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REVIEW ARTICLE

Magnetic resonance imaging versus cone beam computed tomography in diagnosis of periapical pathosis – A systematic review

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KEYWORDS

Cone beam computed tomography;
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Abstract *Objective:* The diagnosis of any dental pathology can vary from being simple to challenging. While the use of cone beam computed tomography (CBCT) is well established, magnetic resonance imaging (MRI) remains a proof of concept. This systematic review aims to compare the diagnostic ability of MRI with CBCT in diagnosing periapical pathosis.

Materials and Methods: This systematic search was performed using the electronic databases of MEDLINE, Cochrane Library, Google Scholar, and Science Direct to identify relevant articles from 2010 to 2020. The search terms used were magnetic resonance imaging, cone beam computed tomography, diagnosis, and periapical diseases.

Result: In total, 3218 potentially relevant abstracts and titles were identified. After removing duplicates, 1288 articles were reviewed for titles and abstracts, and 29 articles were selected for full-text reading. From those, 19 articles were finally selected that included original research studies, case reports, and case series and were included for systematic review. Most of the studies included in this review suggested that the combined use of CBCT and MRI is needed for a better and more precise diagnosis of complex periapical pathoses. The main advantage of MRI is its ability to image soft tissues usingnon-ionizing radiation, and the main disadvantage in the case of CBCT is overdiagnosis of the lesion.

Conclusion: MRI has various advantages over CBCT with similar diagnostic utility. When diagnosing periapical pathogens, both MRI and CBCT are needed for an accurate diagnosis.

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Contents

1. Introduction

A disease diagnosis is essential to derive a treatment plan (Fernandes and de Ataide, 2010). Dental and medical records alone are groundless to arrive at a correct diagnosis (Shah et al., 2014). Collecting and arranging the data are critical to determine an accurate diagnosis (Patel et al., 2009). Radiography plays a critical role in diagnosing periapical pathosis. Conventional radiography has various limitations because it produces two-dimensional images. Other drawbacks can occur, such as masking the area of interest due to anatomical noise and geometric distortion. These drawbacks must be overcome with advances in three-dimensional imaging (3D) techniques (Kaur and Chopra, 2010).

The jaw bone and other bones surround the teeth at a distance from the root apices. These structures become superimposed onto the anatomic features of diagnostic interest, sometimes to the extent that the latter become concealed, making the process of diagnosis very challenging (Venkatesh and Elluru, 2017).

With the advantage of 3D images, better understanding of the anatomic complexities elucidating preoperative intricacies, unseen pathoses and canal complications can be achieved (Ricci et al., 2019). A 3D image defines the extent, type, and amount of the periapical lesion. Assessment of periradicular lesions, differentiation of these lesions from nonodontogenic pathoses, and understanding size and distances are now predictably possible using 3D imaging techniques (Nagarajappa et al., 2015).

Magnetic resonance imaging (MRI) is a noninvasive imaging technique used for diagnosing soft tissue disease without ionizing radiation. The principle behind MRI is the use of non-ionizing radiofrequency electromagnetic radiation in the presence of controlled magnetic fields to obtain high-quality cross-sectional images of the body. MRI techniques are currently evolving in dentistry to diagnose various diseases (Deana and Alves, 2017).

Cone-beam computed tomography (CBCT) has been the outstanding primacy in endodontics for the last decade (Niraj et al., 2016). In a 2D detector, a cone-shaped X-ray beam is centred that performs one rotation around the object, producing a series of 2-D images. Modification of the original cone-beam algorithm is used in reconstructing the 3D images (Hartwig et al., 2009). The appropriate use of CBCT helps determine an accurate diagnosis, which helps in treatment planning (Shah et al., 2014).

A previous systematic review and meta-analysis was performed comparing CBCT and conventional radiography in the diagnosis of apical periodontitis (Leonardi Dutra et al., 2016). This is the first systematic review comparing MRI and CBCT in the diagnosis of periapical pathosis.

