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Recent advances in orthopedic oncology: 3D printing, multidisciplinary approach, and artificial intelligence: a systematic review protocol

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ADMINISTRATIVE INFORMATION

Support - This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Review Stage at time of this submission - The protocol is being registered retrospectively as the review was conducted as part of an academic graduation project at Faculdade Zarns. The methodological decisions, including eligibility criteria, search strategy, and outcome measures, were established prior to data extraction and analysis. The review was conducted in accordance with PRISMA guidelines. The retrospective registration reflects the academic timeline of the research group and the submission deadline for the SBOT Annual Congress 2026.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202670109

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 28 July 2026 and was last updated on 28 July 2026.

INTRODUCTION

Review question / Objective The primary objective is to synthesize recent evidence on the impact of 3D printing, artificial intelligence (AI), and the multidisciplinary approach in orthopedic oncology, focusing on surgical planning, oncological outcomes, and functional results.

PICO Framework:

- Population: Patients with primary bone tumors and bone metastases.
- Intervention: 3D printing, AI/machine learning, and multidisciplinary team management.
- Comparison: Conventional techniques and non-multidisciplinary care.

- Outcomes: Operative time, blood loss, surgical margin accuracy, local recurrence, diagnostic accuracy, and overall survival.

Rationale Orthopedic oncology faces the challenge of balancing safe oncological margins with maximum functional preservation. Recent advancements like 3D printing and AI offer potential improvements in surgical precision and diagnostic accuracy. Furthermore, multidisciplinary tumor boards are crucial for comprehensive care. A systematic review is needed to evaluate the combined impact of these three pillars on clinical and functional outcomes, guiding future standardized protocols.

Condition being studied Orthopedic oncology, specifically the management of primary bone

tumors (e.g., sarcomas) and bone metastases using advanced technological and multidisciplinary approaches.

METHODS

Search strategy Databases: PubMed, Embase, and Web of Science.

Timeframe: January 2018 to January 2026.

Keywords and MeSH terms: “orthopedic oncology”, “3D printing”, “artificial intelligence”, “machine learning”, “multidisciplinary team”, “bone tumor”, “sarcoma”, “metastasis”.

Participant or population Patients diagnosed with primary bone tumors (such as osteosarcoma, Ewing sarcoma, chondrosarcoma) or bone metastases who require orthopedic and oncological intervention.

Intervention 1. 3D printing technology applied to the creation of intraoperative surgical guides and customized metal implants.

2. Artificial intelligence and machine learning algorithms applied to the analysis of radiological images (MRI, CT) for tumor segmentation and diagnosis.

3. Multidisciplinary tumor board evaluations for treatment planning.

Comparator Standard conventional surgical techniques without 3D planning, traditional radiological evaluation without AI assistance, and clinical management outside of a structured multidisciplinary board.

Study designs to be included Original studies, clinical trials, systematic reviews, and meta-analyses.

Eligibility criteria Inclusion criteria: Original studies, clinical trials, systematic reviews, and meta-analyses published in English, Portuguese, or Spanish, evaluating clinical outcomes (quantitative or qualitative).

Exclusion criteria: Isolated case reports, in vitro studies, non-systematic reviews, and articles that do not evaluate relevant clinical outcomes.

Information sources PubMed, Embase, and Web of Science electronic databases.

Main outcome(s) • Oncological: Local recurrence rates, diagnostic accuracy, overall survival.

• Surgical: Operative time, intraoperative blood loss, surgical margin accuracy, osteointegration of customized implants.

• Clinical: Therapeutic adherence, post-operative complications, prognostic estimation.

Additional outcome(s) Quality of life, functional scores of the affected limb, and cost-effectiveness of the proposed technologies (if data is available).

Data management Data will be extracted by two independent reviewers using a standardized form. Disagreements will be resolved by consensus or by the intervention of a third reviewer. Extracted data will include study characteristics, patient demographics, tumor type, intervention details, and outcome measures.

Quality assessment / Risk of bias analysis The methodological quality and risk of bias will be assessed using the Newcastle-Ottawa Scale (NOS) for observational studies and the Cochrane Risk of Bias tool for randomized clinical trials.

Strategy of data synthesis A qualitative synthesis will be performed. If the clinical and methodological homogeneity of the studies allows, a quantitative meta-analysis will be conducted using appropriate statistical models (fixed or random effects). Heterogeneity will be assessed using the I^2 statistic.

Subgroup analysis Subgroup analyses may be performed based on tumor type (primary vs. metastatic) and the specific technology used (e.g., specific AI algorithms).

Sensitivity analysis Sensitivity analysis will be conducted by excluding studies with a high risk of bias or low methodological quality to assess the robustness of the findings.

Language restriction English, Portuguese, and Spanish.

Country(ies) involved Brazil.

Other relevant information The review will be reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

Keywords Orthopedic Oncology; 3D Printing; Bone Metastasis; Artificial Intelligence; Multidisciplinary Approach.

Dissemination plans The results of this systematic review will be submitted for publication in peer-reviewed medical journals and presented at relevant scientific conferences, such as the SBOT Annual Congress.

Contributions of each author

Author 1 - Julia Quintino - Drafted the manuscript and conceptualized the study.

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