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Case Report

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Digital Workflow for a 3D-Printed Removable Partial Denture: A 1-Year Follow-up Clinical Report

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Abstract

Acrylic removable partial dentures have long been used to rehabilitate partially edentulous patients. Conventional fabrication workflows involve multiple clinical and laboratory procedures that require high precision, are time-consuming, and are susceptible to human error. The integration of computer-aided design and computer-aided manufacturing (CAD-CAM) technologies has enabled the development of streamlined digital workflows for prosthesis fabrication. This clinical report describes the rehabilitation of a partially edentulous patient using an acrylic removable partial denture produced through a fully digital workflow. An intraoral scan was obtained using an intraoral scanner, and the prosthesis was designed with CAD software. The denture was fabricated using stereolithography 3D printing in a monolithic tooth-colored resin, followed by characterization of the flanges with pink resin to simulate gingival tissues. The prosthesis demonstrated satisfactory functional and aesthetic outcomes during a 1-year follow-up period, and the patient reported a high level of satisfaction with the treatment.

Keywords: Removable partial denture; CAD-CAM; 3D printing; Additive manufacturing; Intraoral scanning; Digital dentistry.

INTRODUCTION

The global prevalence of complete tooth loss is estimated at approximately 7%, affecting more than 350 million people worldwide. Among individuals over 60 years of age, this prevalence rises to 22.7%, meaning that nearly one in four older adults is edentulous [1].

Many of these patients are rehabilitated with removable prostheses, largely due to their lower cost compared with fixed or implant-supported solutions [2]. However, removable partial dentures with a metal framework (RPDs) cannot always be indicated, as their mechanical and functional performance depends on the presence of an adequate number of healthy abutment teeth. When these conditions are not met, acrylic partial dentures often become the only feasible option despite their known biomechanical and biological limitations [3].

The conventional fabrication protocol for acrylic removable partial dentures, introduced in the 1940s, remains widely used but presents several drawbacks, including a time-consuming workflow and the risk of processing inaccuracies such as acrylic polymerization shrinkage, which may compromise the final fit [4,5].

The increasing integration of CAD-CAM technologies into removable prosthodontics has enabled the development of digital workflows involving intraoral scanning, computer-aided design (CAD), and computer-aided manufacturing (CAM). Although subtractive manufacturing through milling has been commonly used, additive manufacturing (3D printing) offers advantages such as reduced costs and greater efficiency [4].

Despite these advantages, the simultaneous printing of the denture base and teeth remains technically challenging and costly. Consequently, many workflows require printing the base and teeth separately and subsequently assembling them, a process that may introduce inaccuracies in tooth positioning and occlusion [6]. To address these limitations, a novel approach has been proposed in which the prosthesis is printed as a monolithic structure in tooth-colored resin, followed by external characterization of the flange using pink resin [7].

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The present clinical case describes an alternative fully digital protocol for the fabrication of an acrylic removable partial denture and discusses the clinical and laboratory challenges associated with this approach.

CASE REPORT

An 88-year-old partially edentulous male patient presented to the Department of Removable Prosthodontics at the Faculty of Dental Medicine, University of Lisbon. Clinical examination revealed a partially edentulous maxilla classified as Kennedy-Applegate Class II, modification 2, opposing a partially edentulous mandible classified as Kennedy-Applegate Class II, modification 1. The patient had been using the same prostheses for approximately 10 years and complained of poor retention. Examination of the existing prostheses revealed inadequate adaptation and significant tooth wear.

All rehabilitation options were explained and, due to financial constraints, a removable prosthetic solution was selected. Given the absence of a sufficient number of periodontally healthy abutment teeth, the use of a removable partial denture with a metal framework was not considered. Four clinical appointments were planned with the following objectives: digital impressions, digital jaw relation record, teeth try-in, and denture insertion. Post-insertion adjustment appointments were scheduled as needed.

