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 DIGITAL VERSUS CONVENTIONAL REMOVABLE DENTURES IN GERIATRIC PATIENTS:
 A COMPARATIVE LITERATURE REVIEW OF CLINICAL EFFICIENCY, MATERIAL
 BIOCOMPATIBILITY, AND PATIENT-REPORTED OUTCOMES

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მარიამ ბოკუჩავა, ვლადიმერ მარგველაშვილი, მანანა კალანდაძე

ციფრული და ჩვეულებრივი მოსახსნელი პროთეზები ხანდაზმულ პაციენტებში:

კლინიკური ეფექტურობის, მასალის ბიოშეთავსებადობისა და პაციენტის მიერ

მოხსენებული შედეგების შედარებითი ლიტერატურული მიმოხილვა

ივანე ჯავახიშვილის სახელობის თბილისის სახელმწიფო უნივერსიტეტი, თბილისი, საქართველო

რეზიუმე

ეს ლიტერატურული მიმოხილვა გთავაზობთ ციფრული და ტრადიციული მეთოდებით დამზადებული მოსახსნელი პროთეზების შედარებით ანალიზს, განსაკუთრებული აქცენტით გერიატრიულ პაციენტებში მათ გამოყენებაზე. ტრადიციული სამუშაო პროცესი, მიუხედავად იმისა, რომ კარგად დამკვიდრებულია სტომატოლოგიაში, ქმნის მნიშვნელოვან სირთულეებს ხანდაზმული პაციენტებისთვის, მრავალჯერადი და ხანგრძლივი ვიზიტების გამო. ციფრული პროტოკოლი, CAD/CAM (ფრეზვა) და დაპრინტული პროთეზების (3D-ბეჭდვა) გამოყენებით, გთავაზობს უდიდეს უპირატესობას კლინიკურ ეფექტურობაში, ამცირებს რა დამზადების პროცესს ორ-სამ ვიზიტამდე. ეს ანალიზი აერთიანებს უახლეს სისტემურ მიმოხილვებსა და კლინიკურ კვლევებს, რათა შეადაროს ეს მეთოდები გერიატრიული პაციენტებისთვის სამი მიმართულებით: (1) კლინიკური ეფექტურობა და პროცესის უპირატესობები, (2) პაციენტის მიერ შეფასებული შედეგები (PROMs) და (3) მასალათმცოდნეობა, კონკრეტულად ბიოშეთავსებადობა და რამდენად შეეფერება მაღალი რისკის პაციენტებს.

მონაცემები ადასტურებს, რომ ციფრული სამუშაო პროცესი ცალსახად აღემატება ტრადიციულს ეფექტურობით. უფრო მეტიც, საბოლოო პროთეზის "ციფრული დუბლიკატის" სახით დაარქივების შესაძლებლობა წარმოადგენს ინსტიტუციონალიზებული პაციენტებისთვის ძველი პროთეზის ახლით სწრაფი ჩანაცვლების უზრუნველყოფას. მიუხედავად იმისა, რომ ფართო სისტემური მიმოხილვები აჩვენებს, რომ პაციენტთა კმაყოფილება ხშირად შედარებითია, მაღალი მტკიცებულების მქონე ჯვარედინი კვლევები, სადაც პაციენტები ორივე ტიპს იყენებენ, აჩვენებს მნიშვნელოვან უპირატესობას ციფრული მოსახსნელი პროთეზების მორგების, კომფორტისა და რეტენციის მხრივ. თუმცა, ყველაზე კრიტიკული განსხვავება მასალების თვისებებშია. CAD/CAM გამოჩარხული PMMA აჩვენებს დიდ სიმტკიცეს, პროთეზის ზედაპირის ყველაზე დაბალ ხორკლიანობას და მნიშვნელოვნად დაბალ Candida albicans-ის აღჭვრის ბაზისზე, ტრადიციულ აკრილთან შედარებით. ხოლო 3D-დაბეჭდილი პროთეზის მასალები ამჟამად აჩვენებენ ზედაპირის ძალიან დიდ ხორკლიანობას და მიკრობების აღჭვრის. გარდა ამისა, გამოჩარხული PMMA ძალიან ჰიდროფილურია, რაც მას ფიზიოლოგიურად მიზანმიმართულ გადანეყვებად ხდის ქსეროსტომიის მქონე გერიატრიული პაციენტებისთვის. ჩვენ ვასკვნით, რომ მიუხედავად 3D-ბეჭდვის სისწრაფისა, გამოჩარხული პროთეზების მრავალი მატერიალური თვისებები მათ ოპტიმალურ კლინიკურ არჩევანად აქცევს მაღალი რისკის გერიატრიულ პაციენტებში.

