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Review

Beyond radiation: Emerging applications of MRI in dental diagnostics and clinical practice

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Abstract: *Aim:* To explore the evolving role of magnetic resonance imaging (MRI) in dental diagnostics and clinical applications, highlighting its advantages as a radiation-free modality and assessing its integration across various dental disciplines. *Methods:* A narrative review was conducted using peer-reviewed studies from 2011 to 2025, sourced from databases such as PubMed, Scopus, and Google Scholar. Key themes included MRI's diagnostic capabilities, technological advancements, and comparative benefits over traditional imaging modalities. *Results:* MRI demonstrates significant promise in evaluating temporomandibular joint disorders, salivary gland pathology, oral mucosal lesions, periodontal and periapical diseases, endodontics, and implantology. Innovations in MRI-compatible coils, ultrashort echo sequences, and artificial intelligence (AI)-enhanced image analysis are expanding its clinical utility. Compared with cone-beam computed tomography (CBCT), MRI provides superior soft tissue contrast and eliminates radiation risks. *Conclusions:* MRI is emerging as a valuable diagnostic tool in dentistry. While the current limitations include cost, accessibility, and metal artifacts, continued technological developments and interdisciplinary collaboration are expected to make MRI an integral component of precision dental care.

Keywords: MRI; dental imaging; TMJ; radiation-free diagnostics; implantology; endodontics; AI in radiology

1. Introduction

Dental imaging plays a crucial role in diagnosing and managing oral and maxillofacial conditions. Panoramic radiography and cone-beam computed tomography (CBCT) have long been standard imaging techniques, essential for diagnostics and treatment planning [1].

The introduction of CBCT has significantly advanced three-dimensional (3D) imaging, making it a common tool in implantology, endodontics, orthodontics, periodontology, and oral and maxillofacial surgery [2]. By addressing the limitations of traditional two-dimensional imaging, CBCT provides a highly accurate assessment of maxillofacial bone structures and the adjacent soft tissues. However, its primary drawback is the high exposure to ionizing radiation, restricting frequent use within short intervals [3].

As dentistry advances toward safer and more sophisticated modalities, magnetic resonance imaging (MRI) has emerged as a promising diagnostic alternative. With its capacity for high-resolution soft tissue imaging and zero radiation exposure, MRI is uniquely positioned to expand the diagnostic arsenal of dental practitioners.

The diagnostic strength of MRI lies in its ability to exploit the magnetic resonance properties of hydrogen nuclei, which are abundant in water-rich biological tissues. Soft tissues, having a higher water content than calcified structures like dentin and enamel, produce stronger signals and allow for enhanced contrast resolution. This enables detailed visualization of complex anatomical structures, supporting accurate diagnosis and treatment planning across multiple dental disciplines [4].

This review explores the clinical utility, technical considerations, and future potential of MRI in modern dental diagnostics.

2. Methodology

A narrative review was conducted to evaluate the emerging applications of magnetic resonance imaging (MRI) in dental diagnostics between 2011 and 2025. Peer-reviewed studies were identified through comprehensive searches of PubMed, Scopus, and Google Scholar. The following keyword combinations were used: "MRI", "magnetic resonance imaging", "dental MRI", "non-ionizing imaging", "temporomandibular joint disorders (TMJ)", "salivary gland pathology", "oral mucosal lesions", "periodontal disease", "periapical disease", "endodontics", "implantology", "soft tissue imaging", "CBCT", "ultrashort echo time (UTE)", "zero echo time (ZTE)", "artificial intelligence in radiology", "AI-enhanced imaging", "deep learning in medical imaging", and "radiomics in dental imaging". Boolean operators were applied to refine the search.

Selection process: The search was limited to articles published in English. Titles and abstracts were screened to identify relevant studies. On the basis of their thematic relevance and full-text availability, 58 studies were selected for inclusion in the final synthesis.

Inclusion Criteria: Studies were included if they met the following conditions:

- Studies discussing the clinical or technical application of MRI in any field of dental practice;
- Original research, clinical investigations, or systematic/narrative reviews;
- Articles available in full text and published in English.

Exclusion Criteria: We excluded non-English publications; studies unrelated to oral, dental, or maxillofacial imaging; articles lacking full-text access or methodological transparency; conference proceedings; letters; and editorial materials.

