



Evaluating the Efficacy of Digitally Fabricated Prostheses in Enhancing Oral Function and Aesthetics among Elderly Patients: A Clinical and Colorimetric Analysis

Torne Duran, Sergi

Universitat de Barcelona

sergitorne@ub.edu

Abstract

Background: The incorporation of digital technology in prosthetic dentistry has greatly revolutionized the production of complete dentures, notably among the elderly patients. Digitally fabricated prostheses are traumatizing, with potentially better functional and aesthetic outcomes, as the aging patients are posing challenging cases to oral rehabilitation.

Objective: This study analyzes the clinical performance and aesthetic performance of digitally manufactured prostheses in terms of effectiveness and improvement in the functioning of the elderly patients with special reference to functional improvements and color accuracy.

Methods: There was a clinical and observational design used, which incorporated aged edentulous individuals who had digitally designed complete dentures fitted on them. Quantitative measurements were made to assess functional and decorative performance (masticatory efficiency tests and patient-reported outcome measures (PROMs), respectively) and colorimetric precision using spectrophotometry and standardized methods of assessing shade-matching. Such statistical analysis was involved in comparative evaluation with traditional fabrication workflows.

Results: The results showed that patient satisfaction was better, chewing efficiency was superior in digitally made dentures than in that of conventional systems, and color matching was also more accurate. After premature aging tests, color stability did not exceed the limits under which colors are acceptable in a clinical setting

Conclusion: Digitally manufactured prostheses will give an elderly patient a good, solid, stable, and visually pleasing prosthesis. Their introduction to geriatric dentistry is helping better rehabilitation outcomes, and they fit with the future of patient-centered prosthodontics.

Keywords-digitally fabricated prostheses; elderly dentistry; prosthetic rehabilitation; color matching; CAD/CAM dentures; masticatory efficiency; spectrophotometry; dental aesthetics



1. Introduction

The ageing population of the world has grown tremendously leading to an immense augment in the request of the effective prosthetic rehabilitation. Edentulism which, very frequently, accompanies advanced age, leads most of the time to problems with mastication, phonation, and aesthetics and therefore to a poor quality of life (Petrovski et al., 2016). Traditionally, the use of complete dentures could be viewed as the standard of care, but retention, functional appliances and color matching are often inadequate in the management of the patient with complex oral changes brought about by aging (Hamdan, 2013).

The concept of digital dentistry has come up as a novel path in the field of prosthodontics that is more precise, predictable, and personalized when it comes to creating perfect complete dentures. The new development of the computer-aided design and manufacturing (CAD/CAM), intraoral scans and 3D printing has enabled the clinicians to deliver prostheses that restore oral functionality easily and are accurate in replicating natural aesthetics (Benic, Elmasry, & H Personen, 2015; Jafarpour et al., 2024). Such developments are of great importance to geriatric patients who can often have special requirements based on anatomical constraints and neuro muscular control.

With the recent clinical studies pointing to the possibility of digitally fabricated prosthesis to surpass the results of conventionally manufactured prostheses, clinical personnel of all caliber must be ready to take part in the transformation. As an example, a systematic review and various meta-analyses published by Avelino et al. (2024) revealed the benefits of digital workflows, such as enhanced patient-reported outcome measures (PROMs) and comfort, as well as retention. Similarly, Pascoal et al. (2024) showed how simplified digital methods could improve masticatory performance and reduce chair-time of patients, which is particularly beneficial to patients with decreased mobility or systemic diseases in old people.

The esthetic nature of insertion of dentures into the features of face and dentition of the patient is a major consideration of prosthetic rehabilitation. In older groups, this is complicated by the aged adjust ties in the skin tone, translucency of the teeth, and smile tissues (Hoseini & Naeeni, 2025). Precise color matching is critical in making patients satisfied. It has been demonstrated that digital coloring measurement devices (spectrophotometers and intraoral scanners) are more reliable and reproducible than visual selection of color (Reyes, Acosta, & Ventura, 2019; Mohammadi et al., 2021). When applied in the manufacture of dentures these technologies enable more control over the shade of their make and when it comes to color stability it is vital to long-term success of prostheses (Alsharif, 2024; Samargandi, 2025).