2. Materials and methods

The guidelines of the Preferred Reporting Items for Systematic Reviews (PRISMA) statement were followed (Turpin, 2005). This systematic review was registered in PROSPERO, and the registration number is CRD42020192376. The focused question is whether magnetic resonance imaging is a more effective diagnostic tool than cone beam computed tomography in detecting periapical lesions.

2.1. Study design

The review included original research articles, randomized control trials, case reports, and case series.

2.2. Eligibility criteria

2.2.1. Inclusion criteria

- All original research articles including CBCT and MRI as diagnostic tools in identifying periapical pathology conducted in humans.
- All case reports using CBCT and MRI in the diagnosis of periapical pathology.
- Articles published from 2010 to 2020.

Table 1 The QUOROM statement checklist.

Heading	**Sub-Heading**	**Descriptor**	**Reported? (Y/N)**	**Page number**
Title		Systematic review	Y (SR)	1
Abstract		Use a structured format	Y	1
	Objectives	The clinical question explicitly	Y	1
	Data sources	The databases (ie, list) and other information sources	Y	1
	Review methods	The selection criteria (ie, population, intervention, outcome, and study design); methods for validity assessment, data abstraction, and study characteristics, and qualitative data synthesis in sufficient detail to permit replication	Y (but in more detail in main methods section)	1
	Results	Characteristics of studies included and excluded; qualitative findings	Y	1
	Conclusion	The main results	Y	1
Introduction		The explicit clinical problem, biological rationale for the intervention, and rationale for review	Y (no biological rationale as common intervention)	2
Methods	Searching	The information sources, in detail and any restrictions	Y	4
	Selection	The inclusion and exclusion criteria (defining population, intervention, principal outcomes, and study design	Y	4
	Validity assessment	The criteria and process used	Y	4–5
	Data extraction	The process or processes used (eg, completed independently, in duplicate)	Y	4–5
	Study characteristics	The type of study design, participants' characteristics, details of intervention, outcome definitions, &c, and how clinical heterogeneity was assessed	Y	4–5
	Quantitative data synthesis	The principal measures of effect (eg, relative risk), method of combining results (statistical testing and confidence intervals), handling of missing data; how statistical heterogeneity was assessed; a rationale for any a-priori sensitivity and subgroup analyses; and any assessment of publication bias	NA	
Results	Trial flow	Provide a meta-analysis profile summarising trial flow	NA	
	Study character^{s}	Present descriptive data for each trial (eg, age, sample size, intervention, dose, duration, follow-up period)	Y	5 & Fig. 1
	Quantitative data synthesis	Report agreement on the selection and validity assessment; present simple summary results (for each treatment group in each trial, for each primary outcome); present data needed to calculate effect sizes and confidence intervals in intention-to- treat analyses (eg 232 tables of counts, means and SDs, proportions)	NA	.
Discussion		Summarise key findings; discuss clinical inferences based on internal and external validity; interpret the results in light of the totality of available evidence; describe potential biases in the review process (eg, publication bias); and suggest a future research agenda	Y (structured discussion provided as suggested)	5–6

2.2.2. Exclusion criteria

- Review articles, editorial letters and books, personal opinions, book chapters, and conference abstracts;
- Studies conducted using animal models;
- Studies conducted other diagnostic methods, such as ultrasonography and radiographic subtraction, for diagnosing periapical pathology.

2.3. Information sources

Articles were systematically searched in four electronic databases—i.e., MEDLINE (via PubMed), Google Scholar, ScienceDirect, and Cochrane Databases. A comprehensive search of peer-reviewed literature published from 2010 to July 2020 was performed online.