Each study was evaluated according to its publication type, application domain (e.g., endodontics, implantology, temporomandibular joint disorder (TMJ), etc.), and principal contributions. The final sample comprised 56 studies, including a combination of original research articles, clinical studies, and systematic or narrative reviews. This classification enabled a structured synthesis of the literature and facilitated the identification of key technological and clinical trends.

3. Clinical applications of MRI in dentistry

3.1. Temporomandibular joint (TMJ) disorders

MRI has long been widely used in dentistry for diagnosing temporomandibular disorders (TMDs), due to its ability to visualize soft tissues, making it well suited for the specific diagnostic requirements of these conditions [5,6].

MRI excels at imaging the soft tissue components of the TMJ, including the articular disc, synovial membrane, and lateral pterygoid muscle, making it the most effective modality for diagnosing disc displacements. Additionally, MRI has shown promise in identifying early signs of TMJ dysfunction, such as thickening of the anterior or posterior bands, rupture of retrodiscal tissue, changes in disc shape, and joint effusion.

MRI's versatility allows for imaging in multiple planes (sagittal, axial, and coronal), enhancing its diagnostic capabilities. In clinical practice, MRI can help clarify nonspecific cases. One such example involved a patient with mild right-sided jaw discomfort but no evident clinical dysfunction. MRI identified early disc microlacerations without displacement or inflammation, findings that helped guided a conservative management plan (Figure 1). Common imaging sequences, including T1-weighted, T2-weighted, and proton density (PD) images, are typically employed in TMJ evaluations. PD images are particularly useful for visualizing the disc–condyle relationship, while T2-weighted images aid in identifying joint inflammation [7].

The future of MRI in the diagnosis and management of TMJ disorders appears increasingly promising, driven by advancements in high-resolution modalities such as 3T MRI, which enable more precise and earlier detection of joint abnormalities [8]. Complementing these structural insights, functional MRI holds potential for deepening the understanding of the TMJ's biomechanics. Additionally, the development of novel imaging sequences, including ultrashort echo time (UTE) and zero echo time (ZTE), is expected to enhance the visualization of joint effusions, cartilage degeneration, and bone integrity. These sequences offer a more comprehensive assessment of both soft and hard tissues within the TMJ complex. Specifically, UTE allows for signal capture from tissues with extremely short T2 relaxation times, such as bone and tendons, which are typically difficult to image with conventional MRI. ZTE extends this capability by eliminating traditional echo times entirely, enabling rapid signal acquisition. This feature makes ZTE especially advantageous for imaging hard tissues with inherently short T2 values, thereby establishing its value in both musculoskeletal and dental applications [9].

Furthermore, the integration of artificial intelligence (AI) and machine learning into MRI analysis has shown concrete clinical benefit. Nozawa et al. demonstrated that a deep learning model could automatically segment the temporomandibular joint disc in MRI, improving diagnostic accuracy and efficiency in clinical workflows [10].

