ARTICLES SCIENTIFIQUES

Overcoming Prosthetic Space Limitation in Removable Partial Dentures with Digitally Fabricated Teeth

Gestion de la limitation de l'espace prothétique dans les prothèses partielles amovibles par l'utilisation de dents numériques

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Résumé

La hauteur occlusale prothétique utilisable (HOPU) correspond à l'espace nécessaire à l'intégration harmonieuse des composants prothétiques. Sa réduction constitue un obstacle à la conception et à la réalisation d'une prothèse fonctionnelle et esthétique. La prise en charge de cette situation repose d'abord sur l'identification et la correction de son étiologie. Toutefois, lorsque cette gestion étiologique s'avère impossible, il devient essentiel d'adapter la solution prothétique à l'espace disponible. Cet article met l'accent sur l'apport des dents numériques dans ce contexte. Grâce aux technologies de conception assistée par ordinateur (CAO), à la modélisation 3D et à la simulation occlusale, les dents numériques permettent d'optimiser la planification prothétique et d'obtenir des résultats personnalisés, même dans un volume réduit.

Mots clés : Espace prothétique réduit, Prothèse, Dents numériques, Conception assistée par ordinateur (CAO)

Abstract

The usable prosthetic occlusal height (UPOH) refers to the space required for the proper integration of prosthetic components. Its reduction presents a challenge in achieving both functional and aesthetic prosthetic outcomes. Management typically begins with identifying and addressing the underlying etiology. However, when this is not feasible, the prosthetic solution must be adapted to the available space. This article focuses on the role of digital teeth in such situations. Through computer-aided design (CAD), 3D modeling, and occlusal simulation, digital teeth allow for optimized prosthetic planning and customization, even in cases of limited prosthetic space.

Key words : Reduced prosthetic space, Prothesis, Digital teeth, Computer-aided design (CAD)

INTRODUCTION

The growing prevalence of partially edentulous adults is largely attributed to increased life expectancy and the resulting expansion of the elderly population (1). This demographic trend has led to a higher demand for prosthetic rehabilitation, where one of the fundamental parameters to consider is the available prosthetic space. Inadequate space can compromise both the function and esthetics of the prosthetic restoration. Therefore, when the prosthetic space is insufficient, appropriate modification is necessary to accommodate the restorative materials.

Effective management of this limitation begins with the identification of the underlying etiology contributing to the space reduction, which is essential for determining the most suitable therapeutic approach. When surgical correction is not feasible, prosthetic adaptation becomes a critical alternative.

Traditionally, manually sculpted resin teeth were used to accommodate reduced spaces.

However, advances in digital technology have significantly transformed prosthetic fabrication. Computer-aided design and computer-aided

manufacturing (CAD/CAM) systems now enable the precise digital design and fabrication of prosthetic components using both subtractive techniques, such as milling, and additive techniques, including 3D printing (2).

While most studies on removable partial prosthodontics focus on the digital fabrication of RPD frameworks, the digital realization of subsequent steps particularly artificial tooth arrangement remains largely underreported.(3)

Therefore, this report presents a method that incorporates digital techniques in the stages following conventional framework fabrication, allowing for the production of RPDs with customized artificial teeth to solve a limited prosthetic space.

CASE PRESENTATION

A 46 year- old female patient presented for a consultation in the Prosthodontics Department in the Dental Clinic of Monastir, Tunisia, for an oral rehabilitation with functional requests.

Endobuccal examination revealed a Class I Kennedy Appelgate partial edentulism in the maxilla bordered by the canines. The edentulous ridges were high and covered by thin, adherent fibromucosa. In the mandibular arch, the missing teeth were 46,35,36,37. (Figure 1)

Figure 1 Endobuccal view of the maxillary and mandibular arches

The panoramic X-ray showed a radiological crown radiological root ratio less than 1 for all remaining teeth.

Study casts were analyzed on the articulator to evaluate the occlusal plane and the available occlusal space. This analysis revealed an extrusion of the 45 with a value equal to 2mm, and the extrusion of the 47 with a value equal to 3mm.The prosthetic usable occlusal space was insufficient.

The first treatment option given to the patient was the placement of implant-supported crowns; however, due to economic contraints, the patient opted for a combined prothesis. The suggested treatment plan involved the following steps :

• The extraction of tooth 47 to create sufficient prosthetic space as well as the correction of the extrusion of tooth 45 through the placement of a fixed crown. In addition, fixed crowns were planned for teeth 13 and 23 due to the presence of existing restorations: an amalgam filling on tooth 13 and a glass ionomer cement restoration on tooth 23.

• The replacement of the posterior missing teeth using RPD to increase the masticatory efficiency and boost the function.

• Optimize esthetics in the maxillary arch using flexible claps on abutment teeth adjacent to edentulous space.

Peripheral preparation of the maxillary canines and mandibular premolar 45 was performed.

Impressions of the prepared teeth were then taken. After ceramo-metalic crowns' fitting, the sealing was carried out. Maxillary and mandibular anatomo-functional impressions were made using custom impression tray and light silcone.

The metal framework RPDs were conventionally designed, adjusted, finished, and polished by the dental technician. Then, they were validated in mouth. The jaw relationship at centric relation and correct occlusal vertical dimension (OVD) was recorded.

In this case, the vertical prosthetic space was less than 7mm, and so 3D-printed artificial teeth were indicated.

