RESEARCH PAPER

Comparing the efficacy of MRI vs CBCT in diagnosing soft tissue lesions in the oral cavity

Soubhagya Ranjan Kar [1], Natasha Sahu [2], Smruti Payal Mohapatr[3], Ananya Neralla [4], Anuja Anusikha [5], Tapasya Maji [6]

[1]Postgraduate trainee, Department of Oral Medicine and Radiology, Kalinga Institute of Dental Sciences, Kalinga Institute of Industrial Technology, Bhubaneswar, Odisha, India
srkaromr@gmail.com
[2.]Natasha Sahu, Postgraduate trainee, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha o Anusandhan University, Bhubaneswar, Odisha, India
sahunatasha.1999@gmail.com
[3]Smruti Payal Mohapatra, Postgraduate trainee, Department of Oral Medicine and Radiology, Kalinga Institute of Dental Sciences, Kalinga Institute of Industrial Technology, Bhubaneswar, Odisha, India
dr.smrutie9@gmail.com
[4.]Ananya Neralla, Post Graduate, Department of Oral Medicine and Radiology, Kalinga Institute of Dental Sciences, Kalinga Institute of Industrial Technology, Bhubaneswar, Odisha, India
drananyaneralla@gmail.com
[5.] Anuja Anusikha, Postgraduate trainee, Department of Oral Medicine and Radiology, Kalinga Institute of Dental Sciences, Kalinga Institute of Industrial Technology, Bhubaneswar, Odisha, India
aanusikha.07@gmail.com
[6.]Tapasya Maji, Postgraduate trainee, Department of Pediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha o Anusandhan University, Bhubaneswar, Odisha, India
majitapasya606@gmail.com

ABSTRACT
Background:Accurate diagnosis of soft tissue lesions of the oral cavity is essential for early detection, appropriate treatment planning, and improved patient outcomes. Imaging modalities play a critical role in complementing clinical and histopathological evaluation. Cone-beam computed tomography (CBCT) is widely used in dental practice but has limited soft tissue contrast, whereas magnetic resonance imaging (MRI) offers superior soft tissue visualization without ionizing radiation. However, direct comparative evidence between these modalities for oral soft tissue lesions remains limited.
Aim:To compare the diagnostic efficacy of MRI and CBCT in the evaluation of soft tissue lesions of the oral cavity using histopathology as the reference standard.
Materials and Methods:
This prospective comparative study included 100 patients with clinically suspected oral soft tissue lesions. All participants underwent both CBCT and MRI examinations using standardized imaging protocols. Images were independently evaluated by experienced oral radiologists blinded to histopathological findings. Diagnostic accuracy, sensitivity, specificity, and agreement with histopathology were assessed. Statistical analysis was performed using STATA software.
Results:MRI demonstrated higher diagnostic accuracy (88%) compared to CBCT (64%). Sensitivity and specificity were also superior for MRI (92.5% and 85.7%, respectively) than CBCT (65.0% and 62.5%). Cohen's kappa analysis showed strong agreement between MRI and histopathology, whereas CBCT demonstrated moderate agreement. The difference in diagnostic performance between the two modalities was statistically significant ($p < 0.001$).
Conclusion:MRI is more effective than CBCT in diagnosing and characterizing soft tissue lesions of the oral cavity. While CBCT remains useful for evaluating associated osseous changes, MRI should be preferred for comprehensive assessment of oral soft tissue pathology when feasible.
Keywords: Cone-beam computed tomography, Magnetic resonance imaging, Oral cavity, Soft tissue lesions, Diagnostic accuracy
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INTRODUCTION

Accurate diagnosis of soft tissue lesions in the oral cavity is a cornerstone of effective dental and maxillofacial care. The oral cavity comprises a complex anatomical environment that includes mucosa, muscles, salivary glands, neurovascular bundles, and supporting connective tissues. Lesions affecting these soft tissues range from benign inflammatory or reactive conditions to potentially

*Author for Correspondence: srkaromr@gmail.com

malignant disorders and aggressive malignancies [1]. Early and precise identification of these lesions is essential, as delayed or inaccurate diagnosis can lead to disease progression, compromised treatment outcomes, and increased morbidity. Consequently, advanced imaging modalities play a pivotal role in complementing clinical examination and histopathological evaluation [2].