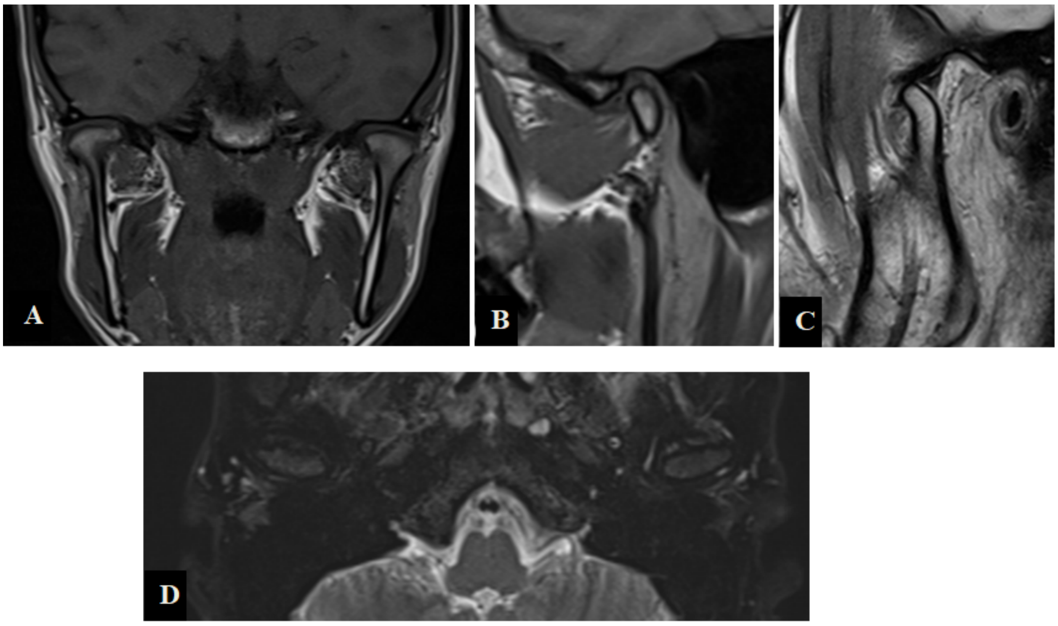

Figure 1. MRI of the temporomandibular joint (TMJ) in a 32-year-old female who presented with mild right-sided jaw discomfort but no clinical signs of dysfunction. MRI was performed to evaluate potential internal derangement. The images reveal degenerative microlacerations of the right articular disc without any associated functional impairment, supporting a conservative, nonsurgical management approach. (A) T1-weighted turbo spin-echo coronal view with the mouth closed. (B) T1-weighted turbo spin-echo sagittal view with the mouth closed. (C) Proton density turbo spin-echo sagittal view with the mouth open. (D) T2-weighted turbo spin-echo with fat saturation and the mouth closed.

3.2. Salivary glands

Magnetic resonance imaging (MRI) has become an essential tool in the assessment of salivary gland disorders, offering superior soft tissue contrast and functional imaging capabilities without ionizing radiation. MRI is widely used for diagnosing both neoplastic and non-neoplastic conditions affecting the salivary glands, facilitating accurate assessment and treatment planning.

MRI plays a pivotal role in differentiating between benign and malignant tumors. Advanced techniques such as diffusion-weighted imaging (DWI) and dynamic contrast-enhanced MRI (DCE-MRI) provide insights into tumors’ cellularity and vascularity, enabling more precise lesion characterization [11]. This is well illustrated by a 57-year-old male, who presented with a slowly enlarging painless mass in the right parotid region. MRI enabled detailed tissue characterization, revealing features consistent with a benign pleomorphic adenoma. The imaging findings guided a confident diagnosis and a well-planned surgical approach (Figure 2).

Pleomorphic adenoma, the most common benign salivary gland neoplasm, typically presents on MRI as a well-circumscribed, hyperintense lesion on T2-weighted images with heterogeneous enhancement on post-contrast sequences.

Beyond tumor assessment, MRI is highly effective in detecting acute and chronic sialadenitis by identifying key pathological changes such as glandular enlargement, ductal dilatation, and inflammation. Additionally, MRI sialography serves as a noninvasive alternative to conventional sialography and computed tomography (CT), allowing for the evaluation of salivary ductal obstructions. This is particularly beneficial in detecting noncalcified stones and ductal stenosis, which may not be as visible with other imaging modalities [12].

