 teeth evaluated. Nine studies were classified as low risk of bias. Most studies focused on changes in treatment planning (n=10) or diagnosis (n=5). CBCT led to diagnostic changes in most cases of primary endodontic treatment (n=6); Studies that evaluated dental trauma showed the most significant improvement. CBCT impacts diagnosis, treatment planning and professional confidence in cases of complex endodontic treatments, often leading to more invasive treatments.

Keywords: Endodontics. Cone beam computed tomography. Diagnosis. Decision making. Confidence.

SUMÁRIO

1 INTRODUÇÃO

A associação entre o histórico clínico do paciente, exames físicos e os resultados de exames radiográficos tem grande valor na Odontologia (GLENNER, 1975). Na endodontia, as radiografias intraorais (RI) desempenham um papel fundamental em todas as etapas do tratamento, desde o processo diagnóstico até o acompanhamento pós-operatório (FAVA; DUMMER, 1997). No entanto, tanto as RI convencionais ou digitais possuem a mesma limitação: apresentam a imagem bidimensional (2D) de uma estrutura tridimensional (3D) (HUUMONEN; ØRSTAVIK, 2002; PATEL et al., 2009). Essa limitação pode resultar em dificuldades na interpretação da região de interesse, devido à sobreposição de estruturas anatômicas (HUUMONEN; ØRSTAVIK, 2002).

O desenvolvimento da tomografia computadorizada de feixe cônico ou *cone beam* (TCFC ou TCCB) possibilitou a avaliação 3D das áreas de interesse, permitindo assim a manipulação e a visualização do exame nos planos axial, sagital, coronal e oblíquos (LIANG et al., 2010; SCARFE; FARMAN; SUKOVIC, 2006). Na endodontia, a TCFC pode ser utilizada em inúmeras situações e momentos clínicos, como diagnósticos de casos complexos, planejamentos cirúrgicos e confecções de impressões 3D (PATEL et al., 2019). Entretanto, as doses efetivas de radiação em exames de RI completos podem variar de 34,9-170,7 mSv; em exames de TCFC essas doses podem variar de 30-1073 mSv, dependendo das especificações de cada aparelho e ajustes de cada exame (ICPR 2007; LORENZONI et al., 2012). Além disso, a exposição à radiação constitui um risco estocástico (cumulativo) à saúde, sendo associada a doenças hereditárias e incidência de câncer (ICRP 2007). Sendo assim, a solicitação da TCFC deve ser justificada para cada paciente, nos quais os benefícios devem superar os riscos da maior exposição à radiação e quando o exame irá adicionar novas informações para ajudar na tomada de decisão clínica, fornecendo um diagnóstico apropriado e tratamento adequado (JAJU; JAJU, 2015; SEDENTEXCT, 2012).

No tratamento endodôntico, a TCFC demonstrou possuir um impacto significativo, em inúmeras situações clínicas, no pensamento diagnóstico e na decisão terapêutica, causando alterações substanciais após seu uso (MOTA DE ALMEIDA; KNUTSSON; FLYGARE, 2014, 2015; RODRÍGUEZ et al., 2017). Quanto à confiança do endodontista, a TCFC aumentou a confiança no diagnóstico e plano de tratamento em casos de média e alta complexidade, quando comparada a associação de exames clínicos e apenas RI (VIANA WANZELER et al., 2020). Além disso, a área de atuação clínica ao utilizar os exames de TCFC demonstrou influenciar na decisão terapêutica, pois apenas especialistas em endodontia não consideraram que a

visualização do exame resultou em um escolha de plano de tratamento mais difícil (RODRÍGUEZ et al., 2017).

Em consultórios odontológicos no Reino Unido, foi demonstrado não ocorrer uso excessivo da TCFC, todavia foi visto pouco conhecimento sobre fatores de exposição ao uso do exame e interpretação das imagens (YALDA et al., 2019). Quanto ao aprendizado sobre TCFC nos EUA, mais da metade dos programas de residência em endodontia oferecem pelo menos uma aula, porém os alunos relatam não estarem satisfeitos com as aulas ministradas (RABIEE et al., 2018). Já em pós-graduações em endodontia no Brasil, o ensino sobre TCFC não está incluso em 74,6% dos programas; já nos programas que incluem o tema, são ministradas poucas aulas teórico/práticas, porém a maioria dos diretores desses programas afirmam estarem satisfeitos com o conteúdo ministrado (COELHO; RIOS, 2023). Portanto, nota-se a necessidade de aperfeiçoar os profissionais que utilizam a TCFC, visando à proteção dos pacientes submetidos a esse exame, principalmente devido a sua maior dose de radiação (BROWN et al., 2014).

Este documento apresenta dois artigos, sendo que o primeiro, intitulado **"Knowledge, use, and impact of cone beam computed tomography by Brazilian endodontists: a web-based survey"**, é um estudo observacional transversal e tem como objetivo verificar os métodos de aprendizagem, o domínio e a utilização clínica da TCFC entre os endodontistas brasileiros e o impacto percebido do exame no diagnóstico, plano de tratamento e segurança em casos clínicos endodônticos.

O segundo artigo, intitulado **"Impact of cone beam computed tomography examinations on diagnosis, treatment planning, and confidence in endodontic cases: a systematic review"** é uma revisão sistemática de literatura com o objetivo de verificar o impacto dos exames de TCFC no nível de confiança, pensamento diagnóstico e/ou plano de tratamento em diversos casos clínicos endodônticos, em comparação com utilização apenas das RIs com ou sem exame clínico.

2 ARTIGO 1: KNOWLEDGE, USE, AND IMPACT OF CONE BEAM COMPUTED TOMOGRAPHY REPORTED BY BRAZILIAN ENDODONTISTS: A WEB-BASED SURVEY

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Knowledge, use, and impact of cone beam computed tomography reported by Brazilian endodontists: a web-based survey

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Knowledge, use, and impact of cone beam computed tomography reported by Brazilian endodontists: a web-based survey

ABSTRACT

Objective: Investigate the learning process, domain, and clinical use of CBCT (cone beam computed tomography) among Brazilian endodontists and the perceived impact of this exam on diagnosis, treatment planning, and confidence in endodontic cases. **Methods:** Data collection occurred using a 24-question electronic questionnaire, covering demographic information, CBCT learning, CBCT clinical utilization, and the perceived impact of CBCT. Data analysis was performed using descriptive statistics and logistic regression; results were presented as Odds Ratios (OR) with 95% confidence intervals (CI) and p-values. **Results:** The sample comprised 300 endodontists, of whom 79.3% reported receiving some form of CBCT education. There was a significant association between the use of the CBCT exam and learning ($p<0.001$). Logistic regression analysis revealed that endodontists who reported relying only on the radiologist report of the CBCT examination had a smaller odds to perceive the impact of the exam on diagnosis (OR 0.17; CI 0.44-0.73), and confidence level (OR 0.18; CI 0.04-0.84). Endodontists with lesser postgraduation time also had a smaller odds to perceived impact of the exam in confidence level (OR 0.18; CI 0.03-0.95). Endodontists who analyze exams in DICOM format have higher odds to report the impact of the exam on patient understanding (OR 4.55; CI 2.16-9.59), and confidence regarding treatment (OR 3.10; CI 1.52-6.31). **Conclusions:** Brazilian endodontists who reported more learning about CBCT are more likely to use the exam. Furthermore, CBCT education and the method used to assess the exam seem to be associated with the reported impact on diagnosis, treatment planning, confidence level, and patient understanding of the case.

Key-words: Cone beam computed tomography, endodontics, diagnoses, treatment planning

INTRODUCTION

Complementary imaging examinations should be employed by healthcare professionals following a comprehensive evaluation of the patient and clinical justification (Ferrante Di Ruffano et al. 2012; Horner et al. 2004; Sedentexct 2012). In the field of endodontics, intraoral radiographs (IR) are routinely used. However, in specific clinical scenarios, the use of cone beam computed tomography (CBCT) is necessary, as it offers a multidimensional view of the region of interest, with no overlapping, overcoming the limitations of IR (Patel, Dawood, Whaites, et al. 2009). Nevertheless, considering its higher radiation dose, CBCT should be recommended in situations where its contribution is expected to change diagnosis and clinical decision-making, and thus its use should be individually justified, demonstrating that the benefits of the examination outweigh its associated risks (Jaju & Jaju 2015; Sedentexct 2012).

The qualification and experience of professionals performing endodontic treatments are related to the success rate (Imura et al. 2007; Ng et al. 2011). The professional is considered a specialist if they have received training with a higher number of hours and have experience in treating more complex cases, in addition to possessing a stronger theoretical foundation (Imura et al. 2007). However, the education in radiology, especially in CBCT, for endodontic specialists appears to be suboptimal (Rabiee et al. 2018; Coelho & Rios 2023). Even though the interpretation of CBCT falls within the domain of an Oral and Maxillofacial Radiology specialist, the endodontists should be capable of assessing the tomographic image, identifying anatomical structures and pathologies, and correlating and applying the examination information with the patient's clinical data to formulate a diagnosis and treatment plan (Brown et al. 2014).

The literature discloses several gaps regarding the teaching process of tomography among endodontic specialists (Rabiee et al. 2018; Coelho & Rios 2023). Nonetheless, CBCT scans are thorough used among endodontists (Patel et al. 2019). Therefore, the objective of this

cross sectional observational study was to examine the clinical utilization, learning methods, and domain of CBCT among Brazilian endodontists, and the perceived impact of the examination on the diagnosis, treatment planning, and safety in endodontic clinical cases.

MATERIALS AND METHODS

This present study was approved by the institutional ethics committee (CAAE 52124521.0.0000.5346) and adhered to the PROBE *guidelines* (Nagendrababu et al., 2023).

The sample comprised exclusively Brazilian dentists holding at least one qualification in endodontics (specialization, master's, doctoral, and/or post-doctoral degree). The sample size calculation considered the population of endodontic specialists in Brazil in 2021 (16.658), a 95% confidence level, and a margin of error of 5%, and an assumed rate of 75% of endodontists who use CBCT examination, resulting in 284 questionnaires.

Data collection took place from June 16, 2021, to June 27, 2023, using electronic questionnaires available on the Google Forms platform. Participants were invited to participate through invitations on messaging apps (such as WhatsApp), social media, and email to endodontic postgraduate programs in Brazil.

Before the questionnaire, each participant read the Informed Consent Form (ICF). Access to the questionnaire was granted only after the participant had electronic signed the ICF voluntarily and of their own free will. The questionnaire consisted of 24 questions, divided into 3 sections. The first section included demographic information such as qualifications in endodontics, gender, year of birth, year of undergraduate graduation, year of postgraduate courses conclusion, and the location of their practice. The second section pertained the CBCT learning, including whether the participant received any related instruction, the timing of this instruction during their education, topics covered during the learning process, and whether they considered their education sufficient. The final section inquired about the utilization of CBCT

examinations, including reasons for requesting the exam, tools for image analysis, and the impact of the examination on diagnosis, treatment planning, the professional's safety level, and the patient's understanding and confidence during treatment. Responses were collected using a Likert Scale, ranging from 1 ("definitely not") to 5 ("definitely yes").

Statistical analysis

Statistical analysis was performed using the SPSS program (Statistical Package for the Social Sciences, version 13; Inc, Chicago, IL). Descriptive analysis was performed for all variables.

The logistic regression analysis evaluated whether sex, age (dichotomized into < or > than 40 years), graduation time (dichotomized into < or > than 16 years), postgraduate time (dichotomized into < or > than 11 years), CBCT lecture (Yes/No), sufficient learning about CBCT (Yes/No), workplace, qualification, and exam evaluation had an impact on the diagnosis, clinical decision making, increase in confidence level, patient’s understanding, and patient’s confidence regarding treatment. Adjusted multivariate logistic regression analyses were then performed with those variables with an initial significant outcome ($P \leq 0.2$) in the binary logistic regression. The variables whose answers were on a Likert scale were dichotomized into 0, 1 and 2 = no; 4 and 5 = yes. Results are presented as Odds Ratios (OR) along with their respective 95% confidence intervals (CI) and a significance level of $P < 0.05$.

The chi-square test was used to compare the independent variable (reported CBCT lecture) with the reported clinical use of CBCT examinations. The significance level was $P < 0.05$.

RESULTS

The final sample comprised 300 dentists with qualifications in endodontics. The average age of the sample was 40.74 years, and most participants were female (55%). Other demographic data are presented in Table 1. Regarding CBCT education (Table 2), most dentists (79.3%) reported having received at least one lesson on the subject, primarily delivered during postgraduate programs (47.3%) and short/intensive courses (42.3%). However, 94 (31.3%) participants considered that their learning was not enough.