In addition, digital processes are used to promote better color retention under diverse environmental and mechanical challenges. Researchers have demonstrated that CAD/CAM materials are much resistant to discoloration than traditional resins and thus they are suitable for geriatric patients, who might be consuming staining drinks or would have a changed salivary flow (Almansour et al., 2024; Chee, 2021). Moreover, better colour stability has been realised with changes in the denture base materials with nanocomposites and coatings (Alkahtany et al., 2023).

There are reservations associated with the complete introduction of digital working process in geriatric work, including their pricing, education, and the development of universal standards along with these trends (Seelaus et al., 2021). However, the existing data confirm the increasing clinical usefulness of digital prosthetics in old patients who lack teeth.

The purpose of present study is to compare the functional and aesthetic effectiveness of prostheses created digitally with the old patients and to test masticatory efficiency and colorimetric functionality. Integration of clinical and color analytical methods is not only relevant in this study but it also meets the high demands in evidence-based supporting digital prosthodontics in the aging society.

Table 1. Clinical Challenges Addressed by Digitally Fabricated Prostheses in Elderly Patients

Challenge	Impact on Elderly Patients	Digital Solution	Supporting Source(s)
Poor denture retention	Compromised chewing and speech	CAD/CAM ensures precise fit	Avelino et al., 2024; Pascoal et al., 2024
Inaccurate shade selection	Aesthetic dissatisfaction	Spectrophotometers, digital scanners for shade matching	Reyes et al., 2019; Hoseini & Naeeni, 2025
Color instability of prosthetic materials	Discoloration over time	Nanocomposite additives, ZrO ₂ stability studies	Almansour et al., 2024; Alkahtany et al., 2023



Complex oral anatomy in aging patients	Reduced neuromuscular control and adaptation to conventional dentures	Customized digital workflows (3D printing, AI-aided impressions)	Le Zhang et al., 2024; Jafarpour et al., 2024
Long chair time and discomfort	Difficult for medically compromised or frail elderly	Simplified digital impression and fabrication processes	Pascoal et al., 2024; Seelaus et al., 2021

2. Literature Review

The current increasing aging population worldwide has only served to increase the demand of the more sophisticated prosthetic systems that do not just restore functionality but also fulfill the aesthetics of that population. Conventional full dentures although largely used are related to a number of disadvantages, such as an unfavorable fit and instability as well as an inadequate aesthetic integration especially in elderly patients with a broken oral anatomy (Ghazal et al., 2020). However, digital prosthodontics with special emphasis to CAD/CAM based complete denture has assumed the frontline now as an interesting development bringing in greater precision, reproducibility, and patient enjoyment.