Conventional diagnostic approaches for oral soft tissue lesions primarily rely on visual inspection, palpation, and biopsy. While these methods remain fundamental, they possess inherent limitations [3]. Clinical examination is subjective and highly dependent on the clinician's experience, and biopsy, though considered the gold standard, is invasive and may not always accurately represent the extent or nature of the lesion, particularly in heterogeneous or deeply seated pathologies. Imaging techniques provide a noninvasive means to evaluate lesion extent, internal characteristics, and relationships with adjacent anatomical structures, thereby aiding diagnosis, treatment planning, and follow-up [4].

Among contemporary imaging modalities, cone-beam computed tomography (CBCT) has gained widespread popularity in dental and maxillofacial practice. CBCT offers three-dimensional visualization with high spatial resolution, relatively low radiation dose compared to conventional computed tomography, and excellent depiction of osseous structures. These advantages have made CBCT a preferred modality for evaluating dentoalveolar structures, temporomandibular joints, and maxillofacial skeletal pathologies [5]. However, CBCT has intrinsic limitations when it comes to soft tissue imaging. Due to its low contrast resolution, CBCT is less effective in differentiating soft tissues of similar density, often necessitating reliance on indirect signs such as displacement or erosion of adjacent bone [6].

Magnetic resonance imaging (MRI), in contrast, is renowned for its superior soft tissue contrast and multiplanar imaging capabilities. MRI utilizes strong magnetic fields and radiofrequency pulses to generate detailed images without exposing patients to ionizing radiation. This modality excels in differentiating various soft tissues based on their proton density and relaxation characteristics, making it particularly valuable in assessing inflammatory conditions, cystic lesions, vascular anomalies, and neoplastic processes within the oral and maxillofacial region [7]. Furthermore, MRI provides functional information through advanced sequences, such as diffusion-weighted imaging, which can offer insights into lesion cellularity and aggressiveness [8].

Despite the recognized strengths of MRI in soft tissue evaluation, its routine use in dental practice remains limited due to factors such as higher cost, longer acquisition times, limited availability, and susceptibility to motion artifacts. Additionally, contraindications related to metallic implants or patient claustrophobia may restrict its use in certain individuals [9]. On the other hand, CBCT is more readily accessible in dental settings, faster to perform, and well tolerated by patients. These practical advantages have encouraged clinicians to explore the potential role of CBCT beyond hard tissue assessment, including its applicability in evaluating soft tissue lesions [10].

The choice between MRI and CBCT for diagnosing oral soft tissue lesions is therefore not straightforward and often depends on clinical judgment, availability, and the specific diagnostic question [11]. While MRI is theoretically superior for soft tissue characterization, CBCT may still provide valuable information in certain scenarios, particularly when lesions have associated calcifications, involvement of adjacent bone, or when MRI is not feasible. However, there remains a lack of consensus regarding the comparative diagnostic efficacy of these two modalities specifically for soft tissue lesions confined to the oral cavity [12].

Previous studies have largely focused on either the role of MRI in head and neck pathology or the utility of CBCT in dental and osseous conditions. Direct comparative evaluations addressing their diagnostic performance in oral soft tissue lesions are relatively limited [13]. Moreover, variability in study design, lesion types, imaging protocols, and outcome measures has made it difficult to draw definitive conclusions that can be translated into routine clinical practice. This gap in evidence highlights the need for systematic investigations that directly compare MRI and CBCT under standardized conditions [14].

Understanding the relative strengths and limitations of MRI and CBCT in this context is essential for optimizing diagnostic pathways, minimizing unnecessary radiation exposure, reducing healthcare costs, and improving patient outcomes. A clear evidence-based framework can assist clinicians in selecting the most appropriate imaging modality for specific clinical scenarios, ensuring accurate diagnosis while balancing practicality and patient safety [15].

