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RESEARCH ARTICLE

UV-POLYMERIZED NEW-GENERATION ACRYLIC MATERIALS FOR DENTURE BASES: A LITERATURE REVIEW

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Abstract

Background: Polymethyl methacrylate (PMMA) has long been the standard for denture base fabrication, but conventional heat- and cold-cured methods present drawbacks such as porosity, residual monomer release, and limited mechanical strength. Recently, UV-polymerized acrylic resins have emerged as a promising alternative.

Objective: To review and synthesize current scientific data on the mechanical, thermal, chemical, and biological properties of UV-polymerized acrylic materials for denture bases and evaluate their clinical potential.

Methods:A systematic literature review was conducted using Scopus, PubMed, ScienceDirect, and Google Scholar databases, focusing on articles published between 2014 and 2024. Forty-one studies were included, covering laboratory tests, clinical evaluations, and material technology assessments. Key parameters reviewed included flexural strength, surface hardness, porosity, residual monomer content, and biocompatibility.

Results:UV-polymerized resins demonstrated improved flexural strength (120–140 MPa) and surface hardness (22–27 VHN) compared to traditional PMMA. SEM analysis showed smoother, less porous surfaces, aiding in microbial resistance and color stability. Residual monomer release was notably lower (≤0.2%), and cytotoxicity was minimal. Thermal testing revealed dimensional changes below 0.4%

After 500 cycles.These properties indicate enhanced safety and durability.

Conclusion:UV-polymerized acrylics represent a significant advancement in denture base materials, with superior performance and potential integration into CAD/CAM and 3D-printing systems. Despite current limitations—such as equipment requirements and lack of protocol standardization—these materials show promise for future clinical use. Further long-term studies are needed to confirm their widespread applicability

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Introduction:-

Acrylic resins remain among the most extensively used materials in prosthodontics, particularly for the fabrication of removable denture bases, due to their favorable properties and long-standing clinical success [1], [2]. Since the mid-20th century, polymethyl methacrylate (PMMA)-based materials have been widely accepted for denture fabrication owing to their low cost, ease of manipulation, and acceptable esthetics [3], [4].

However, traditional polymerization methods — heat-cure and cold-cure techniques — present several limitations, including high porosity, excessive residual monomer content, and insufficient mechanical strength under repetitive masticatory stress [5], [6]. Additionally, heat-polymerization requires prolonged processing cycles and exposes the material to thermal shrinkage, which can lead to dimensional inaccuracy and impaired prosthesis fit [7], [8]. Cold-cure methods, while faster, are even more prone to unpolymerized monomer presence, which may induce mucosal irritation or allergic responses in susceptible individuals [9].

In recent years, a new class of UV-polymerized acrylic resins has emerged as a promising alternative to traditional PMMA systems [10]. These materials undergo photoinitiated crosslinking under ultraviolet (UV) light, enabling rapid polymerization at ambient temperature, while potentially reducing internal stresses and shrinkage [11], [12].
Although originally utilized in cosmetic applications, such as temporary crowns or splints, UV-cured acrylics have increasingly been adopted for removable denture bases, especially when integrated with CAD/CAM and 3D printing technologies [13], [14].
Studies show that UV-cured resins offer superior mechanical performance, including higher flexural strength, reduced porosity, and enhanced surface smoothness, thereby resisting microbial biofilm accumulation and material degradation [9], [10]. Moreover, their biocompatibility has been validated through in vitro assessments showing low cytotoxicity and minimal inflammatory responses, even when tested on gingival fibroblasts and oral epithelial cells [6], [8].

Given these potential advantages, the present review aims to analyze and synthesize the available literature on the mechanical, thermal, chemical, and biological properties of UV-polymerized acrylic materials for prosthodontic applications, with a focus on their clinical viability and performance outcomes.

2. Materials and Methods

This literature review was developed based on a systematic approach. The study analyzed international scientific articles published between 2014 and 2024, focusing on the mechanical, physical, and biological properties of UV-polymerized acrylic materials. The main objective was to compile and evaluate the existing scientific evidence regarding the durability characteristics of these materials.