It was found that most endodontists (89.7%) use the exams and that the majority (85.5%) also report some teaching on the topic. Furthermore, there was a statistical significant association ($p<0.001$) between the use of the exam and endodontists who had some lecture on the topic (Table 3). In addition, endodontists who have had training about CBCT also present statistical significant association in the use of the exam in cases of suspected crack/fracture ($p<0.001$), location and identification of canals ($p<0.001$), internal/external resorption ($p=0.005$), root calcification ($p=0.017$) and pre-surgical planning ($p<0.001$).

Logistic regression analysis analyzed demographic data and reported learning about CBCT to the perceived impact of the exam on diagnosis (Table 4), clinical decision making (Table 5), and increase in confidence level (Table 6). Unadjusted analysis showed that male endodontists, professionals with younger graduation time, having had CBCT education, and having any other qualification increased the perceived impact of the exam. On the other hand, those variables lost significance on the adjusted analysis. In fact, those endodontists who reported relying only on the radiologist report of the CBCT examination had a smaller odds to perceived impact of the exam on diagnosis (OR 0.17; 95% CI 0.44-0.73), and in confidence level (OR 0.18; 95% CI 0.04-0.84). Endodontists with lesser postgraduation time also had a smaller odds to perceived impact of the exam in confidence level (OR 0.18; 95% CI 0.03-0.95) in the adjusted analysis.

Logistic regression analysis also assessed the endodontists' perceived impact of the exam on patient's understanding (Table 7), and confidence regarding treatment (Table 8). The adjusted analysis demonstrated that endodontists who analyze exams in DICOM format have higher odds to report the impact of the exam on patient understanding (OR 4.55; 95% CI 2.16-9.59) and confidence regarding treatment (OR 3.10; 95% CI 1.52-6.31). On the other hand, those who only assess the printed analysis perceive a smaller impact of the exam on the patient understanding (OR 0.17; 95% CI 0.04-0.63) and confidence regarding treatment (OR 0.14; 95% CI 0.03-0.58). Younger endodontists had a smaller odds to perceived impact of the exam on patients understanding (OR 0.41; 95% CI 0.20-0.80) and professionals who worked with both clinics and teaching had a smaller odds to perceived impact of the exam on patients confidence regarding treatment (OR 0.53; 95% CI 0.29-0.96) in the adjusted analysis. The unadjusted analysis showed that having had a CBCT lecture increased the perceived impact of the exam on patient's understanding and confidence regarding treatment.

DISCUSSION

CBCT is being used in dentistry for more than 20 years, improving patients' diagnosis, especially in complex clinical cases (Schulze 2018; Sedentexct 2012). In Endodontology, root calcifications, pronounced curvatures, previous accidents, and tooth position represent technical challenges and configure reasons to refer a patient to an specialist (Alley et al. 2004; Imura et al. 2007). Furthermore, endodontic treatments carried out by specialists can achieve success rates of up to 98%, while general practitioners typically attain values close to 90% (Alley et al. 2004; Imura et al. 2007), demonstrating higher success rates when treatments are performed by specialists (Imura et al. 2007). Nonetheless, no study had evaluated the learning process, proficiency, and clinical utilization of CBCT among endodontists, as well as the perceived impact of this imaging modality at various stages of endodontic treatment.

The majority (89.7%) of Brazilian endodontists claim to use CBCT examination. This finding closely resemble the reality of American endodontists, however, in this sample, the use of CBCT examination was observed in 40% of cases as a routine (Duong et al. 2023). In an study with Turkish endodontists, the use of the CBCT exam was demonstrated by only 41.9%, in which the exam was mainly used for cyst/tumor cases, implant planning and dental trauma (Yalcinkaya et al. 2014). These findings demonstrate that over the years there has been an increase in the use of CBCT exams, probably due to greater access and popularization.

The decision to further request a CBCT scan was more associated with the availability of the equipment in the clinic/office (39%) rather than the lower radiation dose of the exam (24.7%). Setzer et al. (2017) demonstrated that the predominant reason for not using CBCT scans among the American Association of Endodontists members is cost-related (53.79%). Additionally, some endodontists expressed concerns about patient's radiation exposure, supporting its use only in justified cases. In a more recent study involving members of the American Association of Endodontists, it was shown that 95% of respondents had a CBCT machine in their office (Duong et al. 2023). As for Swedish endodontists and general practitioners, results included considerations regarding the risks of radiation exposure, even though the authors also noted limited knowledge among professionals regarding the guidelines for CBCT utilization (Mota de Almeida et al. 2019). This finding suggests that endodontists may have a knowledge gap regarding the radiation dose and the justification guidelines for the scans.

Education and learning regarding CBCT remain understudied on a global scale. Students express less satisfaction than US endodontic residency program directors regarding how the topic is taught (Rabiee et al. 2018). Similar results were observed among postgraduate students in India (Lavanya et al. 2016). A survey among postgraduate endodontics courses in Brazil demonstrated that CBCT teaching is not included in most of the academic programs, and

those that include CBCT education mostly offered a 3-5 hours class on the subject. Surprisingly, directors report satisfaction with those numbers and believe their students are proficient in interpreting CBCT images (Coelho & Rios 2023). The present study showed that the majority of Brazilian endodontists (79.3%) attended at least one CBCT lecture. Furthermore, logistic regression analysis reveals an association between CBCT education and its use in clinical practice. In some clinical situations, such as suspected crack/fracture, location and identification of channels, internal/external resorption, pre-surgical planning, there is also an association between the use of the CBCT exam and learning. However, concern arises when 31.3% of participants feel that their learning process on the subject was insufficient. This highlights the importance of evaluating the quality of CBCT training and ensuring that it meets the needs of endodontic practice.

Regarding the impact of CBCT on diagnosis and clinical decision making, when reported learning was evaluated as a single variable in the unadjusted logistic regression analysis, endodontists who reported more learning about CBCT had a higher perception of CBCT impact. In the adjusted analysis, the exam evaluation played the most significant role: endodontists who relied on only the CBCT report had a lower perception of the impact of the exam on diagnosis. It has already been mentioned that only a small schedule is dedicated to CBCT teaching in postgraduate programs in Brazil.[9] At the same time, studies have shown that using CBCT scans – in spite of IR – may change the diagnosis in 18.9% to 74% of the cases (Bhatt et al. 2021; Chogle et al. 2020; Luz et al. 2022; Mota de Almeida et al., 2015); the same was demonstrated for treatment planning/clinical decision-making in various clinical scenarios, such as initial endodontic treatment (Bhatt et al. 2021; Chogle et al. 2020), root instrument fracture (Kalogeropoulos et al. 2022), dental trauma (Luz et al. 2022), and internal/external root resorptions (Patel et al. 2009). Therefore, it becomes critical for endodontists to feel comfortable in manipulating DICOM images.

After using CBCT exams, previous studies confirm changes in the level of confidence in diagnosis (Patel et al. 2021) and treatment planning (Luz et al. 2022), as well as a reduction in the stress level of examiners (Patel et al. 2019). The present investigation also observed an impact of the CBCT exam on the level of confidence of endodontists with less training time, suggesting that less experienced professionals could benefit more from having a CBCT scan. Moreover, not using DICOM software was related to not associating the exam request with an increase in confidence level.

There is a gap in the literature concerning the endodontist's perception of the impact of CBCT on patient understanding, and confidence regarding treatment. The present investigation supports that CBCT also has a positive impact on patient understanding and confidence, suggesting that the use of these exams would bring benefits. A study on patient perception of CBCT for endodontic treatment was conducted with a military population. In this context, patients were exposed to a CBCT video and subsequently completed a questionnaire. The results demonstrated that the majority of this population considered CBCT scans to be essential (56%), and after viewing the video, most would seek a professional using CBCT images if treatment were required (Burgos et al., 2021).

This study's results were based on the participants' responses and perception, and thus might not necessarily correlate to the impact of CBCT on patient outcome. Furthermore, obtaining contact information for endodontists through Regional Dental Councils proved challenging, with most data collection being limited to messaging apps and social media. In the end, there was a response rate of 300 questionnaires (51.81% of the total sample), which is consistent with previous studies, demonstrating the difficulty in obtaining responses from similar sample sizes (Krug et al. 2019; Luiz et al. 2023). Nonetheless, the use of questionnaires is a commonly employed methodology for assessing various subjects when in-person

evaluation is not feasible (Coelho & Rios 2023). Future research may focus on addressing the limitations identified in this study, especially regarding clinical outcome after the use of CBCT.

The present study on the use of the CBCT exam by Brazilian endodontists emphasizes the increasing use of this exam, consistent with the increase in the global level. Endodontists who have attended CBCT education suggest that the CBCT examination influences the diagnosis, treatment plan, and confidence, as well as the patient's understanding and confidence regarding the diagnosis and treatment. Furthermore, assessing the CBCT scan using DICOM software increased the perceived impact of the exam.

CONCLUSION

This study demonstrates that CBCT education plays a crucial role in the use of CBCT by Brazilian endodontists. Furthermore, an association was demonstrated between CBCT education, and the method used to assess the exam and its impact on diagnosis, treatment planning, confidence level, and patient understanding. These findings have practical implications for the training of endodontists and for improving the quality of CBCT teaching in Brazil.

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Table 1 Descriptive data of the sample in relation to gender, age, graduation/postgraduate degree and workplace

Descriptive data	***Min (Y)***	***Max (Y)***	***Mean (Y)***	***n (%)***
Gender				
Male				135 (45)
Female				165 (55)
Age	24	69	40.74	
Graduate	0.00	43	15.99	
Postgraduate	0.08	40	11.49	278 (92.7)
Master's degree	0.00	30	9.36	134 (44.7)
Doctor's degree	0.00	27	8.39	66 (22)
Workplace				
Office/Clinic/Public Health Unit				268 (89.3)
Teaching				119 (39.7)
Both (Office and teaching area)				89 (29.7)

Min, Minimo; Max, Maximo; Y, Years

Table 2 Knowledge and use of the CBCT

Variables	***Yes – n (%)***			***No - n (%)***	
CBCT Lecture	238 (79.3)			62 (20.7)	
When was the lecture taken?					
Graduate	56 (18.7)			244 (81.3)	
Postgraduate	142 (47.3)			158 (52.7)	
Master's degree	56 (18.7)			244 (81.3)	
Doctor's degree	39 (13)			261 (87)	
Post doctoral	8 (2.7)			292 (97.3)	
Immersion/fast courses	127 (42.3)			173 (57.7)	
Which topics were addressed?					
Exam indications	244 (81.3)			56 (18.7)	
Radiation dose	120 (40)			180 (60)	
Tomographic acquisition protocols	112 (37.3)			188 (62.7)	
Interpretation of images	211 (70.3)			89 (29.7)	
Software training	118 (39.3)			182 (60.7)	
Patiente training	37 (12.3)			263 (87.7)	
Reason for requesting further tests					
Equipment available clinic/office	117 (39)			183 (61)	
Lowe dose of radiation	74 (24.7)			226 (75.3)	
Lowest cost	213 (71)			87 (29)	
Better learning about interpretation	88 (29.3)			212 (70.7)	
Was learning about CBT enough?*	1	2	3	4	5
	94 (31.3)	75 (25)	30 (10)	85 (28.3)	16 (5.3)

*Likert Scale – n (%): 1 - Definitely not; 2 - Probably not; 3 - Uncertain; 4 - Probably yes; 5 – Definitely yes

Table 3 Association between the use of exams and reported CBCT lecture

Question	Yes (%)	No (%)	P
Use of CBCT	269 (89.7)	31 (10.3)	
Lecture (yes)	230 (85.5)	8 (25.0)	**<0.001**
Suspected crack/fracture	220 (73.3)	80 (26.7)	
Lecture (yes)	192 (87.3)	46 (57.5)	**<0.001**
Localization/identification of roots canals	207 (69)	93 (0)	
Lecture (yes)	177 (85.5)	61 (65.6)	**<0.001**
Inconclusive raio-x examination	141 (47,0)	159 (53,0)	
Lecture (yes)	115 (81,6)	123 (77,4)	0.370
Internal/external resorption	139 (46.3)	161 (53.7)	
Lecture (yes)	120 (86.3)	118 (73.3)	**0.005**
Root calcification	137 (45.7)	163 (54.3)	
Lecture (yes)	117 (85.4)	121 (74.2)	**0.017**
Perforation/fracture of instruments	133 (44.3)	167 (55.7)	
Lecture (yes)	112 (84.2)	126 (75.4)	0.063
Pre-surgical planning	106 (35.3)	194 (64.7)	
Lecture (yes)	95 (89.6)	143 (73.7)	**<0.001**
Dental trauma	62 (20.7)	238 (79.3)	
Lecture (yes)	53 (85.5)	185 (77.7)	0.179
Relationship with adjacent structures	48 (16)	252 (84)	
Lecture (yes)	40 (83.3)	198 (78.6)	0.455
3D guide printing	38 (12.7)	262 (87.3)	
Lecture (yes)	34 (89.5)	204 (77.9)	0.099
Endodontic treatment follow-up	34 (11.3)	266 (88.7)	
Lecture (yes)	28 (82.4)	210 (78.9)	0.644
Apical periodontitis detection	33 (11)	267 (89)	
Lecture (yes)	28 (84.8)	210 (78.7)	0.407
Apical periodontitis follow-up	26 (8.7)	274 (91.3)	0.486
Lecture (yes)	22 (84.6)	216 (78.8)	
Other reasons	1 (0.3)	299 (99.7)	
Lecture (yes)	1 (100)	237 (79.3)	0.609

