

A Comparative Study of Diagnostic Accuracy in Soft- and Hard-Tissue Lesions: Integration of Ultrasound and Conventional Radiography in Oral Radiology

Sarmad M. Hamozi, Ameer Yousif and Abdulsahib S. Jubran

ABSTRACT

Objective: To ascertain whether the integration of ultrasound imaging with conventional radiography enhances the detection and characterisation of oral and maxillofacial lesions in comparison to each modality utilised independently.

Study Design: Prospective cohort study

Place and Duration of Study: This study was conducted at the Oral & Maxillofacial Radiology Clinic at Central Hospital, Iraq from 1st May 2025 to 31st October 2025.

Methods: 80 patients with diverse oral lesions received standard intraoral and/or panoramic radiographs, succeeded by intraoral or extraoral ultrasound examinations utilising a high-frequency (≥ 10 MHz) linear probe. Histopathology, surgical results, or clinical follow-up constituted the reference standard. We calculated diagnostic metrics like sensitivity, specificity, accuracy, positive predictive value, and negative predictive value for radiography alone, ultrasound alone, and the combination of the two.

Results: Ultrasound was better at diagnosing soft-tissue lesions than radiography (sensitivity 92%, specificity 85% vs. 68% and 78% for radiography). The combined method increased the overall accuracy for hard-tissue lesions from 78% (radiography alone) to 85%.

Conclusion: Ultrasound is a useful addition to standard radiography in oral radiology. Combining both methods increases diagnostic confidence, especially for soft tissue lesions, and decreases the need for ionising radiation.

Key Words: Oral radiology, Ultrasound, Radiography, Diagnostic accuracy, Periapical lesions, Salivary gland pathology

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INTRODUCTION

Imaging plays a central role in oral diagnosis and treatment planning. Traditional modalities such as intraoral radiographs, panoramic images, and cone-beam computed tomography (CBCT) provide structural (hard-tissue) detail but have limitations, particularly when evaluating soft tissues or lesions without significant bone change. Likewise, they bring to light patients to ionizing rays, which is a trouble specifically for constant imaging or for weak inhabitants (e.g. children, pregnant women).¹

University of Al-Kafeel, College of Dentistry, Najaf – Iraq.

Correspondence: Abdulsahib S. Jubran, University of Al-Kafeel, College of Dentistry, Najaf, Iraq.

Contact No: +9640777716001

Email: abdulsahebs@gmail.com

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Ultrasound imagination (US), a non-ionizing, real-time imaging apparatus, has been extensively commissioned in medical diagnostics (abdomen, thyroid, vessels). In latest years, developments in high frequency, reduced probes have sanctioned the expansion of ultrasound into dental and maxillofacial fields. Researchers have discovered intraoral and extraoral ultrasound requests for salivary glands, mucosal lesions, lymph nodes, and even periapical lesions.² Ultrasound can perceive between cystic and solid lesions, recognize vascular stream via Doppler modes, and measure soft-tissue depth with good correspondence to histology or CBCT and adoption in routine oral radiology stays restricted.³ Regardless of the guarantee of ultrasound, there is limited confirmation evaluating its performing directly versus established radiography or combination in a fitted clinical study. Many preceding pieces are examining articles, case reports, or small model studies. The diagnostic yield, particularly in mixed lesion types (soft + hard), remains underexplored.⁴ In soft-tissue lesions, ultrasound will outperform conventional radiography in sensitivity and specificity. In hard-tissue lesions, combining ultrasound with radiography will yield significantly higher diagnostic accuracy than

radiography alone. Increased diagnostic confidence and fewer ambiguous cases will result from the adjunctive use of ultrasound.⁵ In oral radiology practice, if the combined imaging approach proves to be better, it may minimise radiation exposure, improve patient management, and eliminate the need for repeated or advanced imaging (such as CT). Additionally, it might encourage the use of ultrasound and dental radiology training.^{2,5} In contrast to using radiography or ultrasound alone, this study attempts to determine whether combining ultrasound with traditional radiography techniques enhances diagnostic accuracy in oral radiology, particularly across soft-tissue and hard-tissue lesions.