2.4. Search terms

The following search string summarizes the initial search performed in PubMed: ([''Periapical lesions'' OR ''periapical periodontitis'' OR ''periapical radiolucency' 'apical lesions'' OR ''apical periodontitis'' OR ''apical radiolucency'' OR ''periapical pathology'' OR ''dental pulp diseases'' OR ''periapical diseases'' OR ''apical pathology''] AND [''Diagnosis'' OR ''detection'' OR ''identification''] AND [''Magnetic Resonance Imaging'' OR ''Nuclear Magnetic Resonance Imaging'' OR ''Dental Magnetic Resonance Imaging''] AND [''3-D dental radiography'' OR ''cone beam computed tomography'' OR ''DentalVolumetricTomography'' OR ''3D-X-ray Imaging'']).

2.5. Study selection

A bi-phase selection of articles was conducted. In the first phase, the titles and abstracts of all the identified articles were reviewed based on the inclusion criteria by two independent reviewers. Any article that did not satisfy any or all of the inclusion criteria mentioned in 2.2.1 was excluded from the review. In the latter phase, the selected articles from the first phase were reviewed and screened by the same reviewers. In the case of a discrepancy between the reviewers, a third reviewer with more expertise made the final decision. The final selection was made after full-text reading of the articles.

2.6. Collection process

For all the included studies, the following descriptive characteristics were recorded: study characteristics (authors and year), sample characteristics (type and size), intervention (repetition time, echo time, slice thickness, and field of view for both T1- and T2-weighted MRI images) and comparison parameters (field of view and voxel size). For standardization of the extracted data, information on these parameters was collected because it was mentioned in most of the included studies. All the articles required for the present study were collected by one investigator, and the collected information was cross verified by the second investigator. Any disagreement in either phase was resolved to utilize the discussion, and the third reviewer made a final decision if consensus was not reached by the first 2 reviewers. Because of the heterogeneity of the included studies, the risk of bias was not assessed.

3. Results of the systematic review

A summary of the results of the included studies is shown in Table 1. In total, 3218 studies were identified from PubMed, Google Scholar, and Science Direct. Cochrane databases were checked for any existing systematic reviews on the proposed topic. After removing duplicates, 1288 articles were reviewed for titles and abstracts by two independent reviewers, and 29 articles were selected for full-text reading. Ten studies were excluded because of unsatisfactory inclusion criteria. Nineteen articles that included original research studies, case reports, and case series were included for qualitative analysis. The selection process of the included study is shown in Fig. 1.

The chosen studies included 59% case reports, 35% original research articles, and 10% case series published between 2010 and 2020. Most of the studies included in this review suggest that the combined use of CBCT and MRI is needed for the better and more precise diagnosis of complex periapical pathoses. The main advantage of MRI is its ability to image soft tissues using nonionizing radiation, and the main disadvantage in the case of CBCT is overdiagnosis of the lesion. MRI along with CBCT can potentially be considered the future gold standard in diagnosis (see Table 2).

4. Discussion

This systematic review compares all the invivo studies performed using CBCT and MRI to diagnose periapical pathology. After a vigorous literature search, 19 invivo studies were identified, comprising 11 case reports, 2 case series, and 7 original research articles.

According to this review, both CBCT and MRI are effective in diagnosing odontogenic and nonodontogenic pathologies. A small periapical lesion mimicking apical periodontitis could be an oral manifestation of a life-threatening systemic disease such as metastasis of a malignant lesion (Vander Veken et al., 2018; Idiyatullin et al., 2011; Choi et al., 2012).

