CASE REPORT

HYBRID DIGITAL COMPLETE DENTURE IN A HIGH-DEMAND CLINIC: CASE REPORT, CHALLENGES, AND PERSPECTIVES

PRÓTESE TOTAL DIGITAL HÍBRIDA EM UMA CLÍNICA DE ALTA DEMANDA: RELATO DE CASO, DESAFIOS E PERSPECTIVAS

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ABSTRACT

Advances in digital technologies, such as CAD/CAM systems and 3D printing, have expanded the possibilities for complete denture fabrication, with potential improvements in accuracy, predictability, and reduced clinical time, particularly in edentulous patients. This study reports a clinical case of maxillary complete denture rehabilitation using a hybrid workflow that integrates conventional and digital techniques. An edentulous patient was rehabilitated with a 3D-printed maxillary complete denture, using the patient's pre-existing denture as a custom impression tray and esthetic and functional reference, thereby preserving previously established occlusal relationships. The protocol included scanning of the functionalized denture, denture fabrication by 3D printing, a clinical try-in for functional and esthetic adjustments, and final delivery after finishing and polishing, with treatment completed within 14 days. The denture demonstrated clinically satisfactory retention, adequate adaptation, and favorable esthetics, in addition to a reduced number of clinical appointments and a high level of patient satisfaction, particularly regarding denture stability and shortened treatment time. It can be concluded that the hybrid workflow proved to be efficient and clinically feasible; however, its predictability depends on professional experience and clinical–laboratory integration, making it, under current clinical conditions, a safe and predictable approach for complete denture fabrication.

Keywords: Complete denture; Digital workflow; Three-Dimensional printing; CAD/CAM technology, Geriatric dentistry.

RESUMO

Os avanços nas tecnologias digitais, como o design auxiliado por computador e a fabricação auxiliada por computador (CAD/CAM) e a impressão tridimensional (3D), ampliaram as possibilidades na confecção de próteses totais, com potencial para maior precisão, previsibilidade e redução do tempo clínico, especialmente em pacientes edêntulos. Este estudo tem como objetivo relatar um caso clínico de reabilitação com prótese total superior por meio de um fluxo de trabalho híbrido, associando técnicas convencionais e digitais. Uma paciente edêntula foi reabilitada com prótese total superior impressa em 3D, utilizando sua prótese pré-existente como moldeira individual e como referência estética e funcional, preservando as relações oclusais previamente estabelecidas. O protocolo incluiu escaneamento da prótese funcionalizada, confecção da prótese por impressão 3D, prova clínica para ajustes funcionais e estéticos e entrega final após acabamento e polimento, sendo o tratamento concluído em um período total de 14 dias. A prótese total apresentou retenção clinicamente satisfatória, adaptação adequada e estética favorável, além de redução do número de consultas, com satisfação relatada pela paciente, especialmente quanto à estabilidade da prótese total e ao curto tempo de tratamento. Conclui-se que o fluxo de trabalho híbrido se mostrou eficiente e clinicamente viável; contudo, sua previsibilidade depende da experiência profissional e da integração clínico-laboratorial, configurando-se, no cenário atual, como uma alternativa segura e previsível para a confecção de próteses totais.

Palavras-Chave: Prótese total; Fluxo de trabalho digital; Impressão 3D; Tecnologia CAD/CAM, Odontogeriatria.

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INTRODUCTION

Edentulism is primarily caused by periodontal diseases and dental caries. Its prevalence is often associated with limited access to preventive programs and healthcare policies throughout life. Tooth loss compromises functions directly related to maintaining quality of life, and its impacts may be manifested by reduced masticatory and speech abilities, as well as by nutritional, esthetic, and psychological impairments, including decreased self-esteem and social integration (1).

In the Brazilian cultural context, edentulism is still perceived by part of the population as a natural consequence of aging. However, current evidence indicates that this condition mainly reflects the lack of prevention, information, and adequate oral healthcare, which should be provided primarily to the adult population to enable the maintenance of natural teeth in a functional and healthy condition until advanced ages (2).

In this scenario, computer-aided design and computer-aided manufacturing (CAD/CAM) have emerged as a new approach to the design and fabrication of complete dentures (CD) (3). Recent advances in science and technology have provided methods for producing denture bases, including computer-aided techniques, CAD/CAM systems, and three-dimensional (3D) printing (4).