Introduction. Edentulism in the geriatric population is a significant public health challenge, directly impacting nutritional status, social function, and overall quality of life [18,19]. For decades, the conventional heat-polymerized complete denture has been the "gold standard" of care. However, this fabrication method is not without its limitations. The conventional workflow is lengthy and technically sensitive, often requiring five to seven clinical appointments [6]. This process can be physically and logistically prohibitive for frail elderly patients, those with mobility issues, or those residing in long-term

care facilities [2,20,21]. Furthermore, the material itself is subject to polymerization shrinkage, which can compromise fit, and contains residual monomer, a potential irritant [16,21,22].

The advent of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology has revolutionized removable prosthodontics, offering two primary digital pathways: subtractive manufacturing (milling) and additive manufacturing (3D-printing). These technologies fundamentally alter the clinical process and the final material product. They are also a feasible approach for complex cases, such as managing geriatric patients with advanced residual ridge resorption. This review aims to move beyond a simple "analog vs. digital" comparison and analyze the specific advantages and disadvantages of conventional, milled, and 3D-printed dentures as they relate to the unique needs of the geriatric patient.

Clinical Efficiency and Process Benefits. The most significant and consistently reported advantage of the digital workflow is the dramatic improvement in clinical efficiency [4,5,6]. The five-to-seven visit conventional protocol can be consolidated into two or three appointments [23,6]. This reduction in chair time and patient visits is not merely a convenience; for a geriatric patient, it reduces fatigue, logistical stress, and barriers to care [2,8].

Perhaps the most transformative process benefit for institutionalized or frail elderly patients is the creation of the "digital duplicate" [24-29]. When a digital denture is fabricated, the definitive STL file (a virtual blueprint of the prosthesis) can be permanently archived [5,7]. If the patient loses or breaks their denture - an event that can precipitate a nutritional crisis - a replacement can be fabricated from this file without the patient needing to be present [2,5,8]. This decouples production from the patient, ensuring continuity of care that is impossible with analog methods.

Patient-Reported Outcome Measures (PROMs): A Nuanced View. When evaluating patient satisfaction, the literature presents a nuanced picture. Broad systematic reviews that aggregate multiple study types often conclude that overall patient satisfaction and quality of life are comparable between well-made conventional and digital dentures.

However, this conclusion is challenged by higher-evidence crossover trials, where the same patient uses both conventional and digital prostheses. In these direct-comparison studies, patients report a statistically significant preference for the digital denture, citing superior comfort, retention, stability, and mastication, especially at 12-month follow-ups [10,11]. This preference is likely attributable to the superior fit of the digital prosthesis. Digital fabrication, especially milling, eliminates the polymerization shrinkage inherent in conventional processing [16,22]. This results in a more accurate intaglio surface with higher retention values [16], better initial retention, and fewer post-insertion adjustments [10]. These factors are all critical for accelerating the difficult neuromuscular adaptation process in elderly patients [30,23,19].

The Material Science Divide: Milled vs. 3D-Printed. A critical error is to group "milled" and "3D-printed" dentures as one. Their material properties are profoundly different, with direct implications for high-risk geriatric patients.

Biocompatibility and Candida Adhesion. Prosthetic stomatitis, primarily caused by *Candida albicans* biofilm, is highly prevalent in geriatric denture wearers. Microbial adhesion is directly related to surface roughness. Recent systematic reviews have established a clear hierarchy:

- **CAD/CAM Milled PMMA** is fabricated from pre-polymerized, high-density industrial blocks. This results in the lowest surface roughness and porosity. Consequently, milled dentures show **significantly lower** *Candida albicans* adhesion compared to conventional acrylic.

- **3D-Printed Resins** currently exhibit the highest surface roughness due to the layer-by-layer fabrication process [12,13]. This creates surface irregularities that **significantly promote** microbial adhesion, showing a higher tendency for colonization than both conventional and milled resins [13,14].

For a frail, immunocompromised, or xerostomic patient, a milled denture represents an active risk-reduction strategy against candidiasis, whereas a 3D-printed resin may inadvertently increase that risk.

The Xerostomia Solution: Surface Wettability. Xerostomia (dry mouth) is endemic in the polypharmacy-taking geriatric population and is a primary cause of denture failure [16,17,18]. Retention relies on the physical properties of a thin saliva film. The ability of a material to maintain this film is its "wettability" (hydrophilicity).