P-values for Pearson's chi-square test. P values in bold represent statically significant values

Table 4 Unadjusted and adjusted logistic regression analysis of demographic data and CBCT reported learning to the perceived impact of the exam on diagnosis

Variables	**Unadjusted OR (CI 95%)**	**p-value**	**Adjusted OR (CI 95%)**	**p-value**
Gender (Female)				
Male	3.11 (1.60-6.03)	**0.001**	2.44 (0.88-6,81)	0.088
Age (>40 years)				
< 40 years	2.08 (1.08-3.99)	**0.028**	0.47 (0.05-4.13)	0.500
Graduation time (>16 years)				
< 16 years	2.56 (1.33-4.92)	**0.005**	3.90 (0.32-46.57)	0.282
Postgraduate time (>11 years)				
< 11 years	2.31 (1.19-4.95)	**0.014**	0.51 (0.10-2.56)	0.416
CBCT lecture (No)				
Yes	8.41 (4.26-16.60)	**<0.01**	2.05 (0.63-6.61)	0.230
Sufficient learning about CBCT (No)				
Yes	4.11 (1.68-10.04)	**0.002**	0.73 (0.21-2.50)	0.622
Workplace (clinic)				
Teaching	2.56 (0.58-11.36)	0.220		
Both	0.70 (0.36-1.35)	0.280		
Qualification (Postgraduate)				
+ Master's degree	2.20 (0.98-5.03)	0.060	1.10 (0.34-3.55)	0.868
+ Doctor's degree	4.27 (1.45-12.55)	**0.008**	0.87 (0.21-3.50)	0.850
Exam evaluation (Printed)				
DICOM	2.39 (0.77-7.43)	0.134	2.74 (0.76-9.84)	0.121
Radiologist	2.65 (0.51-13.78)	0.247	3.43 (0.58-20.19)	0.173
Report	0.17 (0.05-0.61)	**0.006**	0.17 (0.44-0.73)	**0.017**

P value, odds ratio (OR), and 95% confidence interval (CI 95%) for the independent variables. The group in brackets is the reference group. P values in bold represent statically significant values

Table 5 Unadjusted and adjusted logistic regression analysis of demographic data and CBCT reported learning to the perceived impact of the exam on clinical decision making

Variables	**Unadjusted OR (CI 95%)**	**p-value**	**Adjusted OR (CI 95%)**	**p-value**
Sex (Female)				
Male	3.36 (1.74-6.49)	**<0.01**	2.70 (0.98-7.40)	0.053
Age (>40 years)				
< 40 years	2.02 (1.06-3.82)	**0.031**	0.32 (0.42-2.51)	0.281
Graduation time (>16 years)				
< 16 years	2.49 (1.31-4.72)	**<0.01**	1.76 (0.19-15.97)	0.612
Postgraduate time (>11 years)				
< 11 years	2.83 (1.45-5.52)	**<0.01**	2.12 (0.41-10.92)	0.369
CBCT lecture (No)				
Yes	8.51 (4.34-16.65)	**<0.01**	2.92 (0.97-9.00)	0.062
Sufficient learning about CBCT (No)				
Yes	5.45 (2.08-14.22)	**<0.01**	1.26 (0.37-4.31)	0.704
Workplace (clinic)				
Teaching	1.64 (0.46-5.80)	0.437	0.38 (0.08-1.69)	0.206
Both	0.65 (0.33-1.24)	0.195	0.48 (0.17-1.37)	0.174
Qualification (Postgraduate)				
+ Master's degree	2.07 (0.94-4.56)	0.070	1.26 (0.41-3.85)	0.676
+ Doctor's degree	6.21 (1.84-20.94)	**0.003**	1.69 (0.38-7.44)	0.485
Exam evaluation (Printed)				
DICOM	2.54 (0.92-6.94)	0.070	2.09 (0.66-6.56)	0.206
Radiologist	7.51 (0.90-62.40)	0.062	6.78 (0.74-61,69)	0.089
Report	0.39 (0.10-1.41)	0.152	0.42 (0.99-1.84)	0.255

P value, odds ratio (OR), and 95% confidence interval (CI 95%) for the independent variables. The group in brackets is the reference group. P values in bold represent statically significant values

Table 6 Unadjusted and adjusted logistic regression analysis of demographic data and CBCT reported learning to the perceived impact of the exam on increase in confidence level

Variables	**Unadjusted OR (CI 95%)**	**p-value**	**Adjusted OR (CI 95%)**	**p-value**
Sex (Female)				
Male	2.33 (1.23-4.40)	**<0.01**	1.50 (0.52-4.27)	0.440
Age (>40 years)				
< 40 years	1.57 (0.84-2.95)	0.157	0.25 (0.02-2.65)	0.252
Graduation time (>16 years)				
< 16 years	1.93 (1.03-3.63)	**0.039**	7.78 (0.56-106.54)	0.124
Postgraduate time (>11 years)				
< 11 years	1.65 (0.86-3.15)	0.130	0.18 (0.03-0.95)	**0.044**
CBCT lecture (No)				
Yes	7.09 (3.63-13.83)	**<0.01**	2.85 (0.86-9.46)	0.086
Sufficient learning about CBCT (No)				
Yes	4.23 (1.73-10.34)	**<0.01**	1.43 (0.42-4.87)	0.567
Workplace (clinic)				
Teaching	1.50 (0.42-5.32)	0.526	0.71 (0.11-4.29)	0.713
Both	0.55 (0.29-1.06)	0.078	0.29 (0.10-0.85)	0.024
Qualification (Postgraduate)				
+ Master's degree	1.36 (0.64-2.88)	0.416	0.51 (0.16-1.64)	0.260
+ Doctor's degree	3.00 (1.11-8.08)	**0.030**	0.28 (0.07-1.17)	0.082
Exam evaluation (Printed)				
DICOM	1.33 (0.43-4.09)	0.612	1.67 (0.46-6.07)	0.434
Radiologist	2.16 (0.40-11.69)	0.370	2.55 (0.40-16.29)	0.322
Report	0.17 (0.046-0.68)	**0.012**	0.18 (0.04-0.84)	**0.029**

P value, odds ratio (OR), and 95% confidence interval (CI 95%) for the independent variables. The group in brackets is the reference group. P values in bold represent statically significant values

Table 7 Unadjusted and adjusted logistic regression analysis of demographic data and CBCT reported learning to the perceived impact of the exam on patient's understanding

Variables	**Unadjusted OR (CI 95%)**	**p-value**	**Adjusted OR (CI 95%)**	**p-value**
Sex (Female)				
Male	1.04 (0.64-1.67)	0.874		
Age (>40 years)				
< 40 years	0.72 (0.44-1.16)	0.179	0.41 (0.20-0.80)	**0.01**
Graduation time (>16 years)				
< 16 years	0.99 (0.61-1.60)	0.987		
Postgraduate time (>11 years)				
< 11 years	1.07 (0.65-1.75)	0.783		
CBCT lecture (No)				
Yes	2.30 (1.30-4.07)	**<0.01**	0.79 (0.32-1.91)	0.601
Sufficient learning about CBCT (No)				
Yes	1.82 (1.07-3.09)	**0.027**	0.76 (0.38-1.49)	0.430
Workplace (clinic)				
Teaching	1.71 (0.69-4.20)	0.239		
Both	0.73 (0.43-1.24)	0.252		
Qualification (Postgraduate)				
+ Master's degree	1.22 (0.68-2.18)	0.487	0.94 (0.47-1.88)	0.875
+ Doctor's degree	2.42 (1.24-4.73)	**<0.01**	0.81 (0.35-1.84)	0.620
Exam evaluation (Printed)				
DICOM	3.69 (1.88-7.24)	**<0.01**	4.55 (2.16-9.59)	**<0.01**
Radiologist	2.04 (0.89-4.66)	0.090	2.18 (0.87-5.46)	0.094
Report	0.24 (0.07-0.82)	**0.024**	0.17 (0.04-0.63)	**<0.01**

P value, odds ratio (OR), and 95% confidence interval (CI 95%) for the independent variables. The group in brackets is the reference group. P values in bold represent statically significant values

Table 8 Unadjusted and adjusted logistic regression analysis of demographic data and CBCT reported learning to the perceived impact of the exam on patient's confidence regarding treatment

Variables	Unadjusted OR (CI 95%)	p-value	Adjusted OR (CI 95%)	p-value
Sex (Female)				
Male	1.13 (0.70-1.80)	0.607		
Age (>40 years)				
< 40 years	1.02 (0.64-1.62)	0.930		
Graduation time (>16 years)				
< 16 years	1.20 (0.75-1.92)	0.435		
Postgraduate time (>11 years)				
< 11 years	1.06 (0.65-1.71)	0.805		
CBCT lecture (No)				
Yes	2.06 (1.17-3.64)	**0.012**	0.59 (0.25-1.37)	0.227
Sufficient learning about CBCT (No)				
Yes	1.58 (0.95-2.63)	0.077	0.63 (0.33-1.18)	0.152
Workplace (clinic)				
Teaching	1.51 (0.63-3.57)	0.348	1.29 (0.49-3.37)	0.594
Both	0.56 (0.33-0.94)	**0.029**	0.53 (0.29-0.96)	**0.038**
Qualification (Postgraduate)				
+ Master's degree	1.31 (0.74-2.32)	0.352	1.04 (0.53-2.03)	0.983
+ Doctor's degree	1.97 (1.05-3.69)	**0.032**	1.06 (0.52-2.14)	0.902
Exam evaluation (Printed)				
DICOM	2.54 (1.33-4.85)	**<0.01**	3.10 (1.52-6.31)	**<0.01**
Radiologist	2.04 (0.89-4.66)	0.090	2.64 (1.06-6.56)	**0.036**
Report	0.16 (0.04-0.64)	**0.010**	0.14 (0.03-0.58)	**<0.01**

P value, odds ratio (OR), and 95% confidence interval (CI 95%) for the independent variables. The group in brackets is the reference group. P values in bold represent statically significant values

3 ARTIGO 2: CONE BEAM COMPUTED TOMOGRAPHY IMPACT ON DIAGNOSIS, TREATMENT PLANNING, AND CONFIDENCE IN ENDODONTIC CASES: A SYSTEMATIC REVIEW.

Este artigo será submetido à publicação no periódico *Journal of Endodontics*, ISSN: 0099-2399, Fator de Impacto: 4.422, Qualis CAPES: A1. As normas para publicação estão descritas no Anexo B.

Cone beam computed tomography impact on diagnosis, treatment planning, and confidence in endodontic cases: a systematic review

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Cone beam computed tomography impact on diagnosis, treatment planning, and confidence in endodontic cases: a systematic review

ABSTRACT

Introduction: This systematic review aims to identify the impact of cone beam computed tomography (CBCT) on diagnosis, treatment planning, and level of professional confidence compared to intraoral radiography (IR) in endodontic clinical cases.

Methods: A systematic search was carried out in PubMed/MEDLINE, Cochrane-CENTRAL, EMBASE, Scopus, LILACS, and Web of Science databases, as well as in gray literature (PROSPERO, Google Scholar, and DANS EASY Archive). Thirty publications were read in full, and 24 fulfilled criteria for inclusion. Information regarding changes in the diagnosis, treatment planning, and level of confidence after CBCT were evaluated. The methodological quality of the included studies was assessed using the QUADAS-2.

Results: Twenty-four studies were included, with a total of 1,144 evaluated teeth. Nine studies were classified as low risk of bias. Most studies focused on changes in treatment planning (n=10) or diagnosis (n=5). CBCT led to diagnostic changes in most of the cases of primary endodontic treatment (n=6); studies evaluating dental trauma showed the most significant improvement. Except for one study, CBCT had an impact on treatment planning, often resulting in more invasive treatments with more clinical interventions and extractions. Professional confidence varied between studies, with some reporting greater difficulty in choosing treatment in cases of external root resorption and complex endodontic cases when using preoperative CBCT.

Conclusions: CBCT impacts diagnosis, treatment planning, and professional confidence in cases of complex endodontic treatments, often leading to more invasive treatments. CBCT examination must be evaluated individually and personalized for each case.

Keywords: Cone beam computed tomography; endodontics; diagnoses; treatment plan

INTRODUCTION

Imaging exams play a fundamental role in the patient diagnosis and evaluation process. With the aim of quantifying and comparing the contribution of each exam, FRYBACK & THORNBURY (1991)[1] introduced a hierarchical model comprising six levels of efficacy, ranging from differences in technical quality to patient outcome and the social costs and benefits associated with the requested examination. This model has been employed by several researchers in order to justify the substitution of one examination with another[2–4].

