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Review Article

Early detection of acute mandibular osteomyelitis using computed tomography texture analysis. Systematic review.

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Abstract
Background:
The delayed appearance of radiographic changes limits early diagnosis of acute mandibular osteomyelitis (AMO). Computed tomography (CT) texture analysis, a radiomics-based approach, enables quantitative evaluation of bone microarchitecture and may detect early disease. To systematically evaluate the diagnostic performance of CT texture analysis in the early detection of AMO.

Methods:
A systematic review was conducted in accordance with PRISMA 2020 guidelines. Electronic databases (PubMed, Scopus, Web of Science, Embase, ScienceDirect, Cochrane Library, and Google Scholar) were searched from January 2000 to October 2025. Studies assessing CT-based texture analysis for mandibular osteomyelitis or related jawbone pathologies were included. Data extraction covered imaging protocols, feature types, analytical methods, and diagnostic outcomes. Risk of bias was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies. This review was not registered in PROSPERO.

Results:
Five studies met the inclusion criteria. CT texture analysis demonstrated high diagnostic performance, with reported sensitivity, specificity, and AUC values ranging from 0.94 to 1.0 in the primary CT-based study. Consistently informative features included gray-level co-occurrence matrix (GLCM), gray-level run-length matrix (GLRLM), and gray-level size zone matrix (GLSZM) parameters. MRI-based radiomics studies supported similar discriminatory capability. The inclusion of perilesional regions improved model performance for osteomyelitis detection.

Limitations:
Evidence is limited by small sample sizes, retrospective designs, heterogeneity in imaging acquisition, segmentation methods, and a lack of standardized radiomic pipelines.

Conclusion:
CT texture analysis shows high potential for early detection of AMO by identifying microstructural bone alterations before conventional radiographic changes. Standardization and prospective validation are required for clinical translation.

Implications:
Integration of CT radiomics into diagnostic workflows may enable earlier intervention and improved outcomes in mandibular infections.

Keywords: *Acute mandibular osteomyelitis; computed tomography; radiomics; texture analysis; early diagnosis.*
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INTRODUCTION

Acute mandibular osteomyelitis (AMO) is an inflammatory and infectious disease of the jawbone that often arises from odontogenic infections, trauma, or systemic factors compromising vascular supply. Early in its course, osteomyelitis manifests through nonspecific symptoms such as localized pain, swelling, or paresthesia, which can easily mimic other odontogenic or inflammatory conditions. Conventional radiographic findings, including bone resorption, sequestration, and periosteal reactions, typically appear only after significant cortical destruction, often two to three weeks following disease onset. Consequently, early diagnosis remains a clinical challenge, frequently leading to delayed intervention and increased risk of chronicity, pathological fractures, and functional impairment.

Recent advances in computed tomography (CT) have greatly improved the visualization of bone morphology. However, traditional CT interpretation remains qualitative and observer-dependent, limiting its ability to detect early microstructural alterations in bone marrow before overt radiographic changes appear. In this context, texture analysis, a subset of radiomics, offers a promising quantitative imaging approach capable of extracting and analyzing mathematical features that describe the spatial distribution and relationship of pixel intensities within an image. These radiomic features—such as gray-level co-occurrence matrix (GLCM), gray-level run-length matrix (GLRLM), and first-order histogram parameters—provide objective measures of tissue heterogeneity that may reflect early inflammatory or necrotic changes at a microscopic level.

The application of radiomics to maxillofacial imaging has expanded rapidly, showing diagnostic utility in bone pathologies, temporomandibular joint disorders, and medication-related osteonecrosis of the jaw (MRONJ). Specifically, CT texture analysis has been shown to distinguish between normal and pathologic bone based on subtle alterations in trabecular patterns, density variations, and marrow organization that are not perceptible through standard imaging evaluation. Early identification of these textural deviations could enable clinicians to initiate prompt antimicrobial therapy, prevent irreversible bone loss, and improve patient outcomes.