- Recent material science studies have demonstrated that **milled PMMA is the most hydrophilic** (best wettability / lowest contact angle) of all denture base materials [12,15].
- Conversely, **3D-printed and conventional resins are more hydrophobic** (poorer wettability / higher contact angle) [12,15].

This makes milled PMMA a physiologically targeted solution for xerostomic patients. Its hydrophilic surface maximizes the retentive forces of minimal available saliva, directly mitigating the patient's biological deficit [15].

Comparative Analysis of Denture Fabrication Modalities. To summarize the key differences relevant to geriatric care, the following table synthesizes the findings from the literature.

Feature	Conventional (Heat-Cured)	CAD/CAM Milled (Subtractive)	3D-Printed (Additive)
Clinical Appointments	5 – 7 Appointments [1]	2– 3 Appointments [2,3,1]	2 – 3 Appointments [2,3,1]
"Digital Duplicate" File	No	Yes [4,5,6]	Yes [7,8,5,6]
Fit (Polymerization Shrinkage)	Yes (compromises fit) [9,10]	None (superior fit)	Minimal (less than conventional)
Flexural Strength	Good	Excellent (Highest)	Fair to Good (Varies) [11,10]
Surface Roughness	High	Very Low (Smoothest)	Very High (Roughest) [12,13]
Candida albicans Adhesion	High	Very Low [14,15,16]	Very High (Highest) [13,14]
Surface Wettability (Hydrophilicity)	Hydrophobic (Poor) [12,17]	Hydrophilic (Excellent) [12,17]	Hydrophobic (Poor) [18,19,12,17]
Surface Wettability (Hydrophilicity)	Fair (High burden, high candida)	Excellent (Low burden, low candida, high wettability)	Fair (Low burden, but high candida/low wettability)

Conclusion. The digital workflow for complete dentures offers undeniable and profound advantages for the geriatric population, primarily through radically improved clinical efficiency and the security of the "digital duplicate." While any well-made prosthesis can provide patient satisfaction [6,8,9], the choice of material is critical for high-risk patients. The evidence points not to a simple binary choice, but a ternary one:

- **Conventional:** The baseline standard, but carries a high patient burden and material disadvantages.

- **3D-Printed:** Offers maximum speed and is the ideal choice for digital duplicates or interim prostheses [29]. However, its high surface roughness and Candida adhesion make it a questionable choice as a definitive prosthesis for high-risk patients [13,14].
- **CAD/CAM Milled:** Represents the optimal clinical choice for the vulnerable geriatric patient. It combines the efficiency of the digital workflow with superior material properties: high strength, low microbial adhesion [14,32,33], and a hydrophilic surface that actively manages the challenges of xerostomia [15].

For the modern geriatric practitioner, material selection must be a deliberate clinical decision. The evidence strongly supports using CAD/CAM milled dentures as the standard of care for definitive prostheses in the high-risk elderly patient.

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SUMMARY

This literature review provides a comparative analysis of digital versus conventional fabrication methods for removable complete dentures, with a specific focus on their application in the geriatric population. The conventional workflow, while established, presents significant burdens for elderly patients, including numerous, lengthy appointments. Digital workflows, utilizing CAD/CAM (milling) and additive manufacturing (3D-printing), offer a profound advantage in clinical efficiency, reducing the fabrication process to as few as two or three visits. This review synthesizes recent systematic reviews and clinical trials to compare these modalities across three critical domains for geriatric care: (1) clinical efficiency and process benefits, (2) patient-reported outcome measures (PROMs), and (3) material science, specifically biocompatibility and suitability for high-risk patients.

Evidence confirms the digital workflow is unequivocally superior in efficiency. Furthermore, the ability to archive the definitive prosthesis as a "digital duplicate" file represents a paradigm shift for providing rapid replacements for frail or institutionalized patients. While broad systematic reviews suggest patient satisfaction is often comparable between methods, high-evidence crossover trials where patients use both types report a significant preference for the fit, comfort, and retention of digital dentures. The most critical divergence, however, is in material properties. CAD/CAM milled PMMA demonstrates superior flexural strength, the lowest surface roughness, and significantly lower *Candida albicans* adhesion compared to conventional acrylic. Conversely, 3D-printed resins currently show the highest surface roughness and microbial adhesion. Furthermore, milled PMMA is the most hydrophilic, making it a physiologically targeted solution for geriatric patients with xerostomia. We conclude that while 3D-printing offers speed, the superior material properties of **milled dentures** make them the optimal clinical choice for high-risk geriatric patients.

Keywords: Digital, Conventional, Removable Dentures, Geriatric Patients