The development of digital methods for CD fabrication is based on subtractive manufacturing (milling), 3D printing, or additive manufacturing (rapid prototyping/successive deposition of material layers) (5). Digital dental technology enables the manufacture of removable prostheses using CAD/CAM technologies throughout the entire workflow, thereby reducing chairside and laboratory time for both patients and clinicians while providing satisfactory or superior functional and esthetic outcomes (5).

In contrast, the conventional method presents significant disadvantages, such as the requirement for five clinical visits, including preliminary impressions, final impressions, maxillomandibular relationship records, wax try-in, and the delivery/insertion of CD (3). Conversely, the digital workflow offers several advantages over conventional dentures, including reduced clinical and laboratory time, greater technical accuracy, smoother surfaces—which decrease biofilm formation—and the elimination of polymerization shrinkage (6).

The cost-time relationship should be evaluated considering the reduced chairside and laboratory time resulting from decreased manual intervention, virtual tooth arrangement, and the ease of storing and reproducing dentures, in contrast to the higher investment required for the acquisition of milling machines, intraoral scanners, and other proprietary equipment (7).

In the context of digital workflow and clinical steps involved in the fabrication of digital removable prostheses, the accurate assessment of the vertical dimension of occlusion (VDO), maxillomandibular relationships, lip support, and the position of the incisal edge of the maxillary anterior teeth may represent a critical step, especially for clinicians in the early stages of familiarization with these protocols (8).

Therefore, this study aimed to report a clinical case of rehabilitation with a 3D-printed maxillary CD using a hybrid workflow, in which the pre-existing denture was used as an esthetic and functional reference, as well as to discuss its application in Naval Dentistry.

CASE REPORT

This study was approved by the Research Ethics Committee of the Hospital Naval Marcílio Dias, Rio de Janeiro, RJ, Brazil, under opinion No. 8.270.937/CAAE: 95159426.5.0000.5256. The participant provided written informed consent.

First Appointment:

Medical history, clinical examination, and photographic documentation

A 79-year-old female patient with a medical history of systemic arterial hypertension and anxiety attended the Geriatric Dentistry Clinic at the Odontoclínica Central da Marinha (OCM) with the chief complaint of requiring replacement of her provisional immediate maxillary CD.

Initial clinical examination revealed the use of an immediate maxillary CD with esthetic and functional impairments, characterized by excessively long lateral incisors, protrusive central incisors, midline deviation, and inadequate retention. Based on these findings, the fabrication of a new maxillary CD was indicated.

Clinical and radiographic evaluation revealed complete maxillary edentulism associated with severe horizontal bone loss, as well as the missing teeth 38, 37, 36, 35, 47, and 48. The patient was wearing a functional and clinically satisfactory mandibular removable partial denture (RPD). Despite evident wear of the remaining teeth, the immediate maxillary CD presented relevant clinical references, including a stable VDO, an adequate occlusal plane, and preserved compensating curves.

For the initial case documentation, extraoral photographs were obtained in frontal and 45° views (Figures 1A and B) using a Canon EOS Rebel T7i digital camera (Canon, Nagasaki, Japan).

Initial planning

After clinical, radiographic, and photographic analysis, a new maxillary CD was planned using a hybrid technique that combines conventional clinical steps with a digital workflow. Initially, a functional impression was performed using the patient's own denture as a custom tray, enabling proper adaptation of the impression material and an accurate recording of the support and retention areas (Figure 1C).

For this procedure, Futura AD addition silicone and silicone in a light-body consistency (DFL, Rio de Janeiro, Brazil) were used in combination with Universal Tray adhesive (Zhermack, Badia Polesine, Italy), ensuring accurate reproduction of the anatomical and functional details of the denture-bearing area.

In the subsequent step, the digital scanning of the CD associated with the functional impression was performed while it was manually maintained in a stable position outside the oral cavity (Figure 1D), using the Primescan intraoral scanner (Dentsply Sirona, Erlangen, Germany). Additionally, an intraoral scan of the mandibular arch was performed with the RPD in functional position (Figures 1E and F).