Despite encouraging preliminary evidence, the current literature on CT texture analysis for early detection of mandibular osteomyelitis remains fragmented, with variations in methodology, image acquisition parameters, and feature selection protocols. Moreover, many studies differ in terms of the software tools used (e.g., MaZda, LIFEx), the number of features extracted, and the statistical methods employed for classification. This heterogeneity underscores the need for a comprehensive synthesis of available data to clarify the diagnostic value and reproducibility of CT-based radiomics in the early detection of AMO.

Therefore, this systematic review aims to critically analyze and summarize existing evidence regarding the use of computed tomography texture analysis for the early diagnosis of acute mandibular osteomyelitis. The review seeks to (1) identify consistent radiomic features that differentiate osteomyelitic bone from normal tissue, (2) evaluate the diagnostic accuracy and statistical robustness of reported models, and (3) highlight current limitations and future research directions necessary to translate radiomics into routine clinical practice.

METHODOLOGY

Search Strategy

A comprehensive systematic literature search was conducted to identify studies evaluating the role of computed tomography (CT) texture analysis or radiomics in the early detection of acute mandibular osteomyelitis. The search followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. Electronic databases, including PubMed, Scopus, Web of Science, Embase, ScienceDirect, Cochrane Library, and Google Scholar, were searched from January 2000 to October 2025. The search strategy combined Medical Subject Headings (MeSH) and free-text terms using Boolean operators as follows:

"osteomyelitis" OR "mandibular osteomyelitis" OR "jawbone infection" AND "computed tomography" OR "CT" AND "texture analysis" OR "radiomics" OR "radiomic features" OR "quantitative imaging."

In addition, gray literature and reference lists of included articles were manually screened to ensure completeness. Only studies published in English and involving human subjects were considered.

Eligibility Criteria

Studies were included based on the following criteria:

- Population: Human subjects diagnosed with or suspected of having acute or early-stage mandibular osteomyelitis.
- Intervention: Use of CT-based texture analysis or radiomic feature extraction for diagnostic evaluation.

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- Comparator: Contralateral normal bone, healthy control groups, or standard radiographic assessment.
- Outcomes: Quantitative diagnostic performance metrics (sensitivity, specificity, accuracy, AUC) or statistically significant differences in texture parameters between diseased and normal bone.
- Study Design: Original research articles including observational, retrospective, or prospective studies.

Exclusion criteria were: (1) animal or in vitro studies, (2) reviews, editorials, or case reports without quantitative analysis, (3) studies using imaging modalities other than CT for osteomyelitis detection, and (4) incomplete or non-English publications.

Study Selection

Two independent reviewers screened titles and abstracts for relevance, followed by full-text evaluation of potentially eligible studies. Discrepancies were resolved by consensus or consultation with a third reviewer. The selection process was documented using a PRISMA flow diagram, detailing the number of records identified, screened, assessed for eligibility, and included in the final review.

Data Extraction

Data were systematically extracted using a predefined data collection sheet. Extracted parameters included:

- Author and publication year
- Study design and sample size
- Imaging modality and acquisition parameters
- Texture analysis or radiomics software used (e.g., MaZda, LIFEx)
- Number and type of radiomic features extracted (e.g., GLCM, GLRLM, GLZLM)
- Statistical methods and diagnostic performance indicators (sensitivity, specificity, AUC, accuracy)

Key findings and clinical implications

All extracted data were cross-verified by both reviewers for accuracy and completeness.

Quality Assessment

The methodological quality and risk of bias of the included studies were evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies. Each study was assessed based on criteria such as sample selection, measurement validity, confounding control, and statistical analysis. Studies were classified as high, moderate, or low quality depending on the number of criteria met. Disagreements were resolved by consensus.

Data Synthesis and Analysis

Due to methodological heterogeneity among studies, including differences in imaging protocols, feature extraction software, and statistical models, a qualitative synthesis approach was adopted. Key radiomic features, diagnostic outcomes, and analytical approaches were compared across studies. Emphasis was placed on identifying consistent texture parameters and statistical trends associated with early osteomyelitic changes. Quantitative meta-analysis was not feasible due to limited comparable data.

