CASE REPORT

Optimizing full arch rehabilitation with a digital workflow: case report

RELATO DE CASO

Otimizando a reabilitação de arco total com um fluxo de trabalho digital: relato de caso

Cauê Fontan[1]
Gustavo Mendonça[2]
Paulo Borella[3]
Renata Cimões[4]
Catherine Ramundo[5]
Rafael Siqueira[6]

Corresponding author:
amorimcavalr@vcu.edu

[1] MsC, PhD Student, Department of Prosthetics and OroFacial Surgery, Federal University of Pernambuco, Recife, Pernambuco, Brazil / Department of Periodontics, School of Dentistry, Virginia Commonwealth University, Richmond, Virginia, USA
[2] PhD, Prosthodontics Department, School of Dentistry, Virginia Commonwealth University, Richmond, Virginia, USA.
[3] PhD, General Practice, School of Dentistry, Virginia Commonwealth University, Richmond, Virginia, USA
[4] PhD, Student,Department of Prosthetics and OroFacial Surgery, Federal University of Pernambuco, Recife, Pernambuco, Brazil.
[5] DDS, Private Practice, North Carolina, USA.
[6] PhD, Department of Periodontics, School of Dentistry, Virginia Commonwealth University, Richmond, Virginia, USA

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Keywords: Rehabilitation; Dental implants; CAD-CAM; Stereophotogrammetry.

Abstract

In full arch rehabilitations, a detailed diagnosis is essential for guiding the selection of the most appropriate therapeutic approach. The complexity of these treatments requires meticulous and individualized planning. The aim of this report is to describe a clinical case of a patient with compromised dentition who was rehabilitated with a full-arch restoration using a digital workflow. A 46-year-old male patient was referred for correction of a partially edentulous maxillary arch. During the clinical examination, it was observed that the remaining dentition could not be utilized in the rehabilitation; therefore, it was decided to proceed with extractions and the placement of six dental implants in the maxilla, with immediate loading. The workflow was digital, incorporating the fabrication of tooth-supported, mucosa-supported, and alveolar contour surgical guides, as well as the use of photogrammetry and CAD-CAM technology. After six months, it was possible to deliver the definitive FP1-type prosthesis made of monolithic zirconia. Since the delivery of the definitive prosthesis, the patient has been closely monitored and reports satisfaction with both the aesthetic and functional results. This case highlights the importance of a thorough diagnosis in determining the appropriate rehabilitative approach for full-arch cases. Digital workflows streamline treatment, enhance accuracy, and, when combined with personalized planning, lead to optimized outcomes in implant rehabilitation.

Palavras-chave: Reabilitação; Implantes dentários; CAD-CAM; Estereofotogrametria

Resumo

Nas reabilitações de arcos totais, um diagnóstico detalhado é essencial para orientar a seleção da abordagem terapêutica mais adequada. A complexidade desses tratamentos exige um planejamento meticuloso e individualizado. O objetivo deste relato é descrever um caso clínico de um paciente com dentição comprometida que foi reabilitado com uma prótese sobre implantes de arco total usando um fluxo de trabalho digital. Um paciente do sexo masculino, de 46 anos, foi encaminhado para correção de um arco maxilar parcialmente edêntulo. Durante o exame clínico, observou-se que a dentição remanescente não poderia ser utilizada na reabilitação; portanto, decidiu-se proceder com as extrações e a instalação de seis implantes dentários na maxila, com carga imediata. O fluxo de trabalho foi digital, incorporando a fabricação de guias cirúrgicos suportados por dentes, suportados por mucosa e contorno alveolar, bem como o uso de fotogrametria e tecnologia CAD-CAM. Após seis meses, foi possível entregar a prótese definitiva do tipo FP1, feita de zircônia monolítica. Desde a entrega da prótese definitiva, o paciente tem sido acompanhado de perto e relata satisfação com os resultados estéticos e funcionais. Este caso destaca a importância de um diagnóstico completo na determinação da abordagem reabilitadora apropriada para casos de arco total. Os fluxos de trabalho digitais agilizam o tratamento, aumentam a precisão e, quando combinados com o planejamento personalizado, levam a resultados otimizados na reabilitação com implantes.