For the interocclusal record, the complete denture-functional impression assembly was repositioned intraorally, followed by the corresponding scan, enabling the capture of the maxillomandibular relationship under the previously established clinical conditions (Figure 1G).

Furthermore, the impression was poured using the conventional technique with dental stone to obtain the maxillary edentulous cast, which was used in the subsequent laboratory procedures for mounting on a semi-adjustable articulator (SAA) and subsequent occlusal verification.

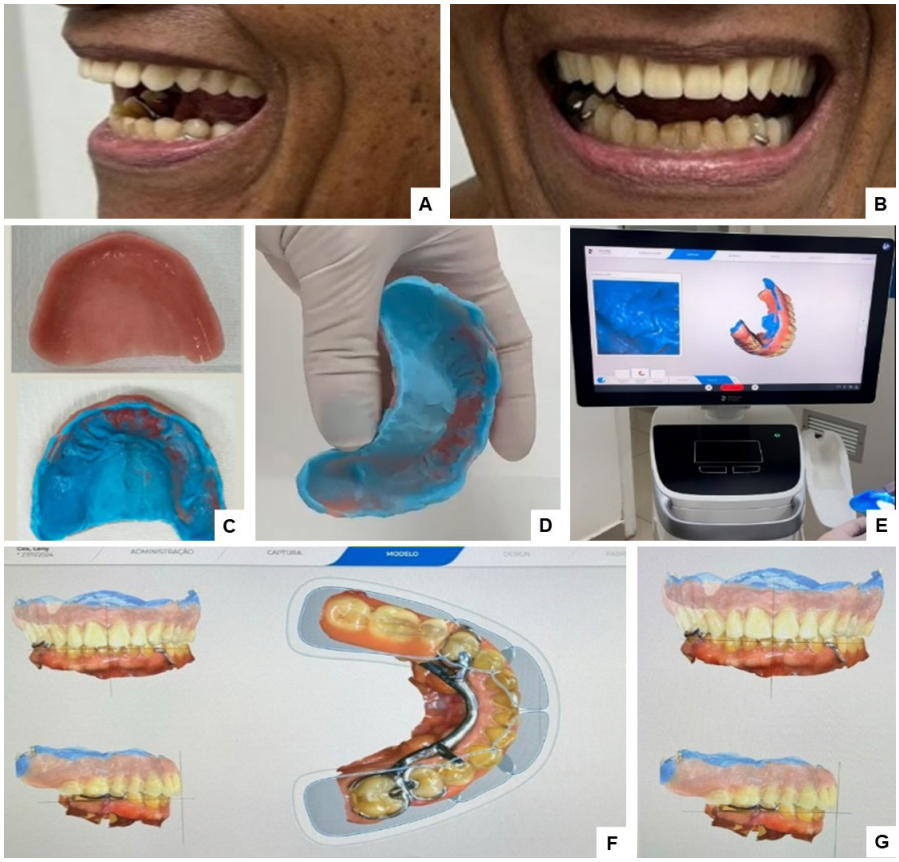

Figure 1 - Clinical and digital workflow for the fabrication of a maxillary complete denture (CD) using a hybrid technique. Initial extraoral photographs in lateral and frontal views, showing esthetic impairment of the maxillary CD (A–B). Functional impression performed using the patient's existing denture and addition silicone (C–D). Extraoral scanning of the denture/functional impression assembly, maintained in a stable position outside the oral cavity (E). Digital models of the maxillary and mandibular arches, including the mandibular removable partial denture (RPD) in functional position (F). Interocclusal record obtained via intraoral scanning with the assembly repositioned intraorally, enabling capture of the maxillomandibular relationship (G).

Laboratory Phase 1

All esthetic and functional corrections previously identified in the immediate CD were duly documented in writing and forwarded to the dental laboratory technician responsible for the case. The instructions included reduction of anterior incisor protrusion, repositioning of the lateral incisors for improved esthetics, correction of the occlusal plane on the patient's left side (second quadrant), and adjustment of the midline.