In endodontics, periapical intraoral radiography (IR) is the most frequently employed imaging exam, used throughout all treatment phases, from diagnosis to post-operative follow-up[5]. Nonetheless, IR is a two-dimensional examination of a three-dimensional (3D) object, resulting in anatomical structure superimposition, often making it difficult to assess the region of interest, and thereby compromising patient diagnosis[6]. Cone beam computed tomography (CBCT) overcomes this challenges and enables 3D evaluation of areas of interest, assisting the visualization of more intricate structures[7]. In endodontics, CBCT may be used in numerous clinical situations, ranging from complex diagnoses and surgical planning to 3D-printed guides[8].

Current studies suggest CBCT exams have an impact on diagnosis[9,10] and treatment planning[11,12]. Furthermore, the inclusion of CBCT exams implies increased professional confidence in carrying out the diagnosis and treatment planning[13,14]. However, considering the stochastic effects associated with X-ray exposure, CBCT should not be employed as a routine examination but rather justified for those cases in which the healthcare professional deems that the examination will provide new information for patient management[15].

Considering the increasing use of CBCT examination in endodontics, the higher dose of radiation used in the examination, and the diversity in the results evaluated in previous studies, the present study aimed to systematically review the literature in order to identify the

impact of CBCT on the diagnosis, treatment planning, and professional confidence in comparison with IR.

MATERIALS AND METHODS

Protocol and Registration

The protocol adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist[16] and was registered in the International Prospective Register of Systematic Reviews (PROSPERO; registration number CRD42022385479).

Research Question

This systematic review was guided by the following focused question: " How cone beam computed tomography (CBCT) impacts on diagnostic thinking and professional's level of confidence in establishing the diagnosis and/or treatment plan in endodontics?". The structured question strategy was as follows: Population (P): endodontic clinical cases; Exposure (E): use of CBCT; Comparison (C): use of radiographic methods with or without clinical information; Outcome (O): alteration in diagnosis, treatment plan, or confidence level.

Eligibility Criteria

Observational and diagnostic studies that presented endodontic clinical cases, in which IR (with or without clinical history of the case) and CBCT exams were used, and which aimed to analyze the impact of using CBCT on diagnosis, treatment planning, and/or level of confidence were included. Editorials, in vitro studies, case reports, animal studies, literature reviews, studies that aimed to analyze other areas of Dentistry, and studies that only verified the exams' sensitivity and specificity were excluded.

Search strategy

Search strategies were developed for the following databases: PubMed/MEDLINE, Cochrane-CENTRAL, EMBASE, Scopus, LILACS, and Web of Science. The gray literature records were carried out in the PROSPERO (http://www.crd.york.ac.uk/PROSPERO/), Google

Scholar and DANS EASY Archive databases. Appropriate combinations of terms were used according to each database (Appendix 1). The end date of the searches was October 18th, 2023, in all databases. No language restrictions, publication period, or document format were applied. All references were imported into Rayyan, in order to identify duplicates[17].

Study selection

Data extraction was carried out by two reviewers (J.L.T. and L.M.M.), independently, in two phases. In phase I, the titles and abstracts of the articles retrieved from databases were read. Studies that met the inclusion criteria, or did not have an available abstract, were selected for full-text reading. In phase II, the articles selected by both reviewers were read in full. Cases of disagreement between reviewers were resolved by discussion. If uncertainty persisted, a third reviewer (G.S.L.) was consulted. Additionally, the reference lists of all studies selected for full-text reading were assessed for articles with potential eligibility. Studies that met all eligibility criteria were included in the systematic review.

Data collection

The selected articles were subjected to data extraction by two reviewers (J.L.T. and L.M.M.) independently. The following descriptive data were collected: authors; year of publication; country; sample (total number of teeth evaluated and type of clinical case analyzed); IR protocol and type of sensor used; CBCT acquisition protocol; assessments (type: diagnosis, treatment planning and/or confidence, scale, and characteristics); examiners (number and qualifications); interval between assessments; main results; and conclusions.

Risk of bias

The methodological quality of the studies included in the systematic review was assessed using the Quality Assessment Tool for Diagnostic Accuracy Studies (QUADAS-2), composed of four domains: patient selection (endodontic clinical cases), index test (TCFC), reference standard (RI), and flow and time (evaluation interval)[18]. Two reviewers (J.L.T. and

L.M.M.) independently classified the risk of bias as “low risk”, “high risk”, or “unclear” for each domain. Disagreements were resolved through discussion between the reviewers, and when a mutual agreement could not be reached, the final decision was made by a third reviewer (G.S.L.).

RESULTS

Study selection

A total of 6,270 studies were identified through searches in PubMed (n=991), Embase (n=896), SCOPUS (n=3,949), Cochrane (Central) (n=99), Lilacs (n=173), and Web of Science (n=162) databases. After removing duplicates (n=1,806), 4,464 abstracts were read, of which 30 were selected for full-text reading. Searches in the gray literature, which covered the PROSPERO, Google Scholar, and DANS EASY archive databases, resulted in 212 studies found, of which 1 was read in full. A search was carried out in the reference lists of studies selected for full reading, however there were no results. Therefore, 24 studies were included in this systematic review (Figure 1). The reasons why studies were not included are provided in Appendix 2.

Characteristics of included studies

The studies included in the systematic review were published between 2009 and 2022 and evaluated 1,144 teeth in total. Regarding the endodontic cases evaluated in the studies: 13 studies evaluated teeth that required endodontic treatment and/or retreatment[9–11,14,19–27], 3 studies evaluated external root resorption[12,28,29], 3 studies evaluated cases of dental trauma[30–32], 3 studies evaluated surgical cases of endodontic treatment and/or retreatment[13,33,34], 1 studies evaluated external and internal root resorption[35] and 1 study evaluated fracture of endodontic instruments[36]. Regarding study examiners and their qualifications, 19 studies covered endodontic specialists, or postgraduate/residency students in endodontics. Only 3 studies included endodontics along with other specialties;[13,29,37] only 2 included general dentists[21,22].

Information regarding qualitative data extracted from the included studies is presented in Table 1.

Risk of bias and applicability

Nine studies were classified as having a low risk of bias[11,13,21,22,24,29–31,33]. The other presented one or more domains considered to have a "high" or "unclear" risk of bias. The main limitations of these studies were present in the "flow and time" and "index test" domains (Figure 2). As for applicability concerns, 5 studies demonstrated an "unclear" classification in relation to the "index test" domain[9,19,25,28,37]. Appendix 3 presents the classification of signaling questions for each of the four domains.

Qualitative Synthesis

Most studies exclusively evaluated changes in the treatment plan (n=10)[12,13,19,22,27,29,31,33,36,38] or in association with changes in diagnosis (n=5)[9,10,24,25,35] and/or confidence (n=4)[14,21,29,31] after using CBCT, 2 studies evaluated changes in diagnosis and confidence,[22,32] 1 study evaluated changes in the level of confidence only,[19] and 1 study exclusively evaluated changes in diagnosis[27].

Regarding the impact of the CBCT on diagnosis, in the studies that evaluated cases regarding primary endodontic treatments (n=6), it was observed that only one study did not verified a change in the diagnosis after CBCT assessment[22]. Furthermore, all studies that evaluated diagnoses of teeth that suffered trauma observed greater change in diagnosis after CBCT images, with this exam improving clinical diagnosis[31,32]. All included studies carried out these assessments using multiple-choice questions, with the examiner being able to either choose just one treatment/diagnosis option, or several options.

An impact of CBCT examination on treatment planning was also verified, except for one study.[23] Four studies have shown that CBCT exams resulted in a more invasive treatment plan, for cases of endodontic retreatment[11,37] and dental trauma[30,31]. The treatment options were

presented to the examiners with multiple-choice answers, consistent with the case being evaluated.

Confidence in establishing the diagnosis and/or the treatment plan and its relationship with the CBCT exam was verified in the included studies using a Likert scale with a limit of 5 to 8 points, where 1 was always considered the worst. Two studies found no difference between the exams[21,22], one study found no difference in relation to the diagnosis[31], and one study reported increased difficulty level in choosing treatment when using preoperative CBCT[13].

Information regarding the evaluations, results, and conclusions drawn from the included studies are presented in Table 2.

DISCUSSION

This systematic review analyzed the impact of CBCT exams on the diagnosis, treatment plan, and level of professional confidence, in comparison with IRs. Studies concerning several clinical situations related to endodontics – endodontic treatment, external and internal root resorption, dental trauma, instrument fractures, and surgical planning – were included, demonstrating the importance of CBCT in endodontic clinical practice, especially in complex endodontic treatments.

In complex endodontic treatments, CBCT has a substantial impact on diagnostic thinking, resulting in approximately 55% change compared to initial diagnoses[3,9,10]. In endodontically treated teeth without apical periodontitis (AP), a change in diagnosis was also demonstrated, with this change being 6 times more likely to occur in these cases[25]. The absence of diagnostic changes after CBCT assessment was observed in only one study, in which the examiners were general practitioners[22]. This emphasizes that CBCT should be reserved for complex cases, in which its use adds important information, not justifying its use in routine practice.

CBCT has been shown to change the treatment plan in most cases, changing the clinical decision in up to 56% of medium and high complexity cases[9–11,13,14,20,25,38]. However, one study demonstrated that there was no difference either in relation to the measurement or treatment plan of AP[23]. Cases involving surgical planning demonstrated that CBCT exams were considered necessary, and changed the treatment plan[21,25,33]. However, a more invasive treatment plan was presented after using CBCT exams, being the extraction procedure more often selected after tridimensional assessment[21]. When assessing the success of endodontic treatment, CBCT examinations provided less favorable outcomes for the tooth, suggesting higher failure rates[11]. Therefore, the request for a CBCT examination should be justified by the patient's clinical and symptoms, since it could lead to a more aggressive therapy or less favorable outcome.

In situations of dental trauma, CBCT images showed impact on the diagnosis[31], with this examination being more accurate for all cases[32]. However, the use of CBCT also resulted in more clinical interventions proposed as treatment, rather than longitudinal follow-ups[30,31]. In cases of external cervical resorption, changes in the treatment plan have been demonstrated in up to 72.2% of cases[12,28,29], which is in agreement with current guidelines[39,40] indicating its use. Nonetheless, an increase in extraction as a treatment option was observed after CBCT assessment[29]. In internal and external root resorption, an impact of this examination was also observed on diagnosis and treatment plans[24,35]. Fractures of endodontic instruments were analyzed in only one study, and a change in the treatment plan was observed after using CBCT, with the location of the fractured instrument being more likely to induce a change in the treatment plan after analyzing the images[36].

Regarding the level of stress for the clinical analysis of cases referred for endodontic treatment, a moderate or very stressful level was found in 75% of endodontists and endodontic residents when using IRs, and 5% when using CBCT exams, thus demonstrating a reduction in

the level of self-reported stress[19]. Regarding confidence for diagnosis after using CBCT exams, no impact was observed in cases of endodontic treatment[22]; as for cases of dental trauma, there is no agreement among the findings, as one study did not observe impact[31] and another demonstrated greater confidence after using CBCT exam[32]. However, there was an impact of the CBCT exam in relation to confidence in treatment planning[31]. Regarding the diagnosis of complex cases, CBCT proved to increase confidence[14]. There was also an impact on confidence regarding the treatment of external root resorption, but an increase in the level of difficulty in choosing treatments was demonstrated[29]. This increase in the difficulty in choosing treatment has also been reported for complex endodontic cases, except when the examiners were endodontists[13]. In cases of endodontic retreatment, no change was observed in the levels of difficulty reported after CBCT exams[21]. Clinical conditions and diagnosis are throughout considered in articles and recommendation guidelines. Nonetheless, practitioners' increased confidence might also be related and impact on treatment outcome.

Among the main limitations of this systematic review, there is the lack of homogeneity of the included studies, both in relation to the selected cases and the options for diagnosis and treatment planning. Furthermore, due to the heterogeneity, it was not possible to carry out a quantitative analysis of the data. Very different time intervals were also observed between assessments with IR and CBCT, which may have an influence on the examiners' memory bias. Furthermore, the examiners included in the studies were not only endodontists, covering numerous areas in dentistry, and the training of examiners is also a source of heterogeneity.

The results of this systematic review demonstrate the impact of CBCT examinations, especially in relation to diagnosis and treatment planning. All studies evaluated levels 3 and 4 of diagnostic efficacy, which concern diagnosis and treatment planning. Therefore, there is still a lack of studies at level 5, which report the effects of exam information on patient outcomes, and level 6, regarding the costs and social benefits of the requested exam[1]. Furthermore, CBCT

impacts the professional's confidence. However, even with these findings that demonstrated the impact of the CBCT exam in numerous stages and clinical situations, the exam should only be indicated after carrying out a thorough clinical examination and IR tests[37]. Therefore, the indications for CBCT exams must continue to follow strict criteria as indicated[39-41], in which their use must be applied in situations where IR does not provide sufficient information for a correct diagnosis and/or treatment plan, and the benefits of the exam overcome their risks.