At the first appointment, digital impressions were obtained using an intraoral scanner (TRIOS® 3 Wired, 3Shape®, Copenhagen, Denmark). The scanning procedure began on the occlusal and buccal surfaces of the remaining teeth to establish a stable reference framework. The scan was then extended to the adjacent edentulous areas, progressing from anatomically stable regions, such as the palate, toward more compressible mucosa. This sequence followed the manufacturer's recommended protocol. S-shaped sweeping motions were used, ensuring continuous overlap with previously captured areas to maintain data coherence and prevent tracking loss during acquisition (Figure 1).

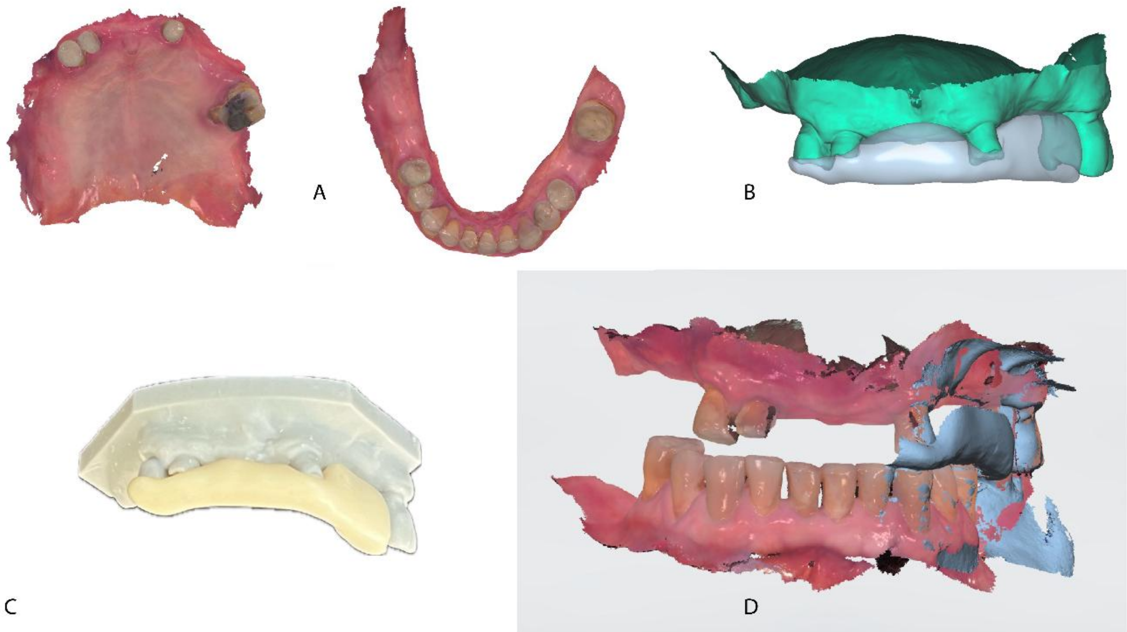

Figure 1: Optical scan of the edentulous maxilla and mandible (A); CAD design of the JIG (B); 3D-printed JIG (C); maxillomandibular relationship record (D)