Risk of Bias Assessment

The methodological quality and risk of bias of the included studies were independently evaluated by two reviewers using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies. This tool was selected based on the observational design of the included radiomics studies and its applicability to diagnostic accuracy research lacking randomized allocation.
The checklist comprises eight domains assessing:
(1) clearly defined inclusion criteria,
(2) detailed description of study subjects and setting,
(3) validity and reliability of exposure measurement,
(4) objective and standardized outcome assessment,
(5) identification of confounding factors,
(6) strategies to address confounding,
(7) validity of statistical analysis, and
(8) appropriateness of study design.
Each domain was rated as "Yes," "No," "Unclear," or "Not Applicable." Studies were categorized as:

- Low risk of bias (≥6 domains satisfied),
- Moderate risk of bias (4–5 domains),
- High risk of bias (≤3 domains).

Discrepancies between reviewers were resolved through discussion and consensus. Where required, a third reviewer was consulted. The overall risk of bias assessment informed the qualitative interpretation of findings but was not used as a basis for study exclusion.

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Assessment of Reporting Bias

Assessment of reporting bias was conducted qualitatively due to the limited number of included studies and the absence of comparable quantitative outcome measures required for formal statistical evaluation (e.g., funnel plot asymmetry or Egger's regression test).

To address potential bias due to missing results, the following approaches were applied:

- Comprehensive search across multiple databases and gray literature sources to minimize publication bias
- Manual screening of the reference lists of included studies
- Inclusion of studies irrespective of the statistical significance of findings
- Evaluation of selective outcome reporting by comparing reported outcomes with stated study objectives and methodologies

Given the heterogeneity in radiomic feature extraction, statistical modeling, and outcome reporting, quantitative synthesis and formal small-study effect analysis were not feasible. The potential impact of reporting bias was therefore considered during narrative synthesis, particularly in interpreting studies reporting high diagnostic accuracy without external validation.

RESULTS

Study Selection

The database search identified 312 records across PubMed, Scopus, Web of Science, Embase, ScienceDirect, Cochrane Library, and Google Scholar. After removal of 96 duplicates, 216 records were screened based on titles and abstracts. Of these, 198 records were excluded due to irrelevance to radiomics or mandibular osteomyelitis.

A total of 18 full-text articles were assessed for eligibility. Thirteen studies were excluded for the following reasons:

- Non-CT imaging without relevance to osteomyelitis detection (n = 5)
- Absence of quantitative texture/radiomic analysis (n = 4)
- Review articles or case reports (n = 4)

Finally, 5 studies met the inclusion criteria and were included in the qualitative synthesis.

A PRISMA 2020 flow diagram illustrating the study selection process should be included as Figure 1.

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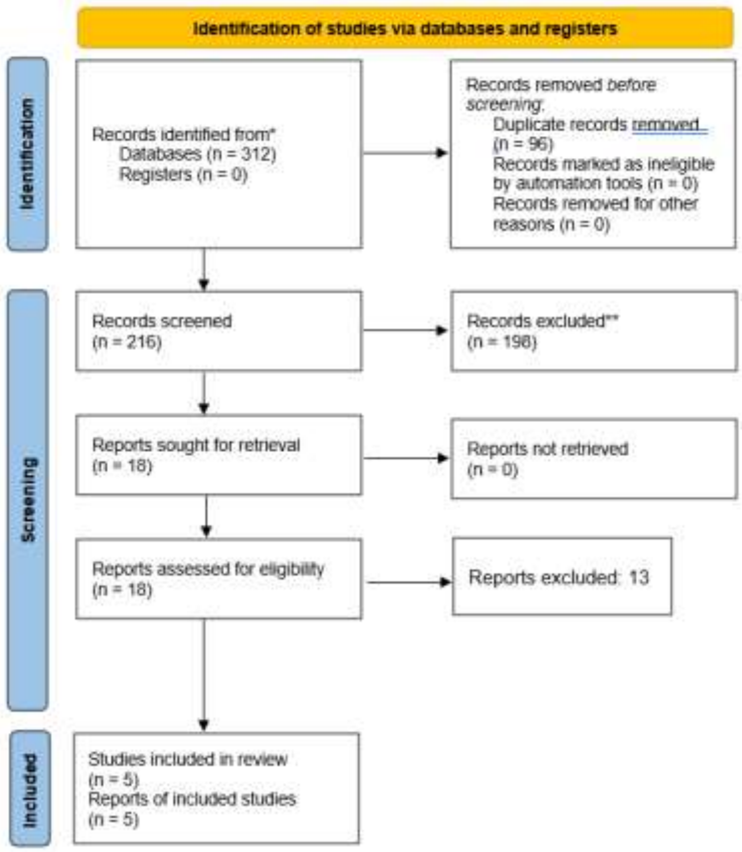