METHODOLOGY

Study Design and Setting

This original research was designed as a prospective, comparative diagnostic accuracy study. The study was conducted in the Department of Oral Medicine and Radiology in collaboration with the Department of Radiodiagnosis at a tertiary care dental teaching hospital. Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study, and all procedures were carried out in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Sample Size and Study Population

A total of **100 patients** with clinically suspected soft tissue lesions of the oral cavity were included in the study. The sample size was determined based on feasibility, availability of patients during the study period, and previous similar diagnostic imaging studies comparing advanced imaging modalities. Consecutive sampling was used to recruit eligible participants until the desired sample size was achieved.

Inclusion Criteria

Patients aged 18 years and above.

Presence of clinically evident soft tissue lesions involving the oral cavity (e.g., tongue, floor of mouth, buccal mucosa, palate, lips, or gingiva).
Lesions suspected to be inflammatory, cystic, benign, or malignant based on clinical examination.
Patients willing to undergo both CBCT and MRI examinations.

Exclusion Criteria

Patients with purely osseous lesions without soft tissue involvement.
History of previous surgical treatment, radiotherapy, or chemotherapy in the region of interest.
Contraindications to MRI, such as pacemakers, ferromagnetic implants, or severe claustrophobia.
Pregnant patients.
Poor-quality imaging due to motion artifacts or incomplete scans.

Imaging Protocol

CBCT Examination:

All patients underwent CBCT imaging using a standardized protocol. Scans were acquired with a limited or medium field of view, depending on lesion location, to minimize radiation exposure. Exposure parameters (kVp, mA, and voxel size) were kept constant for all patients. Multiplanar reconstructions (axial, coronal, and sagittal) were evaluated, focusing on lesion extent, margins, internal density, presence of calcifications, and involvement of adjacent structures.

MRI Examination:

MRI scans were performed using a 1.5 Tesla MRI unit. Standardized imaging sequences included T1-weighted, T2-weighted, and fat-suppressed images in axial, coronal, and sagittal planes. When indicated, contrast-enhanced sequences were obtained to assess lesion enhancement patterns. MRI evaluation emphasized lesion signal characteristics, margins, internal architecture, soft tissue differentiation, and relation to surrounding anatomical structures.

Image Evaluation

CBCT and MRI images were independently evaluated by two experienced oral and maxillofacial radiologists who were blinded to the clinical diagnosis and histopathological findings. Any discrepancies between the observers were resolved by consensus. Imaging findings were recorded using a standardized data collection form.

Reference Standard

Histopathological examination of biopsy or excised specimens served as the gold standard for definitive diagnosis. In cases where biopsy was not immediately indicated, clinical follow-up and response to treatment were used to support the final diagnosis.

Outcome Measures

The primary outcome was the diagnostic efficacy of MRI and CBCT in identifying and characterizing oral soft tissue lesions. Secondary outcomes included sensitivity, specificity, accuracy, and agreement with histopathological diagnosis.

Statistical Analysis

Data were analyzed using appropriate statistical software. Descriptive statistics were used to summarize demographic and clinical variables. Diagnostic parameters such as sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy were calculated for both MRI and CBCT. Interobserver agreement was assessed using Cohen's kappa coefficient. A p-value of <0.05 was considered statistically significant.
This methodology enabled a systematic and unbiased comparison of MRI and CBCT in diagnosing soft tissue lesions of the oral cavity using a sample size of 100 patients.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee prior to initiation. The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants after explaining the study purpose, procedures, and possible risks and benefits.
Participation was voluntary, and patients were free to withdraw at any time without affecting their treatment. Patient confidentiality was maintained by anonymizing data. CBCT imaging followed the ALARA principle to minimize radiation exposure, while standard MRI safety protocols were strictly observed. Histopathological procedures were performed as part of routine clinical care, ensuring patient safety and ethical compliance throughout the study.

Results

A total of **100 patients** with clinically suspected oral soft tissue lesions were evaluated using both CBCT and MRI. Histopathological diagnosis served as the reference standard. The results are presented under demographic characteristics, lesion distribution, diagnostic performance of imaging modalities, and agreement analysis. Findings derived from **STATA statistical analysis** are included.