Introduction

Dental implants have demonstrated their efficacy over the years for replacing missing teeth in patients partial or complete edentulous[1]. With the increasing use of dental implants and more outcomes data on treatment success available, a more detailed assessment of the biological and mechanical complications that are commonly involved in the process[2] became possible and brought more attention to the importance of patient-centered outcomes. The choice of treatment for the complete edentulous patient is particularly challenging and should account for functional needs, aesthetics, and patient expectations. Digital technology has introduced varied protocols with different types of treatment planning, surgical and prosthetic implant solutions, expanding options to meet patients' clinical requirements[3,4].

Patients with multiple missing teeth and compromised remaining dentition present significant challenges in rehabilitation. The primary difficulty is determining whether to preserve and restore the remaining teeth while addressing edentulous areas or to extract all teeth and proceed with a full-arch treatment[5]. This decision must be carefully balanced to avoid potential risk of overtreatment and often depends not only on the type of structures compromised but also heavily on the patient's compliance, financial means, expectations, and preferences[6]. With technological advancements, digitization has progressively replaced conventional techniques, offering a way to enhance clinical outcomes by enabling more precise prosthetic planning and optimizing implant positioning through guided surgery. With continuous advancements, these digital tools provide an integrated and efficient approach that meets complex clinical demands, bringing greater predictability and accuracy to implant rehabilitation[7].

The digital workflow can be particularly helpful to improve the fabrication process for interim and final implant-supported prosthesis by replacing traditional methods of intraoral pick up of prefabricated interim dentures and conventional impressions for final prosthesis. In this context, 3D printing and intraoral scanners have become tremendously popular in the last decade. However, intraoral digital scanners still face challenges that can affect precision for complete edentulous cases, leading some researchers to still consider conventional impressions to be more accurate than digital methods[7,8]. Stereophotogrammetry stands out for its ability to transfer data while minimizing three-dimensional, angular, and linear errors establishing itself as a solid alternative to conventional techniques and intraoral scanning for complete edentulous rehabilitations.

Photogrammetry has been used as an efficient adjunctive tool in the digital workflow for completely edentulous patients[8-12].

Beyond the precision of the digital workflow, the choice of prosthetic material is essential. Studies have shown that complete edentulous patients show an increase in masticatory muscle thickness when rehabilitated with implant-supported prostheses, which positively impacts mastication[13,14]. Just as technology has advanced workflow processes, prosthetic manufacturing materials have also improved with 3D printed resins recently being an alternative option for interim implant-supported dentures[15]. Monolithic zirconia has become the most popular material for final prosthesis due to its ability to to overcome the chipping issues often associated with ceramics. In addition to its excellent biocompatibility and aesthetics, zirconia provides less wear to opposing teeth and offers greater simplicity in the workflow[16-18].

The present case report describes the rehabilitation of a patient with a full-arch implant-supported a prosthesis utilizing a fully digital workflow that includes digital planning, computer guided surgery, photogrammetry and 3D-printing applications for prosthesis fabrication.

Case Report

A 46-year-old patient presented to the post-graduate periodontal clinic at the School of Dentistry of Virginia Commonwealth University, with a chief complaint for “correction of his upper teeth”. Clinical examination revealed presence of only the maxillary left lateral incisor, left canine, and central incisors, with probing depths of 2-3 mm. The mandible exhibited missing molars, except for the right first molar, generalized probing depths of 3-5 mm, tooth 31 (FDI) with a gingival recession of 6 mm and an inadequate band of keratinized mucosa, and insufficient bone ridge thickness in the 36 (FDI) region for dental implant placement (Figure 1).

Figure 1: Initial intraoral condition. A) frontal view in occlusion. B) Remaining dentition in the maxilla. C) Occlusal view of the mandibular dentition.