CONCLUSION

CBCT images have an impact on diagnosis, treatment planning, and professional confidence in cases of complex endodontic treatments and dental trauma. In cases of dental trauma, surgical endodontic retreatment, and external cervical resorption, CBCT assessment seems to be associated with more invasive treatments, with clinical interventions and extractions being more common after using the exams. The use of CBCT exams, however, must be evaluated individually for each clinical situation.

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Table 1 Qualitative data of the included studies

Author, Year of publication, Country	Sample size (teeth) and type of cases	IR protocol (sensor type)	CBCT protocol	Assessment	Examiners (n) and qualification	Interval between assessments
Al-Salehi and Horner, 2016, United Kingdom	34; Endodontic treatment	PR - Parallelism technique; Vistascan Mini phosphor plate system	kV: 90 mA: - FOV: 4 cm Voxel: - T: -	Confidence Diagnosis	4 general dentists	3 months
Balasundaram et al., 2012, United States	24; Symptoms and presence of AP greater than 3mm	PR - Parallelism technique; Schick CMOS sensor	kV: 120 mA: 3-5 FOV: 0.25 mm Voxel: - T: 14.7 s	Treatment plan	6 endodontists	2 weeks
Bhatt et al., 2021, Canada	128; Indication of CBCT based on clinical history and PR	NS	kV: - mA: - FOV: 5 cm Voxel: 0.9 mm T: -	Diagnosis Treatment plan	NS, postgraduate students in endodontics	NS
Chogle et al., 2020, United States	45; Indication of CBCT according to AAE/AAOMR	NS	NS	Diagnosis Treatment plan	3 faculty members	4 months
Davies et al., 2016, England	98; Endodontic retreatment with symptoms or underfilling	PR - Parallelism technique; Digora Optime	kV: 90 mA: 3-5 FOV: 40 mm Voxel: - T: 17.5 s	Treatment plan	2 endodontists	1 week
Ee et al., 2014, United States	30; Diverse clinical situations	PR - Two horizontal angles; Schick CDR	NS	Diagnosis Treatment plan	3 endodontists	2 weeks

Goodell et al., 2017, United States	30; External cervical resorption	PR - Parallelism technique; Carestream TVG 6200	kV: 90 mA: 7 FOV: 40 mm Voxel: 0.08 mm T: -	Treatment plan	2 endodontists and 4 endodontic residents	NS
Kakavetsos et al., 2020, Greece	104; Endodontic treatment	NS	kV: 90 mA: 3-7 FOV: 50 mm Voxel: - T: 9 s	Diagnosis Treatment plan	2 endodontists	NS
Kalogeropoulos et al., 2022, Greece	52; Instrument fractures	PR - Two horizontal angles; NS	kV: 90 mA: 6.3-12.5 FOV: 50 x 80 mm Voxel: - T: 15 s	Treatment plan	2 endodontists	15 days
Kruse et al., 2018, Denmark	74; Surgical endodontic retreatment	PR - Parallelism technique; Dürr Dental VistaScan Plus	kV: 90 mA: 10 FOV: 6 cm Voxel: - T: 23 s	Treatment plan	2 endodontists and 1 radiologist	NS
Luz et al., 2022, Brazil	15; Dental trauma	PR - Parallelism technique; NS	kV: - mA: - FOV: - Voxel: 0.1 mm T: -	Confidence Diagnosis Treatment plan	12 endodontists	1 month
Mazón et al., 2022, Spain	12; External root resorption	PR - Parallelism and bitewing technique; Carestream RVG 6100	kV: 84 mA: 0.8 FOV: 5 cm Voxel: - T: 12 s	Confidence Treatment plan	60 dentists: 10 endodontists, 10 prosthodontists, 10 surgeons, 10 periodontists, 10 orthodontists and 10 general dentists	4 weeks

Mota de Almeida et al., 2014, Sweden	81; Endodontic treatment according to European Commission guidelines	PR - Parallelism technique; NS	kV: 85 mA: 5 FOV: 40-60 mm Voxel: 0.08-0.125 mm T: 9-30.8 s	Treatment plan	3 endodontists and 4 endodontic residents	NS
Mota de Almeida et al., 2015, Sweden	81; Endodontic treatment according to European Commission guidelines	PR - Parallelism technique; NS	kV: 85 mA: 5 FOV: 40-60 mm Voxel: 0.08-0.125 mm T: 9-30.8 s	Diagnosis	3 endodontists and 4 endodontic residents	NS
Mota de Almeida et al., 2021, Sweden	18; Dental trauma to immature anterior teeth	PR - Parallelism technique; Schick CDR	kV: 85 mA: 7 FOV: 4 cm Voxel: 0.9 mm T: -	Treatment plan	3 endodontists and 2 endodontic residents	NS
Patel et al., 2009, England	15; Internal and external root resorption	PR - Parallelism technique; CCD sensor	kV: 80-120 mA: 3-5 FOV: - Voxel: - T: 17.5-20 s	Diagnosis Treatment plan	2 endodontists and 4 postgraduate students in endodontics	1 week
Patel et al., 2016, England	115; External root resorption	PR - Two horizontal angles; Digora Optime/ Planmeca Prostyle	kV: 90 mA: 3-5 FOV: 4 cm Voxel: 0.08 mm T: 17.5 s	Treatment plan	3 endodontists and 3 postgraduate students in endodontics	NS
Patel et al., 2019, England	60; Endodontic treatment	PR - Radiographic positioner; Digora Optime	kV: 90 mA: 5 FOV: - Voxel: 0.08mm T: 17.5 s	Confidence	5 endodontic residents	NS

Patel et al., 2021, England	35; Dental trauma	PR - Parallelism technique and upper standard occlusal; NS	kV: 90 mA: 3-5 FOV: - Voxel: - T: 17.5 s	Confidence Diagnosis	3 endodontists and 7 endodontic residents	2 weeks
Portigliatti et al., 2017, Argentina	15; Highly complex endodontic treatment	NS	NS	Treatment plan	2 endodontists	NS
Rodríguez et al., 2017a, England	8; Endodontic treatment with symptoms and presence of AP	PR - Parallelism and bitewing technique; Carestream RVG 6100	kV: - mA: - FOV: 5 x 8 cm Voxel: - T: -	Confidence Treatment plan	120 dentists: 40 endodontists and 80 general dentists	1 month
Rodríguez et al., 2017b, England	30; Surgical endodontic retreatment	PR - Parallelism and bitewing technique; Carestream RVG 6100	kV: - mA: 8 FOV: 5 x 8 cm Voxel: - T: 12 s	Confidence Treatment plan	140 dentists: 40 endodontists, 40 prosthodontists, 28 surgeons and 32 periodontists	4 weeks
Sheth et al., 2020, India	20; Presence of PA and need for surgery	PR - Parallelism technique; Sopix 2 sensors	kV: 120 mA: 5 FOV: 5 x 8 cm Voxel: - T: 7 s	Treatment plan	3 endodontists	10 days
Viana Wanzeler et al., 2019, Brazil	20; Endodontic treatment, according to AAE	PR - Parallelism technique; VistaScan	kV: 89 mA: 8 FOV: 5 cm Voxel: - T: 12 s	Confidence Treatment plan	15 endodontists and postgraduate students in endodontics	30 days

AP, apical periodontitis; AAE/AAOMR, American Association of Endodontists/American Academy of Oral and Maxillofacial Radiology; CBCT, cone beam computed tomography; FOV, field of view; IR, intraoral radiograph, kV, kilovoltage; mA, milliamperage; NS, not specified; PR, periapical radiography; s, seconds; T, exposure time

Table 2 Assessments, results, and conclusions of the included articles

Author, Year of publication, Country	Assessed (Scale/Characteristics)	Main results	Conclusions
Al-Salehi and Horner, 2016, United Kingdom	1.What is your provisional DG based on the CH and photographic images? 2.What are your radiological findings? 3.What is your FD based on CH, clinical photographs, and radiological findings? 4.How confident are you of your FD? 5.How helpful were the radiographic images in determining the FD? 4 and 5 using 5-point LS	The availability of CBCT changed the diagnosis in a minority of cases (ranging from 7 to 15 out of 34 cases). Only one examiner achieved a significant increase in safety with CBCT images, and only one also demonstrated a significant increase in the diagnostic utility of the exam.	Routine use of CBCT cannot be justified based on a change in diagnosis and carefully selected use is appropriate.
Balasundaram et al., 2012, United States	The extent of the AP and TP: 1. RCT; 2. PS; 3. RCT + PS; 4. None	There was no statistical difference in measuring AP size between modalities. No significant difference was noted in the TP selected by observers using the two modalities ($p>0.05$).	The size of AP and the choice of treatment based on CBCT do not change significantly compared to choices made based on IR.
Bhatt et al., 2021, Canada	Composed of 3 groups, which required CBCT for some reason. DG and TP were carried out before and after CBCT. Dichotomized responses: DG or TP changed with the use of CBCT = 1; If no additional information = 0	Both the DG ($p=0.001$) and the TP ($p=0.005$) initially made by examining IR were significantly altered by the subsequent CBCT examination by revealing information such as new AP, missed canals, or involvement bone.	The additional information obtained from CBCT scans resulted in changes to initial DG as well as subsequent TPs.
Chogle et al., 2020, United States	Multiple choice questions: A. Pulpar DG; B. Periradicular DG; C. Etiological factors; D. Recommendation/TP; E. Assessment for need of CBCT	For endodontic DG, there was a 19% change in the pulpal diagnosis category when CBCT imaging was added, whereas there was a 30% change in the apical DG. The selections changed in 55% of the cases when determining etiology and in 49% of the cases when making recommendations.	CBCT imaging has a significant effect on determining the etiology of endodontic pathologies and recommending treatment.
Davies et al., 2016, England	TP: 1. ES; 2. ER; 3. Preservation; 4. Extraction	Result of 93% success for teeth (96% roots) was recorded when the assessment was undertaken by IR compared with 77% success for teeth (87% roots) when assessed by CBCT. When comparing the future	CBCT resulted in significantly fewer favorable outcomes than IR in ER, thus significantly affecting the outcome of future management. This significantly

		management plan based on IR alone, there was a significant difference between IR and CBCT based management (p=0.01).	affected the future management of cases attending for a review.
Ee et al., 2014, United States	DG: 1. PA; 2. VRF; 3. External/internal RR; 4. RP; 5. No pathology; TP: 1. RCT; 2. ER; 3. RP repair; 4. ES; 5. Extraction	A difference in TP between the 2 imaging modalities was recorded in 19 of 30 cases (63.3%, p=.001), 17 of 30 cases (56.6%, p=.012), and 20 of 30 cases (66.7%, p=.008) for examiners 1, 2, and 3, respectively.	Preoperative CBCT image provides more diagnostic information than a preoperative IR and this information can directly influence the TP.
Goodell et al., 2017, United States	TP: 1. Without treatment; 2. ES without an attempt to repair AP; 3. ES with an attempt to repair the AP using an internal approach; 4. ES with an attempt to repair the AP using an external approach; 5. Surgical repair without RCT; 6. Extraction	All 30 ECR cases were identified by CBCT imaging, and 29 IR. TPs developed from CBCT scans differed from those developed with RI in 56.7% of the cases. Examiners recommended ECR repair in most cases (59.8% of CBCT images and 56.7% of RI).	TPs changed between IR and CBCT imaging in many cases evaluated. ECR lesion size is consistently underestimated in both size and extent classification with IR.
Kakavetsos et al., 2020, Greece	DG: change with yes or no; TP: 1. ES; 2. RCT; 3. RCT + ES; 4. Extraction; 5. None	In 18 out of 104 (17.3%) cases, there has been a change of the initial diagnosis after CBCT interpretation. Posterior and endodontically treated teeth without lesions presented 4.35 and 6.6 times higher odds, respectively, of having a change in the initial diagnosis after CBCT evaluation.	CBCT scanning was considered necessary both for all surgical treatment planning cases and the evaluation of inflammatory resorptive defects.
Kalogeropoulos et al., 2022, Greece	TP: 1. Retain the IF; 2. Remove the IF; 3. Bypass the IF	Change in the TP with IR as a reference, following evaluation of CBCT, was observed in more than half of the teeth. The difference was statistically significant ($p < 0.001$). Apical location of the fragment was more likely to induce a perceived change in TP after CBCT evaluation ($p<0.01$).	Preoperative CBCT has a significant impact on management planning in cases of IF.
Kruse et al., 2018, Denmark	TP: 1. None; 2. Preservation; 3. SER; 4. Extraction	The radiographic assessment was changed because of the CBCT evaluation in 38 cases (51.4%), of which 35 (47.3%). TP was changed for 18 teeth (24.3%). For 14 teeth (18.9%) the change was from no treatment or	The use of CBCT for long-term follow-up after SER may lead to more cases diagnosed with persistent or recurrent AP and hence often to the