The models were fabricated using 3D printing with a Flashforge 3D printer (Zhejiang Flashforge 3D Technology Co., Jinhua, China), resulting in the corresponding physical models. These printed models were mounted on an SAA (Bio-Art Equipamentos Odontológicos Ltda., São Paulo, Brazil) (Figure 2A) to preserve the VDO and enable future occlusal adjustments of the 3D-printed denture.

This step proved particularly relevant due to the modifications performed, according to the subsequent virtual planning, in the teeth of the left quadrant, aimed at correcting the previously compromised curve of Spee. These modifications involved reducing tooth length to reestablish an adequate occlusal curvature.

After virtual planning was completed using the inLab 22 CAD/CAM software (Dentsply Sirona, Erlangen, Germany), the denture base and artificial teeth were designed as separate structures. Each component was then independently fabricated by 3D printing, using Prizma Bio Denture 3D resin (Makertech Labs, São Paulo, Brazil) for the denture base and Prizma Bio Crown 3D resin (Makertech Labs, São Paulo, Brazil) for the artificial teeth (Figure 2B).

Following printing and post-processing, the teeth were positioned in their respective sockets within the denture base and bonded using the same printing resin, followed by light curing, ensuring adequate integration between the components of the printed CD (Figure 2C).

Subsequently, the occlusal contacts were verified on the SAA (Figure 2D) to evaluate and adjust the occlusion of the newly fabricated printed CD. During this procedure, adjustment of the left posterior region of the denture base was deemed necessary, specifically in the coronomaxillary space, due to the presence of an undercut in the maxillary tuberosity on that side.

The esthetic characterization of the teeth was performed using an extrinsic staining technique with the light-curable laboratory resin Lite Art Stain (Shofu Inc., Kyoto, Japan), aiming to enhance the natural appearance of the prosthesis (Figure 2E).

Figure 2 - Laboratory procedures. (A) Printed models mounted on a semi-adjustable articulator (SAA) to preserve the vertical dimension of occlusion (VDO) and enable subsequent occlusal adjustments. (B) Resin used for 3D printing of the denture base and teeth. (C) Denture base and teeth fabricated using the FlashForge 3D Printer. (D–E) Mounting of the printed CD on the SAA to verify occlusal contacts. (F) Finishing and polishing procedures.

Second Appointment

After the occlusal adjustments of the 3D-printed CD had been performed on the SAA, an intraoral evaluation was conducted to assess esthetic and functional parameters previously established during the laboratory procedures. Once its clinical adequacy had been confirmed, the denture was returned to the laboratory for the final finishing and polishing procedures.

During the same clinical appointment, the mandibular RPD was relined on the left side due to modifications made to the curve of Spee of the maxillary teeth, which had been previously planned in the digital environment to correct the occlusal plane. This approach enabled the reestablishment and bilateral balancing of occlusal contacts.

Laboratory Phase 2

For the finishing procedure, a medium cross-cut Maxicut spherical tungsten carbide bur (American Burrs, Santa Catarina, Brazil) was used. Polishing

was performed with pumice, followed by calcium carbonate powder ($CaCO_3$; Spanish white), to obtain a smooth surface suitable for clinical use (Figure 2F).

Third Appointment

The 3D-printed CD was delivered without the need for additional adjustments. Clinical examination demonstrated satisfactory retention, indicating appropriate adaptation to the supporting tissues. The patient expressed satisfaction with the treatment, particularly highlighting the short time required to complete the procedure, which totaled 14 days from the initiation of the clinical protocol (Figures 3A–C).

Fourth Appointment

The follow-up appointment was conducted ten days after the denture delivery. At this evaluation, no clinical adjustments were necessary, and no areas of discomfort or ulceration of the supporting tissues were identified. Denture retention remained stable and satisfactory, confirming both the adequate clinical performance and the patient's adaptation to the new prosthetic appliance (Figure 4A).

Fifth Appointment

The fifth appointment was conducted 12 months after digitally fabricated CD. At this evaluation, the prosthesis remained structurally intact, with no pronounced wear or significant staining. However, clinical examination revealed a loss of retention, a finding that was also reported by the patient, indicating compromised denture stability over the course of use (Figures 4B–E). It is noteworthy that, in this case, the second appointment could have been omitted, allowing delivery of the digital CD in only two visits. This would represent a substantial reduction in the need for travel for geriatric patients.