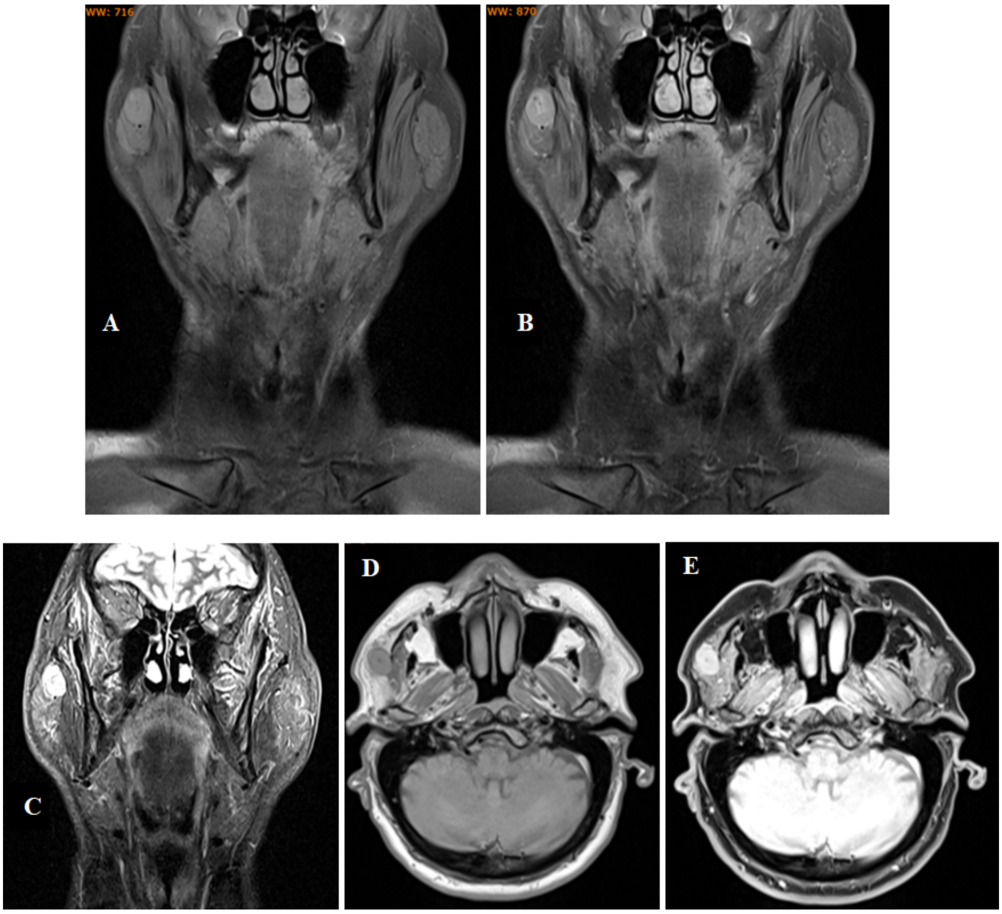

Figure 2. MRI of a 57-year-old male with a heterogeneous, irregular mass in the right parotid gland, characterized by undulating margins and 2–3 small cystic microlesions in the superior portion. The inferior component is solid, isointense on T1, and hyperintense on T2. Post-contrast images show peripheral enhancement of the solid portion, indicating moderate internal vascularization. Imaging features are consistent with a benign hypovascular lesion of mixed composition, suggestive of a pleomorphic adenoma. (A) T1-weighted turbo spin-echo with fat saturation (pre-contrast). (B) T1-weighted turbo spin-echo with fat saturation (post-contrast). (C) T2-weighted turbo inversion recovery magnitude (T2 TIRM). (D) T1-weighted turbo spin-echo with fast Dixon (pre-contrast). (E) T1-weighted turbo spin-echo with fast Dixon (post-contrast).

In autoimmune disorders such as Sjögren's syndrome, MRI plays a pivotal role in assessing salivary gland involvement. Characteristic imaging findings include glandular atrophy, fatty infiltration, and multiple cystic areas. Furthermore, advanced techniques like DWI and DCE-MRI provide crucial functional insights into salivary flow and glandular vascularity, supporting early diagnosis and disease monitoring [13].

The integration of radiomics and artificial intelligence (AI) into MRI analysis has opened new avenues for the noninvasive characterization of salivary gland tumors. Radiomics involves extracting quantitative features from medical images, which, when analyzed using AI algorithms, can enhance diagnostic accuracy. A systematic review highlighted the potential of radiomics in distinguishing between benign and malignant salivary gland tumors, emphasizing the need for standardized methodologies to improve clinical applicability [14–16].

3.3. Oral mucosa

MRI of the oral cavity's mucosa, which include the mucous membrane lining the lips, cheeks, gums, tongue, and the floor and roof of the mouth, is an essential modality for evaluating soft tissue alterations associated with pathological conditions such as inflammation, neoplasms, and infections. Owing to its superior soft tissue contrast based on magnetic properties, MRI offers significant diagnostic advantages over conventional imaging techniques like X-ray and computed tomography (CT), which primarily target osseous structures [17]. This makes MRI particularly effective in detecting and staging oral malignancies, such as squamous cell carcinoma, through accurate assessments of tumor size, depth of invasion, and potential perineural involvement.

Additionally, advanced MRI protocols such as contrast-enhanced imaging, diffusion-weighted imaging (DWI), and magnetic resonance spectroscopy (MRS), further augment diagnostic precision by enabling a comprehensive characterization of soft tissue pathology [18].

In summary, MRI of the oral mucosa constitutes a noninvasive and highly informative tool for the assessment of soft tissue pathology. With its growing application in diagnosing and monitoring a wide range of oral and maxillofacial conditions, MRI is expected to play an increasingly prominent role in clinical practice, especially as technological advancements continue to enhance its capabilities.

3.4. Periodontal and periapical disease

MRI has become an increasingly valuable nonionizing diagnostic tool for periodontal and periapical diseases, offering superior soft tissue contrast and the ability to detect pathological changes that conventional radiographic techniques may miss.