The size, shape, and extent of the periapical lesion can be accurately calculated (Yilmaz et al., 2016). CBCT also offers

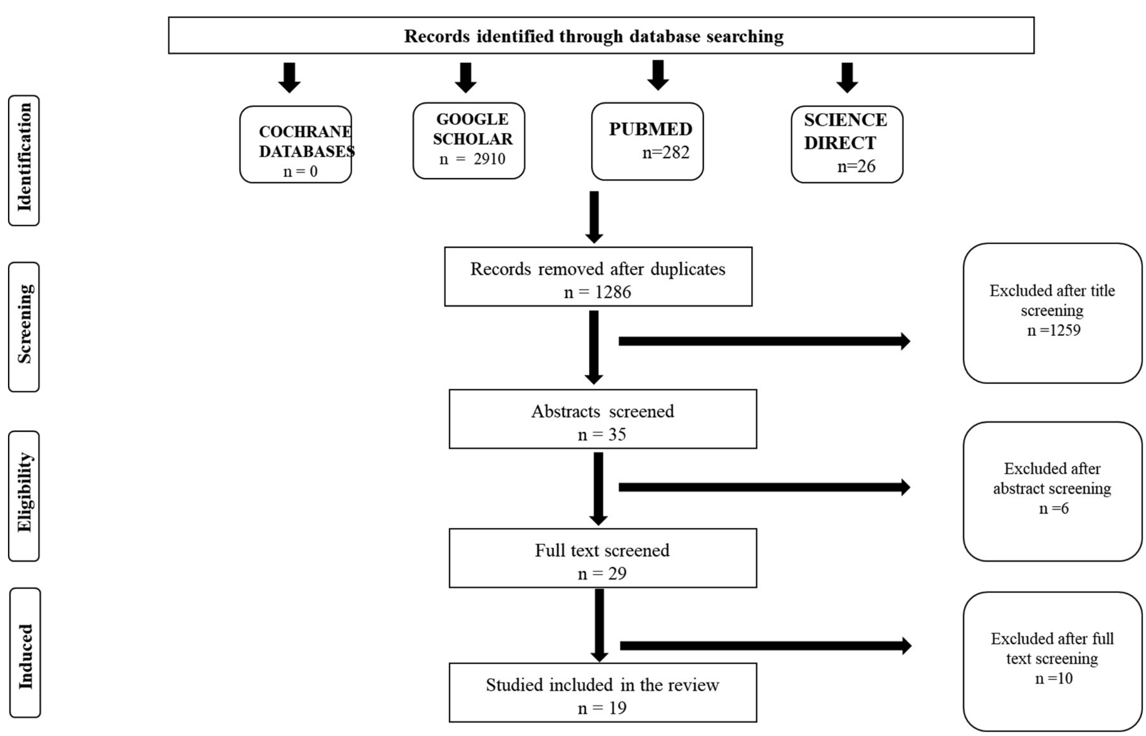

Fig. 1 Selection process of the included studies.

Table 2 List of included studies and their main characteristics.

S. no	Author & year	Country	Study design	Comparison (CBCT) parameters	Intervention (MRI) parameters	Comparison characteristics	Intervention characteristics	Inference
1	Juerchott et al., 2020	Germany	Prospective study	3D Accuitomo 170 system (J Morita) Cylindrical volume range:4X4-8X8cm Voxel size: 0.16mm	3 Tesla MRI system **T1** Repetition time - 15.6ms Echo time - 2.45ms Slice thickness- 0.7mm FOV (cm)- 153X223mm^2 **T2** Not mentioned	99 furcation entrances showed no FI, whereas 93 furcation entrances revealed FI. The furcation entrances with FI were subdivided into 35 degrees I, 19 degrees II, and 39-degree III defects.	High accuracy for the three different furcation sites, with sensitivity rates of 86% for buccal, 93% for distopalatal, and 100% for mesiopalatal FI.	Horizontal loss of periodontal tissue in maxillary molars was analyzed on 3D MRI and CBCT. Compared to CBCT, MRI proves accuracy and reliability for diagnosis of periodontal disease.
2	Galvao et al., 2019	Brazil	Case report-2 cases	i-CAT GXCB 500 FOV:16X6cm Voxel size:0.2 Mm	Achieva 1.5T unit **T1** Repetition time - 478ms Echo time -16ms Slice thickness- 2.0mm FOV (cm)- 21X21cm **T2** Repetition time - 6.5ms Echo time -90ms Slice thickness- 2.0mm FOV (cm)- 21X21cm	**CASE1** Involvement of the mandibular canal and also buccal and lingual cortical expansion is seen **CASE 2** Thinning of buccal and lingual cortices, expansion of the hypodense area and displacement of mandibular canal is seen.	Showed a circumscribed lesion of intermediate signal. T1 and T2 MRI SPIR showed regions of a hyper signal within the lesion- Presence of fluid. T1- a circumscribed lesion with an intermediate signal. T2-MRIFLAIR-Regions of high signal intensity- Liquid content.	Diagnosis-Plexiform Ameloblastoma Unicystic ameloblastoma MRI revealed internal characteristics of the lesion- Provided additional information to CBCT
3	Christofzik, 2018	Germany	Case Report	Not mentioned	Not mentioned	Apical lesion on the mesial root near the mental nerve	T2-Signal reduction in the mandibular corpus in the 33 to 37 regions.	Diagnosis: Vincent symptom with apical periodontitis in the region of 36 Vincent's symptom was diagnosed through the use of MRI.