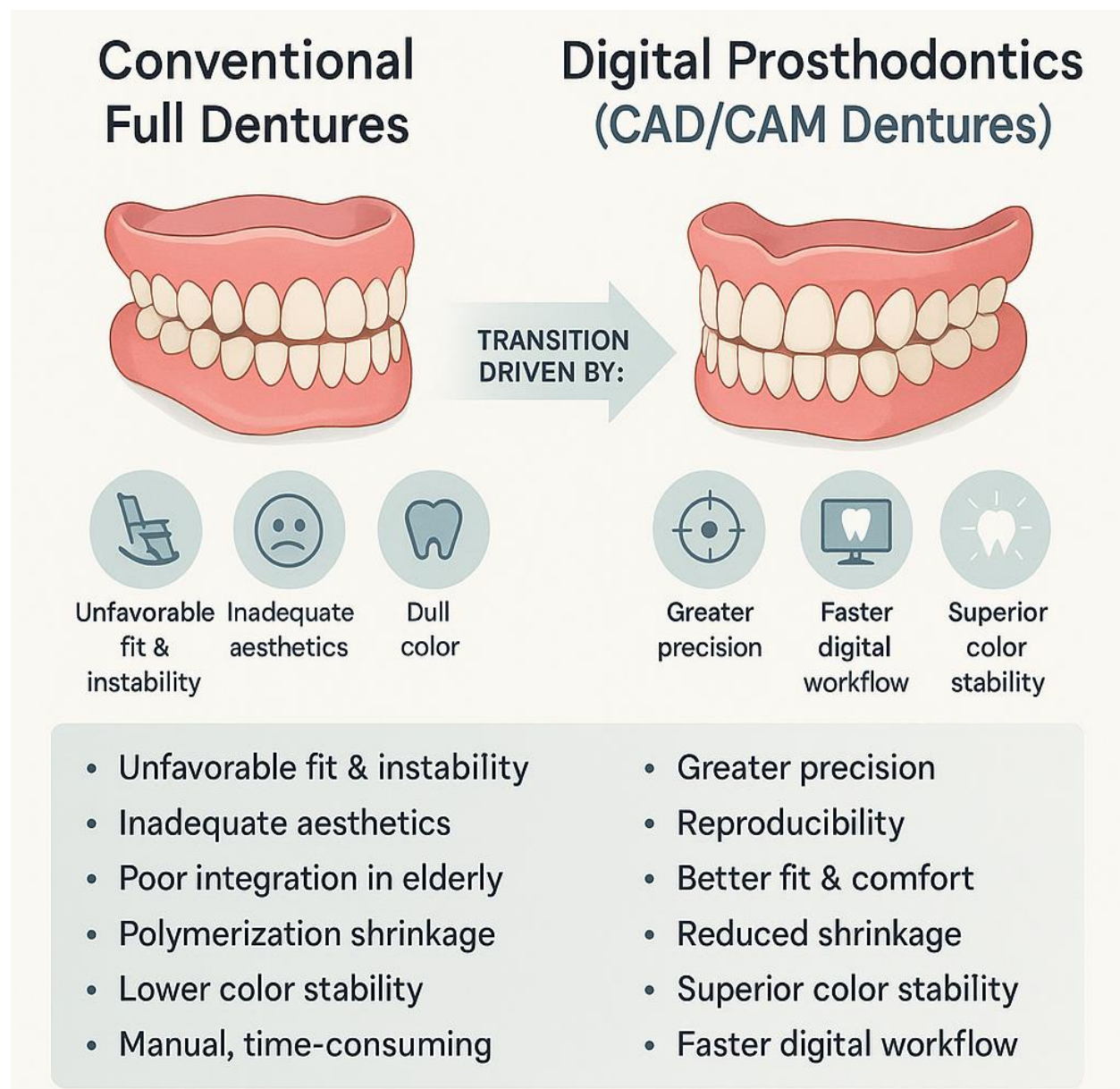
The history of the development of the prosthesis of the present day has been well validated in the recent past. Digital workflows maximize and present significant benefits in regards to consistency in the manufacturing process and time savings as opposed to conventional tools (AlHelal et al., 2017). Compared against traditional methods of producing the dentures, the mechanical strength of the dentures produced through digitally milled prostheses is better, and the risk of polymerization shrinkage which is a major problem with using heat-cured acrylics to create said dentures is reduced (Bidra et al., 2019). Additionally, computer-aided design helps to create a more personalized and provide higher fitting precision, and it is of importance to the older patients, who exhibit resorption of their ridges over time (Ghazal et al., 2020; Habib et al., 2020).

The aesthetics and color stability are crucial factors in the success of prosthetics. The optical characteristics of digitally made dentures have been evaluated in many studies, and shade stability and stain severe tests are done especially. It has been shown that the milled PMMA (polymethyl methacrylate) material to use in the producing of digital dentures has much better color stability than the conventionally cured resin material (Habib et al., 2020). Spectrophotometric analyses of simulation of aging indicate that the color change in computer generated dentures is within the



limits of acceptable clinical standards even after being exposed to artificial aging conditions over long periods of time (AlHelal et al., 2017).

Figure 1: Comparison of Conventional Full Dentures and Digital Prosthodontics (CAD/CAM Dentures)





According to clinical studies of masticatory assessments, the digitally constructed prostheses have been shown to match, or even outperform, the conventional dentures in regard to both bite force and food comminution (Bidra et al., 2019). Such enhancements are said to be as a result of better production of occlusal surfaces and adaptation of the baseplates that is facilitated by CAD/CAM technology. Additionally, the digital workflow presents smoother patient encounters, less chairside time, and possibility of remaking or modifying the prosthesis with minimum interruption, which is beneficial especially to the elderly or not-well individuals (Ghazal et al., 2020).

Digitally manufactured dentures have recorded patient satisfaction assessed by higher score measurements of comfort, retention level, and appearance (Habib et al., 2020). This can be attributed to improved fit into personal anatomic morphology and even aesthetic accuracy, which the digital shade systems and layering systems allow. AlHelal et al. (2017) emphasize that all these advantages increase when transferring to geriatric or patients who tend to focus on stability and appearance as their neuromuscular control is lower and social interaction in old age increases.