Studies have demonstrated MRI's efficacy in visualizing periapical pathologies and assessing inflammation and bone defects with high accuracy [19]. MRI also effectively differentiates between healthy and diseased periodontal and peri-implant tissues without exposing patients to ionizing radiation, making it a promising tool for comprehensive dental assessments [20].

Furthermore, research has highlighted the feasibility of using MRI to detect apical periodontitis (AP), particularly for identifying periapical lesions and inflammatory changes before they are visible on traditional radiographs [21].

Recent advancements in MRI, including specialized sequences like 3D short-tau inversion recovery (STIR), have enhanced the detection of early inflammatory changes in periodontal tissues and bone edema associated with apical periodontitis. These advancements hold great potential for improving the early diagnosis and intervention of periodontal and periapical diseases [22]. However, challenges such as motion artifacts and prolonged scan times persist, highlighting the need for further refinement of specialized dental MRI protocols to enhance diagnostic accuracy and expand clinical applicability in periodontology.

Overall, these advancements underscore the importance of developing dedicated dental MRI protocols to improve diagnostic accuracy and broaden its clinical application in periodontology and endodontics.

3.5. Endodontics

MRI is increasingly recognized as a valuable tool in endodontics, particularly for the early detection of pulp necrosis, assessment of dental vitality following traumatic injuries, and evaluation of soft tissue structures without the risks associated with ionizing radiation. Despite not being routinely utilized in dental practice, studies such as those by Assaf et al. (2015) have highlighted the potential of 3-Tesla MRI in evaluating dental pulp conditions in pediatric populations following trauma [23].

MRI's superior tissue contrast proves particularly beneficial for visualizing the progression of dental caries and distinguishing carious lesions. Moreover, MRI has shown promise in assessing apical periodontitis and contrast enhancement patterns in the healthy pulp, providing valuable insights for endodontic diagnosis [24]. In addition, MRI offers an advanced imaging modality for evaluating periapical lesions and predicting treatment outcomes, including the healing of periapical lesions and root canal status. Cankar et al. (2020) utilized T2 mapping to assess the dental pulp's response to caries progression [25].

Technological innovations such as intraoral flexible coils and ultrashort echo time (UTE) have enhanced MRI's ability to visualize dental root canals and detect caries lesions that are difficult to image with conventional methods [26,27]. These developments are positioning MRI as a valuable adjunct in complex endodontic cases.

With ongoing technological advancements, MRI has the potential to significantly enhance diagnostic accuracy, treatment planning, and clinical outcomes in endodontics.

3.6. Implantology

MRI has gained significant interest in the field of implantology due to its nonionizing properties, high soft tissue contrast, and ability to provide detailed anatomical visualization. Unlike conventional imaging techniques like CBCT and panoramic radiography, MRI provides a radiation-free alternative, making it particularly suited for application for preoperative assessment, postoperative follow-up, and the evaluation of implant-related complications.

MRI plays a crucial role in evaluating the condition of peri-implant soft tissues, detecting inflammation, and evaluating the surrounding bone structure. It has also been investigated as a tool for determining bone quality and quantity prior to implant placement. MRI is also useful in evaluating critical anatomical structures such as the proximity of implants to the mandibular canal, nerves, foramina, and the boundaries of the maxillary sinus, ensuring optimal planning and reducing the risk of complications [28]. Several studies have demonstrated the efficacy of MRI in evaluating bone density through advanced imaging sequences such as ultra-short echo time (UTE) [29,30] and zero echo time (ZTE), which enable the acquisition of rapidly decaying signals [31]. These advanced MRI sequences have been found to correlate well with CBCT-based measurements of bone structure [32]. Furthermore, incorporating advancements such as intraoral and mandibular coils, along with specialized dental MRI protocols, has enabled high-resolution, high-contrast imaging of dentomaxillofacial structures while reducing the acquisition time [33].

Despite these advancements, the presence of metal-induced artifacts in MRI remains a challenge in implantology. These artifacts can compromise image quality and accuracy, originating from the metal composition of dental restorations, magnetic field inhomogeneity, and patients' movements. Dental implants, particularly metallic components, can exacerbate these distortions [34]. However, studies indicate that titanium implants cause minimal distortion, while zirconia implants produce even fewer artifacts, making them a more suitable choice for MRI-based assessments [35]. To mitigate these challenges, the use of UTE protocols has proven effective in reducing metal-induced artifacts and field inhomogeneities, thereby enhancing the accuracy of dental implant imaging [36].