Table 2 (*continued*)

S. no	Author & year	Country	Study design	Comparison (CBCT) parameters	Intervention (MRI) parameters	Comparison characteristics	Intervention characteristics	Inference
4	Veken et al., 2018	Belgium	Case Report	FOV:8X8cm	Not mentioned	Change in the morphology of mandibular corpus, an asymmetry between left and right posterior mandible.	A metastatic area at the lower part of the mandibular corpus.	Diagnosis: Breast Carcinoma metastasis. CBCT & MRI- Diagnosis of non-odontogenic periapical pathosis.
5	Lizio et al., 2018	Italy	Original Research-34 subjects	Not mentioned	1.5T Superconducting magnet **T1** Repetition time: 400-500 ms Echo time:9-12ms Slice thickness-3mm Interslice gap:0.3mm **T2** Repitition time: 3,440-3,680 ms Echo time:120ms Slice thickness-3mm Interslice gap:0.3mm	More artifacts present	Low SI on T1- fluid and fibrous tissue T2- Evident fibrous wall of the cyst	24 out of 34 cases diagnosis from MRI consistent with CBCT. CBCT- Overdiagnosis.
6	(Fortunato et al., 2018)	Italy	Original Research 29 cases with some malignancy	Not mentioned	Not mentioned	Define the relationship of the lesion with the mandibular nerve	Distinguish limits of necrosis and osteitis in cases of MRONJ	Confirmed by histopathology. MRONJ cases treated for malignancy - differentiated bone necrosis from metastasis
7	Lu et al., 2017	Taiwan	Case series 16 cases with numb chin syndrome	Not mentioned	Not mentioned	Progressive osteolysis somewhere along the whole mandible and loss of lamina dura, root resorption, periodontal and periapical-like lesions with ill-defined borders in many teeth	MRI did before CBCT led to the accurate diagnosis.	CBCT –A true isotropic volume image and improved spatial resolution in the anatomic destruction pattern and osseous permeation in mandibular metastasis and MRONJ is obtained. MRI leads to an accurate diagnosis.

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Table 2 (*continued*)