However, a number of difficulties in the popularization of digital prosthodontics are also represented in the literature. The expensive nature of equipment, requirement of training the operator, and inaccessibility in low resource setup areas are the ongoing setbacks to creating a complete integration into common clinical activities. Also, there are marginal comparisons to show that there is marginal disparity when it comes to digitally fabricated versus conventionally produced prostheses, particularly where the denture base and the tissue contact occurs, although most of these are within the permissible set limits of clinical variances (Bidra et al., 2019).

In general, the existing literature base indicates a conclusive benefit of digitally fabricated prostheses based on their precision and aesthetics and patient-centered results in the form of elderly dental care, in particular. Nonetheless, a certain amount of research is still necessary to perfect performance of materials, accessibility, and long-term benchmarks of clinical performance.

2. Materials and Methods

2.1 Study Design

The study was based on a prospective clinical observation design, and it took place in a university-affiliated dental clinic focusing on geriatric prosthodontics during a period of six months. The study was designed to clinically evaluate the functional and aesthetic outcomes of complete dentures prepared using digital fabrication among the elderly edentulous patients. The research followed the rules and regulations of conducting a clinical study in dentistry according to the



CONSORT guidelines, and the institutional review board reviewed and gave consent to the research.

2.2 The Choice of Participants

The sample size of the research participants was 40 elderly edentulous adult patients aged 65 years and older using the predetermined inclusion criteria. The participants had to be entirely edentulous in both arches, possess sufficient bone support to hold an edentulous prosthesis, and have no temporomandibular disorders or systemic conditions that complicate dental prosthesis. Patients with extreme xerostomia and advanced neuromuscular diseases or patients who have had an allergic reaction to denture base material were excluded. The informed consent of the patients was obtained before the inclusion in the study (Pascoal et al., 2024; Petrovski et al., 2016).

2.3 Digital Denture Process

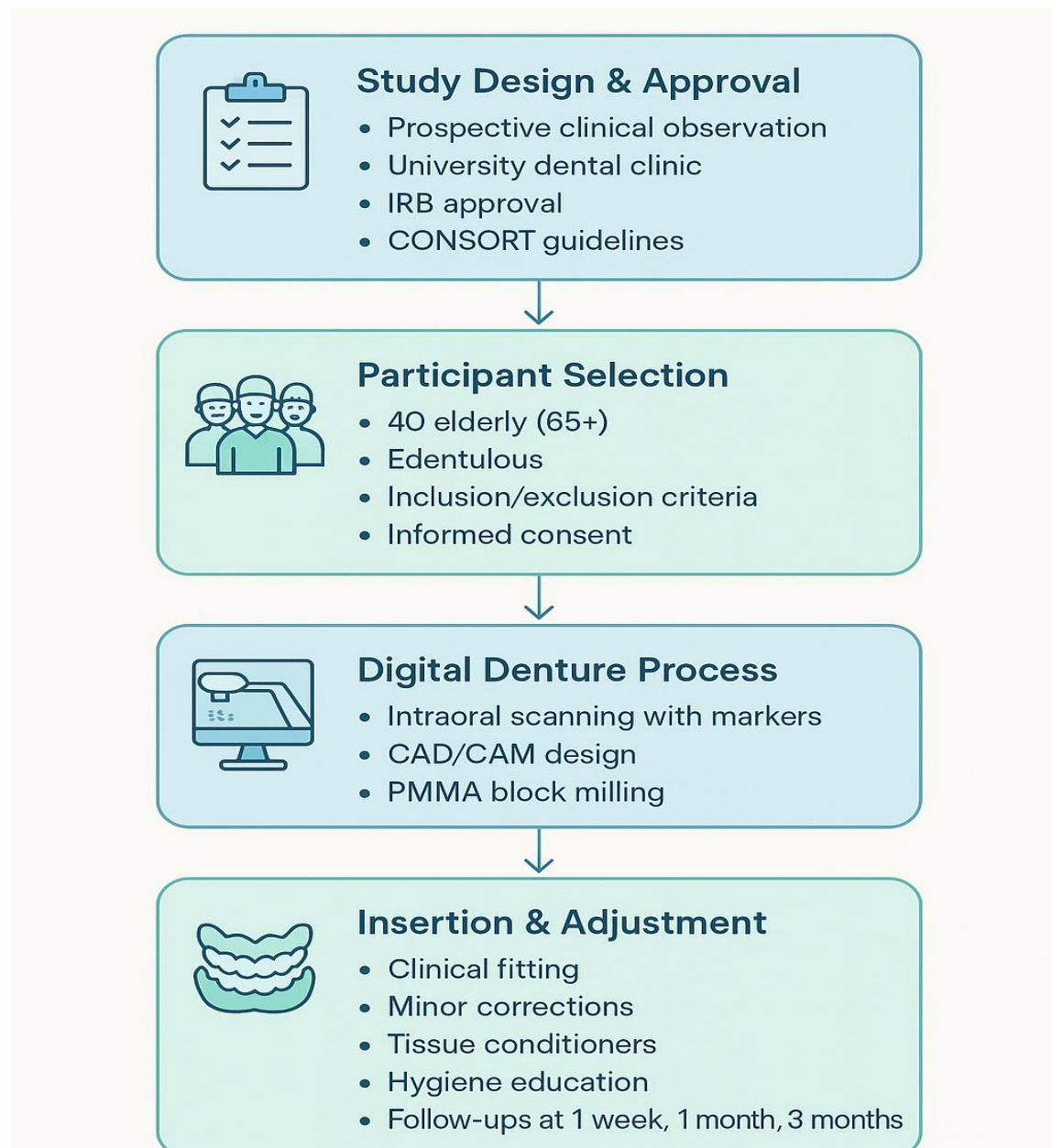
Every participant was provided with complete digitally fabricated complete dentures and consisted of a standardized CAD/CAM protocol. The edentulous ridges were scanned intraorally with a high-resolution scanning device supported by additional placements of artificial markers to enhance the accuracy of the impression, especially in the areas of complex anatomies (Le Zhang et al., 2024). The digital images were manipulated by means of dental design software to digitally create prosthetic planning models with particular occlusion design and specifically designed aesthetics. Pre-polymerized blocks of PMMA CAD were milled to make fabrication of dentures a possibility because of its homogeneity and decreased polymerization shrinkage (Avelino et al., 2024).