Metal-induced artifacts are also present in CBCT, particularly in patients with dental implants and restorations. MRI generally experiences less severe artefact formation with zirconium implants, whereas CBCT images show less severe artifacts from titanium and titanium–zirconium alloy implants [37]. Despite these differences, both imaging techniques can be impacted by metal-induced distortions, which can still affect image quality and compromise diagnostic accuracy.

Overall, the application of MRI in implantology presents a promising alternative to conventional imaging techniques. While current limitations exist, advancements in MRI technology, along with the development of compatible implant materials, are likely to enhance its clinical relevance in the near future. Future research should focus on refining imaging protocols and expanding the use of MRI in dental implantology to fully realize its potential.

4. Comparison with traditional imaging methods

Advancements in dental imaging have substantially transformed modern clinical practice, establishing imaging as a cornerstone of diagnosis, treatment planning, and post-treatment evaluation. The continual evolution of imaging technologies has markedly improved clinicians' ability to visualize complex dental anatomy with greater precision, thereby enhancing diagnostic accuracy and patient outcomes [38].

Among these innovations, digital radiography has played a pivotal role by offering a rapid, accessible, and cost-effective method for routine assessments. However, as a two-dimensional (2D) modality, it projects 3D anatomical structures onto a planar surface, resulting in the superimposition of details and limited spatial resolution [39]. While adequate for routine examinations, its inherent limitations often necessitate more advanced modalities in complex diagnostic scenarios.

CBCT addresses many of these limitations by providing high-resolution 3D imaging of dental and maxillofacial structures. CBCT enables comprehensive visualization in cases requiring intricate treatment planning, including implant placement, endodontic evaluation, and maxillofacial surgery. Its ability to resolve spatial relationships that are not clearly visible in 2D images offers significant diagnostic advantages [40,41].

Nonetheless, the use of CBCT is constrained by the associated ionizing radiation dose, which, while lower than that of conventional CT, remains a concern, particularly when repeated imaging is required. The need to balance diagnostic benefit against potential biological risk underscores the importance of exploring nonionizing alternatives that offer comparable or superior clinical insights.

MRI has consequently emerged as a promising modality in dental diagnostics. Unlike CBCT and conventional CT, MRI operates without ionizing radiation, thereby eliminating radiation-related health risks. Through the use of specialized sequences tailored for both soft and, increasingly, hard tissue imaging, MRI has demonstrated efficacy in assessing periodontal and pulpal pathology, detecting carious lesions, and supporting implant planning [27,42–44].

Moreover, MRI offers unique diagnostic advantages by enabling high-resolution visualization of neurovascular and muscular structures, capabilities that are beyond the reach of both CBCT and conventional radiography [45]. These attributes extend its utility to a broader range of clinical applications, particularly where detailed soft tissue characterization is essential.

A pivotal advancement in MRI's evolution for hard tissue evaluation lies in the development of short T2 imaging sequences, particularly ultrashort echo time (UTE), zero echo time (ZTE), and sweep imaging with Fourier transformation (SWIFT). These techniques address the challenge of capturing rapidly decaying signals from tissues such as cortical bone, dentin, and enamel, which are typically invisible using conventional MRI. UTE and ZTE have already demonstrated improved visualization of osseous structures in the temporomandibular joints, periapical regions, and implant sites [9,31]. Notably, SWIFT has shown promise in detecting fine dental cracks and vertical root fractures, some as narrow as 20 µm, with diagnostic accuracy and contrast comparable with CBCT, while avoiding metal artifacts and radiation exposure [46–48]. These advances suggest a transformative shift in MRI's diagnostic scope, positioning it as a potential radiation-free alternative to CBCT in selected hard-tissue assessments.

Table 1. Comparative overview of dental imaging modalities.