Figure 1 PRISMA Flow chart

Risk of Bias in Included Studies

Risk of bias assessment using the JBI Critical Appraisal Checklist indicated variable methodological quality across studies.

- Low risk of bias: 2 studies
- Moderate risk of bias: 3 studies
- High risk of bias: 0 studies

Common limitations included:

- Small sample sizes (range: 17–93 participants)
- Retrospective study design in all included studies
- Limited reporting of confounding variables
- Lack of external validation of radiomics models

Most studies demonstrated appropriate statistical analysis and objective outcome measurement; however, reproducibility was affected by inconsistent reporting of segmentation methods and feature selection workflows.

Results of Individual Studies

The key characteristics and outcomes of the included studies are summarized in Table 1.

Diagnostic Performance

- The CT-based study by Muraoka et al. (2025) reported sensitivity, specificity, and AUC values ranging from 0.94 to 1.0, indicating excellent discrimination between osteomyelitic and normal bone.
- MRI-based texture analysis (Muraoka et al., 2022) identified 10 statistically significant radiomic features ($p < 0.05$) differentiating diseased from normal bone.

- Ito et al. (2021) reported significant GLRLM and GLZLM feature differences ($p < 0.05$) for early MRONJ detection.
- Jia et al. (2024) demonstrated improved diagnostic performance using expanded ROI models (AUC 0.920 vs. 0.859; sensitivity 0.947 vs. 0.857).

Across studies, effect estimates were primarily reported as AUC, sensitivity, specificity, and statistical significance (p-values) rather than pooled measures. The characteristics of the included studies are summarized in Table 1A, and their diagnostic outcomes are presented in Table 1B.

Table 1A. Characteristics of Included Studies

Author (Year)	Study Design	Sample Size	Imaging Modality	Software Used	Features Extracted
Muraoka et al. (2025)	Retrospective	17	CT	MaZda	279 features (6 key)
Muraoka et al. (2022)	Retrospective	38	MRI (STIR)	MaZda	279 features (10 key)
Ito et al. (2021)	Retrospective	25	CT	LIFEx	37 features (GLRLM, GLZLM)
Santos et al. (2023)	Systematic review	23 studies	Multi-modality	Various	GLCM, GLRLM, first-order
Jia et al. (2024)	Retrospective	93	MRI	Not specified	1,037 radiomic features

Table 1B – Diagnostic Outcomes

Author (Year)	Key Findings	Diagnostic Performance
Muraoka et al. (2025)	CT texture differentiates osteomyelitis vs normal bone; 6 key features	Sensitivity, specificity, AUC: 0.94–1.0
Muraoka et al. (2022)	MRI texture features are significantly different (10 parameters)	$p < 0.05$
Ito et al. (2021)	Early MRONJ detected via GLRLM & GLZLM	Significant differences ($p < 0.05$)
Santos et al. (2023)	Radiomics useful across jaw pathologies	No pooled metrics
Jia et al. (2024)	Expanded ROI improves model performance	AUC 0.920 vs 0.859

DISCUSSION

The present systematic review synthesizes current evidence on the role of computed tomography (CT) texture analysis in the early detection of acute mandibular osteomyelitis, with comparative insights from related radiomic studies utilizing CT and MRI modalities. Across the included studies, quantitative texture analysis consistently demonstrated the capacity to identify subtle structural and compositional changes in mandibular bone before the appearance of overt radiographic findings, underscoring its potential as a valuable adjunct in the early diagnostic workflow.