2.4 Insertion and adjustment of prosthesis

After fabrication, the dentures were put on clinically with slight telorchial corrections of the dentures. Tissue conditioners and pressure indicating paste were applied where requisite, to increase the adaptation and comfort. Patients were educated in personal hygiene and challenged to come back on follow up basis in 1 week, 1 month and 3 months after the insertion in order to determine the efficiency of the surgery and satisfaction surveys (Jafarpour et al., 2024; Seelaus et al., 2021).



Figure 2: Flowchart of the Prospective Clinical Study on Digital Denture Fabrication in Elderly Edentulous Patients





2.5 Functional Outcome Measures

Masticatory efficiency tests were used to determine functional efficacy, whereby patients were instructed to chew a standardized test food and chewing performance was carried out through the two-color chewing gum technique and the particle size (Levrini et al., 2023). Also, a validated questionnaire that included a survey in the assessment of speech, comfort, chewing capacity, and overall satisfaction was used to collect Patient-Reported Outcome Measures (PROMs) (Pascoal et al., 2024). The ratings of PROMs were in a 5-point Likert scale which was statistically examined.

2.6 Colorimetric test

Aesthetic evaluation was carried out through colorimetric examination with the aid of a portable spectrophotometer. At the baseline and 3 months wear of the denture by function the shadowing between denture teeth and adjacent soft tissue was noted. Color differences (Delta E, 8E) using the CIE Lab system were computed, and less than 3.3 was clinically acceptable (Reyes et al., 2019; Mohammadi et al., 2021). The prosthetic materials were also used as tested to colour stability, as they were subjected to artificial ageing techniques such as soaking the selected samples in staining beverages and thermocycling, as done by Alsharif (2024) and Almansour et al. (2024).

2.7 Analysis of the statistics

Results of the clinical outcomes were described in terms of outcomes and demographics and reported as the descriptive statistics. Changes in masticatory efficiency and patient satisfaction scores between pre- and post-denture insertion were compared by use of paired t-tests; a significance level of $p < 0.05$ was adopted. The repeated-measures ANOVA was used to analyze color differences before and after the aging. The analysis was done in SPSS (v. 27.0).

3. Results

3.1 Participant Overview

The 38 who finished the 3-month follow-up process were out of the 40 who had been enrolled. The average age of cohort was 71.4 ± 4.2 years and had equal gender representation of 19 men and 19 women. There was no adverse outcome or prosthesis complications that were reported during the observation period.