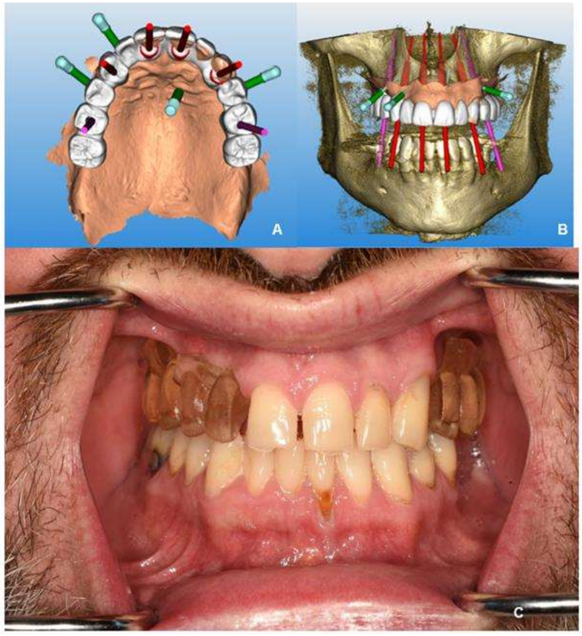

Figure 2: Digital Planning and wax-up. A) Occlusal view. B) Frontal view. C) Intraoral try-in of the 3D-printed wax-up.

The patient reported a penicillin allergy, no comorbidities or medication use, and is a former smoker, having quit three years ago. Due to the lack of support for a removable partial denture, patient's desire for a fixed restoration, and esthetic demands, the treatment plan included a maxillary full-arch implant-supported prosthesis combined with alveolar ridge augmentation and the placement of a single implant in the region of tooth 36.

Intraoral scans and CBCT were initially loaded on an implant planning software (RealGuide, ZimVie, USA) and properly aligned. In this case the implant planning included a virtual wax-up and multi-unit like abutments. This software allows the export of the scanbodies associated with the abutments selected to prosthesis design even before implant placement. After alignment the .STL files were exported into Dental Systems (3Shape, Denmark) to plan the prosthesis according to the initial implant plan. A version of the wax-up was 3D printed to evaluate occlusion and confirm posterior teeth positioning before extractions (Surgical guide resin, Form 3B, FormLabs, USA) along with planning for surgical guides. In the software, the implants were planned based on the wax-up, arranged in a parallel configuration in the regions of the central incisors, canines, and first molars, leaving a minimal cantilever (Figure 2).

Digitally planned and 3D-printed guides (Surgical guide resin, FormLabs) included a tooth-supported guide for drilling in the free-end areas, a mucosa-supported guide for use in regions following extractions (Figure 3), and a guide for defining bone contours.

Figura 3: 3D-printed surgical guides. A) tooth-supported surgical guide for fixation pins and posterior implants placement. B) Mucosa-supported surgical guide for implant placement.

For the surgical procedure, 2g of clindamycin, 800mg of ibuprofen, and 2mg of lorazepam were administered as preoperative medications, and the procedure was performed under intravenous sedation. After local anesthesia, the tooth-supported guide was placed solely for the fixation pin perforations, and supracrestal incisions were made in the free-end areas, with sulcular incisions in the dentate region. A full-thickness flap was reflected, and the tooth-supported guide was then secured without deviation upon placement. The regions of teeth 13, 15, and 25 (FDI) were contoured, and drilling for implants was conducted in the free-end areas (Figure 4).