Feature	Digital radiography	CBCT	MRI
Image dimensionality	2D	3D	3D
Tissue visualization	Hard tissue only	Primarily hard tissue, limited soft tissue	Soft and hard tissues: soft tissue contrast is excellent [6,8]; UTE/ZTE/SWIFT improves hard tissue imaging [29,3,47,48]
Image resolution and clarity	High for hard tissues; superimposition limits clarity	High resolution of bone; limited soft tissue detail	High soft tissue resolution: nerves [9], vessels [31], TMJ [6,8], salivary glands [11], mucosa [13]; improving for hard tissues [27,29]
Radiation exposure	Low	Moderate (lower than CT)	None
Diagnostic applications	Caries detection, periodontal bone loss, follow-up	Implant planning, trauma, cysts, endodontics	Periodontal and pulpal pathology [19,21,22]; TMJ disorders [6,8]; implantology (bone quality, peri-implant tissues) [28]; nerve and vessel proximity [9,31]; salivary gland and oral mucosa [11,13]; caries and dental cracks [27,42,46]
Limitations	Overlapping structures, lacks depth	Radiation, artifacts from metal, limited soft tissue information	Cost, limited access, scan time, metal artifacts [34]
Suitability for repeated use	Safe for routine use	Limited by cumulative radiation dose	Excellent, no radiation [4]

Ongoing research continues to refine dental-dedicated MRI (ddMRI) technologies, with the aim of optimizing imaging protocols, enhancing spatial resolution, and improving their integration into routine dental workflows. These innovations hold significant potential for delivering radiation-free, high-fidelity imaging tailored to the anatomical and clinical demands of oral healthcare. However, further empirical studies are needed to validate the diagnostic accuracy and clinical applicability of ddMRI across diverse dental conditions, ensuring its reliable adoption in evidence-based practice [49].

Table 1 presents a comparative overview of the imaging modalities used in dentistry, highlighting MRI's expanding role. While CBCT remains superior for hard tissue evaluation, MRI's strength lies in soft tissue diagnostics and noninvasive follow-up care.

5. Challenges and limitations

Despite its well-documented advantages in soft tissue imaging, the routine implementation of MRI in dental practice remains constrained by a combination of technical, logistical, and educational factors. A primary limitation lies in the infrastructural demands of MRI systems, which require specialized shielded imaging environments and complex hardware configurations. These requirements are typically beyond the capacity of conventional dental clinics. Furthermore, the necessity for patients to remain motionless within a confined scanner for extended periods presents additional difficulties, particularly for pediatric populations and individuals with anxiety or claustrophobia [50,51].

From a practical standpoint, access to MRI equipment dedicated to dental use remains limited. Most facilities prioritize MRI for neurologic, musculoskeletal, or oncologic indications, rendering scheduling and integration into routine dental workflows challenging. Moreover, the cost-effectiveness of MRI in dental diagnostics is currently suboptimal. The high cost of purchasing and maintaining MRI equipment, along with the lower number of patients that can be scanned in a day compared with CBCT, makes MRI less economically practical, especially for small clinics or those in low-resource settings [52].

In addition to logistical constraints, MRI's diagnostic performance for mineralized structures remains limited. Although it offers exceptional soft tissue contrast, its spatial resolution for hard tissues is inferior to that of CBCT. Metallic restorations or implants may introduce magnetic susceptibility artifacts, degrading image quality in regions critical to diagnosis and treatment planning [53].

Nonetheless, advancements in MRI technology are beginning to address some of these limitations. Sequences such as ultrashort echo time (UTE) and zero echo time (ZTE) have demonstrated potential in improving visualization of mineralized tissues, including cortical bone and dental structures. These techniques significantly reduce signal loss in hard tissues and minimize artifacts, making MRI a more viable diagnostic tool in dental imaging [50, 53].

Cost and expertise also play a crucial role in limiting MRI's integration into everyday dental practice. The scarcity of dental professionals trained in MRI acquisition and interpretation remains a persistent barrier. Moreover, dental curricula generally lack formal training in MRI-based diagnostics, perpetuating a skills gap that hinders MRI's widespread adoption [54].

Together, these interrelated challenges underscore the complexity of adopting MRI as a standard imaging technique in dental settings. Overcoming these barriers will require not only technological innovation but also systemic changes in infrastructure, education, and clinical workflows to fully leverage the diagnostic potential of MRI in dentistry.

6. Future directions and technological innovations

As the field of dental imaging evolves, recent advancements in MRI technology, materials science, computational imaging, and device engineering are converging to redefine its clinical potential. One significant area of innovation lies in the development of MRI-compatible dental materials. These materials not only improve the diagnostic reliability of MRI in patients with existing dental work but also enhance safety during imaging procedures.