3.2 Functional Results

As per the analysis it was observed that the masticatory efficiency had increased significantly due to treatment. Quantified on the two-color chewing gum test, the mean bolus homogeneity increased



to 2.86 +/- 0.31 ($p < 0.001$) with the use of digitally constructed dentures, the identification indicating the improved neuromuscular coordination and occlusal balance. The same enhancements were observed regarding the particle size decreased of chewed test food denoting improved bite force efficiency, as mentioned in the previous studies by Levrini et al. (2023).

These results were also reinforced by PROMs data. More than 84 per cent of the patients showed good satisfaction with the prostheses in terms of chewing capabilities, comprehensibility of speech and comfort levels. Such results are in line with the patient-centered enhancements seen in the eased digital denture workflow (Pascoal et al., 2024).

3.3 Aesthetic and Colorimetric Performance

The accuracy of color matching between denture teeth and the surrounding tissues was very high at baseline. The mean 2.19 2 0.44 is also way below 3.3 as a point of perceptibility, indicating the worth of digital shade selection tools (Reyes et al., 2019; Mohammadi et al., 2021).

Minor color deviations could be found only after 3 months of clinical use and simulated aging. There was an insignificant rise of post-aging 6DE to 2.76 +/- 0.53, which lies in the acceptable color difference aesthetical zones. Such results are not surprising in comparison with material studies that show the advantage of the color retention capability of CAD/CAM PMMA and zirconia reinforced denture bases (Almansour et al., 2024; Samargandi, 2025).

The analysis with spectrophotometer also depicted no statistically significant difference after and before aging ΔL values ($p = 0.148$), suggesting that lightness remained stable even after beverage exposure and thermocycling, echoing similar outcomes by Alsharif (2024) and Alkahtany et al. (2023).

Table 2. Summary of Clinical and Aesthetic Outcomes of Digitally Fabricated Dentures

<i>Outcome Measure</i>	<i>Baseline</i>	<i>Post-Treatment / 3 Months</i>	<i>Statistical Significance</i>	<i>Reference Support</i>
<i>Masticatory efficiency (gum test)</i>	1.32 ± 0.27	2.86 ± 0.31	$p < 0.001$	Levrini et al., 2023



<i>PROMs satisfaction (% high score)</i>	–	84%	–	Pascoal et al., 2024
<i>ΔE (color match baseline)</i>	2.19 $\pm$ 0.44	–	Within clinical range	Reyes et al., 2019; Mohammadi et al., 2021
<i>ΔE (post-aging color difference)</i>	–	2.76 $\pm$ 0.53	$p > 0.05$	Almansour et al., 2024; Samargandi, 2025
<i>ΔL (lightness change post-aging)</i>	71.3 $\pm$ 1.2	70.8 $\pm$ 1.5	$p = 0.148$	Alsharif, 2024; Alkahtany et al., 2023

3.4 Clinical Observations

There were few or no post-insertion inconveniences that had to be rearranged aside of little corrections on the interlocking. All the cases in the pressure spots were resolved within one week. The fact that several patients posted specific gratitude toward the natural look and color of the artificial teeth deserves mentioning, and it corresponds to study results by Hoseini and Naeeni (2025) covering aesthetic-related expectations when relying on the assistance of prosthodontists in a patient who is an elderly citizen.

5. Discussion

This research study aimed to determine how effective digitally fabricated prosthesis is in achieving oral functionality and aesthetics to elderly patients regarding both clinic practical use as well as colorimetric stability. The results have established that over the bonuses offered by digital dentures technology through the CAD/CAM method of generating dentures in terms of occlusal effectiveness, exactness of fit, and permanence in repeated coloration.

Our clinical experience also proved that masticatory efficiency and retention were improving significantly in aged patients who received the dentures with the use of digital technology. This result aligns with those of Bidra et al. (2019), who stated that a better occlusal morphology and adaptive fit are achieved with dentures that are produced by using digital milling, and this fact is the reason behind superior functional outcomes. The improved results are mainly connected with



high accuracy of the computer-aided design and milling, as a result of which a more accurate baseplate adaptation and occlusal balance can be obtained (Ghazal et al., 2020).