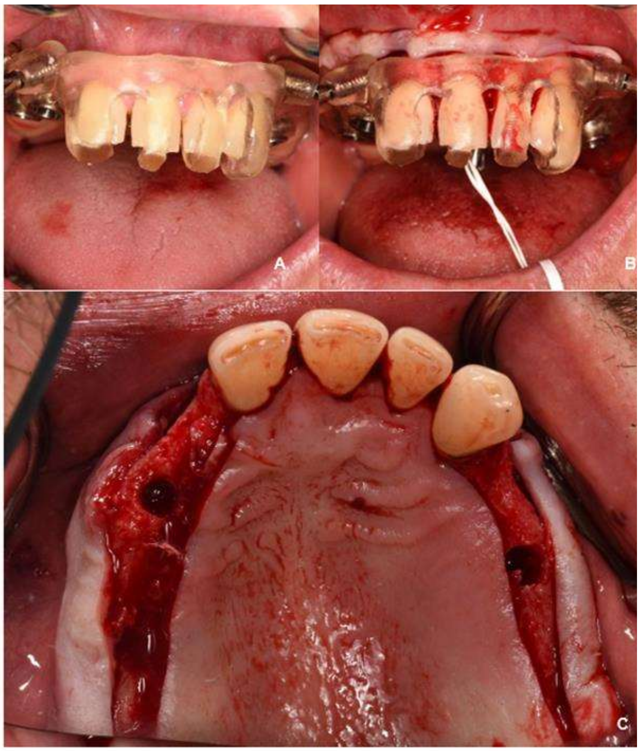

Figure 4: Tooth-supported guide. A) Tooth-support for fixation pins placement. B) Adaptation of the guide after incision and flap reflection. C) Aspect after osteotomy preparation in the edentulous areas.

The tooth-supported guide was removed, and the maxillary teeth were extracted using conventional forceps, during which a fracture of the buccal cortical plate was observed in the region of tooth 23 (FDI). The mucosa-supported guide was then installed with good stability for the remaining drillings, and all six implants (DS PrimeTaper, Dentsply Sirona, Charlotte, NC, USA) in the maxilla were fully guided and installed with an individual torque of equal or greater to 35N.cm (#16 - 3.6x 11 mm, #13 - 3.6x 11 mm, #11 - 3.6x 13mm, #21 - 3.6x 13mm, #23 - 4.2x 13mm, #26 - 4.2x 13mm) (Figure 5).

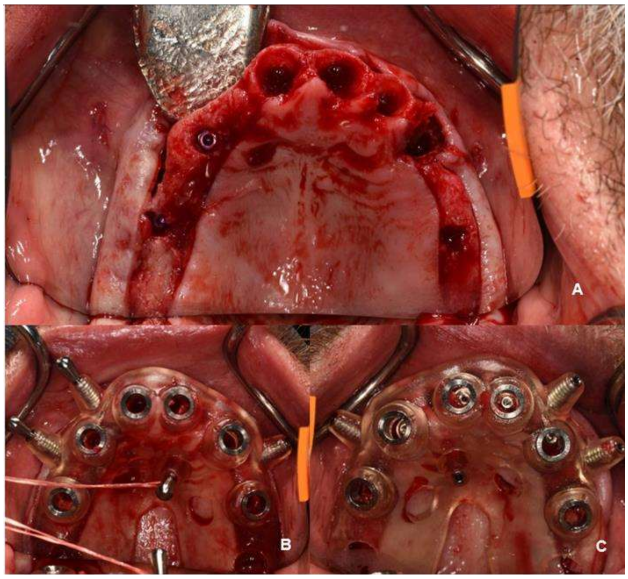

Figure 5: Adaptation of the mucosa-supported guide. A) Oclusal view after the teeth extractions. B) Adaptation of the guide using the previously established fixation pins position. C) Occlusal view after implant placement.

The cover screws were installed, and the bone contours were shaped with the aid of the bone sculpting guide, to establish 3-4 mm distance from the future zenith of the crowns while preserving 1 mm of bone coronal to the implants platform. The multibase abutments (DS PrimeTaper, Dentsply Sirona) were installed, and photogrammetry (Micronmapper, Claronav, USA) was utilized for transferring implant positions for the fabrication of the immediate interim prosthesis. It was also necessary to do an additional tissue scan using the intraoral scanner to capture the soft tissue (Trios5, 3Shape, Denmark). While the prosthesis was being printed, the region of the cortical plate fracture was grafted with autogenous bone and 0.25 FDBA (Oragraft, LifeNet, Virginia Beach, USA), and covered with a collagen membrane (BioGide, Geistlich, Switzerland). The jump gaps of the extractions sockets were filled with allograft (FDBA, Oragraft) (Figure 6). Suturing was carried out, and the 3D-printed (OnX Tough 2 Resin, Pro55S, Sprintray, USA) interim prosthesis was installed (Figure 7). In this step the STL file from Micronmapper containing only the scanbodies, the intraoral scan file with the tissue and scanbodies were aligned to each other and also aligned to the previous scan of the patient before surgery. The new scans were aligned according to the initial implant plan and prosthesis design files. This allows the temporary to be quickly redesigned based on the implant placement but already adjusted to patient occlusion and teeth position.