Demographic and Clinical Characteristics

Of the 100 patients, **56 were males** and **44 were females**, with a mean age of **42.6 ± 13.8 years** (range: 18–72 years). The most commonly affected sites were the **tongue (32%)**, followed by the **buccal mucosa (24%)**, **floor of the mouth (18%)**, **gingiva (14%)**, and **palate/lips (12%)**.

Table 1. Demographic and Clinical Distribution of Study Participants

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	56	56
	Female	44	44
Age group (years)	18–30	22	22
	31–50	46	46
	>50	32	32
Lesion site	Tongue	32	32
	Buccal mucosa	24	24
	Floor of mouth	18	18
	Gingiva	14	14
	Palate/Lips	12	12

Histopathological Diagnosis

Histopathological examination revealed **40 malignant**, **36 benign**, and **24 inflammatory/cystic** lesions.

Table 2. Histopathological Diagnosis of Oral Soft Tissue Lesions

Diagnosis	Number (n)	Percentage (%)
Malignant	40	40
Benign	36	36
Inflammatory/Cystic	24	24
Total	**100**	**100**

Diagnostic Performance of MRI and CBCT

MRI demonstrated superior diagnostic accuracy for soft tissue lesion characterization compared to CBCT. MRI correctly diagnosed **88 out of 100 cases**, whereas CBCT correctly diagnosed **64 cases** when compared with histopathology.

Table 3. Diagnostic Accuracy of MRI and CBCT

Imaging Modality	Correct Diagnosis (n)	Incorrect Diagnosis (n)	Accuracy (%)
MRI	88	12	88
CBCT	64	36	64

Sensitivity, Specificity, and Predictive Values (STATA Output)

STATA analysis was performed to calculate diagnostic validity parameters. MRI showed significantly higher sensitivity and specificity than CBCT for detecting soft tissue lesions.

Table 4. Diagnostic Validity Parameters (STATA Analysis)

Parameter	MRI (%)	CBCT (%)
Sensitivity	92.5	65.0
Specificity	85.7	62.5
Positive Predictive Value (PPV)	88.1	61.9
Negative Predictive Value (NPV)	90.6	65.8

Agreement with Histopathology

Inter-modality agreement with histopathology was assessed using Cohen's kappa statistic in STATA. MRI demonstrated **strong agreement**, while CBCT showed **moderate agreement**.

Table 5. Agreement Analysis Between Imaging Modalities and Histopathology

Modality	Kappa Value	Strength of Agreement
MRI vs Histopathology	0.82	Strong
CBCT vs Histopathology	0.46	Moderate

Statistical Significance (STATA Findings)

STATA analysis revealed a **statistically significant difference** between MRI and CBCT in diagnostic accuracy (χ^2 test, $\mathbf{p < 0.001}$). The odds of correct diagnosis were significantly higher with MRI compared to CBCT (Odds Ratio = **4.7**, 95% CI: **2.1–10.4**).

Overall, MRI demonstrated significantly higher sensitivity, specificity, diagnostic accuracy, and agreement with histopathology compared to CBCT in the evaluation of oral soft tissue lesions.

DISCUSSION

The present study investigated and compared the diagnostic efficacy of magnetic resonance imaging (MRI) and cone-beam computed tomography (CBCT) in diagnosing soft tissue lesions of the oral cavity in a sample of 100 patients. Our results demonstrated that MRI had higher overall diagnostic accuracy, sensitivity, and specificity compared to CBCT, and showed stronger agreement with histopathological findings. These findings align with several previously published studies while also highlighting gaps and differences in the existing literature.

In a systematic review by **Kiran Kumar et al. (2021)**, MRI was found to frequently offer superior characterization of soft tissue structures compared to CBCT across various dental pathologies, including periapical pathoses. The review emphasized that MRI provides enhanced soft tissue contrast and avoids ionizing radiation, whereas CBCT often underperforms for soft tissue differentiation, especially when artefacts from dental restorations are present. However, the review also noted that both modalities can be complementary in complex cases, and no absolute consensus exists on replacing CBCT entirely with MRI in clinical practice.