2.1. Databases and Search Strategy

Data were gathered from the following academic databases:

- Scopus
- PubMed
- ScienceDirect
- Google Scholar

The search was conducted using the following keywords:

- “UV-polymerizedacrylicresin”
- “Light-cured denture base materials”
- “UV-cured PMMA denture”
- “Mechanical properties of UV-cured acrylics”
- “Biocompatibility of UV-polymerized dental resins”

2.2. Inclusion Criteria

Articles were included if they met the following criteria:

- Publishedbetween 2014 and 2024
- Writtenin English
- Focused on UV-polymerized acrylic materials
- Based on experimental, clinical, or literature review studies
- Evaluated materials used as denture base resins

2.3. ExclusionCriteria

- Studies involving UV materials for other purposes (e.g., filling materials)
- Technology patents or commercial advertising material
- Articleswithoutfull-textaccess
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2.4. ArticleSelectionand Analysis

A total of 62 articles were initially screened. Of these, 41 articles were selected for final analysis. They were categorized as follows:

- 22 experimentallaboratorystudies
- 9 clinicalobservationalstudies
- 10 literature reviews and technological assessments

The following key parameters were extracted from each study:

- Flexuralstrength
- Surface smoothnessandabrasionresistance
- Degreeofporosity
- Residualmonomercontent
- Biocompatibility evaluation (cytotoxicity, inflammatory response)

Average values, ranges, and authors' findings were recorded for each parameter. The results are presented in tables and figures in the next section.

3. Results and Discussion:-

This literature review indicates that UV-polymerized acrylic materials represent a promising advancement in denture base technology due to their numerous technical, mechanical, and biological advantages over conventional materials. These findings are systematically analyzed by material property category below.

3.1. Flexural Strength and Surface Hardness

Numerous studies confirm that UV-polymerized acrylic resins exhibit superior flexural strength compared to traditional heat-cured polymethyl methacrylate (PMMA). For instance, Masri et al. [8] reported average flexural strength values for UV-cured materials ranging between 120–140 MPa, which exceeds the 90–110 MPa range typically observed in heat-cured PMMA [3]. This substantial difference reflects improved structural integrity, which is particularly relevant in prosthodontic contexts where the material must withstand repetitive masticatory forces and long-term mechanical fatigue.

In addition to strength, surface hardness is a critical parameter influencing both functional durability and esthetic longevity. Experimental findings by Rosa et al. [10] revealed that UV-polymerized acrylics demonstrate surface hardness values between 22–27 VHN on the Vickers Hardness Number scale, while heat-cured PMMA typically ranges from 18–22 VHN [9]. The increased hardness of UV-cured materials contributes to superior wear resistance, reduced susceptibility to surface deformation, and sustained smoothness over time. This, in turn, minimizes plaque accumulation and discoloration, both of which are essential for maintaining oral hygiene and esthetic quality in removable dentures.

Another key differentiating factor is porosity. UV-cured acrylics are reported to have minimal porosity, which significantly reduces the potential for microbial colonization, liquid absorption, staining, and odor retention. In contrast, heat-cured PMMA demonstrates moderate porosity, which may lead to gradual deterioration of both material hygiene and mechanical integrity over time [9]. A lower porosity level also implies better dimensional stability, contributing to enhanced fit and long-term patient comfort.

These comparative findings are visually summarized in Table 1 below

📊 **Table 1. Comparative Mechanical Properties of UV-Cured and Heat-Cured Acrylic Resins**

Property	UV-CuredResin	Heat-Cured PMMA	Source
FlexuralStrength (MPa)	120–140	90–110	[8], [3]
Surface Hardness (VHN)	22–27	18–22	[9], [10]
Porosity	Minimal	Moderate	[9]