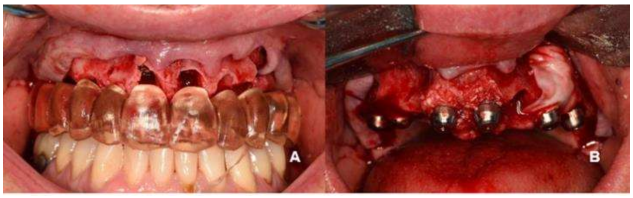

Figure 6: Bone sculpting guide. A) Adaptation of the guide. B) Jump Gaps filling.

Figure 7: Interim prosthesis fabrication. A) Occlusal view after suturing. B) Frontal view of interim prosthesis. C) Occlusal view after the installation of the interim prosthesis. D) Immediate patient's smile after the procedure.

Nineteen days postoperatively, the patient underwent a second procedure for the installation of the implant in the region of tooth 36 (4.2x11mm; DS Prime Taper).

Three weeks postoperatively, the patient underwent a third surgical procedure for root coverage in the region of tooth 31 (FDI) using a free gingival graft. Six months after maxillary implants placement, the patient returned for a follow-up visit where mucosal inflammation was observed around the distal implant site on the right maxilla surrounding the prosthesis (Figure 8).

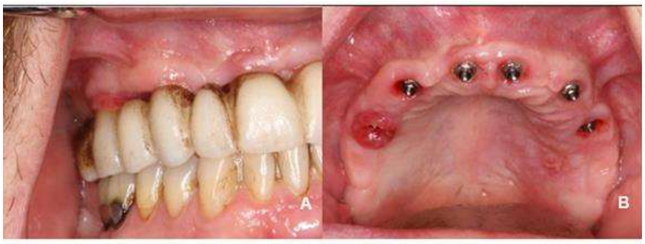

Figure 8: Six Month follow-up visit. A) Mucosal inflammation is observed around most posterior right implant site. B) Clinical condition after prosthesis removal.

The prosthesis was then removed, the area was mechanically cleaned and irrigated with chlorhexidine (0.12%) and a new prosthesis with modified contour in the area was fabricated and installed to create a more concave submucosal area where patient could easily clean (Figure 9).

Figure 9: Delivery of the new modified interim prosthesis. A) Comparison of the interim prostheses. On the left, the new prosthesis. B) Intraoral frontal view after installation. C) Occlusal view after installation. D) Patient's smile after the installation.

The patient returned two weeks after the prosthesis reshaping with no associated complaints and improved soft-tissue health. Six months after the initial surgical procedure, the interim prosthesis was removed, and the definitive FP-1 monolithic zirconia (3Y, Ivoclar, Liechtenstein) prosthesis was installed, followed by adjustments. With the patient's approval and satisfaction, a panoramic radiograph was taken, and the crown on implant 36 was cemented. A new scan was also conducted with the prosthesis for the fabrication of an occlusal splint (Figure 10).

