

## Exploring osteoimmune pathologies through dental ultrasound: A tool for jaw bone density evaluation

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### Abstract

The noninvasive application of ultrasonography (US), is growing critical awareness in medicine and the growing emphasis on the immunological sustainability of medicinal interventions. An alternative viewpoint on the decades-old diagnostic use of ultrasonography in dentistry. The screening and early identification of osteoimmune disorders is one of the most promising uses of dental ultrasonography. Ultrasound is especially useful in high-risk patient populations because it can detect minute alterations in soft tissue properties and bone surface integrity before it become in higher risk.

This review has tailored the emphasis, usages of ultrasonography in early detection of osteoimmune changes without ionizing radiation.

**Keywords:** Noninvasive, osteoimmune, ultrasonography

### Introduction

The maxillofacial region, a complex anatomical region where inflammatory processes, immunological responses, and bone metabolism come together to provide a special microenvironment. Osteomyelitis, osteonecrosis of the jaw, autoimmune-mediated bone degradation, and inflammatory disorders linked to periodontal disease are among the many ailments that fall under the category of osteoimmune illnesses that affect the jaw. Conventional radiography, computed tomography (CT), and magnetic resonance imaging (MRI) are examples of traditional imaging modalities that have been the gold standard for identifying these disorders. However, each of these modalities has inherent drawbacks, such as radiation exposure, high costs, and restricted accessibility<sup>[1]</sup>.

Dental ultrasonography is becoming more and more used as a supplemental or alternative imaging method for assessing jaw osteoimmune disorders. Ultrasound is especially useful in the evaluation of these intricate disease processes because it can give real-time, high-resolution imaging of soft tissues, cortical bone surfaces, and inflammatory changes. Furthermore, ultrasonography is a vital tool in contemporary dental and oral maxillofacial practice due to its non-invasive nature, dynamic examination capabilities, and ability to direct interventional therapies<sup>[2]</sup>.

Henceforth, the current manuscript gives an insight view of to safely monitor bone healing, detect early osteoimmune changes without ionizing radiation.

### Ultrasound techniques & modalities

#### B-mode & Color/Power Doppler

B-mode visualizes echogenicity variations. Increased vascular flow is detected by Doppler, which is helpful for tracking inflammation and healing in jaw lesions. The extent, maturity, and structural characteristics, including loculations (possible internal chambers) and internal content, can be seen using the B-mode imaging technique. Power and color Blood flow in the lesion and surrounding tissues can be confirmed by Doppler<sup>[3]</sup>.

#### Trans-alveolar Ultrasound (TAU/TAU-n)

A transmit-receive setup across bone, offering density mapping and defect detection, including fatty-degenerative

osteonecrosis. The TAU-n device uses trans-alveolar ultrasonic pulses to detect and locate cavitations in the jawbone, detecting fatty-degenerative dissolution. It generates an ultrasonic pulse, guides it through the jawbone, and measures it using an ultrasound receiver. The device is designed for easy insertion into the patient's mouth, with acoustic coupling achieved using a semi-solid gel and a special ultrasound gel pad. Results are displayed on a color screen<sup>[4, 5]</sup>.

#### High-resolution & Intraoral Probes

It emphasizes on the fact that it is used for intramural usages and enhances imaging of anterior jaw lesions, while extraoral high-res probes capture periosteal changes. It utilizes the frequency range 2–20 MHz<sup>[2]</sup>.

#### Diagnostic applications in jaw lesions

##### a. Intraosseous Lesions (Cysts, Tumors, Bone Defects):

USG provided accurate information on the content of intraosseous jaw lesions before any surgical procedure. In it, the echographic patterns gave the interpretations of hyperechoic area revealing higher echo intensity and almost always indicated solid content. The irregular hyperechoic pattern in anechoic areas was highly suggestive of air, similar to the echographic appearance of air in other parts of the body<sup>[6, 9]</sup>.

USG and histopathologic gave the fruitful results regarding content assessment. Ultrasound does not eliminate the necessity of using invasive procedures like aspiration, incisional, and excisional biopsies for final diagnosis of intraosseous lesions. However, this safe modality is highly recommended for evaluating intraosseous jaw lesions in size and content<sup>[10, 14]</sup>.

