International Platform of Registered Systematic Review and Meta-analysis Protocols

INPLASY

Antimicrobial activity and biocompatibility of 3D-printed denture base resins incorporated with inorganic particles: A systematic review and meta-analysis

INPLASY2025110084
doi: 10.37766/inplasy2025.11.0084
Received: 25 November 2025
Published: 26 November 2025

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Preliminary searches.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY2025110084

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 26 November 2025 and was last updated on 26 November 2025.

INTRODUCTION

Review question / Objective Do 3D-printed denture base resins modified with inorganic particles exhibit improved antimicrobial activity compared to unmodified resins, and do these modifications affect their biocompatibility?
To evaluate whether 3D-printed denture base resins modified with inorganic particles demonstrate improved antimicrobial activity against oral microorganisms compared to unmodified resins, and to assess whether these modifications affect biocompatibility.

Rationale Three-dimensional (3D) printing denture base resins are increasingly used for complete dentures, however the intaglio surface is easily covered by oral biofilm and does not have any natural antimicrobial effect. This surface is often relatively rough and may become even rougher over time due to printing defects, finishing, polishing and brushing, which favors Candida albicans adhesion, biofilm formation and denture stomatitis. To reduce this biofilm, several in vitro studies have added inorganic particles, such as silver-containing fillers, titanium dioxide, zirconia or graphene, to 3D printing resins and reported lower fungal and/or bacterial growth compared with unmodified resins. However, these antimicrobial findings are spread across individual studies and have not been systematically evaluated along with their cytotoxicity to oral cells. A systematic review and meta-analysis focused on the antimicrobial activity of 3D printing denture base resins modified with inorganic particles is therefore needed.

Condition being studied The modification of 3D printing denture base resins with inorganic particles to enhance antimicrobial performance. This includes evaluating how these modifications affect microbial adhesion, biofilm formation and biocompatibility when compared with unmodified 3D printing denture base resins.

METHODS

Search strategy The search strategy will be developed using Medical Subject Headings

(MeSH) and free-text terms related to denture base resins, 3D printing, inorganic particles, antimicrobial activity and biocompatibility outcomes. The initial strategy will be built for MEDLINE (via PubMed) and subsequently adapted for other databases (Embase, Scopus, Web of Science). No date or language restrictions will be applied.

Participant or population Specimens of 3D-printed denture base resins.

Intervention Incorporation of inorganic particles into 3D-printed denture base resins, regardless of particle type, concentration or incorporation method.

Comparator Unmodified 3D-printed denture base resin specimens.

Study designs to be included In vitro studies.

Eligibility criteria
Studies will be included if they meet all the following criteria:
Study design: In vitro experimental studies.
Material: Specimens fabricated from 3D-printed denture base photopolymer resins intended for complete or partial denture bases.
Intervention: Incorporation of inorganic particles into the denture base resin formulation prior to printing.
Comparator: A control group consisting of the same 3D-printed denture base resin without inorganic particle incorporation.
Outcomes: Quantitative assessment of antimicrobial activity, such as colony-forming unit (CFU) counts, biofilm biomass quantification, metabolic/viability assays, microscopy-based quantification or other measurable antimicrobial outcomes.
Microorganisms: Use of oral microorganisms relevant to denture biofilms or denture stomatitis (e.g., Candida albicans, other Candida species, Streptococcus mutans, Staphylococcus aureus, Enterococcus faecalis).
Biocompatibility: Studies evaluating direct or indirect cytotoxicity or cell viability will be included but not required for inclusion if antimicrobial outcomes are present.

Studies will be excluded if they involve:
Coating-based modifications (surface coatings, spraying, brushing, plasma, or other post-processing treatments).
Non-denture-base resins, such as modeling resins, castable resins, and temporary crown resins.
Purely qualitative antimicrobial tests, such as agar diffusion without quantitative measurement.
Studies without a control group using the unmodified 3D-printed denture base resin.
Reviews, case reports, conference abstracts without full text, or non-in vitro designs (in vivo, clinical, ex vivo).

Information sources The search will be conducted in the following electronic databases: MEDLINE (via PubMed), Embase, Scopus and Web of Science. Additional studies will be identified through manual searches and gray literature sources, including the System for Information on Grey Literature in Europe (SIGLE). Conference abstracts and unpublished studies such as theses and dissertations will be retrieved using ProQuest® Dissertations & Theses Global and institutional repositories.