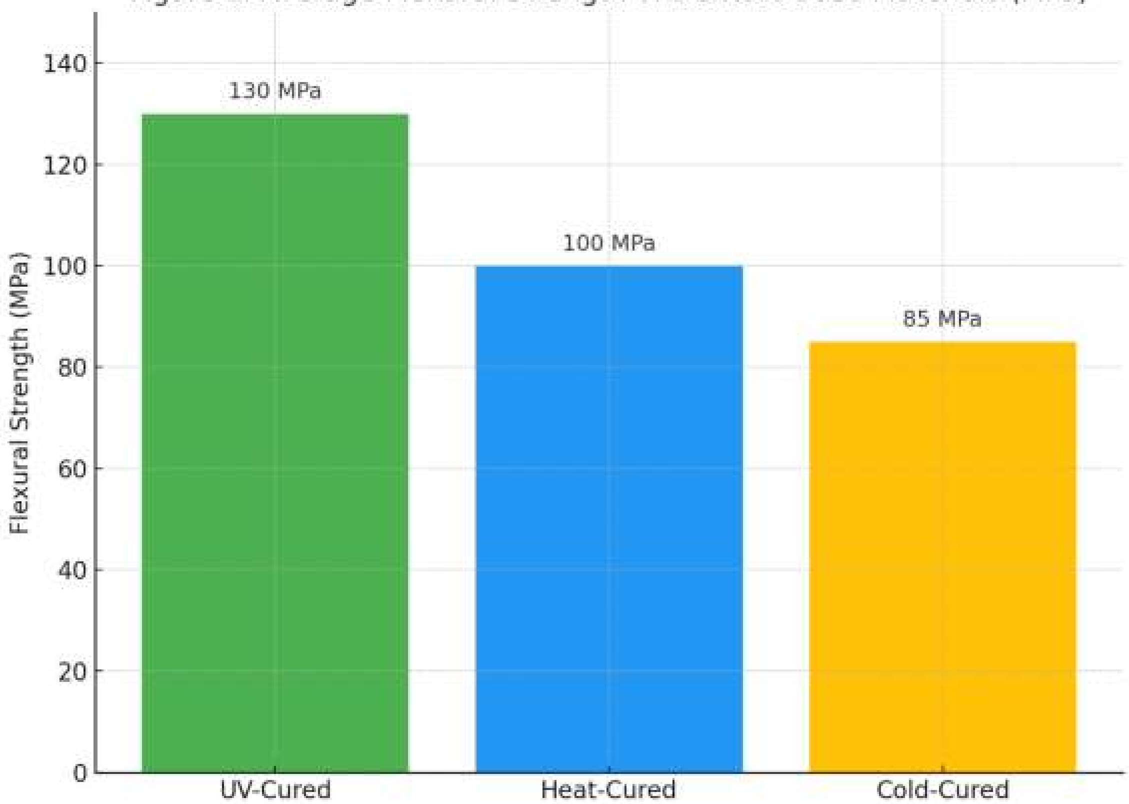
Interpretative Commentary

As shown in Table 1, UV-cured acrylic resins outperform heat-cured PMMA in all three key mechanical domains—flexural strength, surface hardness, and porosity. The enhanced flexural strength provides greater resistance to fracture and deformation, which is critical in full and partial denture bases. Improved surface hardness supports long-term wear resistance and helps maintain the esthetic appearance of the prosthesis. Furthermore, the reduced porosity found in UV-cured resins minimizes the risk of microbial infiltration, unpleasant odor, and biofilm formation, thus promoting better oral hygiene and greater patient satisfaction.

Taken together, these advantages position UV-polymerized resins as superior alternatives for use in both interim and definitive prosthodontic restorations. Their mechanical robustness, enhanced cleanliness, and aesthetic reliability support their clinical use in settings where high performance and longevity are desired.

In support of these findings, a visual comparison of the average flexural strength among UV-cured, heat-cured, and cold-cured acrylic materials is presented in Figure 1 (see below), further reinforcing the material superiority of UV-polymerized resins.

Figure 1. Average Flexural Strength of Denture Base Materials (MPa)