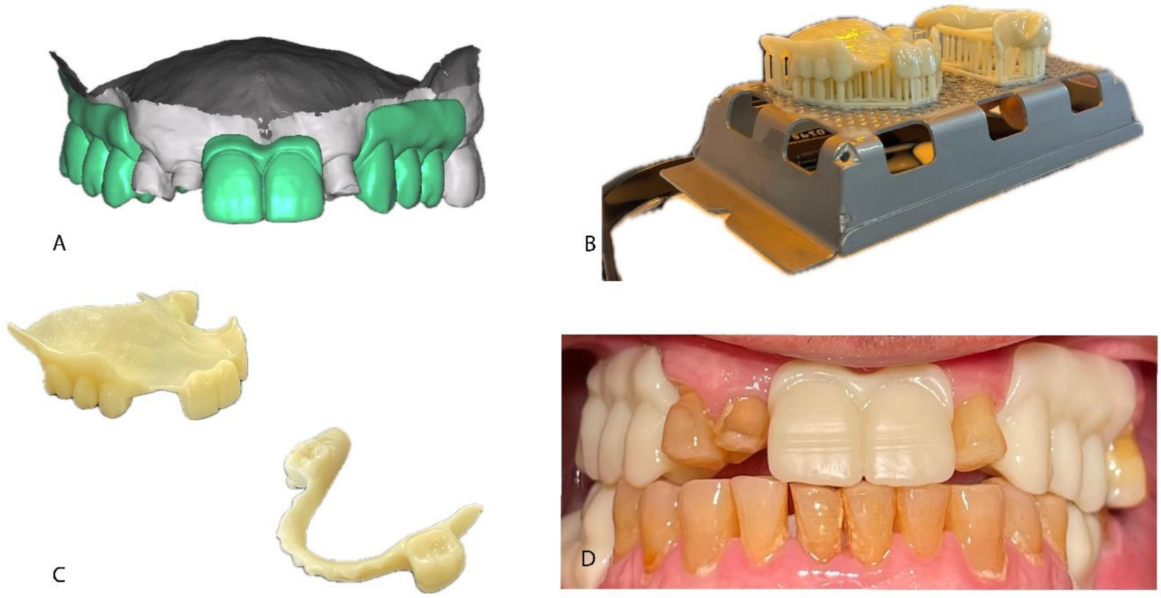

Figure 2: Final CAD design of the try-in (A); 3D printing of the try-in (B); maxillary and mandibular try-in (C); intraoral validation of the teeth try-in (D)

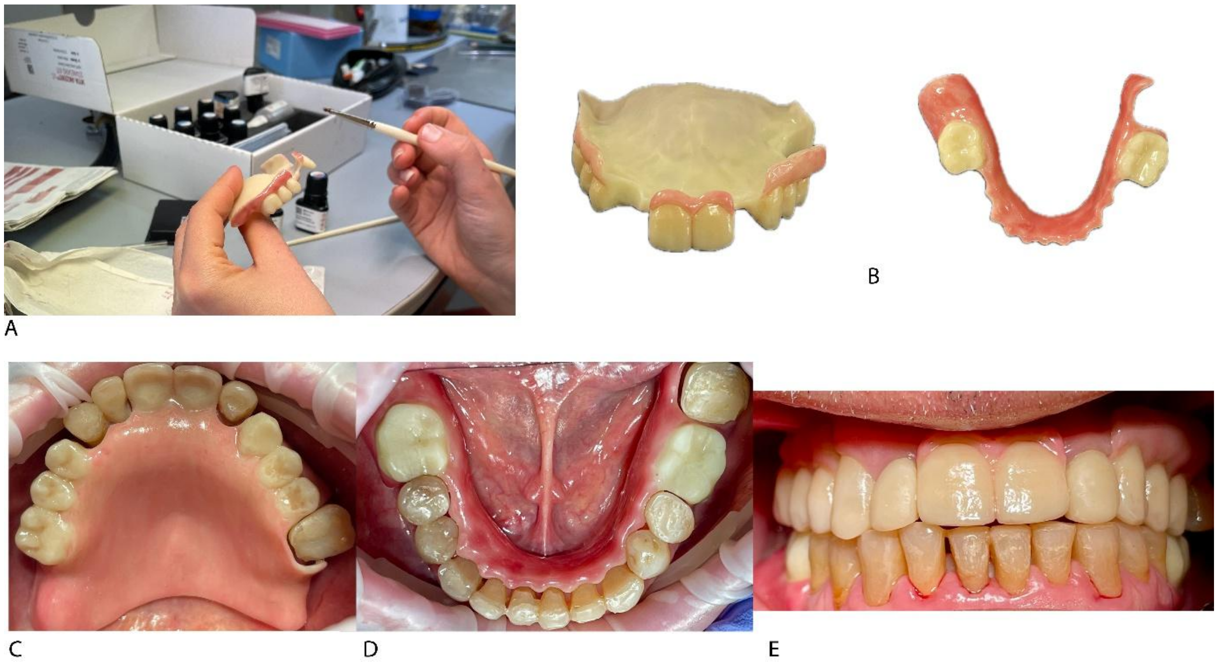

Figure 3: Custom characterization with application of a pink acrylic layer on the outer surface of the prosthesis and tooth pigmentation using photopolymerized acrylic to individualize the shade of each tooth (A); finished maxillary and mandibular prostheses (B); occlusal view of the maxillary prosthesis (C); occlusal view of the mandibular prosthesis (D); frontal view of the prostheses in situ after resin reconstructions of teeth 13, 12, and 22