		further observation to a more invasive TP (SER or extraction), p=0.005.	recommendation of a more invasive treatment modality.
Luz et al., 2022, Brazil	DG: Numerous options, and all observed should be marked. TP: Two questionnaires before and after CBCT. All responses were dichotomized. Confidence: It was conducted by means of a 5-point LS in the DG and TP.	Differences in DG were observed when using IR or CBCT images ($p<0.05$), and the use of IR was associated with a greater number of "unsure" responses to questions about DG. Clinical interventions were proposed more frequently when using CBCT images than when using IR ($p<0.05$). The participants' degree of confidence in their diagnostic thinking was not different after analysis by IR or CBCT ($p>0.05$). There was a difference between IR and CBCT images in participants' confidence in their TPs ($p<0.05$).	In dental trauma cases, CBCT imaging influenced participants' diagnostic thinking and choice of treatment modality and affected their confidence in the decision-making process.
Mazón et al., 2022, Spain	TP: 1. Flap elevation; 2. Intentional reimplantation; 3. Surgical extrusion; 4. Orthodontic extrusion; 5. Internal access; 6. Internal and external access; 7. Revision; 8. Protection; 9. Forward to a specialist. Confidence: 1 and 2: Easy, 3: Moderate, 4 and 5: Difficult.	After the CBCT evaluation, the clinicians changed their TP in 72.2% of the cases ($p<0.05$). The self-reported level of difficulty in choosing a treatment changed in all groups after evaluating the CBCT scans ($p<0.05$). After viewing the CBCT scan, the extraction option increased significantly in all groups ($p<0.05$).	CBCT scan had a significant impact on clinical decision-making in cases of ECR evaluated by different specialists.
Mota de Almeida et al., 2014, Sweden	Stage I: A TP was recorded (using only IR). Stage II: After CBCT, the TP was re-evaluated. Stage III: The effect of CBCT on clinical decision-making through a scale, where T1 was less influential, and T5 was highly necessary.	The TP was changed in 29 patients (55%) after CBCT analysis. In 28 patients (53%) and 35 teeth (43%), the change in the TP could be attributed to the CBCT examination.	The examination has a significant impact on clinical decision-making and helps to improve the subjective accuracy of the therapy performed, being recommended for complex endodontic cases.
Mota de Almeida et al., 2015, Sweden	Stage I: A DG was recorded (using only IR). Stage II: After CBCT, the DG was re-evaluated. Stage III: The effect of CBCT on clinical DG through a scale, where D1 was less influential, and D5 was highly necessary.	The DG was changed in 22 patients (42%) between stage 1 and stage 2. There were 28 DG changes among all teeth examined (35%). In 19 of the 52 cases, the examiners	CBCT is recommended in a small group of patients with complex endodontic cases and has a substantial impact on diagnostic thinking.

		stated that they used conventional CT if they did not have access to CBCT.	
Mota de Almeida et al., 2021, Sweden	TP: A. No treatment; B. Watchful waiting; C. Endodontic orthograde treatment; D. Extraction	After CBCT, practitioners changed TPs in 30% of the 90 assessments, 74% of which were more aggressive (p=0.028). In 49% of the assessments, practitioners who chose the watchful and waiting TPs before CBCT changed to a more aggressive therapy such as endodontic orthograde treatment and extraction after CBCT (p=0.005).	CBCT has influenced endodontic therapeutic decision-making in relation to immature traumatized teeth with suspected pulp necrosis, particularly when expectant management was selected prior to examination.
Patel et al., 2009, England	DG: external RR or internal RR; TP: 1. Leave alone; 2. Review; 3.RCT; 4. RCT; 4. RCT + ES; 5. Extraction	The RP receiver operator characteristic values were 0.780 and 0.830 for diagnostic accuracy of internal and ECR respectively. There was a significantly higher prevalence (p = 0.028) for the correct treatment option being chosen with CBCT (%) compared with IRs (%).	CBCT was effective and reliable in detecting the presence of resorptive lesions. The superior diagnostic accuracy of CBCT has also resulted in a greater likelihood of correct treatment of resorptive lesions.
Patel et al., 2016, England	DG ECR: 1. Yes or no; 2. Heithersay classification; 3. Circumferential spread; 4. Location of the lesion. TP: 1. Restorable; 2. Restore (+ RCT) or unrestorable; 3. Extraction/review	IRs had a limited ability to accurately detect the size (0.75), circumferential spread (0.60), and location of ECR compared with CBCT imaging (p<.001). Significant differences (p<.001) were apparent in the treatment plans formed when IRs were assessed versus CBCT imaging.	IR has specific limitations in the detection, evaluation, and treatment planning of ECR when compared with CBCT images. In cases of potentially restorable resorptions, a prior CBCT scan should be considered.
Patel et al., 2019, England	3 groups: Group 1 (IR); Group 2 (CBCT images) and Group 3 (IR, CBCT image and 3D Endo software). A questionnaire with an 8-point LS and a specific question about the degree of stress was completed in two moments: firstly, to assess the anatomy of the root canal and, secondly, during the RCT.	Groups 2 and 3 were significantly better than group 1 (p<0.001) in evaluating the number of root canals and anatomy and in estimating the working length. Doctors considered the treatment moderately or very stressful in 75%, 5% and 0% in groups 1, 2 and 3, respectively.	The 3D software in conjunction with CBCT was considered the most appropriate for evaluating the root canal anatomy and the length of the work, thus reducing the examiners' stress levels.
Patel et al., 2021, England	DG: 1. No trauma; 2. Lateral dislocation; 3. Extrusive dislocation;4. Cortical bone fracture; 5. Horizontal/oblique root fracture.	CBCT imaging was significantly more accurate for all DG (traumatic dental injuries: 91% vs 70%, lateral dislocations: 83% vs	CBCT imaging improved the clinical diagnosis of traumatic dental injuries. CBCT imaging

	Confidence (5-point LS): scale from 1 to 5, where 1 is very insecure and 5 is very confident.	61%, extrusive dislocations: 92% vs 68%, alveolar cortical plate fractures: 78% vs 48%, and horizontal root fractures: 93% vs 82%). Examiners had the most CF with CBCT imaging and the least CF in DG using IR.	improved confidence in the DG of traumatic dental injuries cases and TP compared with IR.
Portigliatti et al., 2017, Argentina	Initially with IR, and the examiners had a table where they noted clinical time, necessary resources, intra-radicular pin, and TP. After providing the CBCT image, the examiners filled in the same data again in the table.	There was changes in all cases, at least in part, after CBCT analysis. Regarding the TP, there were changes in 47% of the cases analyzed.	The use of CBCT in highly difficult cases allows a more precise estimate of the resources required for endodontic treatment and its use as a complement to diagnostic is justified.
Rodríguez et al., 2017a, England	1. ER; 2. PS; 3. Intentional reimplantation; 4. Extraction. CF (5-point LS): 1 and 2- easy decision, 3- moderate decision, 4 and 5- difficult decision.	The examiners altered their TP after viewing the CBCT scan in 49.8% of the cases. A significant difference in the TP between the 2 imaging modalities was recorded for endodontists and general practitioners ($p<.05$). After CBCT evaluation, neither group altered their self-reported level of difficulty when choosing a TP ($p=.0524$). The extraction option rose significantly (20%) after viewing the CBCT scan ($p<.05$).	CBCT imaging directly influences ER strategies among general dental practitioners and endodontists.
Rodríguez et al., 2017b, England	TP: 1. No treatment; 2. Wait 6-12 months; 3. RCT; 4. ER; 5. PS; 6. ER + PS; 7. Extraction; CF (5-point LS): 1 and 2- easy decision, 3- moderate decision, 4 and 5- difficult decision.	The CBCT scans only had a significant influence on the TP when the endodontic case was classified as high difficulty ($p<.05$). The level of difficulty in choosing a treatment choice was significantly more difficult after viewing a preoperative CBCT scan ($p<.05$), except for the endodontists ($p=.033$). After viewing the CBCT scan, the extraction option increased significantly ($p<.05$).	CBCT imaging has a substantial impact on endodontic decision making among specialists, particularly in high difficulty cases.
Sheth et al., 2020, India	1. No RCT; 2. RCT, 3. PS; 4. Apexification; 5. ER; 6. RCT + PS; 7. RCT + ER + apexification.	Significant difference was noted in the TP selected by the observers using the two modalities ($p < 0.05$).	Change in TP was observed after viewing additional information with CBCT. Thus, CBCT helps in

			accurate TP and providing safer treatment.
Viana Wanzeler et al., 2019, Brazil	TP before CBCT: 1. Request CBCT; 2. Clinical and radiographic monitoring; 3. Non-surgical clinical procedure; 4. Non-surgical clinical procedure + CBCT; 5. Surgical endodontic procedure without CBCT; 6. Surgical endodontic procedure + CBCT; 7. Extraction. TP after CBCT: 1. Clinical and radiographic monitoring; 2. Non-surgical clinical procedure; 3. Surgical endodontic procedure; 4. Extraction. Regarding CF, we received the DG and TP with a 5-point LS: 1 not very confident and 5 very confident.	Regarding the level of confidence in diagnosing complex cases after using CBCT, there was a significant difference for positive scores (31.3%). The use of CBCT changed TPs in 54% (moderate cases) and 56% (complex cases).	CBCT has increased endodontists' CF in their DG and TPs, especially in complex endodontic cases.

AP, apical periodontitis; CBCT, cone beam computed tomography; CH, clinical history; CF, confidence; DG, diagnosis; ECR, external cervical resorption; FD, final diagnosis; ER, endodontic retreatment; ES, endodontic surgery; IF, instrument fracture; IR, intraoral radiograph; LS, Likert Scale; PS, periapical surgery; RCT, root canal treatment; RP, root perforation; RR, root resorption; SER, surgical endodontic retreatment; TP, treatment plan; VRF, vertical root fracture.

