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Characteristics of Acrylic Produced Additively by 3D Printing in Dentistry: Comparison of Mechanical and Surface Parameters - A Systematic Review with Meta-Analysis of Novel Reports

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ADMINISTRATIVE INFORMATION

Support - None reported.

Review Stage at time of this submission - Completed but not published.

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 12 August 2025 and was last updated on 12 August 2025.

INTRODUCTION

Review question / Objective Population (P): Acrylic resin specimens fabricated using 3D printing techniques; Intervention (I): Evaluation of mechanical and surface properties; Comparison (C): Additively manufactured 3D-printed specimens versus conventionally fabricated specimens; Outcomes (O): Quantitative values of assessed mechanical and surface characteristics; Study design (S): In vitro studies.

Rationale The objective of this systematic review is to compare the mechanical and surface properties of denture bases fabricated using conventional polymerization techniques with those produced through 3D printing. Specifically, this review seeks to determine whether contemporary additive manufacturing materials and methods can constitute a viable alternative to traditional acrylic denture fabrication in terms of durability, functional performance, and clinical safety.

Condition being studied For a material to be effectively utilized in the fabrication of denture bases, it must demonstrate appropriate mechanical properties. Among the most critical are:
- Impact strength - the ability of a material to absorb energy from sudden impacts. Brittle materials exhibit low impact strength, whereas more elastic materials demonstrate higher values. This parameter determines a denture's resistance to fracture caused by accidental drops or masticatory stresses.
- Surface hardness - the resistance of a solid surface to deformation caused by abrasion or indentation by a harder material. In the context of removable dentures, hardness influences the prosthesis' resistance to wear and deformation under occlusal forces.
- Surface roughness - the presence of microscopic surface irregularities resulting from the manufacturing process. This characteristic is particularly important for acrylic resins. A rough denture base surface promotes the accumulation of pathogenic microorganisms, which can

adversely affect surrounding oral tissues. Furthermore, higher surface roughness reduces esthetic quality by facilitating pigment penetration into the porous surface.
These parameters are critical for ensuring the durability and functional performance of denture bases, and therefore serve as fundamental benchmarks in evaluating the clinical suitability of novel 3D-printed materials.

METHODS

Search strategy Search string: (resins OR base resins) AND 3D AND print AND denture databases: PubMed (PMC), Scopus, Web of Science and Embase.

Participant or population Population (P): Acrylic resin specimens fabricated using 3D printing techniques.

Intervention Intervention (I): Evaluation of mechanical and surface properties.

Comparator Comparison (C): Additively manufactured 3D-printed specimens versus conventionally fabricated specimens.

Study designs to be included In-vitro studies.

Eligibility criteria This systematic review applied the following inclusion criteria:
Type of study: in vitro studies;
Outcome measures: surface properties such as surface roughness, and mechanical properties including hardness, elasticity, impact strength, and elastic modulus;
Subject of investigation: comparison of mechanical and surface properties of acrylic materials fabricated by 3D printing versus conventional methods;
Material focus: acrylic materials.

Information sources Databases: PubMed (PMC), Scopus, Web of Science and Embase.

Main outcome(s) The applied search strategy initially identified 942 potential articles: 227 from PubMed and PubMed Central, 70 from Embase, 265 from Web of Science, and 380 from Scopus. After the removal of 277 duplicates, 665 articles remained for screening. Subsequently, 594 records were excluded as irrelevant to the review topic.
Of the remaining 71 studies, one article was excluded due to unavailability in online databases. An additional 38 articles were excluded because they focused on properties of acrylic materials unrelated to the scope of this review. Five articles were rejected because their results could not be accurately extracted, as the data were reported exclusively in graphical form. The final exclusion involved 12 studies that did not include the required control group of conventionally fabricated heat-polymerized acrylic resin denture bases; instead, they used pressure- or injection-molded acrylic resins.
Ultimately, 15 studies - all in vitro experiments - met the inclusion criteria and were analyzed.

Additional outcome(s) None reported.

Data management We have used Zotero and Mendeley tool.

Quality assessment / Risk of bias analysis To evaluate the risk of bias in the included studies, a study-type-specific quality assessment scale-the Quality Assessment Tool for In Vitro Studies conducted in dentistry (QUIN Tool) - was employed. The selection of the QUIN Tool was based on its alignment with the search criteria and its relevance to in vitro research in dentistry, thereby ensuring a high level of precision in bias evaluation.

Strategy of data synthesis In the data synthesis, emphasis was placed on extracting information regarding specific mechanical and surface properties—namely surface hardness and roughness, elastic modulus, and impact strength. Quantitative data were expressed as mean ± standard deviation (SD) using SI units (e.g., Vickers Hardness Number [VHN], megapascals [MPa], micrometers [μm], kilojoules per square meter [kJ/m^2]) in accordance with the original reporting of the analyzed studies. Where different studies reported results using varying units, conversions were performed to standardize the data, enabling direct comparison. Whenever possible, pooled data were presented in tabular form. Due to the limited amount of data related to impact strength, a narrative synthesis was employed for this parameter instead of a meta-analysis. The analysis focused on a qualitative comparison of the results, identifying common trends and discrepancies acrossstudies.

Subgroup analysis We have performed 3 meta-analyses according to each of mechanical parameters: hardness, surface roughness, elastic modulus.

Sensitivity analysis Meta-analysis was performed with the R version 4.4.2 statistical program using a random-effect model via metafor R package. Mean difference (MD) was calculated as an effect

estimate. Heterogeneity was assessed quantitatively using I2-statistics and Cochran's Q. The results were considered statistically significant at $p<0.05$. Publication bias was estimated using funnel plot and carrying Egger's test of its asymmetry.

Language restriction No restrictions included.

Country(ies) involved Poland.

Keywords resins; base resins; acrylic; 3D printing; additive manufacturing; dentures; mechanical parameters; surface parameters.

Dissemination plans None reported.

Contributions of each author

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