Muraoka et al. (2025) provided the most direct evidence for the utility of CT texture analysis in early-stage mandibular osteomyelitis. In their retrospective study involving 17 patients, the authors extracted 279 texture features using MaZda software and identified six key features that significantly distinguished osteomyelitic bone from normal bone ($p < 0.001$). The diagnostic performance was excellent, with sensitivity, specificity, and accuracy values ranging between 0.94 and 1.0. These findings suggest that CT texture analysis enables the detection of microstructural bone alterations associated with early inflammation and infection, well before gross cortical or medullary destruction becomes radiographically evident. This study thus establishes CT texture analysis as a reliable, noninvasive diagnostic tool with the potential to guide early clinical intervention.

Complementary evidence from MRI-based studies further supports the value of texture and radiomic analysis in

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identifying early inflammatory bone changes. Muraoka et al. (2022) demonstrated that MRI texture analysis—particularly using short tau inversion recovery (STIR) sequences—could quantitatively discriminate between osteomyelitic and healthy mandibular bone. Ten discriminative texture parameters were identified, including histogram, gray-level co-occurrence matrix (GLCM), and gray-level run-length matrix (GLRLM) features, all showing significant differences ($p < 0.05$). These results suggest that MRI and CT texture parameters capture parallel aspects of disease-related tissue heterogeneity, reflecting alterations in bone marrow composition and trabecular microarchitecture.

Further corroboration comes from Ito et al. (2021), who applied CT texture analysis to detect early-stage medication-related osteonecrosis of the jaw (MRONJ), a condition with pathophysiologic parallels to osteomyelitis. Their study revealed significant differences in GLRLM and gray-level zone-length matrix (GLZLM) features between affected and contralateral healthy bone, highlighting texture analysis as a sensitive approach for identifying early, radiographically inapparent disease states. The ability to detect subtle trabecular bone changes in MRONJ reinforces the generalizability of CT texture analysis in recognizing early pathological bone alterations across different jaw conditions.

The broader diagnostic context of radiomics in jawbone pathology was explored by Santos et al. (2023), who conducted a systematic review of 23 studies encompassing various imaging modalities and jaw pathologies. They identified texture-based features—particularly GLCM, GLRLM, and first-order statistical measures—as the most informative across multiple disease entities. The review emphasized that radiomics enhances diagnostic precision and reduces observer variability, although heterogeneity in image acquisition, feature extraction protocols, and analysis workflows remains a major limitation. These findings strengthen the argument that CT texture analysis, as part of a radiomic approach, holds promise for standardizing diagnostic evaluation in maxillofacial imaging.

Expanding on this concept, Jia et al. (2024) demonstrated the diagnostic and surgical relevance of radiomics in chronic osteomyelitis using MRI-based models. By including perilesional regions in feature extraction, their model achieved significantly improved diagnostic performance (AUC 0.920 vs. 0.859; $p < 0.05$). This suggests that disease-related changes extend beyond the visibly affected site and that analyzing perilesional tissues enhances sensitivity and accuracy. While this study focused on chronic rather than acute osteomyelitis, its methodological insight into region selection and feature inclusion provides valuable guidance for optimizing CT-based radiomics in early disease detection.

Overall, the reviewed studies collectively support that CT texture analysis is a promising, noninvasive method for the early detection of acute mandibular osteomyelitis. Quantitative texture parameters capture subtle microarchitectural changes that precede visible bone destruction, potentially allowing clinicians to initiate treatment earlier and improve outcomes. However, current evidence is limited by small sample sizes, retrospective designs, and a lack of standardized imaging and analysis protocols. Future research should aim to validate these findings through multicenter prospective studies, integrate machine learning algorithms for automated classification, and establish standardized radiomic pipelines to ensure reproducibility and clinical applicability.