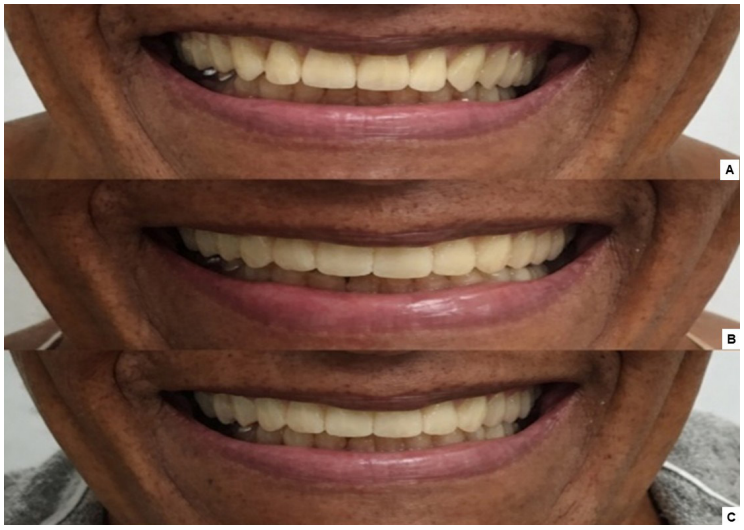

Figure 3 - Comparative photographs. (A) Previous CD, (B) Printed CD during the clinical try-in stage at the second appointment, and (C) Delivery of the adjusted and polished printed CD, showing satisfactory retention.

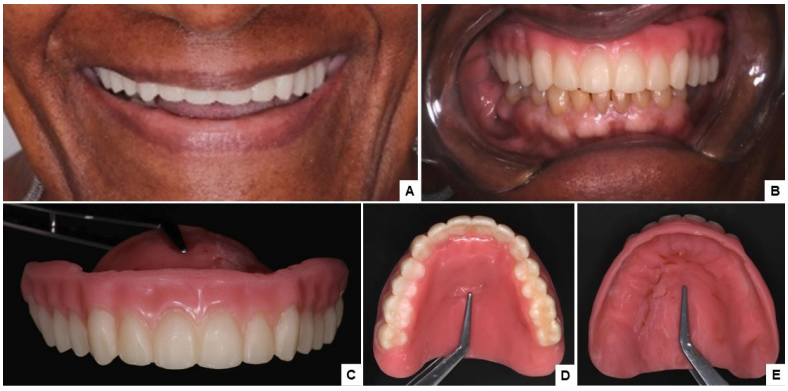

Figure 4 - Follow-up appointments. (A) First follow-up appointment, 10 days after denture delivery. (B-E) Clinical appearance of the CD after 12 months of use.

DISCUSSION

This case report describes the fabrication of a CD by means of a predominantly digital workflow (hybrid technique), in which an immediate CD was used as a reference. The main distinguishing feature of this approach was the completion of treatment within 14 days, highlighting its clinical and academic relevance, particularly in the context of the learning curve associated with the adoption of new technologies in dental practice within a high-demand clinical setting.

Although the use of CAD/CAM systems for CD was first described by Maeda et al. (9) in 1994, these early CAD/CAM dentures were produced using rapid prototyping technology based on photopolymerized acrylic resin and fabricated with a three-dimensional laser lithography (LL) system. The complexity of the clinical and laboratory procedures delayed the consolidation of commercially available CAD/CAM systems for approximately two decades (10). Despite technological advances, limitations related to the determination of the VDO, the establishment of esthetic references, and the functional impression of the oral mucosa persist, hindering the adoption of a fully digital workflow. Furthermore, the inability to establish the mandibular occlusal plane, the limited participation of the patient during clinical workflow, and the high costs of materials and laboratory procedures remain relevant drawbacks (8,11,12). Therefore, the hybrid protocol employed in this case report represents a viable clinical alternative, combining digital and conventional techniques to optimize treatment predictability and functional and esthetic outcomes.