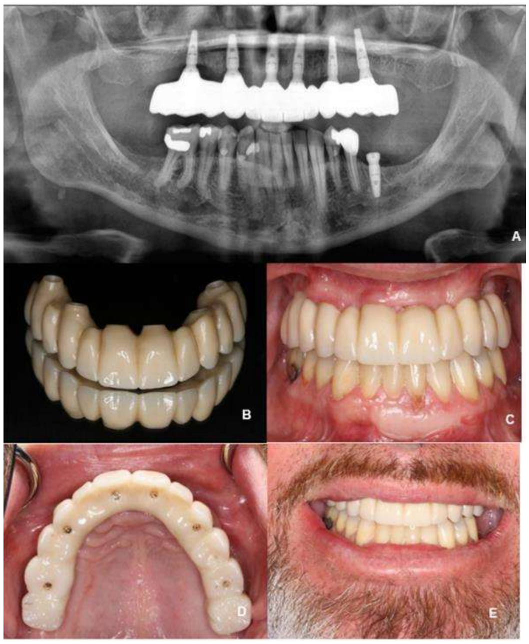

Figure 10: Final delivery. A) Panoramic X-ray. B) FP-1 Monolithic Zirconia prosthesis. C) Frontal view. D) Occlusal view. E) Patient´s smile.

At the seven-month follow-up visit, an improvement in soft tissue health was observed and the patient was very satisfied with the final outcome (Figure 11). Periapical radiographs revealed good prosthesis fit and bone levels compatible with physiologic bone remodeling (Figure 12).

Figure 11: Seven-month follow-up visit: A) Frontal view. B) Occlusal splint. C) FP-1 Monolithic Zirconia prosthesis. D) Patient´s smile.

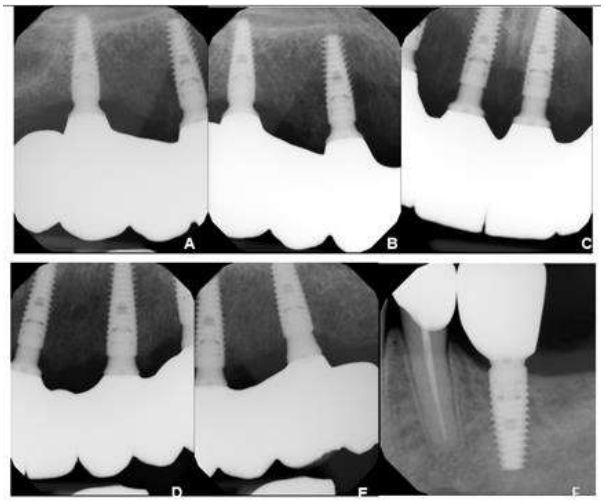

Figure 12: Seven-month follow-up visit radiographs: A) Bone level around site 16. B) Bone level around site 13. C) Bone level around site 11 and 21. D) Bone level around site 23. E) Bone level around site 26. F) Bone level around site 36.

Discussion

Before considering dental implant rehabilitation options, a comprehensive diagnostic assessment is essential to ensure treatment success. In the present case report, clinical examination revealed that the patient retained only four teeth in the maxilla which had no periodontal issues. However, their inadequate positioning and distribution presented a complex challenge for partial rehabilitation with removable dentures or dental implants[19-21]. Given these limitations, along with the patient's desire for a fixed solution and improved aesthetics, the treatment plan involved extracting these teeth and proceeding with full-arch implant rehabilitation.".

The literature has yet to establish an ideal number of implants for treatment longevity, making distribution of implants a significant factor. Several studies recommend a range of 6 to 8 implants, while others argue that 4 implants are adequate for a maxillary implant-supported prosthesis[22-24]. It may seem intuitive that a higher number of implants would increase support, but it can affect distribution distribution or positioning of implants that may be associated with biological complications or result in implant in close proximity or in distal cantilevers[25,26]. Two systematic reviews sought to evaluate survival, bone loss, and biological and mechanical complications in relation to the number of implants. Both reported no differences between groups regarding rehabilitation survival or incidence of complications[23,27]. However, Sharaf et al. (2024)[27] observed greater marginal bone loss with 4 implants, while the use of CAD/CAM technology and parallel distribution of implants were linked to significantly higher survival rates in the 6-implant group. Given that the patient had sufficient bone availability, the installation of 6 implants was feasible without the need for additional alveolar ridge augmentation procedures. Digital planning was essential for anticipating positioning based on the prosthesis design, ensuring minimal cantilevers and optimal parallelism.