S. no	Author & year	Country	Study design	Comparison (CBCT) parameters	Intervention (MRI) parameters	Comparison characteristics	Intervention characteristics	Inference
8	MacDonald et al., 2017	Canada	Case Report	iCAT FOV:6 x15 cm Voxel size:0.2mm	Sigma HDxt 3T GEMSMR3T MR unit	Expansile lesion obstructing the entire right maxillary sinus, erosion of the buccal and palatal cortices of the alveolus.	The lesion measured 5.1 cm anteroposteriorly, 3.7 cm axially; and 3.8 cm vertically	Diagnosis: B cell Non-Hodgkin Lymphoma Confirmed by histopathology and immunohistochemistry. CBCT-superior spatial resolution MRI revealed a differential diagnosis of squamous cell carcinoma.
9	Pinto et al., 2016	Brazil	Case Report	GENDEX GXCB-500 FOV:16X6.0cm Voxel size:0.2mm	Achieva 1.5T 8-channel phased-array head coil **T1** Repetition Time-478ms Voxel Size:0.72mm isotropic Echo Time:16ms FOV:21X21cm Slice gap:2.0mm **T2** Repetition Time-6.5ms Voxel Size:0.72mm isotropic Echo Time:90ms FOV:21X21cm Slice gap:2.0mm	A well-defined unilocular lesion with a thin radiopaque border bilaterally adjacent to the area of the third mandibular molars.	T1-Intermediate to low signal intensity surrounded by a thin delineation of hypointense compatible with the cortical bone. T2-Homogeneous high signal content, indicating inflammatory response and elliptical appearance.	Diagnosis-Paradental cyst confirmed by histopathology. CBCT-Extent of the lesion MRI-Analysis of lesion contents.
10	Gamba et al., 2016	Brazil	Case Report	Not mentioned	Not mentioned	Dense soft tissue lesion and expansion, thinning, and also disruption of the lingual cortex in mandibular ramus and body.	T1-Intermediate signal image occupying the entire mandibular left body and ramus, rupture of the lingual cortical bone, an extension to the floor of the mouth. T2-Hypersignal areas inside the lesion-Pericoronitis.	Diagnosis: Keratocystic odontogenic tumor Confirmed by histopathology CBCT-Extent of lesion MRI-Superior images in the internal composition of the lesion.
11	Ertas et al.,	Turkey	Case Reports	Not mentioned	Not mentioned	Mandibular lingual wall defect	T1 fat-saturated, T2 fat-	The posterior variant of Stafne

Table 2 (*continued*)

S. no	Author & year	Country	Study design	Comparison (CBCT) parameters	Intervention (MRI) parameters	Comparison characteristics	Intervention characteristics	Inference
	2015			(NewTom 5G; QR, Verona	Not mentioned	at the molar region with vestibular extension Radiolucent area located on the anterior region of the mandible lingual to mental foramen	saturated, the posterior part of the bone cavity is filled with anterosuperior part of the submandibular gland. T1 and T2 sequences, anterior part of the cavity showed hyperintense signals-with proteinaceous content in this area T1 fat-saturated, T2 fat-saturated, MRI images, the bone cavity is filled with continuous soft tissue similar to mylohyoid muscle fill the bone cavity.	Bone Cyst The anterior variant of Stafne Bone Cement CBCT-Examination of the radiolucent lesion with lower radiation exposure and higher speed MRI-Superior soft tissue characterization and differentiation and without ionizing radiation
12	Adachi et al., 2015	Japan	Case report	Not mentioned	Not mentioned	18X 11–mm osteolytic lesions with the destruction of the lingual and buccal cortical plate at teeth #28 to 30	T1-weighted- and enhanced margin of the lesion, and high signal intensity.	Inflammatory MyofibroblasticTumor. Confirmed by histopathology. CBCT and MRI are needed for diagnosis.
13	Geibel et al., 2015	Germany	Original Research-19 cases	(Galileos, Sirona Dental Systems, Germany) with an in-plane resolution of 0.287mm, a field of view of 150x150x150 mm^3	Achieva 3 T, Philips Medical T1:9:06 min T2:5:43 min	The lesion appears homogeneous, artifacts are seen.	T1: Hypointense-identification of fluids. T1W &T2W Isointense T2W-Identification of cyst core and wall	34 Periapical lesions MRI & CBCT showed similar sensitivity MRI-Low diagnostic ability
14	Linz et al., 2015	Germany	Case series 197 subjects	Galileos CBCT unit FOV:15cm Isotropic voxels: (512X512X512) 0.3mm	1.5T/3T scanner T1 Contrast-enhanced fat-saturated images. T2 Fat saturated STIR	Degradation or erosion of cortical bone revealed osseous tumor invasion.	Hypointense T1 and hyperintense T2 reveals tumor necrosis.	CBCT: High spatial resolution images, periodontal disease may be misinterpreted as the metastatic bone invasion MRI- accuracy similar to CBCT But superior in imaging surrounding soft tissues.
15	Pigg et al., 2014	Sweden	Comparative study-20 Subjects with Atypical Odontalgia.	3D Accuitomo	1.5T Sonata system Axial T1 weighted images T2-STIR	Evidence of periapical bone defect.	Abnormal findings in 8 cases 1 case –signal depicted periapical bone defect	8 cases revealed a dental pathology causing the odontalgia.
16	Choi et al.,	Korea	Case Report	Not mentioned	Not mentioned	Revealed an ill-defined bony	T1- Low signal intensity.	Diagnosis-Primary