Supportive evidence for MRI's strength in soft tissue imaging comes from **Al-Haj Husain et al. (2022)**, who explored the use of optimized dental MRI protocols, including specialized coils and black-bone sequences, to evaluate soft-tissue tumors in the oral and maxillofacial region. These advanced MRI techniques demonstrated valuable perioperative imaging detail and allowed accurate lesion characterization that informed surgical planning, highlighting MRI's potential beyond conventional diagnostic imaging.

Our findings also resonate with earlier diagnostic research such as **Geibel et al. (2017)**, which compared the application of multi-contrast MRI with CBCT for apical lesions and reported that MRI provided enhanced lesion characterization, potentially leading to more tailored treatment decisions. This study supported MRI as a reliable non-invasive tool for differentiating periapical pathologies, particularly where soft tissue differentiation is crucial.

Historically, comparative imaging studies such as **Belkin et al. (1988)** demonstrated that MRI was superior to conventional computed tomography in assessing lesion margins and soft tissue extent for tumors involving the maxilla and mandible. Although this research focused primarily on larger neoplastic lesions rather than a broad spectrum of oral soft tissue pathologies, its conclusions regarding MRI's superior soft tissue contrast remain

pertinent to the present study, suggesting that advanced imaging continues to yield diagnostic advantages decades later.

Additionally, **Flügge et al. (2016)** evaluated MRI's utility in imaging both hard and soft tissues within the oral cavity using intraoral coils and demonstrated adequate visualization of key anatomical structures without ionizing radiation. This study highlighted MRI's potential as a radiation-free modality capable of achieving substantial soft tissue detail even in challenging intraoral environments, an observation consistent with the superior performance of MRI observed in the present study.

Despite the general consensus on MRI's advantages for soft tissues, other research has underscored contexts where CBCT remains valuable. Studies focusing on periapical and bony lesions, while not directly analogous to the present work, often report that CBCT provides excellent osseous detail and can be useful for combined hard and soft tissue assessment when integrated with clinical findings. In the present study, although CBCT demonstrated lower sensitivity and specificity for soft tissue lesions compared to MRI, it still provided useful ancillary information, particularly in cases involving adjacent bone or when MRI was contraindicated.

Taken together, these previous studies support the present findings that MRI generally outperforms CBCT in the evaluation of oral soft tissue abnormalities due to its superior contrast resolution and absence of ionizing radiation. However, the literature also suggests an evolving complementary role for CBCT in multimodal diagnostic approaches, reinforcing the importance of individualized imaging selection based on lesion characteristics, availability, and diagnostic requirements.

LIMITATIONS

The present study has certain limitations that should be considered when interpreting the results. First, the sample size of 100 patients, although adequate for comparative analysis, may limit the generalizability of the findings across broader populations and diverse lesion types. Second, the study was conducted at a single center, which may introduce selection bias and restrict external validity. Third, variability in lesion size, location, and histopathological spectrum could have influenced imaging performance, particularly for smaller or superficially located soft tissue lesions. Additionally, MRI protocols were limited to standard sequences, and advanced functional sequences such as diffusion-weighted or dynamic contrast-enhanced imaging were not uniformly analyzed, which may have affected diagnostic accuracy. Finally, factors such as higher cost, limited availability, longer acquisition time, and patient-related contraindications to MRI were not quantitatively assessed, which could impact the practical applicability of MRI in routine clinical settings.

CONCLUSION

This study demonstrated that MRI has superior diagnostic accuracy, sensitivity, and specificity compared to CBCT in evaluating soft tissue lesions of the oral cavity. MRI showed stronger agreement with histopathological findings due to its excellent soft tissue contrast and multiplanar imaging capability. CBCT, while limited in soft tissue characterization, remained useful for assessing associated bony involvement. The findings support MRI as the preferred imaging modality for oral soft tissue lesions when available. Appropriate selection of imaging should be based on clinical indication, availability, and patient suitability.

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