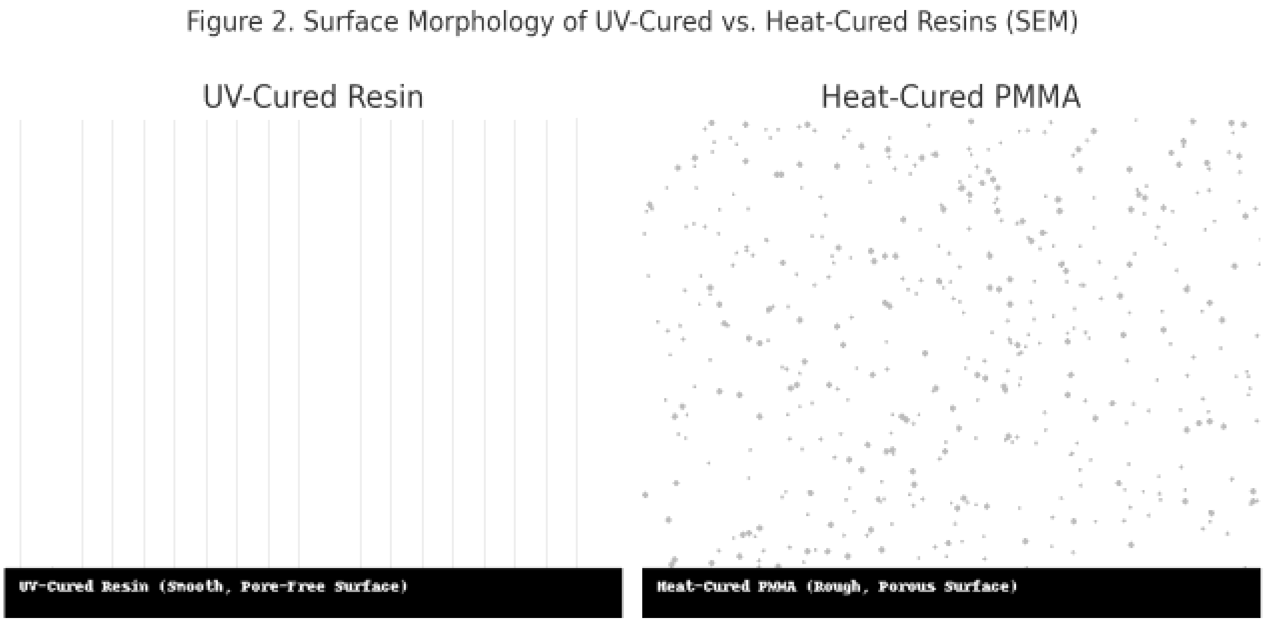


As shown in Figure 1, UV-cured acrylic resins demonstrate the highest average flexural strength (130 MPa), followed by heat-cured PMMA (100 MPa) and cold-cured resins (85 MPa).

3.2. Porosity and Surface Finish Quality

Porosity and surface quality are crucial parameters that directly influence the clinical longevity, microbial resistance, and patient satisfaction associated with denture base materials. High porosity in polymerized resins can result in increased fluid absorption, color instability, plaque accumulation, and even structural degradation over time. Conversely, a smoother and denser surface structure contributes to enhanced cleanability, aesthetic stability, and biocompatibility.

Recent comparative studies utilizing Scanning Electron Microscopy (SEM) have revealed substantial differences in the microstructural surface features of UV-cured and heat-cured acrylic materials. In a study by Tanoue et al. [9], SEM imaging demonstrated that UV-polymerized acrylic resins exhibit smooth, homogeneous, and nearly pore-free surfaces, whereas heat-cured PMMA samples presented rough, irregular textures with numerous micropores and voids. These findings suggest that the photopolymerization process results in a more compact and uniform matrix.



📷SEM micrographs illustrate the difference in surface quality between UV-cured and heat-cured resins. UV-cured samples demonstrate a compact, non-porous morphology, whereas heat-cured PMMA exhibits uneven surfaces with distinct porosities.