##### b. Osteomyelitis & Periosteal Inflammation:

Ultrasonography (USG) plays a valuable role in the early detection and monitoring of osteomyelitis and periosteal inflammation in the maxillofacial region. Osteomyelitis is an infection of the bone, often affecting the mandible, and is frequently preceded by periosteal inflammation. While conventional

radiographs detect changes only after significant bone destruction, USG can identify early signs such as periosteal elevation, cortical irregularities, and subperiosteal abscesses. On B-mode USG, anechoic or hypoechoic areas indicate fluid collections or inflammation, while Color Doppler imaging reveals increased vascularity, suggesting active infection.<sup>15</sup> These features make USG especially useful for guiding early treatment, monitoring therapeutic response, and assisting in drainage procedures. It is non-invasive, free from ionizing radiation, and suitable for repeated use—making it ideal for children, pregnant women, and medically compromised patients. Thus, USG complements other imaging modalities in managing osteoimmune conditions of the jaw effectively<sup>[16]</sup>.

### c. Osteonecrosis, Bone Marrow Defects & Immune-Related Lesions

An advanced ultrasonographic method called transalveolar ultrasound with necrosis detection (TAU-n) enables quantitative assessment of bone marrow attenuation, especially in the jaw. Due to the subtlety of changes within cancellous bone, it is very effective in detecting fatty-degenerative osteonecrosis of the jaw, also known as AIOJ – Aseptic Ischaemic Osteonecrosis of the Jaw or FDOJ – Fatty Degenerative Osteolysis of the Jaw. This condition is frequently undetectable on standard radiographs or CBCT scans. In order to determine the loss of healthy bone density and vascularity, TAU-n measures the attenuation of ultrasonic waves as they pass through the jawbone structures. Significantly reduced signal transmission is indicative of this process. This method is especially useful in chronic or cryptic conditions where patients experience persistent pain or systemic symptoms without radiographic evidence. This approach is particularly helpful in cryptic or chronic illnesses where patients have systemic symptoms or chronic pain without radiographic proof. In such osteoimmune jaw diseases, TAU-n offers a non-invasive, radiation-free, and quantitative diagnostic tool that improves early diagnosis and decision-making for surgical debridement or regenerative therapies<sup>[17]</sup>.

### d. TMJ Degeneration & Immune Disorders:

Ultrasonography (USG), a non-invasive, real-time, radiation-free substitute for traditional imaging, is becoming more and more acknowledged as a useful method for assessing temporomandibular joint (TMJ) abnormalities. With diagnostic sensitivity and interobserver agreement levels similar to CBCT and MRI in many clinical settings, high-resolution USG can identify TMJ osteophytes, bone erosions, subcortical cysts, joint effusion (fluid buildup), and disc displacement. It makes it possible to dynamically assess joint movement and the disc's spatial relationship during mouth opening and closure. Synovial vascularity can be further evaluated with Colour Doppler, which is helpful in inflammatory diseases like arthritis. For initial screening and follow-up, USG is a dependable, affordable, and accessible technique, particularly in areas with limited resources, even if MRI is still the gold standard for soft tissue visualisation. It is particularly useful in juvenile idiopathic arthritis,

rheumatoid arthritis, and internal derangement cases, offering a safe modality for repeated evaluation without radiation exposure<sup>[18]</sup>.

- e. **Sjögren's syndrome:** The exocrine glands are impacted by the chronic autoimmune disease known as Primary Sjögren's syndrome (PSS). Research shows that US results for PSS have a high specificity. The authors found correlations between systemic autoantibodies, exocrine function glandular inflammation, and the intensity of dryness complaints and US findings. According to the authors, US is a useful technique for determining salivary gland involvement in PSS<sup>[18]</sup>.

### Advantages

- No radiation—safe for repeat monitoring.
- Real-time dynamic imaging, including sonopalpation.
- Differentiates lesion content and vascularity.
- Inexpensive, widely available, good patient compliance<sup>[2]</sup>.

### Limitations

- Acoustic shadowing limits posterior jaw visualization.
- Efficacy depends on probe type, frequency, and operator skill.
- Thick bone may block imaging of deep lesions.
- Requires training and interpretation standards<sup>[2]</sup>.

### Future directions & recommendations

**Standardisation:** Establish uniform guidelines for probe frequency, parameters, and interpretation standards.

**Equipment Development:** Bone-through ultrasound systems and enhanced intraoral probes.

**Integration and Training:** Include in oral and maxillofacial and dental curriculum. Large-scale, randomised trials comparing diagnosis and outcomes against CBCT/MRI are needed for this research.

**AI & Quantitative Tools:** Apply algorithms to measures of bone density, vascular signal, and echogenicity.

### Conclusion

Dental ultrasonography is a valuable diagnostic tool for assessing osteoimmune conditions in the jaw due to its non-invasive nature, real-time imaging capabilities, and excellent soft tissue resolution. It enhances diagnostic accuracy when used with traditional imaging modalities. The technology's success requires adequate training, standardized protocols, and quality assurance measures. Future research should focus on evidence-based guidelines, diagnostic criteria, and new applications for emerging ultrasound technologies.