Computer guided surgery was utilized in this case report which allowed for greater precision compared to freehand surgery[28]. Although freehand-installed implants exhibit a similar survival rate to guided ones[29], studies indicate a lower number of early failures and a more comfortable postoperative experience with guided surgery[30]. A digital wax-up was performed and 3D-printed to evaluate the posterior occlusal dimension, confirming that the remaining alveoli could be utilized for implant placement. The first guide, supported by the teeth, provided stability and precision, while the mucosa-supported guide was secured using the same perforations pins established by the tooth-supported template, highlighting the accuracy of the planning and digital impression.

Immediate esthetics are of paramount importance for patients. The literature suggests that immediate loading does not alter implant and prosthesis survival rates as long as some criteria are met including adequate implants primary stability and control of patient's occlusion and habits[31]. By employing the utilized protocol, satisfactory positioning and torque for immediate loading were achieved.

The workflow that incorporates 3D printing offers advantages over traditional techniques. This technology facilitates the production of dental prostheses, allowing for the creation of personalized end products with reduced material waste. With its ability to achieve high resolution, 3D printing enhances efficiency, significantly reducing treatment time compared to conventional approaches. Its reversible nature also allows for easy adjustments and refinements, providing greater flexibility in the prosthetic workflow[32].

Despite the consolidation of the digital process, arch scans do not demonstrate greater efficiency, remaining a sensitive technique in the absence of anatomical landmarks[33,34]. An in vitro study observed similar accuracy between intraoral scans and scans of edentulous arches[34], while a systematic review indicated that intraoral scanning is accurate for edentulous arches but emphasizes the need for more clinical studies[36].

Due to the sensitivity of techniques for transferring the three-dimensional positioning of implants in full arches, the literature still does not provide a definitive answer on how to ensure this precision. An in vitro study comparing four different techniques found similar accuracy among intraoral scanning, scanning with a splint, and conventional techniques; however, the use of a splint reduced initial deviations but did not decrease errors throughout the procedure. In contrast, stereophotogrammetry demonstrated greater accuracy with fewer three-dimensional erros[12]. Another study showed that adding a splint may enhance the performance of intraoral scanning, but stereophotogrammetry remained the most precise technique[9]. The literature still presents limitations, such as the difficulty in capturing accurate images of soft tissue[12]; however, the availability of a photogrammetry device may be an excellent ally in achieving the desired precision such as obtained in the present case report.

As with the entire process, the patient's prosthesis was also designed and fabricated using CAD-CAM technology in zirconia. In addition to biocompatibility, favorable esthetics, and reduced working time, zirconia is associated with lower rates of biological and mechanical complications[16,17,37]. Although other materials have longer study periods and advantages such as lower cost and ease of repair, various disadvantages can also be observed, including changes in prosthetic tooth positioning, veneered acrylic fractures, and screw loosening[36]. The literature shows that zirconia, when fabricated using CAD-CAM technology, offers superior fit due to its entirely virtual and predictable production capacity, along with an excellent survival rate[37,38]. In a retrospective study evaluating 71 edentulous patients, zirconia implant-supported fixed prostheses demonstrated a survival rate of over 90% at six years, establishing it as a suitable material for full-arch implant-supported rehabilitation[18].

In the reported case, the patient presented with a low smile line and preservation of anterior vertical dimension by the remaining teeth. Therefore, no bone reduction was required for better adaptation of the prosthesis to be installed. A regularization of only the alveolar contours was performed, using a printed guide to accommodate an FP1-type prosthesis. The choice of prosthesis type was primarily based on the preservation of bone structure in a young patient, allowing for potential retreatment in the event of rehabilitation failure. Additionally, the FP1-type prosthesis is lighter and easier to clean, reducing the likelihood of complications, and features contours that more closely resemble natural teeth compared to an FP3-type prosthesis.

Conclusion

This case report illustrates the challenges involved in treating the complete edentulous patient and highlights the advantages of a digital workflow, not only for reduced treatment time but for improved predictability of the clinical outcomes. This comprehensive approach underscores the importance of individualized treatment planning and the integration of emerging technologies to optimize outcomes in implant dental rehabilitation.

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