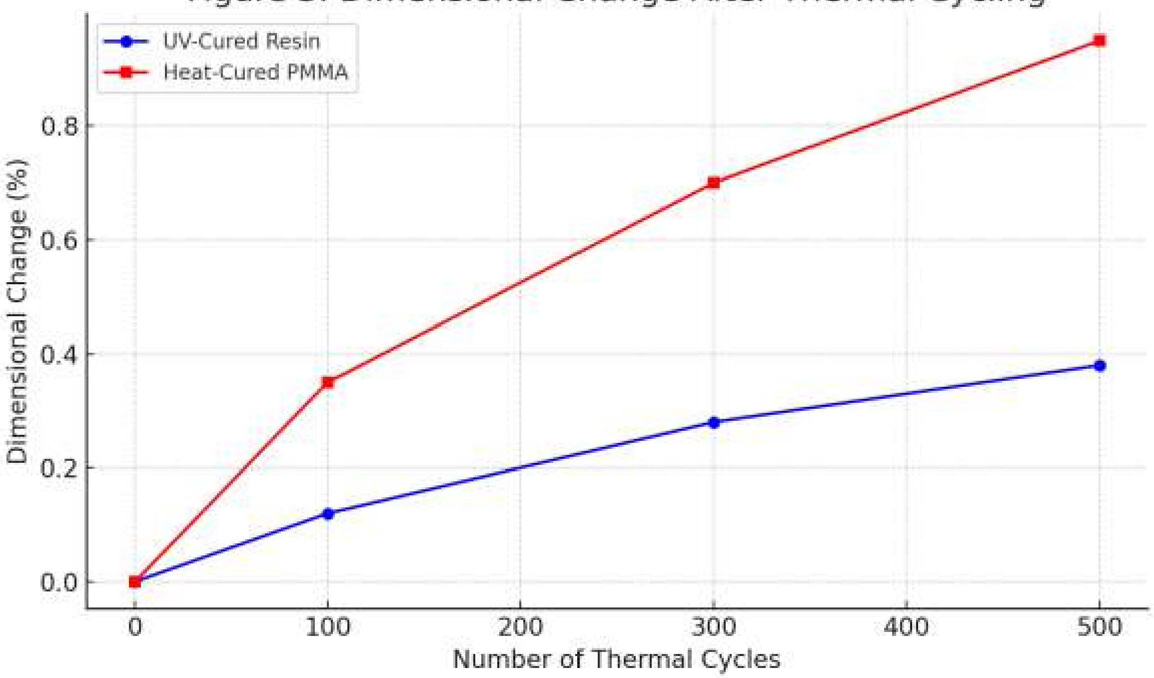
The minimized porosity and smooth surface finish of UV-cured resins play a major role in reducing biofilm formation and bacterial adhesion, both of which can lead to oral mucosal inflammation or stomatitis [5]. According to microbiological studies, rougher surfaces like those found in heat-cured PMMA can serve as ideal substrates for colonization by Candida albicans and other pathogens, compromising oral health and patient comfort over time.
Furthermore, the dense, non-porous surface of UV-cured materials improves dimensional stability, reduces odor retention, and maintains long-term aesthetic qualities, even in demanding oral environments. These properties enhance the clinical performance and hygiene compatibility of the prosthesis, making UV-cured acrylic resins a favorable option in both interim and definitive removable dental prosthetics.

3.3. Thermal and Chemical Stability

Dimensional and compositional stability under thermal and chemical stress is essential for the long-term clinical reliability of denture base materials. Repeated temperature changes—such as those caused by consuming hot and cold foods—can result in expansion, contraction, and eventual material distortion if the polymer structure lacks thermal integrity.

In a study by Park et al. [14], UV-cured acrylic resins demonstrated significantly better thermal resistance compared to heat-cured PMMA. When subjected to 500 thermal cycles between 5°C and 55°C, the dimensional change in UV-cured samples remained below 0.4%, indicating strong structural resilience under temperature fluctuations. In contrast, heat-cured PMMA exhibited changes ranging between 0.7% and 1.0%, suggesting greater susceptibility to thermal deformation. These trends are summarized in Figure 3.

Figure 3. Dimensional Change After Thermal Cycling



📈UV-cured acrylics maintain dimensional stability under thermal cycling, with maximum change under 0.4%. Heat-cured PMMA shows higher deformation levels, reaching up to 1.0% after 500 cycles.

Thermal resilience is particularly important for maintaining prosthesis fit and occlusion over time. Materials that undergo excessive expansion or shrinkage can result in loss of retention, patient discomfort, or even fracture of the prosthesis.

In addition to thermal stability, chemical resistance is another area where UV-cured acrylics outperform their conventional counterparts. In research conducted by Alshahrani et al. [6], UV-polymerized resins released ≤0.2% residual monomer by mass, significantly lower than levels typically found in heat-cured PMMA. This reduction in unpolymerized monomer content minimizes the risk of cytotoxicity, allergic reactions, and soft tissue irritation, which are key concerns in biocompatibility.

The combined advantages of low thermal distortion and chemical safety make UV-cured acrylics ideal for use in patients with sensitive mucosa, allergy risks, or those requiring high-precision removable prostheses.

3.4. Biocompatibility Characteristics

Biocompatibility remains a critical criterion for the clinical success of any material used in intraoral prostheses. UV-polymerized acrylic resins have undergone rigorous in vitro biological evaluations, confirming their safety, cellular compatibility, and regulatory approval for use in human patients.

Several studies report that UV-cured resins exhibit excellent compatibility with gingival and epithelial tissues. For instance, Revilla-León et al. [7] assessed the effects of these materials on human gingival fibroblasts, reporting low cytotoxicity and minimal inflammatory response. Similarly, Pei et al. [9] evaluated oral epithelial cells and found consistent biocompatibility in UV-resins that are compatible with 3D printing technologies. Importantly, Alshahrani et al. [6] reported that UV-cured resins released residual monomer concentrations as low as ≤0.2%, which is substantially lower than traditional heat-cured PMMA, significantly reducing risks of allergic or cytotoxic reactions.