At this stage, intermaxillary registration could not be performed because the vertical dimension of occlusion was reduced and occlusal contacts did not provide tripodization, resulting in an unstable occlusal position. Therefore, a customized Lucia Jig with a palatal ramp was designed using CAD software (Modifier, Zirkonzahn®, Gais, Italy) to stabilize the mandible at the correct vertical dimension of occlusion and centric relation. Due to the absence of maxillary anterior teeth, the Lucia Jig was adapted to engage the posterior teeth to ensure adequate stabilization (Figure 1). After design, the file was exported in STL format for three-dimensional printing (NextDent® 5100, 3D Systems®, California, USA). Printing was performed using NextDent® Try-in resin (3D Systems®, California, USA) with a layer thickness of 50 µm. After printing, the jig was ultrasonically cleaned in 99.5% isopropyl alcohol (AGA, Portugal) for 15 minutes and subsequently post-cured in an LC-3D Print Box (NextDent B.V., The Netherlands) for 10 minutes (Figure 1).

At the second appointment, the occlusal vertical dimension was determined using Thompson's method, and the Lucia Jig was adjusted accordingly. Maxillomandibular relation is then recorded in centric relation at the established vertical dimension by scanning the vestibular surfaces of the teeth and residual ridges with the jig in place. The software automatically identified and articulated the digital dental arches (Figure 1).

The try-in design was performed using CAD software (Modifier, Zirkonzahn®, Gais, Italy), selecting teeth from a digital library according to the patient's remaining dentition. The file was exported for three-dimensional printing using 3D Sprint Basic® software (3D Systems®, California, USA). Printing was performed with NextDent® Try-in resin (3D Systems®, California, USA) with a layer thickness of 100 µm using a NextDent LCD1 printer (NextDent B.V., The Netherlands) (Figure 2). After printing, the objects underwent the same cleaning and final photopolymerization protocol previously described.

During the digital design stage, reconstruction of the remaining maxillary anterior teeth was considered beneficial to improve the final aesthetic outcome. Digital designs for teeth 13, 12, and 22 were therefore created to assist in the planning of direct composite restorations. A new model was printed, and a silicone index was fabricated to guide the future composite resin reconstruction.

At the third appointment, the try-in was evaluated intraorally. During the initial evaluation, the maxillary central incisors were found to be excessively long, and the vertical dimension was increased by approximately 1 mm. The design was therefore modified and a new try-in was printed. Once the try-in had been aesthetically and functionally validated, the tooth shade was selected using a conventional shade guide (Vita Zahnfabrik, Germany) (Figure 2). The definitive prostheses were printed using NextDent® C&B MFH resin (3D Systems®, California, USA) in shade N1.5.

The 3D printing software was used to import the STL files, orient the model at 90°, and generate the support structures. After printing and removal from the build platform, the dentures were cleaned and underwent final photopolymerization in an LC-3D Print Box (NextDent B.V., The Netherlands) for 10 minutes.

Subsequently, the gingival areas were characterized using a photopolymerizable pink resin (VITA AKZENT LC, Vita Zahnfabrik, Germany), and each artificial tooth was individually characterized to achieve a more natural appearance, for example by increasing chroma in the canine teeth (Figure 3).

At the denture insertion appointment, minor adjustments were made to the lingual embrasures to establish a single path of insertion, together with minor occlusal refinements. No pain associated with the denture bases was reported. Direct composite resin restorations were then performed on teeth 13, 12, and 22 (Figure 3).

At the one-week follow-up, no pain was reported, retention was adequate, and overall satisfaction wth the rehabilitation was high. At the one-year follow-up appointment, the patient reported no complaints. Clinical examination showed that the prostheses were well integrated and that the patient maintained good daily oral hygiene practices. Minor pigmentation was observed, particularly on the artificial teeth; however, the prostheses remained functionally stable, showing adequate retention, stable occlusal contacts, absence of mucosal lesions or discomfort, and high patient satisfaction, while maintaining an acceptable aesthetic appearance (Figure 4).