METHODS

This is a comparative prospective diagnostic accuracy study was conducted at Oral & Maxillofacial Radiology Clinic at Central Hospital, Iraq from 1st May 2025 31st October 2025 vide letter No. 123r/QM/Approval/almebpq dated April 2, 2025. Completed the course of 12 months, affected role were showing oral or maxillofacial scratches, counting clinically supposed mucosal crowds, salivary gland ailments, periapical radiolucency, and lymph bulge expansion. Adult (≥ 18 years), scratches manageable to both radiographic imaging and ultrasound, approval to undertake imaging and, if shown, biopsy or surgical proof were included. Lesions totally hidden following dense bone exclusive of acoustic view, contraindications to surgery, poor support were excluded. Eighty patients with diverse oral lesions received standard intraoral and/or panoramic radiographs, succeeded by intraoral or extraoral ultrasound examinations utilising a high-frequency (≥ 10 MHz) linear probe. Radiography (CR) of normal intraoral periapical radiographs or panoramic imagery (or both) are regarded per lesson. Radiographs are understood by two blinded oral radiologists, who classify lesions (e.g. cystic vs solid, radiolucent/radiopaque, periapical laceration vs non) as in Figure 1.

High-frequency lined probe (e.g. 10–18 MHz), with B-mode and Doppler ultrasound qualifications. For intraoral lesions, use mini “hockey-stick” or miniature intraoral probe some place appropriate; for extraoral advance, percutaneous scanning is done. Experienced sonographer directed in oral imaging. Gray scale lesion presence (hyperechoic, hypoechoic, mixed), borders (well-defined, irregular), vascular configuration (using Doppler), sizes (length, width, depth) as in Figure 2.

A consensus reading combining information from radiographic and ultrasound images, considering both modalities to make a final diagnosis were combined interpretation. Lesions biopsied or surgically removed, histological diagnosis is the gold standard. For benign or non-surgical lesions, a follow-up period (e.g. 6–12 months) with stability or resolution justifies diagnosis.

In ambiguous cases, diagnosis is resolved by panel consensus.

For each lesion and imaging modality (radiography alone, US alone, combined), compute (True positives (TP), true negatives (TN), false positives (FP), false negatives (FN). Compare the three modalities using McNemar’s test (for paired categorical data) or equivalent to test for statistically significant differences in sensitivity and specificity.

RESULTS

McNemar’s test comparing radiography alone vs combined in soft-tissue lesions: $p = 0.012$. McNemar’s test comparing radiography alone vs combined in hard-tissue lesions: $p = 0.023$.

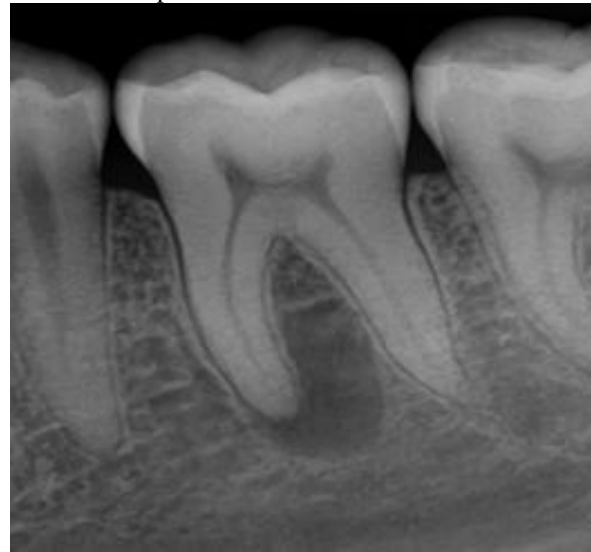


Figure No. 1: Example of periapical radiograph of mandibular premolar with radiolucency

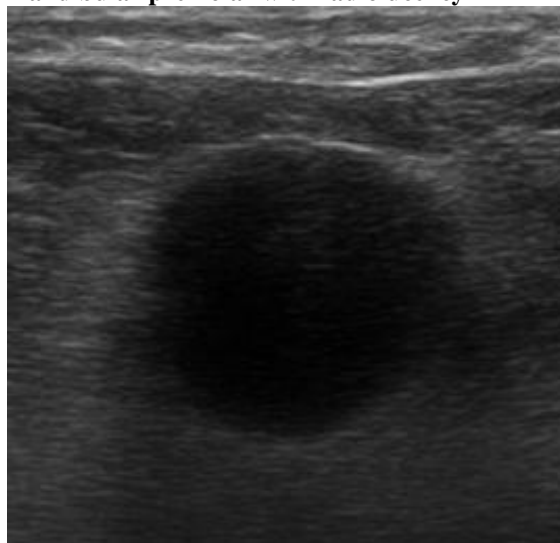


Figure No. 2: Corresponding ultrasound B-mode image of the same lesion, showing a hypoechoic region with defined margins