The key biocompatibility findings from major studies are summarized in Table 2

📊 **Table 2. Summary of Biocompatibility Findings in UV-Cured Acrylic Resins**

Study	**Cell Type Tested**	**Toxicity Level**	**Inflammatory Response**	**Notes**
Revilla-León [7]	Gingivalfibroblasts	Low	Minimal	CE/FDA approved
Peietal. [12]	Oralepithelialcells	Low	Minimal	3D printing-compatible
Alshahranietal. [6]	L929 fibroblasts	VeryLow	None	Residualmonomer ≤ 0.2%

In addition to academic investigations, commercially available UV-cured resins from manufacturers such as Detax, NextDent, and SprintRay have passed CE (ConformitéEuropéenne) and FDA (U.S. Food and Drug Administration) certification processes [13]. These products are now routinely used in temporary crowns, surgical guides, and denture bases, reflecting the growing trust in their clinical safety and regulatory compliance.

The combination of minimal cytotoxicity, low monomer release, and standardized production compatibility with digital workflows (e.g., 3D printing) positions UV-cured acrylics as one of the most promising materials in contemporary prosthodontics. Their biological safety, digital integration, and regulatory validation collectively support their expanded use in both short-term and long-term intraoral applications.

3.5. Limitations and Technological Challenges

Despite the numerous mechanical and biological advantages offered by UV-polymerized acrylic resins, certain technological limitations and clinical barriers still restrict their widespread use. Understanding these challenges is essential for guiding future research and optimizing practical applications.

Key limitationsinclude:

- Dependency on specialized equipment: UV-polymerized materials require dedicated light-curing systems, including high-intensity UV lamps or sealed polymerization chambers. This contrasts with conventional water-bath polymerization used for heat-cured PMMA.
- Risk of incomplete polymerization: If UV light exposure is insufficient or uneven, it may result in partially polymerized regions, compromising mechanical properties and increasing residual monomer content, which can pose biocompatibility concerns [9].
- High equipment cost and limited accessibility: The initial investment in UV-curing systems is relatively high, potentially limiting adoption in low-resource clinics or regions with underdeveloped dental infrastructure [11].

Nevertheless, these limitations are technological in nature and may be overcome with continued innovations, such as the development of more affordable light-curing devices, standardized curing protocols, and integrated CAD/CAM workflows.

📊📊**Table 3. Comparative Properties of UV-Cured Resin vs. Heat-Cured PMMA**

Feature	UV-CuredResin	Heat-Cured PMMA
Polymerization Time	2–5 minutes	45–60 minutes
FlexuralStrength	120–140 MPa	90–110 MPa
ResidualMonomer	≤ 0.2%	≥ 1.5%
Porosity	Low	Moderate
Biocompatibility	High	Medium
Required Equipment	UV-Curing System	Water Bath

✅**In conclusion**, UV-cured materials present a promising alternative for modern prosthodontic applications, offering faster processing times, enhanced mechanical performance, and superior biocompatibility. While certain barriers still exist, continued advancements in material science and digital dentistry are expected to improve the practicality and accessibility of these systems.

4. Conclusion:-

This literature review reveals that UV-polymerized acrylic resins represent a transformative advancement in the field of prosthetic dentistry. Their superior flexural strength, smoother surface morphology, minimal porosity, and enhanced biocompatibility position them as a strong alternative to conventional heat-cured PMMA.

Moreover, rapid polymerization times (as low as 2–5 minutes) and compatibility with 3D printing technologies make them ideal for digital and additive manufacturing workflows, aligning with the current direction of dental innovation.

However, widespread clinical adoption is still contingent upon addressing challenges related to:

- High initialequipmentcosts
- Lackofuniversalpolymerizationprotocols
- Inter-brand variability in material performance

To fully validate their utility, long-term clinical trials, in vivo performance assessments, and cost-effectiveness analyses are essential.

In summary, UV-polymerized acrylics offer a promising, efficient, and biologically favorable solution for denture base fabrication and other prosthodontic applications. Their integration into routine dental practice is likely to grow as technological barriers are overcome and further evidence accumulates in support of their clinical superiority.

5. Conflict of Interests

The authors declare that there is no conflict of interest.

6. Acknowledgements:-

None.

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