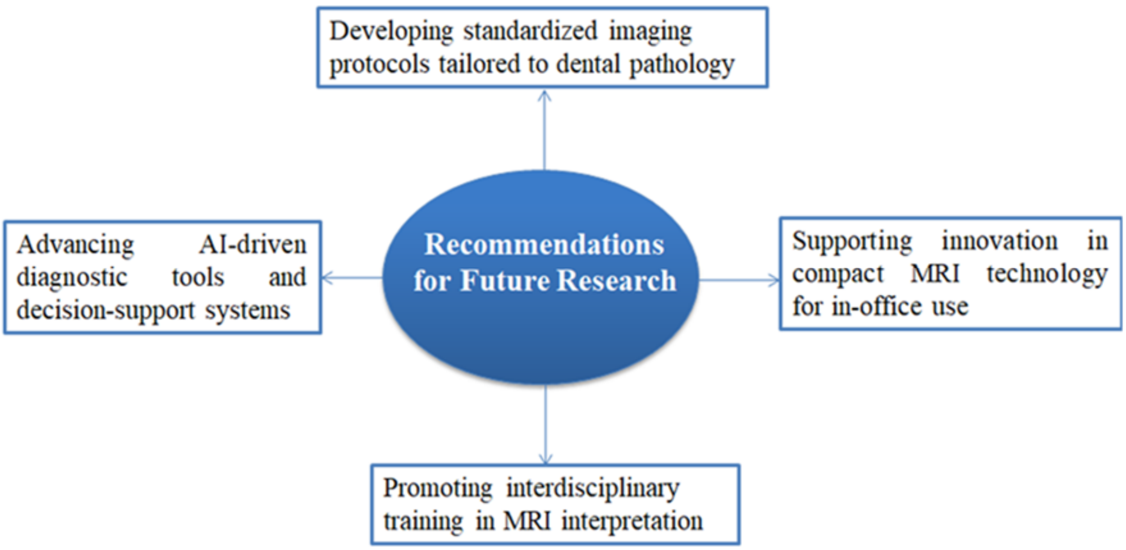

Figure 3. Framework for advancing research in dental imaging. This schematic outlines strategic directions for enhancing MRI's integration into dental diagnostics. Key components include: Standardizing MRI protocols for dental pathology, fostering interdisciplinary training in MRI interpretation, developing compact and office-based MRI systems, and leveraging artificial intelligence to automate image analysis and support decision-making. Together, these efforts aim to make MRI more accessible, efficient, and integral to precision dental care.

Parallel to material advancements, emerging imaging techniques such as UTE and ZTE are improving the visualization of hard tissues, which are traditionally challenging to assess with MRI. Concurrently, the development of intraoral and surface coils optimized for the maxillofacial region has enhanced image resolution and signal-to-noise ratios [29,31,55].

Complementing these hardware and sequence improvements, AI and machine learning (ML) are increasingly being integrated into the MRI diagnostic pipeline to enhance image reconstruction, automate anatomical segmentation, and support diagnostic decision-making. Deep learning models have shown promise in differentiating between benign and malignant lesions, quantifying inflammation, and predicting treatment outcomes. These technologies are expected to reduce interpretation time, increase diagnostic accuracy, and standardize reporting protocols in dental imaging [56].

Perhaps one of the most transformative innovations is the emergence of compact and office-based

MRI systems. Progress in low-field and portable MRI technologies suggests the feasibility of integrating compact MRI units into dental offices. Although they currently exhibit lower resolution compared with high-field units, ongoing refinements in coil design and image processing are progressively narrowing this gap [49].

Taken together, these technological innovations expand the scope of MRI from a specialized diagnostic modality to a potentially routine tool in dental care. Further research is needed to validate diagnostic protocols and streamline implementation (Figure 3).

7. Conclusions

MRI is redefining dental diagnostics by providing radiation-free, high-resolution visualization of soft and, increasingly, hard tissues. Its application across multiple dental specialties is expanding rapidly, driven by technological innovation and growing demand for safer diagnostics. While challenges remain, continued interdisciplinary collaboration and research will be essential to fully integrate MRI into routine dental practice.

Use of AI tools declaration

No AI tools were used in the creation of this article.

Authors' contributions

Conceptualization, G.H.; methodology, G.H. and N.C.; software, G.H. and N.C.; formal analysis, G.H. and N.C.; data curation, G.H. and N.C.; writing—original draft preparation, G.H. and N.C.; writing—review and editing, G.H. and N.C.

Conflict of interest

The authors declare no conflicts of interest.

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