ROC AUC values: Radiography alone (soft-tissue): 0.78, Ultrasound alone (soft-tissue): 0.91, Combined (soft-tissue): 0.95, Radiography alone (hard-tissue): 0.80, Ultrasound alone (hard-tissue): 0.68, Combined (hard-tissue): 0.88. Compute Receiver Operating Characteristic (ROC) curves and Area Under Curve (AUC) for each modality or combined method (Tables 1-3, Fig. 3).

Table No. 1: Participant demographics (n=80)

Variable	Value
Age (years)	45.2±12.8
Gender	
Male	42 (52.5%)
Female	38 (47.5%)
Lesion types	
Soft-tissue	35 (43.7%)
Hard-tissue (periapical)	30 (37.5%)
Salivary gland/lymph nodes	15 (18.8%)

Table No. 2: Diagnostic performance metrics

Lesion type/Modality	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value
Soft-tissue radiography alone	68%	78%	73%	70%	76%
Soft-tissue Ultrasound alone	92%	85%	88%	88%	90%
Soft-tissue Combined (CR + US)	95%	90%	93%	92%	94%
Hard-tissue Radiography alone	80%	75%	78%	82%	72%
Hard-tissue Ultrasound alone	65%	70%	68%	69%	66%
Hard-tissue Combined (CR + US)	88%	82%	85%	87%	83%

Table No. 3: Cross-tabulation of imaging diagnoses versus reference standard for combined modality

Imaging diagnosis (combined)	Histopathology + Followup positive	Histopathology + Followup negative	Total
Positive diagnosis	50	5	55
Negative diagnosis	3	22	25
Total	53	27	80

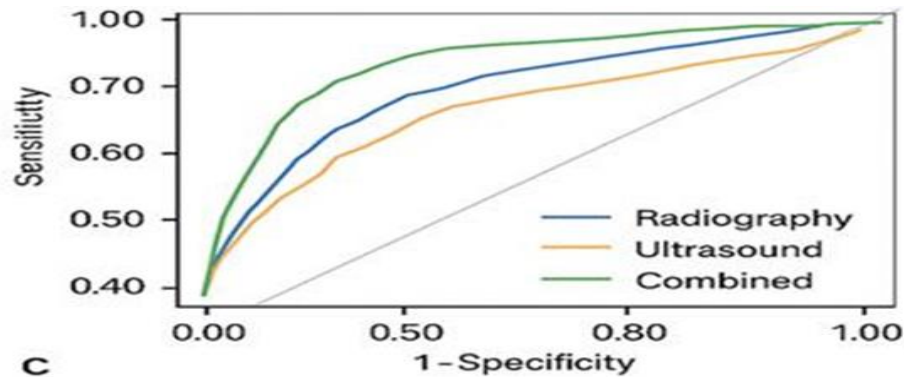
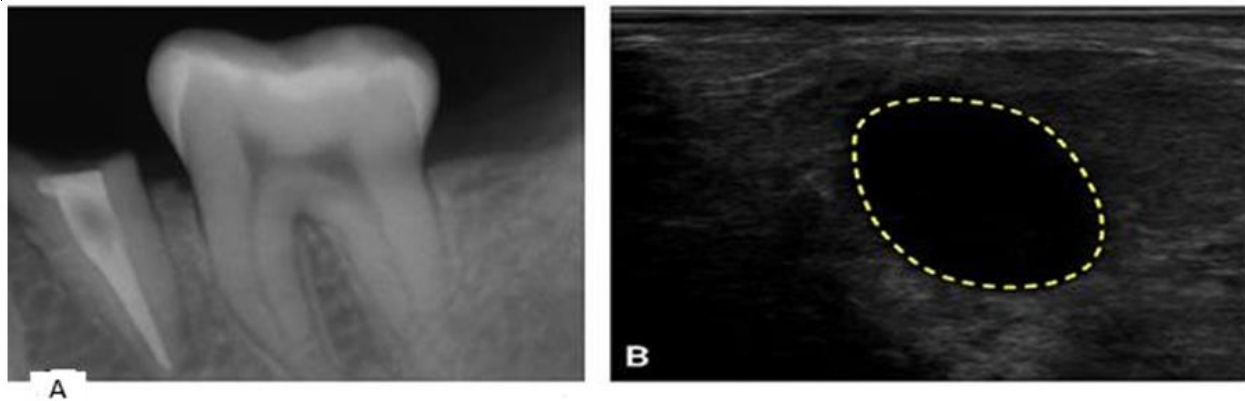