Figure 4: One-year follow-up

DISCUSSION

Fully digital workflows have recently emerged as a viable alternative to conventional techniques for the fabrication of removable prostheses. Previous studies have reported that digital protocols may reduce both clinical and laboratory time while maintaining high levels of accuracy in the final prosthetic outcome [8.10].

The final manufacturing step of digital prostheses can be performed using either additive or subtractive technologies [11]. In the present case, an additive manufacturing approach was selected, which relies on photosensitive liquid resins [12]. The main advantages of additive manufacturing include high manufacturing precision, reduced material waste, and potentially lower production costs compared with subtractive methods [8,12,13].

Two main additive manufacturing strategies have been described for denture fabrication. One involves printing the denture base in pink resin and the denture teeth in tooth-colored resin, followed by bonding of both components. Alternatively, the entire prosthesis may be printed as a monolithic structure using a single tooth-colored material, with subsequent surface characterization to enhance the esthetics of the teeth and prosthetic flanges. The first approach presents the disadvantage of a higher likelihood of occlusal discrepancies caused by minor distortions during the bonding procedure. In addition, the bonding step may introduce cumulative errors that can affect occlusal accuracy and prosthesis fit [6].

In the present clinical report, a monolithic prosthesis was printed using a tooth-colored resin approved for long-term intraoral use. To improve the final esthetic outcome, surface characterization of both the prosthetic teeth and buccal flanges was performed, following previously described techniques [7,14].

Although digital technologies are increasingly applied in complete denture fabrication, considerably fewer studies have reported their application in removable partial dentures. Previous reports have shown that RPD components can be digitally designed and manufactured separately using CAD-CAM and three-dimensional printing technologies, followed by assembly through bonding [15,16]. However, this additional step may introduce minor discrepancies between components. In this context, the fabrication of a monolithic single-material prosthesis, as presented in the present case, represents an interesting alternative to minimize potential inaccuracies associated with bonding procedures. Nevertheless, final esthetic characterization such as gingival pigmentation and tooth characterization, may still be performed using conventional techniques, as described by Gomes [7], Sousa [17] and Garcia [14].

Despite these advantages, the fully digital workflow also presents limitations that must be considered. The high initial investment required for acquiring intraoral scanners and CAD-CAM systems, [18] the limited variety of resins currently available for three-dimensional printing, and the need for additional esthetic characterization of monolithic prostheses represent factors that may hinder widespread clinical adoption. In addition, aspects related to long-term durability, pigmentation stability, cleaning protocols, and the feasibility of future repairs or relining procedures remain insufficiently documented in the literature [19,20].

Nevertheless, once the digital design has been completed, additive manufacturing enables rapid prosthesis fabrication. Furthermore, as many clinicians now have access to in-office three-dimensional printers, on-site prosthesis fabrication becomes feasible, representing an advantage not achievable with conventional techniques or subtractive milling workflows. This approach may therefore represent a practical option in clinical situations where simplified workflows and rapid prosthesis delivery are desirable.

CONCLUSION

This clinical report presents an alternative approach for the fabrication of a removable partial denture using a fully digital workflow that integrates intraoral scanning and CAD-CAM technology. The proposed monolithic printing technique represents an innovative strategy to overcome some limitations associated with multi-component printed prostheses while maintaining the possibility of subsequent esthetic characterization. The fabricated prosthesis fulfilled the required functional criteria and was well tolerated by the patient, as demonstrated by the absence of complaints after insertion and continued satisfaction at the one-year follow-up. Although the present findings suggest that this approach may represent a promising alternative for the fabrication of removable partial dentures, further long-term clinical studies are required to confirm its durability, accuracy, and patient satisfaction.

Authorship contribution

Filipa Reis: Data curation; Writing - original draft. Isabel Gomes: Conceptualization; Investigation; Methodology; Project administration; Supervision; Writing - review & editing. João Paulo Martins: Conceptualization; Methodology; Supervision; Visualization; Writing - review & editing. Cátia Branco: Methodology; Software. Luís Miguel Pires Lopes: Conceptualization; Writing - review & editing.

Conflicts of Interest

The author reports no conflicts of interest.

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