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Table 2 (*continued*)

S. no	Author & year	Country	Study design	Comparison (CBCT) parameters	Intervention (MRI) parameters	Comparison characteristics	Intervention characteristics	Inference
	2012					destructive lesion with perforation of the buccal and lingual cortical plate.	T2- High signal intensity Revealed adjacent soft tissue involvement, extending laterally into buccinators and masseter muscle, with invasion into the medial pterygoid and masticator space.	Intraosseous Squamous Cell Carcinoma Confirmed by histopathology. CBCT-Size, shape, and appearance of the lesion MRI-Showed the polymorphic features of the lesion.
17	Rodrigues et al., 2011	Brazil	Case Report	I-Cat; Imaging Sciences	Gyros can T-5-II; Phillips Medical Systems International, Best	Well-circumscribed lesion immediately below the roots of tooth 18 that extended from below tooth 17 to the mental foramen.	The Hypodense area in the left side of the mandibular body affected the mental foramen area and extended back to the apex of the mesial root of tooth #17, the alveolar border, in the region of tooth #19, and the lower cortex of the mandible.	Diagnosis: Lymphangioma Confirmed by histopathology CBCT and MRI are needed for diagnosis.
18	Idiyatullin et al., 2011	The U.S. A	In vivo feasibility study	iCAT; Imaging Sciences, 60 mm field of view (FOV) at 37 mA/s for 27 seconds and 120 kV with a resolution of 0.2 mm	90-cm, 4-T magnet SWIFT sequence Repetition time - 2.5 ms. Gradient-echo (GRE) sequence Echo time-3ms	Streaking artifact reduces the diagnostic utility	The cancellous bone, mucosa, and gingival tissues appear bright	No pathology detected Artifacts that were visible in CBCT due to existing amalgam restoration did not appear in the MRI.
19	Hendrikx et al., 2010	Netherlands	Retrospective study-23 cases with Squamous Cell Carcinoma with the mandibular invasion	I-CAT scanner	1.5 T MR, with a CP-neck-array coil Slice thickness-3mm	Mandibular invasion of the medullar bone via the cortex.	Reveals invasion of the mandible in 85% of patients	CBCT underestimates the extent of the lesion while MRI overestimates the lesion.

superior spatial resolution with lower radiation exposure and higher speed than computed tomography (CT) (Jain et al.,2019). Though CBCT offers an accurate diagnosis, controversy exists regarding disease over estimation in CBCT. For example, localized periodontal disease in the mandible may mimic invasive squamous cell carcinoma of the jaw on CBCT. Furthermore, although CBCT uses less ionizing radiation than CT, the overall X-ray exposure is still higher than that of conventional two-dimensional radiography (Al Najjar et al., 2013).

A radiation-free modality for imaging with excellent envisioning of the soft tissue is dental MRI. There is a growing interest in MRI use in dentistry because it generates good quality images, attributed to improvement in coil systems and optimization of sequence techniques (Juerchott et al., 2018).