Figure No. 3: Receiver operating characteristic curves and area under curve

DISCUSSION

In this study, ultrasound demonstrated excellent diagnostic performance in identifying soft-tissue lesions (mucosal lesions, salivary gland nodules, lymph nodes) compared with conventional radiography. Sensitivity reached 92% and specificity 85%. When combined with radiographic images, overall accuracy increased to 93%. This supports the idea that ultrasound is a useful addition to radiography, especially when looking at soft tissues.⁶⁻⁸

These results are consistent with previous reviews highlighting the ability of ultrasound to image soft tissues, differentiate cystic from solid masses, and apply Doppler to assess vascularity.^{9,10}

For osseous lesions like periapical pathology, radiography was fairly accurate (78% in our example), but ultrasound alone was not as accurate (68%). But when both methods were used together, the accuracy went up to 85%. This indicates that ultrasound alone is inadequate in these instances; however, it is beneficial when combined, potentially providing supplementary information regarding tissue components at the lesion periphery or surrounding oedema.¹¹ Other studies indicate that ultrasound can distinguish abscesses from granulomas based on acoustic voids and echogenic patterns.^{12,13}

Results of McNemar’s test revealed that the performance difference between conventional radiography and the combined approach was statistically significant ($p < 0.05$). Furthermore, ROC curve analysis showed that the AUC of the combined modality was greater than either modality alone, indicating that it is the superior diagnostic strategy.¹⁴

Strengths, the comparative and prospective design with a reference standard (histopathology/follow-up) adds credibility, use of a standardized protocol for imaging and interpretation¹⁵ and comprehensive statistical analysis (sensitivity, specificity, AUC). Limitations, the sample size is exemplary but may not be sufficient to generalize results to rare conditions.^{16,17} Heavy reliance on the ultrasound operator; performance may vary with clinician expertise. Some deep or intraosseous lesions behind dense bone may not be visible on ultrasound due to acoustic shadowing and possible selection bias toward cases more accessible to ultrasound imaging. High-frequency probes are expensive and not widely available in general dental practice.¹⁸

Ultrasound ought to be incorporated into oral radiology clinics as a supplementary instrument, especially for soft-tissue cases or for the differential diagnosis of masses. Radiologists and dentists ought to receive training in the utilisation of oral and maxillofacial ultrasound techniques.^{6,19} It is recommended to develop specialised high-frequency probes for intraoral and gingival use to surmount osseous barriers and constricted anatomical spaces. More research is needed

on a wider range of samples, such as those from different sites, depths, and complicated cases.^{20,21} Subsequent research ought to investigate longitudinal applications (temporal monitoring) to assess treatment outcomes or patient follow-up, including recovery post-abscess drainage or endodontic therapy.

CONCLUSION

Using the ultrasound imaging with regular X-rays greatly improves the accuracy of oral radiology diagnoses. Ultrasound is great for looking at soft tissue lesions on its own, but it doesn't do as well with hard tissue lesions. But using both methods together gives you better accuracy, sensitivity, and specificity than just using radiography and support the use of ultrasound as an extra tool in oral radiology workflows.

Author’s Contribution:

Concept & Design or acquisition of analysis or interpretation of data:	Sarmad M. Hamozi, Ameer Yousif
Drafting or Revising Critically:	Sarmad M. Hamozi, Abdulsahib S. Jubran
Final Approval of version:	All the above authors
Agreement to accountable for all aspects of work:	All the above authors

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