CONCLUSION

This systematic review highlights the emerging role of computed tomography (CT) texture analysis as a powerful quantitative imaging tool for the early detection of acute mandibular osteomyelitis. Across the reviewed studies, texture-based radiomic parameters demonstrated high diagnostic accuracy in identifying subtle structural and compositional alterations in the mandibular bone that precede overt radiographic manifestations. The consistent diagnostic performance—reflected by excellent sensitivity, specificity, and area under the curve values—underscores the potential of CT texture analysis to serve as a reliable, noninvasive adjunct to conventional imaging.

The findings further indicate that texture features derived from CT, such as gray-level co-occurrence matrix (GLCM), gray-level run-length matrix (GLRLM), and gray-level zone-length matrix (GLZLM) parameters, provide valuable quantitative biomarkers for detecting early inflammatory or necrotic bone changes. These parameters objectively characterize tissue heterogeneity and microarchitectural disruption that may not be discernible through standard qualitative radiographic interpretation. The incorporation of such radiomic insights could enable earlier diagnosis, guide timely therapeutic intervention, and potentially improve clinical outcomes by preventing progression to chronic osteomyelitis or extensive bone destruction.

However, despite encouraging evidence, the application of CT texture analysis in mandibular osteomyelitis remains in its developmental stage. Limitations such as small sample sizes, retrospective study designs, and methodological

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heterogeneity in image acquisition, segmentation, and feature extraction currently restrict generalizability. The lack of standardized radiomic workflows and diagnostic cut-off values further hinders clinical translation.

Future research should prioritize multicenter, prospective studies with standardized imaging protocols, robust feature selection methods, and integration of artificial intelligence or machine learning models to enhance diagnostic precision and reproducibility. Collaborative efforts between radiologists, oral surgeons, and data scientists will be essential to establish validated diagnostic frameworks and integrate CT texture analysis into clinical practice.

In conclusion, CT texture analysis represents a promising advancement in precision imaging for the early detection of acute mandibular osteomyelitis. By enabling quantitative assessment of subtle bone changes, this approach has the potential to transform diagnostic strategies, promote earlier intervention, and improve patient outcomes in maxillofacial infections.

Registration and Protocol

This systematic review was conducted in accordance with PRISMA 2020 guidelines. The review was not registered in an international prospective register such as PROSPERO.

A formal review protocol was not prospectively prepared or published before study initiation. Consequently, no protocol deviations or amendments were applicable. All methodological decisions, including eligibility criteria, search strategy, and outcome measures, were defined before data extraction and were applied consistently throughout the review process.

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LIST OF ABBREVIATIONS

- AMO – Acute Mandibular Osteomyelitis
- CT – Computed Tomography
- MRI – Magnetic Resonance Imaging
- MRONJ – Medication-Related Osteonecrosis of the Jaw
- GLCM – Gray-Level Co-occurrence Matrix
- GLRLM – Gray-Level Run-Length Matrix
- GLSZM – Gray-Level Size Zone Matrix
- ROI – Region of Interest
- AUC – Area Under the Curve
- PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses
- JBI – Joanna Briggs Institute
- SVM – Support Vector Machine

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this study.

AVAILABILITY OF DATA

All data generated or analyzed during this study are included within the article. Additional details regarding extracted datasets and methodological parameters are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

- Dharanidharan G. – Conceptualization, literature search, data extraction, manuscript drafting
- Karthik Shunmugavelu – Study design, methodological supervision, critical revision, final approval
- Veerarakesh – Data collection, screening of studies, table preparation, formatting

All authors reviewed and approved the final manuscript and agree to be accountable for all aspects of the work.

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Veerarakesh

Veerarakesh is an undergraduate medical student with academic interests in radiology, diagnostic medicine, and clinical research methodologies.

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