Despite the clinical predictability of the conventional method for CD fabrication, consolidated over nearly a century, its limitations—such as the need for multiple appointments, high costs, laboratory variability, compromised adaptation of denture bases due to polymerization shrinkage, and difficulty in denture duplication—have driven the adoption of digital workflows. From a clinical perspective, this technology has relevant potential for healthcare practice, public health, education, and research (13). In this context, the hybrid digital approach adopted in this case report aimed to streamline clinical steps, reduce the number of appointments, and minimize technical variability, thereby promoting greater standardization of the rehabilitation process. Such a strategy represents a viable alternative that is progressively aligned with operational demands of the OCM, particularly in the care of geriatric patients.

Nevertheless, other technical challenges remain, particularly regarding the scanning of soft tissues in edentulous patients. The absence of dental references, mucosal mobility, and the presence of saliva complicate intraoral scanning and may compromise the accuracy of digital models. Recent studies indicate that conventional impressions with border molding still provide better denture base retention than intraoral scanning alone (8). Patzelt et al. (14) demonstrated that, although scanning edentulous mandibles is feasible, its accuracy remains limited due to mobile areas and smooth saliva-covered surfaces, highlighting the need for further technological improvements. Similarly, Thu et al. (15) reported that impressions with border molding continue to provide superior retention of digitally fabricated bases compared with intraoral scanning alone. Wada et al. (12) observed that conventional techniques are still necessary, especially for recording soft tissues and establishing occlusal planes that cannot be determined solely by intraoral scanning. Consistent with these findings, obtaining clinical references by means of conventional methods or from the patient's existing denture, as in this case, contributed to the optimization of the clinical workflow and to the reproducibility of the treatment planning process.

The retention of digital CD remains a controversial topic in the literature. Aboheikal et al. (16) reported the highest mean retention values in the 3D-printed group, followed by the conventional and milled groups. In general, CAD/CAM systems have demonstrated lower polymerization shrinkage and better adaptation of denture bases compared to conventional techniques, factors that may contribute to better retention. In a clinical study, AlHelal et al. (17) compared the retention of milled and conventionally fabricated maxillary denture bases and concluded that denture bases milled from pre-polymerized poly(methyl methacrylate) (PMMA) resin provided significantly greater retention than conventional heat-polymerized denture bases. Therefore, milled denture bases appear to be an appropriate option when greater retention is required (17). Furthermore, clinical evidence suggests that both milled and 3D-printed dentures may exhibit superior mechanical performance after artificial aging compared with conventionally heat-polymerized dentures (18). In this case, denture retention was considered clinically satisfactory, consistent with the findings of Aboheikal et al. (16), who reported a positive correlation between denture retention and patient satisfaction.

According to Al-Fouzan et al. (19), CAD/CAM systems can reduce both clinical and laboratory

time, improve communication between the clinic and the laboratory, and enable digital storage of data for future denture reproduction. In addition, denture bases milled from PMMA have been associated with greater dimensional accuracy, lower surface roughness, and reduced microbial adhesion, factors that may contribute to improved retention and prosthesis longevity. However, these advantages should be interpreted with caution, as the final clinical performance depends not only on the material itself but also on the quality of the scanning process, virtual treatment planning, and clinical execution. In this regard, Macrynikola et al. (20) highlighted that intraoral scanning can minimize the discomfort associated with conventional impression materials and reduce clinical risks, making it particularly advantageous for patients with mobile remaining teeth. Nevertheless, limitations related to the extent of edentulous areas, the accuracy of soft tissue capture, and the operator's level of experience reinforce the need for an individualized approach when determining the indication for this technology.

Thu et al. (15) reported that, compared to the conventional workflow, digital CD required significantly less clinical time, resulting in time savings ranging from 205 to 233 minutes. Laboratory time was reduced by up to five hours. However, in addition to the recommended number of appointments, extra visits may still be required for the adjustment of digital dentures (15).

Evidence from the same research group reinforces the consistency of the benefits associated with digital workflows for CD fabrication. In a comparative study conducted in a university setting, a two-appointment digital protocol significantly reduced clinical time and overall costs compared with the conventional protocol. Despite higher material costs, the digital approach demonstrated the potential for institutional cost savings and a more favorable cost-benefit ratio from a societal perspective (21). These findings were further supported by a subsequent systematic review, in which CAD/CAM-fabricated complete dentures demonstrated superior mechanical performance and surface properties, improved retention, and reduced clinical time requirements compared to conventional dentures. Milled dentures exhibited greater flexural strength and flexural modulus, whereas 3D-printed dentures showed higher adaptation accuracy, although with lower color stability. Despite the operational and biomechanical advantages observed, esthetic limitations were still reported, particularly for printed dentures, indicating that, although promising, digital technology continues to face clinical challenges that must be addressed (22).