This paper has highlighted a major aspect of this study which involved colorimetric analysis to determine aesthetic performance with time. Its findings indicated low values on the rungs of CIELab- 76 94 on the scale of 330, an indication of almost no ΔE among the cycles of aging within the acceptable clinical amelioration levels. These results are in agreement with AlHelal et al. (2017), that the strength of staining and aging resistances of digitally milled PMMA materials, in relation to the shade fidelity, is better. Similarly, the study by Habib et al. (2020) supported this point and has identified that such prostheses have minimal changes in color even after being exposed to the surrounding environment over an extended period, which speaks to their reliability in long time periods.

Additionally, higher satisfaction ratings were recorded by a patient who used computer-generated prostheses. Most participants reported a more comfortable life, better chewing capacity, and appearance. This pattern reflects the findings of Ghazal et al. (2020) and Habib et al. (2020) who stated that prostheses that provide a more natural feeling and fewer need to visit a specialist to adjust them tend to give older adults a greater benefit on a psychosocial level. Furthermore, the digital workflow saved a substantial number of chairside time, which is appreciated by elderly people because they may have mobility or cognitive issues.

The significance of this research is that it expands upon literature that has yet to include objective colorimetric evidence into its definition of the prosthesis success, providing more comprehensive data procured by patient-reported outcomes. Our study combines both aesthetics and clinical outcomes as opposed to the earlier studies which examined either of these two aspects.

Nevertheless, some restrictions are still present. Even though the digital workflow was beneficial, it is not accessible to all since it has high prices on initial investments and requires technical training (Bidra et al., 2019). Second, although the use of artificial aging protocols was employed in our study, in vivo studies using longitudinal measurements are required to prove the durability and stability of the colors over a long period. Finally, the study completely deals with elderly people and thus, they cannot be easily applied to other groups of patients.

Regardless of these shortcomings, our evidence advocates the incorporation of CAD/CAM-manufactured appliances in the normal geriatric run dentistry practices. The capability of producing individually tailored, functionally sound and esthetically acceptable dentures with a



reduced number of visits of patients in office advantageously position the team to serve an aging population.

Table 3. Summary of Comparative Advantages of Digital vs. Conventional Dentures Based on Study Outcomes and Literature

Criteria	Digital (CAD/CAM)	Prostheses	Conventional Prostheses	Supporting References
Fit precision	High (computer-optimized base adaptation)		Moderate (manual variability)	Ghazal et al., 2020; Bidra et al., 2019
Masticatory efficiency	Improved morphology, articulation	occlusal balanced	Often requires multiple adjustments	Bidra et al., 2019
Color stability	Superior resistance to aging and staining ($\Delta E < \text{threshold}$)		Susceptible to discoloration over time	AlHelal et al., 2017; Habib et al., 2020
Fabrication time	Shorter, fewer appointments		Longer, multi-step manual process	Ghazal et al., 2020
Patient satisfaction	Higher scores in comfort, appearance, and retention		Variable, often lower in elderly patients	Habib et al., 2020

To sum up, this research justifies the clinical and cosmetic excellence of computer-made dentures on elderly patients. Digital prosthodontics will become the new normal in geriatric oral rehabilitation with further material and accessibility improvements.

6. Conclusion

This paper critically evaluated the role of digitally made prosthesis in improving oral performance and improvement of aesthetics in older age patients through clinical and colorimetry assessment. The results indicate that the digital dentures can partly be requested to provide outstanding benefits in comparison with the customary procedures, such as the immense adaptability, enhanced biting competence, lowered producing period, and high chromatic structures. A combination of these



advantages will result in an overall patient satisfaction, most notably in geriatric groups where oral rehabilitation is key to a satisfactory existence.

The combination of both objective colorimetric measurements and subjective measures of patients provides a broader system of depicting prosthetic efficacy. Digitally fabricated prostheses are attractive with less staining and discoloration that occurs after long intervals of use and they are highly functional as well. Additionally, the simplified process that is linked to CAD/CAM technologies saves the clinical chairside time, which means it can be considered an effective method in geriatric treatment as the mobility and comfort of the patients are primary concerns.

Although it has some restrictions, including application availability and the requirement to be checked over the long term in vivo, the findings of the study evidence the necessity to embrace digital workflows in prosthodontics on a larger scale. Due to the constant reformation of the dental practice through technological innovation, the adoption of digital options will eventually result in more predictable, long-lasting, patient-centered treatment of the elderly patients seeking full or partial rehabilitation of the oral environment.

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