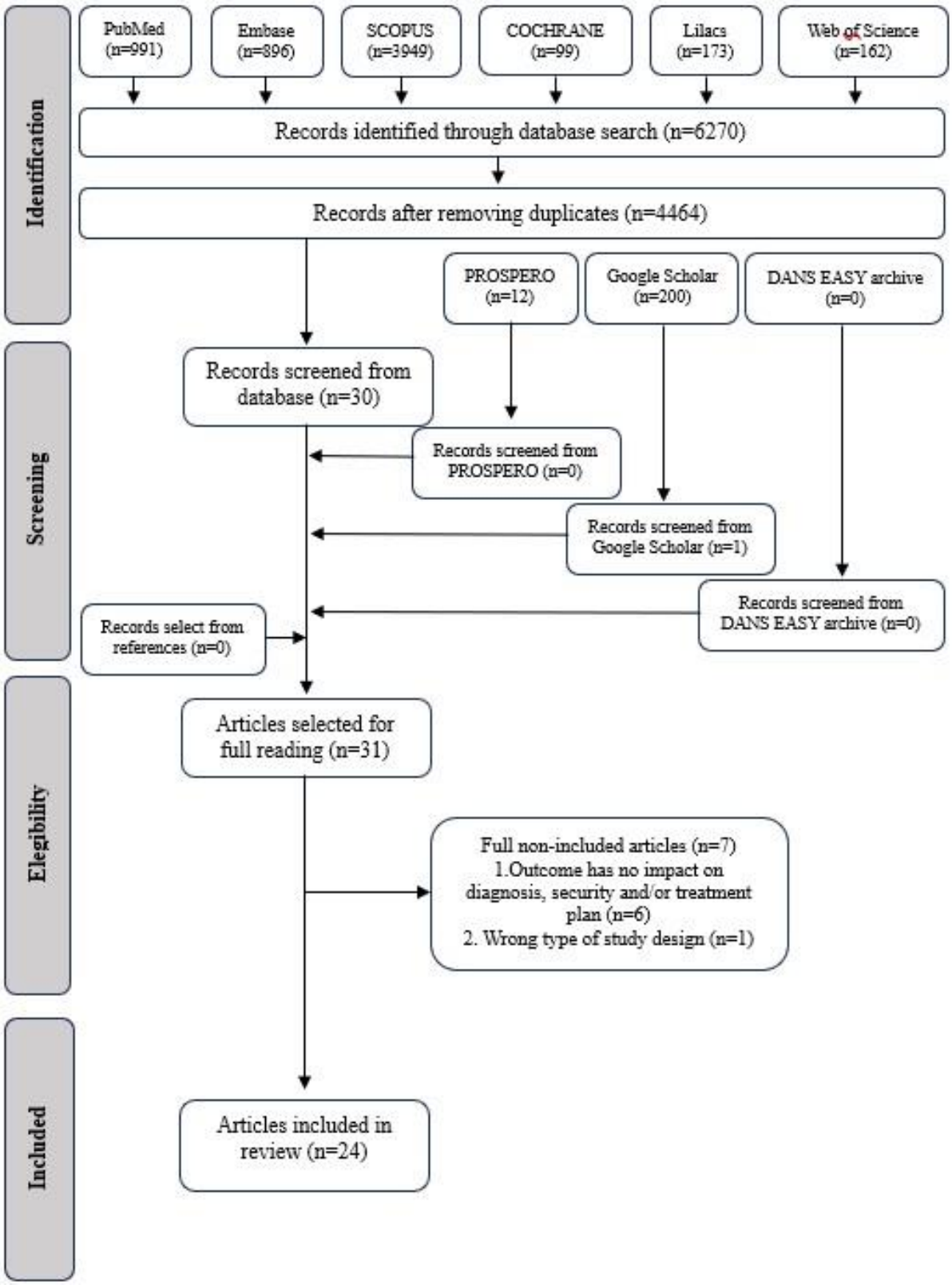


Fig 1. Flow diagram of literature search and selection criteria

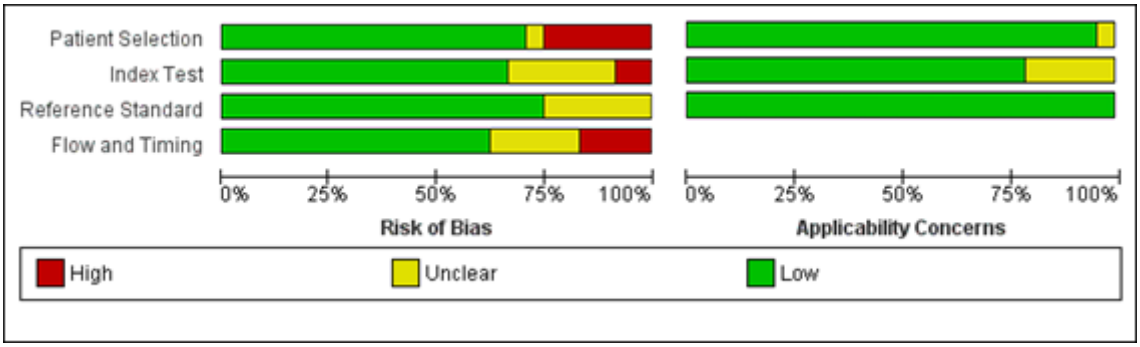


Fig. 2 Risk of bias and applicability concerns graph: assessment of the authors' judgments on each domain of the included studies presented in percentages

Appendix 1 Search strategies for each database

Database	Search
Cochrane (Central)	"Endodontists"Mesh OR “Endodontist” OR "Endodontics"Mesh OR “Endodontology” OR “Dental Pulp Diseases”Mesh OR “Pulp Diseases, Dental” OR “Diseases, Dental Pulp” OR “Pulp Disease, Dental” OR “Dental Pulp Disease” OR “Disease, Dental Pulp” OR “Root Canal Therapy”Mesh OR “Canal Therapies, Root” OR “Canal Therapy, Root” OR “Root Canal Therapies” OR “Therapies, Root Canal” OR “Therapy, Root Canal” AND “Cone-Beam Computed Tomography”Mesh OR “Computed Tomography, Cone-Beam” OR “Cone Beam Computed Tomography” OR “CT Scan, Cone-Beam” OR “CT Scan, Cone Beam” OR “CT Scans, Cone-Beam” OR “Cone-Beam CT Scan” OR “Cone-Beam CT Scans” OR “Scan, Cone-Beam CT” OR “Scans, Cone-Beam CT” OR “Tomography, Cone-Beam Computed” OR “Tomography, Cone Beam Computed” OR “Tomography, Volume Computed” OR “Computed Tomography, Volume” OR “Volume Computed Tomography” OR “Volumetric CT” OR “CT, Volumetric” OR “Volumetric Computed Tomography” OR “Computed Tomography, Volumetric” OR “CAT Scan, Cone-Beam” OR “CAT Scan, Cone Beam” OR “Cone-Beam CAT Scan” OR “Cone-Beam CAT Scans” OR “Cone-Beam Computerized Tomography” OR “Computerized Tomography, Cone-Beam” OR “Cone Beam Computerized Tomography” OR “Tomography, Cone-Beam Computerized” OR “Cone-Beam CT” OR “CT, Cone-Beam” OR “Cone Beam CT” OR “Volume CT” OR “CT, Volume” AND “Radiography”Mesh OR “Diagnostic X-Ray” OR “Diagnostic X Ray” OR “Diagnostic X-Rays” OR “Roentgenography” OR “X-Ray, Diagnostic” OR “X Ray, Diagnostic” OR “Diagnostic X-Ray Radiology” OR “Diagnostic X Ray Radiology” OR “Radiography, Dental”Mesh OR “Dental Radiography” AND “Diagnosis”Mesh OR “Diagnoses” OR “Diagnose” OR “Diagnoses and Examinations” OR “Examinations and Diagnoses” OR “Decision Making”Mesh OR “Therapeutics”Mesh
PubMed (MEDLINE)	"Endodontists"[Mesh] OR “Endodontist” OR "Endodontics"[Mesh] OR “Endodontology” OR “Dental Pulp Diseases”[Mesh] OR “Pulp Diseases, Dental” OR “Diseases, Dental Pulp” OR “Pulp Disease, Dental” OR “Dental Pulp Disease” OR “Disease, Dental Pulp” OR “Root Canal Therapy”[Mesh] OR “Canal Therapies, Root” OR “Canal Therapy, Root” OR “Root Canal Therapies” OR “Therapies, Root Canal” OR “Therapy, Root Canal” AND “Cone-Beam Computed Tomography”[Mesh] OR “Computed Tomography, Cone-Beam” OR “Cone Beam Computed Tomography” OR “CT Scan, Cone-Beam” OR “CT Scan, Cone Beam” OR “CT Scans, Cone-Beam” OR “Cone-Beam CT Scan” OR “Cone-Beam CT Scans” OR “Scan, Cone-Beam CT” OR “Scans, Cone-Beam CT” OR “Tomography, Cone-Beam Computed” OR “Tomography, Cone Beam Computed” OR “Tomography, Volume Computed” OR “Computed Tomography, Volume” OR “Volume Computed Tomography” OR “Volumetric CT” OR “CT, Volumetric” OR “Volumetric Computed Tomography” OR “Computed Tomography, Volumetric” OR “CAT Scan, Cone-Beam” OR “CAT Scan, Cone Beam” OR “Cone-Beam CAT Scan” OR “Cone-Beam CAT Scans” OR “Cone-Beam Computerized Tomography” OR “Computerized Tomography, Cone-Beam” OR “Cone Beam Computerized Tomography” OR “Tomography, Cone-Beam Computerized” OR “Cone-Beam CT” OR “CT, Cone-Beam” OR “Cone Beam CT” OR “Volume CT” OR “CT, Volume” AND “Radiography”[Mesh] OR “ Diagnostic X-Ray” OR “Diagnostic X Ray” OR “Diagnostic X-Rays” OR “Roentgenography” OR “X-Ray, Diagnostic” OR “X Ray, Diagnostic” OR “Diagnostic X-Ray Radiology” OR “Diagnostic X Ray Radiology” OR “Radiography, Dental”[Mesh] OR “Dental Radiography” AND “Diagnosis”[Mesh] OR “Diagnoses” OR “Diagnose” OR “Diagnoses and Examinations” OR “Examinations and Diagnoses” OR “Decision Making”[Mesh] OR “Therapeutics” [Mesh]
Scopus	endodontists OR endodontist OR endodontics OR {Dental Pulp Diseases} OR {Dental Pulp Disease} OR {Root Canal Therapy} OR {Root Canal Therapies} AND {CONE-BEAM COMPUTED TOMOGRAPHY} OR {CONE BEAM COMPUTED TOMOGRAPHY} OR {CONE-BEAM CT SCAN} OR {CONE-BEAM CT SCANS} OR {CONE-BEAM CAT SCAN} OR {CONE-BEAM CAT SCANS} OR {CONE-BEAM COMPUTERIZED TOMOGRAPHY} OR {COMPUTERIZED TOMOGRAPHY, CONE-BEAM} OR {CONE BEAM COMPUTERIZED

	TOMOGRAPHY} OR {CONE-BEAM CT} OR {CONE BEAM CT} OR {VOLUME CT} AND radiography OR {diagnostic x-ray} OR {diagnostic x ray} OR {diagnostic x-rays} OR roentgenography OR {diagnostic x-ray radiology} OR {diagnostic x ray radiology} OR {dental radiography} AND Diagnosis OR Diagnoses} OR {Decision Making} OR therapeutics
Web of Science	"Endodontists" OR "Endodontist" OR "Endodontics" OR "Endodontology" OR "Dental Pulp Diseases" OR "Dental Pulp Disease" OR "Root Canal Therapy" OR "Root Canal Therapies" AND "Cone-Beam Computed Tomography" OR "Cone Beam Computed Tomography" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Volume Computed Tomography" OR "Volumetric CT" OR "Volumetric Computed Tomography" OR "Cone-Beam CAT Scan" OR "Cone-Beam CAT Scans" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT" OR "Volume CT" AND "Radiography" OR "Diagnostic X-Ray" OR "Diagnostic X Ray" OR "Diagnostic X-Rays" OR "Roentgenography" OR "Diagnostic X-Ray Radiology" OR "Diagnostic X Ray Radiology" OR "Dental Radiography" AND Diagnosis OR "Diagnoses" OR "Diagnose" OR "Diagnoses and Examinations" OR "Examinations and Diagnoses" OR "Decision Making" OR "Therapeutics"
LILACS	"Endodontists" OR "Endodontist" OR "Endodontics" OR "Endodontology" OR "Dental Pulp Diseases" OR "Dental Pulp Disease" OR "Root Canal Therapy" OR "Root Canal Therapies" AND "Cone-Beam Computed Tomography" OR "Cone Beam Computed Tomography" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Volume Computed Tomography" OR "Volumetric CT" OR "Volumetric Computed Tomography" OR "Cone-Beam CAT Scan" OR "Cone-Beam CAT Scans" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT" OR "Volume CT" AND "Radiography" OR "Diagnostic X-Ray" OR "Diagnostic X Ray" OR "Diagnostic X-Rays" OR "Roentgenography" OR "Diagnostic X-Ray Radiology" OR "Diagnostic X Ray Radiology" OR "Dental Radiography"
EMBASE	('endodontist'/exp OR 'endodontist' OR 'endodontists' OR 'endodontics'/exp OR 'endodontics' OR 'tooth pulp disease'/exp OR 'dental pulp autolysis' OR 'dental pulp calcification' OR 'dental pulp disease' OR 'dental pulp diseases' OR 'dental pulp exposure' OR 'dental pulp gangrene' OR 'dental pulp necrosis' OR 'dental pulp test' OR 'nonvital tooth' OR 'reactionary dentin (disease)' OR 'tertiary dentin (disease)' OR 'tooth pulp disease' OR 'tooth pulp gangrene' OR 'tooth, nonvital' OR 'endodontic procedure'/exp OR 'endodontic method' OR 'endodontic procedure' OR 'endodontic technique' OR 'pulp canal therapy' OR 'root canal procedure' OR 'root canal therapy') AND ('cone beam computed tomography'/exp OR 'cbct (cone beam computed tomography)' OR 'cone beam ct' OR 'cone beam computed tomography' OR 'cone beam computerized tomography' OR 'cone-beam computed tomography' OR 'spiral cone-beam computed tomography' OR 'volume ct' OR 'volume computed tomography' OR 'volumetric ct' OR 'volumetric computed tomography') AND ('radiography'/exp OR 'x ray imaging' OR 'dual-energy scanned projection radiography' OR 'electroradiography' OR 'pneumoradiography' OR 'radiogram' OR 'radiographic method' OR 'radiography' OR 'radiography, dual-energy scanned projection' OR 'radioimaging' OR 'radiophotography' OR 'roentgen photography' OR 'roentgenography' OR 'roentgenoscopy' OR 'rontgenography' OR 'x ray photography' OR 'x ray system'/exp OR 'tooth radiography'/exp) AND ('diagnosis'/exp OR 'bacteriologic diagnosis' OR 'diagnosis' OR 'diagnostic screening' OR 'diagnostic screening programs' OR 'diagnostic sign' OR 'diagnostic tool' OR 'diagnostics' OR 'disease diagnosis' OR 'medical diagnosis' OR 'physical diagnosis' OR 'decision making'/exp OR 'therapy'/exp)
PROSPERO	Endodontists OR Endodontist OR Endodontics OR Endodontology AND Cone-Beam Computed Tomography" OR Cone Beam Computed Tomography AND Radiography OR Diagnostic X-Ray OR Diagnostic X Ray OR Diagnostic X-Rays AND Diagnosis OR Diagnoses OR Diagnose OR Decision Making
Google Scholar	"Endodontists" OR "Endodontist" OR "Endodontics" OR "Endodontology" AND "Cone-Beam Computed Tomography" OR "Cone Beam Computed Tomography" AND Radiography OR "Diagnostic X-Ray" OR "Diagnostic X Ray" OR "Diagnostic X-Rays" AND Diagnosis OR Diagnoses OR Diagnose

DANS EASY Archive	“endodontics” OR “cone beam computed tomography” AND “periapical radiograph”

Appendix 2 Articles that did not met the eligibility criteria after full-text reading (n=7)

Author, year	Reason for not being included*
1. Cheung et al., 2013 [1]	1
2. Krug et al., 2019 [2]	1
3. Lou Rong, 2014 [3]	1
4. Low et al., 2008 [4]	1
5. Patel et al., 2007 [5]	2
6. Ptak et al., 2021 [6]	1
7. Yapp et al., 2023 [7]	1

1. Studies in which the outcome has no impact on diagnosis, security, and/or treatment plan; 2. Wrong type of study design

1. CHEUNG, G. S. P.; WEI, W. L. L.; MCGRATH, C. Agreement between periapical radiographs and cone-beam computed tomography for assessment of periapical status of root filled molar teeth. **International Endodontic Journal**, v. 46, n. 10, p. 889–895, 2013.