MRI has shown similar sensitivity to CBCT in most of the studies. MRI produces superior images, revealing the internal characteristics and contents of the lesion. MRI overpowers CBCT, providing superior characterization of soft tissues than CBCT and without using ionizing radiation. Additionally, the presence of artefacts due to pre-existing dental restorations hampers the diagnosis in CBCT, while this drawback is overcome by MRI. Previous studies have depicted that pre-existing dental restorations are not eroded by MRI (Rodrigues et al., 2011).

MRI and CBCT are used to diagnose both odontogenic and nonodontogenic diseases. Five included studies used both CBCT and MRI to diagnose periapical pathoses with an odontogenic origin. In a comparative study (Lizio et al., 2018) on subjects with atypical odontalgia, 8 of 20 subjects were diagnosed with an underlying dental disease using CBCT and MRI, dental disease that was otherwise not visible in conventional radiographs. Additionally, no consensus existson the diagnostic criteria for atypical odontalgia, necessitating using a combination of three-dimensional imaging techniques in such cases (Veken et al., 2018). A feasibility study included in this review compared the diagnostic utility of CBCT and MRI with sweep imaging with Fourier transformation (SWIFT) for imaging, and simultaneous imaging of hard and soft tissues could be effectively performed using the MRI SWIFT technique (Rodrigues et al., 2011). Two included studies diagnosing apical periodontal diseases showed similar diagnostic abilities of CBCT and MRI (Juerchott et al., 2020) and (Geibel et al., 2015).

The remaining fifteen incorporated studies have availed both CBCT and MRI to diagnose a periapical lesion that results in the diagnosis of a nonodontogenic disease. The diagnosis reported varied from a benign Stafne's bone cyst (Ertas et al., 2015), a paradental cyst (Pinto et al., 2016), lymphangioma (Rodrigue et al., 2011) and myofibroma (Adachi et al., 2015) to a malignant non-Hodgkin's lymphoma (MacDonald et al., 2017), breast carcinoma metastasis (Veken et al., 2018) and squamous cell carcinoma (Choi et al., 2012; Hendrikx et al., 2010; Galvao et al., 2019). Benign lesions such as ameloblastoma (Gamba et al., 2016) and keratocystic odontogenic tumour (Pinto et al., 2016) that could turn aggressive if left untreated were diagnosed aptly using CBCT and MRI. In a case report that presented pulp necrosis with apical periodontitis and paresthesia, the application of CBCT and MRI led to the diagnosis of Vincent's Symptom (Christovik et al, 2018).

Comparing MRI and CBCT in all the included studies, the diagnosis obtained from MRI is consistent with that of CBCT, although many studies have depicted over diagnosis using CBCT alone. Although MRI is still evolving in the diagnosis of odontogenic diseases, the utilization of a combination of CBCT and MRI is more effective to diagnose nonodontogenic diseases.

A few disadvantages of dental MRI, compared with CBCT, are that MRI is more expensive and limited in availability. Although the overall scanning time was within 10 min, the patient preparation and overall time required for MRI scanning were more than those required for CBCT. Additionally, most of the included studies involved administering a contrast agent to the patient for better visualization of hard tissues; thus, additional caution is required (Olt et al., 2004). Additionally, MRI cannot be used in patients with retainers or orthodontic brackets because they are made of ferromagnetic alloys (Geibel et al. 2015).

5. Conclusion

Although MRI has various advantages over CBCT with similar diagnostic utility, the combined use of CBCT and MRI provides a better and more precise diagnosis in periapical pathoses. It cannot be substantiated that MRI is better than CBCT after reviewing the published articles. Most of the articles published in this field are case reports, indicating the need for more randomized controlled trials to be performed in this arena. If extensive research is performed in this field, these three-dimensional imaging techniques have the potential to precisely diagnose any complex periapical lesion and replace the gold standard invasive histopathology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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