### References

1. Robert Huber, Elisa Choukroun, Harald Fahrenholz, Florian Notter. Dental Ultrasonography for Visualizing Osteoimmune Conditions and Assessing Jaw Bone Density: A Narrative Review. *Medical Devices: Evidence and Research*, 2025, 1–13. doi:10.2147/MDER.S491331
2. Surowiec RK, Does MD, Nyman JS. *In vivo* assessment of bone quality without X-rays. *Current Osteoporosis*

- Reports, 2024. PMID: 38227178. doi:10.1007/s11914-023-00856-w
3. Delantoni A, Sarafopoulos A, Giannouli N, Rafailidis V. Maxillofacial inflammations visualized with ultrasonography. Description of the imaging features and literature review based on a characteristic case series. *Journal of Ultrasonography*,2023;23(93):80–89. doi:10.15557/jou.2023.0015. PMID: 37520752; PMCID: PMC10379848
  4. T Lechner J, Zimmermann B, Schmidt M, von Baehr V. Ultrasound Sonography to Detect Focal Osteoporotic Jawbone Marrow Defects Clinical Comparative Study with Corresponding Hounsfield Units and RANTES/CCL5 Expression. *Clinical, Cosmetic and Investigational Dentistry*,2020;12:205–216. doi:10.2147/CCIDE.S247345. PMID: 32801922; PMCID: PMC7401665
  5. Tymofiev OO, Fesenko II, Cherniak OS, Serha OO. Ultrasonographic assessment of masseter muscle region and minimally invasive treatment of post-extraction osteomyelitis. *Journal of Diagnostic and Treatment of Oral and Maxillofacial Pathology*,2023;7(4):33–38
  6. Lauria L, Curi MM, Chammas MC, Pinto DS, Torloni H. Ultrasonography evaluation of bone lesions of the jaw. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, Endodontology*,1996;82:351–357
  7. Gundappa M, Ng SY, Whaites EJ. Comparison of ultrasound, digital and conventional radiography in differentiating periapical lesions. *Dentomaxillofacial Radiology*,2006;35:326–333
  8. White SC, Pharoah MJ. *Oral radiology: principles and interpretation*. 6th ed. St. Louis: Mo. Mosby, Elsevier, 2009, 641–675.
  9. Cotti E. Advanced techniques for detecting lesions in bone. *Dental Clinics of North America*,2010;54:215–235.
  10. McGahan JP, Goldberg BB. *Diagnostic ultrasound*. 2nd ed. London, New York: Informa Healthcare, 2008, 564–721.
  11. Gibbs V, Cole D, Sassano A. *Ultrasound physics and technology: how, why, and when*. 1st ed. Edinburgh, New York: Churchill Livingstone, 2009, 137.
  12. Cotti E, Campisi G. Advanced radiographic techniques for the detection of lesions in bone. *Endodontic Topics*,2004;7:52–72
  13. Weinberg B, Diakoumakis EE, Kass EG, Seife B, Zvi ZB. The air bronchogram: sonographic demonstration. *American Journal of Roentgenology*,1986;147:593–595
  14. Lichtenstein D, Mezière G, Biderman P, Gepner A. The "lung point": an ultrasound sign specific to pneumothorax. *Intensive Care Medicine*,2000;26:1434–1440
  15. Tymofiev OO, Fesenko II, Cherniak OS, Serha OO. Ultrasonographic assessment of masseter muscle region and minimally invasive treatment of post-extraction osteomyelitis. *Journal of Diagnostic and Treatment of Oral and Maxillofacial Pathology*,2023;7(4):33–38
  16. Hosokawa T, Ohnishi T, Sato S, Tanami Y, Oguma E. Ultrasound evaluation of inflammation in patients with chronic recurrent multifocal osteomyelitis involving the mandible: report of three cases. *Radiology Case Reports*,2021;17(3):802–807. doi: 10.1016/j.radcr.2021.12.006
  17. Lechner J, Zimmermann B, Schmidt M, von Baehr V. Ultrasound Sonography to Detect Focal Osteoporotic Jawbone Marrow Defects Clinical Comparative Study with Corresponding Hounsfield Units and RANTES/CCL5 Expression. *Clinical, Cosmetic and Investigational Dentistry*,2020;12:205–216. doi:10.2147/CCIDE.S247345. PMID: 32801922; PMCID: PMC7401665
  18. Evirgen Ş, Kamburoğlu K. Review on the applications of ultrasonography in dentomaxillofacial region. *World Journal of Radiology*,2016;8(1):50–58. doi:10.4329/wjr. v8.i1.50. PMID: 26834943; PMCID: PMC4731348.