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Applications of Artificial Intelligence in Histological Analysis of Bone Tissue: A Scoping Review

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ADMINISTRATIVE INFORMATION

Support - CAPES, FAPEMIG, CNPq.

Review Stage at time of this submission - Data extraction.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 20 September 2025 and was last updated on 20 September 2025.

INTRODUCTION

Review question / Objective How is artificial intelligence applied in the histological analysis of bone tissue, and what evidence exists regarding its effectiveness?

Background Histological analysis of bone tissue is fundamental to understanding skeletal remodeling and pathological conditions, with significant implications for research and diagnosis. Traditional methods, including histological staining and histomorphometry, enable the evaluation of structural parameters but are limited by subjectivity, interobserver variability, and high time demands, particularly in large datasets. In this context, artificial intelligence has emerged as a promising tool, automating image segmentation and quantification to improve reproducibility and reduce bias.

Rationale This scoping review aims to investigate how artificial intelligence has been applied in the histological analysis of bone tissue and what evidence supports its effectiveness. Current approaches using machine learning and deep neural networks have been explored for segmentation, cellular identification, and 3D reconstruction, showing potential to enhance diagnostic accuracy and efficiency. Synthesizing these findings is essential to standardize methodologies, identify existing gaps, and support the integration of automated solutions into research workflows and clinical practice.

METHODS

Strategy of data synthesis Electronic searches were performed in the PubMed, EMBASE, Web of Science, Scopus, and Cochrane Library databases for publications up to January 2025. The search strategies were developed using the Medical Subject Headings (MeSH) and Embase Subject Headings (Emtree). Boolean operators (AND and OR) were used to combine the descriptors, optimizing the search strategy through different combinations and respecting each database

syntax rule. No filters were utilized in the search strategy.

Eligibility criteria The following inclusion criteria were established according to the PCC criteria: (P) Population: Any human population or animal model; (C) Concept: Application of artificial intelligence techniques for histological analysis of bone tissue; (C) Context: Different histological analysis purposes and applications (e.g., diagnostic, quantitative, or qualitative assessment). Clinical diagnostic accuracy studies that reported data on the use of artificial intelligence in the diagnosis of bone diseases were included, as well as human and animal studies that provided data on artificial intelligence techniques for the histological analysis of bone tissue structures, including mineralized tissue, bone matrix, and cellular components of bone. In addition, only articles in the English language were considered. Research articles that did not follow the inclusion criteria were excluded. Conference proceedings, short communications, letters to the editor, protocol articles, historical reviews, and unpublished manuscripts were also excluded, as were studies focusing on bone marrow structures.

Source of evidence screening and selection The study selection process was conducted by two researchers working independently. Initially, titles and abstracts of the records were screened against the predefined inclusion and exclusion criteria, and those deemed irrelevant were removed. Full-text articles meeting the eligibility requirements were then reviewed in detail by both researchers to confirm inclusion. Any discrepancies in selection decisions were resolved by discussion and consensus, or, when necessary, by consultation with a third reviewer. Studies fulfilling the selection criteria proceeded to data extraction. Articles excluded after full-text assessment were documented separately, along with the specific reasons for their exclusion.

Data management Two investigators independently read all studies and extracted the data from all included studies. The data extracted from the studies were: a) study design; b) country; c) sample type; d) sample size; e) study groups; f) source of bone tissue; g) methods of obtaining; i) staining technique; j) intelligence artificial (IA) type; k) IA evaluation method; l) IA data processing; m) IA analyzed substrate; n) IA analysis type; o) statistical test used; and p) main study outcomes. The extracted data were organized into a table created in Excel. After completing the data extraction, disagreements were discussed and resolved through consensus with the third reviewer.

Reporting results / Analysis of the evidence The studies will be categorized into human and animal studies. A table will be created to outline the characteristics of the included studies and highlight the key information pertinent to the review question. A logical and descriptive summary of the results will be prepared based on the review objective and research question.

Language restriction Yes, only English.

Country(ies) involved Brazil.

Keywords Artificial Intelligence; Machine Learning; Bone Tissue; Histological Technique.

Dissemination plans The results will be published in an international scientific journal and presented at scientific conferences in the field.

Contributions of each author

Author 1 - Eduardo Maciel - Conducted the selection and data extraction process and writing of the manuscript.
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