2. KRUG, R. et al. When and how do endodontic specialists use cone-beam computed tomography? **Australian Endodontic Journal**, v. 45, n. 3, p. 365–372, 2019.

3. LUO RONG, CG. Detection of early root fracture in maxillary molar: cone beam CT versus periapical radiographs. **Chinese Journal of Tissue Engineering Research**, v. 18, n. 29, p. 4712-4716, 2014.

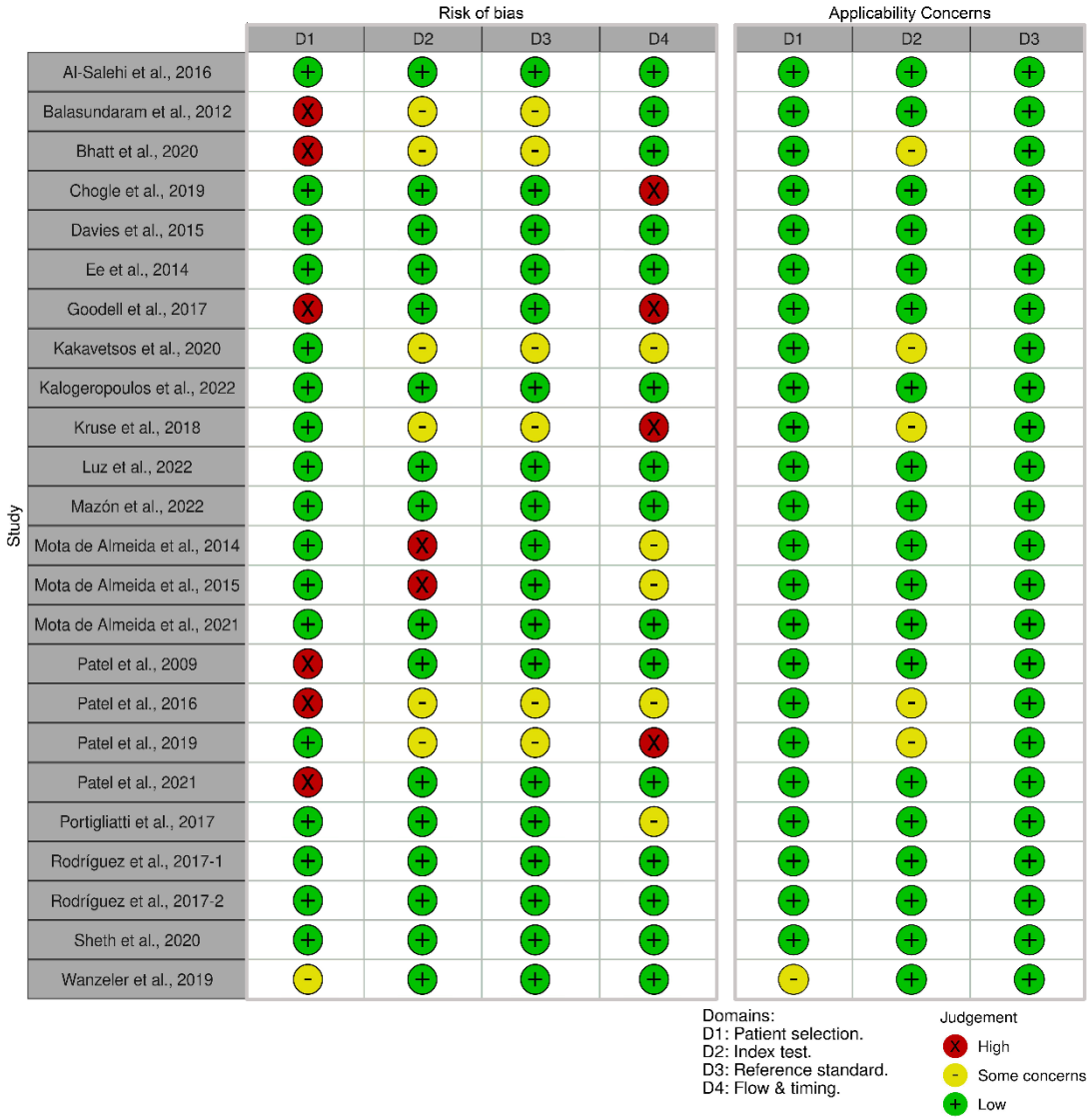
4. LOW, K. M. T. et al. Comparison of Periapical Radiography and Limited Cone-Beam Tomography in Posterior Maxillary Teeth Referred for Apical Surgery. **Journal of Endodontics**, v. 34, n. 5, p. 557–562, 2008.

5. PATEL, S. et al. The potential applications of cone beam computed tomography in the management of endodontic problems. **International Endodontic Journal**, v. 40, n. 10, p. 818–830, 2007.

6. PTAK, D. M.; FINKELMAN, M. D.; AMATO, R. B. The Association between Choice of Diagnostic Imaging Modality and Long-term Treatment Outcomes for Patients Undergoing Nonsurgical Root Canal Treatment on Maxillary First Molars. **Journal of Endodontics**, v. 47, n. 4, p. 572–576, 2021.

7. YAPP, K. E. et al. Periapical Radiography versus Cone Beam Computed Tomography in Endodontic Disease Detection: A Free-response, Factorial Study. **Journal of Endodontics**, v. 49, n. 4, p. 419–429, 2023.

Appendix 3 Risk of bias and applicability concerns summary



4 CONSIDERAÇÕES FINAIS

A TCFC vem sendo cada dia mais utilizada na prática clínica dos dentistas devido ao seu maior acesso e popularização. Os endodontistas utilizam os exames em diversas situações clínicas, desde diagnósticos até acompanhamentos pós-operatórios. Porém, sabe-se que o exame deve ser indicado quando as RIs não permitam esclarecer o caso, e deve ter um impacto no diagnóstico e/ou tomada de decisão clínica, não sendo indicado como um exame de rotina.

No primeiro artigo, foi realizado um estudo observacional transversal sobre a forma de aprendizado, domínio e utilização clínica da TCFC entre os endodontistas brasileiros e o impacto percebido do exame no diagnóstico, plano de tratamento e confiança em casos clínicos endodônticos. Este estudo demonstrou que o uso da TCFC por endodontistas brasileiros está fortemente associado a melhorias nos diagnósticos, planos de tratamento e/ou confiança, além de impactar na compreensão do paciente em relação ao caso/tratamento. Além disso, a educação sobre TCFC desempenha um papel crucial na sua utilização, pois ficou demonstrado que endodontistas que tiveram alguma aula sobre o tema, possuíam mais chances de utilizar os exames.

Enquanto isso, o artigo 2 teve como objetivo revisar sistematicamente a literatura disponível e identificar o impacto da TCFC no diagnóstico, plano de tratamento e/ou nível de confiança do profissional em comparação com as RI, em casos endodônticos. Os achados desta revisão sistemática demonstram que as imagens de TCFC têm impacto no diagnóstico, no planejamento do tratamento e na confiança profissional em casos de tratamentos endodônticos complexos e traumatismos dentários. A TCFC também impacta a confiança profissional em casos de reabsorção radicular externa e no plano de tratamento em casos de fraturas de instrumentos, planejamento cirúrgico e reabsorção radicular interna/externa. Nos casos de traumatismo dentário, retratamento endodôntico cirúrgico e reabsorção cervical externa, a avaliação da TCFC parece estar associada a tratamentos mais invasivos.

Sendo assim, de acordo com o resultado dos presentes estudos, a TCFC apresenta um impacto em inúmeras etapas do tratamento endodôntico. Todavia, é preciso considerar as limitações presentes nesses estudos: No estudo 1, a natureza autorreferida das respostas dos participantes e a ausência de abordagem sobre a dose de radiação utilizada durante os exames de TCFC, pois consiste em um fator extremamente relevante. Enquanto no estudo 2, destaca-se a falta de heterogeneidade nos estudos incluídos, tanto em relação aos casos selecionados quanto em relação às opções diagnósticas e planos de tratamento. Devido a esta

heterogeneidade, não foi possível realizar uma análise quantitativa dos dados. Todos os estudos incluídos avaliaram os níveis 3 e 4 de eficácia diagnóstica, que dizem respeito ao diagnóstico e planejamento do tratamento. Portanto, ainda faltam estudos de nível 5, que relatam os efeitos das informações do exame nos resultados dos pacientes, e de nível 6, sobre os custos e benefícios sociais do exame solicitado (FLYBACK & THRNBURY, 1991). Sendo assim, pesquisas futuras podem se concentrar em abordar as limitações identificadas nestes estudos.

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Results: Only experimental results are appropriate in this section (i.e., neither methods, discussion, nor conclusions should be in this section). Include only those data that are critical for the study, as defined by the aim(s). Do not include all available data without justification; any repetitive findings will be rejected from publication. All Figures, Charts, and Tables should be described in their order of numbering with a brief description of the major findings. The author may consider the use of supplemental figures, tables or video clips that will be published online. Supplemental material is often used to provide additional information or control experiments that support the results section (e.g., microarray data).

Figures: There are two general types of figures. The first type of figures includes photographs, radiographs, or micrographs. Include only essential figures, and even if essential, the use of composite figures containing several panels of photographs is encouraged. For example, most photos, radio- or micrographs take up one column-width, or about 185 mm wide X 185 mm tall. If instead, you construct a two columns-width figure (i.e., about 175 mm wide X 125 mm high when published in the JOE), you would be able to place about 12 panels of photomicrographs (or radiographs, etc.) as an array of four columns across and three rows down (with each panel about 40 X 40 mm). This will require some editing to emphasize the most important feature of each photomicrograph, but it greatly increases the total number of illustrations that you can present in your paper. Remember that each panel must be clearly identified with a letter (e.g., "A," "B," etc.), in order for the reader to understand each individual panel. Several nice examples of composite figures are seen in recent articles by Jeger et al (J Endod

2012;38:884–888); Olivieri et al., (J Endod 2012;38:1007 1011); Tsai et al (J Endod 2012;38:965–970). Please note that color figures may be published at no cost to the authors and authors are encouraged to use color to enhance the value of the illustration. Please note that a multi-panel, composite figure only counts as one figure when considering the total number of figures in a manuscript (see section 3, below, for the maximum number of allowable figures).The second type of figures is graphs (i.e., line drawings including bar graphs) that plot a dependent measure (on the Y-axis) as a function of an independent measure (usually plotted on the X axis). Examples include a graph depicting pain scores over time, etc. Graphs should be used when the overall trend of the results are more important than the exact numerical values of the results. For example, a graph is a convenient way of reporting that an ibuprofen-treated group reported less pain than a placebo group over the first 24 hours, but was the same as the placebo group for the next 96 hours. In this case, the trend of the results is the primary finding; the actual pain scores are not as critical as the relative differences between the NSAID and placebo groups.

Tables: Tables are appropriate when it is critical to present exact numerical values. However, not all results need be placed in either a table or figure. For example, the following table may not be necessary:Instead, the results could simply state that there was no inhibition of growth from 0.001-0.03% NaOCl, and a 100% inhibition of growth from 0.03-3% NaOCl (N=5/group). Similarly, if the results are not significant, then it is probably not necessary to include the results in either a table or as a figure. These and many other suggestions on figure and table construction are described in additional detail in Day (1998).

Discussion: This section should be used to interpret and explain the results. Both the strengths and weaknesses of the observations should be discussed. How do these findings compare to the published literature? What are the clinical implications? Although this last section might be tentative given the nature of a particular study, the authors should realize that even preliminary clinical implications might have value for the clinical leadership. Ideally, a review of the potential clinical significance is the last section of the discussion. What are the major conclusions of the study? How does the data support these conclusions

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References: The reference style follows Index Medicus and can be easily learned from reading past issues of the JOE. The JOE uses the Vancouver reference style, which can be found in most citation

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