Main outcome(s) Antimicrobial activity of 3D-printed denture base resins modified inorganic particles compared with unmodified specimens. Outcomes will be assessed through microbial adhesion or biofilm formation, colony-forming unit (CFU) counts, morphology of microorganisms, microbial proliferation, and metabolic or viability assays related to microbial growth. When reported, data will be extracted as mean and standard deviation or equivalent quantitative measures. Methods of microbial assessment (e.g., CFU quantification, biofilm biomass analysis, or microscopy-based measurements) will be collected as described in each study and standardized for comparison when possible.

Additional outcome(s) Biocompatibility of 3D-printed denture base resins modified with inorganic particles, assessed through direct or indirect cytotoxicity, cell morphology, cell proliferation, cell metabolism, or cell viability using relevant cell lines. Biocompatibility outcomes will be extracted according to the assays used (e.g., MTT, AlamarBlue, PrestoBlue, LDH, live/dead staining), and quantitative results such as viability percentage, absorbance, fluorescence intensity, or normalized metabolic activity will be recorded.

Data management All obtained references will be exported to a reference manager (EndNote Web) and subsequently imported into Rayyan (platform for systematic review management) for study selection. Screening will be conducted in two phases: first by titles, then by abstracts. Full-text articles will be retrieved for all potentially eligible studies and assessed according to the predefined inclusion criteria. Studies meeting the criteria will be used for data extraction, management and

subsequent analysis. This process will be performed independently by two reviewers, with disagreements resolved by a third reviewer.

Quality assessment / Risk of bias analysis Risk of Bias analysis will be evaluated using the QUIN Tool. Each of its 12 items will be scored as 2, 1 or 0, with non-applicable items excluded. Final percentage scores will classify studies as low (>70%), medium (50–70%) or high RoB (<50%). Two reviewers will assess studies independently, with a third resolving disagreements.

Strategy of data synthesis Data will be synthesized using both qualitative and quantitative approaches. The qualitative synthesis will describe study characteristics, types of inorganic particles and biological outcomes. When at least two studies report comparable outcome measures, a meta-analysis will be performed. Depending on the consistency of measurement units, pooled effects will be calculated using either weighted mean difference (WMD) or standardized mean difference (SMD). Random-effects models will be applied due to the expected methodological and biological variability among studies.

Subgroup analysis Subgroup analyses will be conducted when sufficient data are available to explore potential sources of heterogeneity. These analyses will consider the type and concentration of inorganic particles incorporated into the resin, the type of microorganism evaluated, and the specific antimicrobial or cytotoxicity outcome measured. Additional subgroups may be examined if patterns in the data suggest other relevant moderator variables.

Sensitivity analysis The leave-one-out approach will be used, sequentially excluding each study to evaluate its influence on effect sizes and heterogeneity. In addition, analyses will be repeated after excluding studies classified as high risk of bias to determine whether the overall conclusions remain consistent.

Language restriction No restriction will be imposed.

Country(ies) involved Brazil.

Other relevant information None.

Keywords 3D printing; denture base resins; inorganic nanoparticles; antimicrobial activity; biofilm; Candida albicans; cytotoxicity; biocompatibility.

Dissemination plans Publication of the findings in high-impact peer-reviewed journals, as well as dissemination at local, regional and international dental research events. Results will also be shared with research groups and through academic and professional social media platforms.

Contributions of each author

Author 1 - Pedro Salvajoli-Dias - Author 1 will participate in all stages of the systematic review, including study selection, data extraction and risk of bias assessment and will be responsible for drafting the manuscript.
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Author 2 - Vinícius Pereira-de-Oliveira - Author 2 will contribute to study selection, data extraction and risk of bias assessment.
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Author 3 - Amanda Ferro - Author 3 will provide methodological expertise, resolve disagreements between the primary reviewers and review and contribute to the writing of the manuscript.
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Author 4 - Janaina Jorge - Author 4 will contribute as the field expert, assisting in defining the research question, supporting protocol registration, guiding data extraction and contributing to the writing of the manuscript.
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