Schwindling and Stober (23) reported in a pilot study that achieving harmonious esthetics with digital CD required additional clinical corrections, increasing the mean number of appointments to 5.4. These adjustments were primarily related to esthetic factors, including midline deviations, discrepancies involving the interpupillary line and Camper's plane, alterations in lip support, reduction of the buccal corridor, and localized tooth repositioning. The complications observed largely reflect the clinical and laboratory learning curve associated with the implementation of new digital workflows and are similar to the challenges encountered when harmonizing artificial teeth with the oral cavity and facial features (23). The authors further emphasized that the inclusion of an additional clinical appointment may increase the predictability of esthetic outcomes for less experienced users, whereas more experienced clinicians may benefit from simplified protocols requiring fewer clinical steps (23).

Thu et al. (15) reported that esthetic complications are relatively common in digital complete dentures, including midline misalignment, unsatisfactory tooth shade, and occlusal discrepancies, which may require additional clinical appointments. In this context, virtual esthetic try-ins have been shown to be less predictable than conventional wax try-ins (15). In this case, the inclusion of a clinical try-in appointment helped minimize potential esthetic shortcomings, contributing to greater predictability of the final outcome.

Within the Brazilian Navy Health System, the incorporation of a digital workflow for the rehabilitation of older patients carries implications that go beyond individual clinical outcomes, directly impacting care organization and institutional logistics. Considering that the technological infrastructure is already in place, the consolidation of this model primarily depends on the technical training of the multidisciplinary team and the alignment of clinical and laboratory workflows. In high-demand settings such as geriatric dentistry, the reduction in the number of appointments, clinical chair time, and indirect costs may enhance operational efficiency, with a potential impact on reduced waiting times and improved access to treatment. In this sense, the structured adoption of a digital workflow within a military healthcare environment should be understood not only as a technological innovation, but also as a

strategy for optimizing resources and ensuring the sustainability of healthcare delivery (Chart 1).

Nevertheless, the effective incorporation of CAD/CAM technology requires continuous investment, specialized training, and consistent integration between clinical and laboratory workflows, with the active participation of the dentist in digital treatment planning being a key factor for achieving functional and esthetic predictability. It should be emphasized that the findings of this case report derive from a single clinical observation with a limited follow-up period, which restricts the generalizability of the conclusions. Therefore, controlled clinical studies with larger sample sizes and long-term follow-up are necessary to more robustly establish the true clinical, economic, and organizational impact of digital and hybrid workflows in CD rehabilitation.

Chart 1 - Comparative overview of conventional versus hybrid digital workflows for CD fabrication.

Conventional Steps Maintained	Incorporated Digital Steps	Clinical Benefits
Functional impression using the patient's existing denture as a custom tray	Scanning of the functionalized denture and antagonist	Greater anatomical fidelity and integration between techniques
Stone casting	Digital articulation of the models	Accurate maxillomandibular relationships
Mounting on an SAA	3D printing of the models	Predictable and reproducible treatment planning
Occlusal adjustments on the SAA	Virtual simulation and preliminary adjustments	Reduction of laboratory and clinical time
Try-in appointment	3D printing of the prosthesis	Reduction in the number of clinical appointments
Finishing and polishing	Digital data storage	Ease of future reproduction

CONCLUSION

This case report demonstrates that a digital workflow for CD fabrication may be a viable and clinically satisfactory approach, associated with a reduction in the number of appointments and overall treatment time, which is particularly relevant in geriatric patient care. Initial retention, functional stability, and patient-reported comfort reinforce the potential of this technique as an alternative to conventional approaches. Although long-term controlled clinical studies are still needed, the combination of conventional methods and CAD/CAM technology appears to be a promising strategy to improve predictability, efficiency, and clinical safety in prosthetic rehabilitation.

The authors declare no conflict of interest.

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