As part of the protocol, the dental cast and the removable partial denture (RPD) framework assembly were scanned together using a desktop scanner (Dental Wings 7 Series) to obtain a digital file in STL format for the subsequent digital workflow.(figure 2)

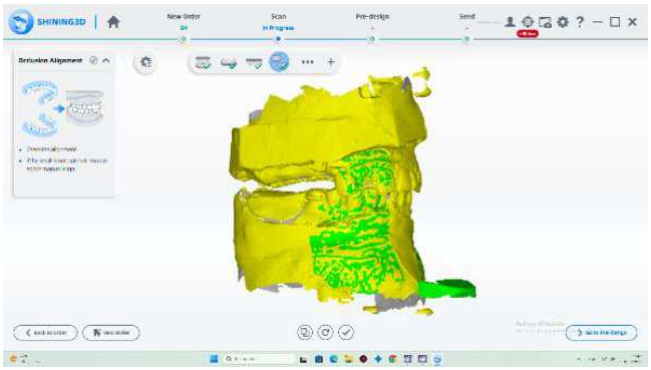

Figure 2 Combined Scan of the Dental Cast and Removable Partial Denture Framework Using a Desktop Scanner

Teeth were chosen with reference to the smile design data and the residual dentition.
The library of prosthetic teeth contains a large selection of different designs and shapes to match the morphology of the natural dentition. (Figure3)

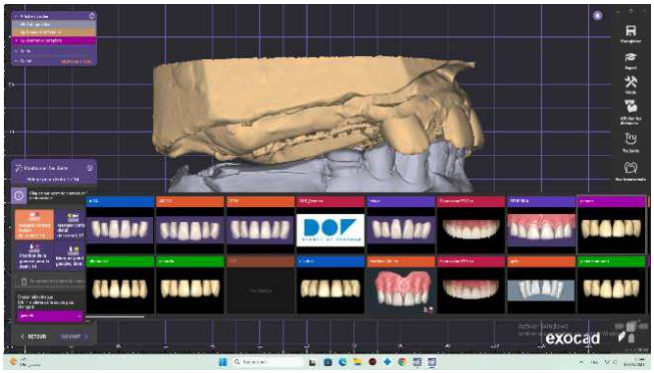

Figure 3 Digital interface of Exocad software displaying the 3D scan of the maxillary and mandibular arches, along with the dental libraries and tools used for the design and selection of artificial teeth.

The digital arrangement of the artificial teeth on 3D models was performed while taking into account the patient's maxillo-mandibular relationship, which was previously recorded (figure 4).

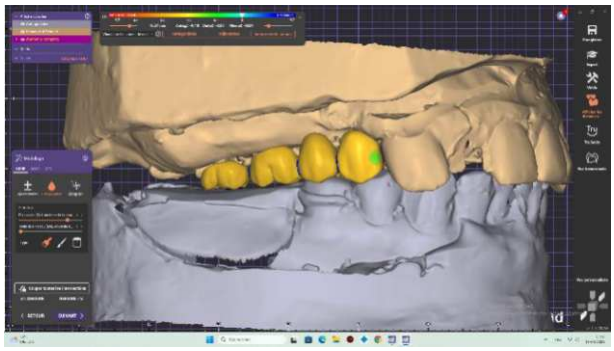

Figure 4 Arrangement of artificial teeth

The virtual design of teeth arrangement was exported as individual STL files .Then the design data, was sent in the format of STL files into a support-and-build preparation soft-ware. This software helped to correctly place the virtual object on the building plate (figure 5).

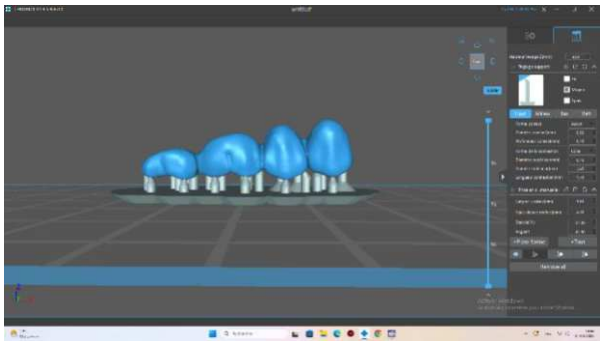

Figure 5 Orientation of Artificial Teeth Arrangement on the Build Platform

The construction process was achieved with a, 3D printer using PMMA liquid. Printed PMMA teeth were waxed on the framework and the validation of the teeth mounting was carried out and the resin of the prosthesis was cured. The framework RPDs were fitted in the mouth and the equilibration was carried out. (Figure 6)

Figure 6 The prosthesis fitted in mouth

The framework RPDs were well integrated in the mouth and the patient was very satisfied with the result (Figure 7). Routine instructions on the new partial dentures maintenance were given to the patient.

Figure 7 The final esthetic result

DISCUSSION

Managing a reduced prosthetic space remains a significant challenge for clinicians, requiring a thorough and individualized approach.(4)When treating the underlying cause of the space limitation is not feasible, prosthetic solutions must be adapted to the available intraoral conditions. In such situations, alternatives such as sculpted resin teeth can help restore both function and aesthetics within the constrained space. Recent advances in digital dentistry have expanded the possibilities for managing these complex cases. Computer-aided design and computer-aided manufacturing (CAD-CAM) allow for precise customization of tooth dimensions and morphology, enabling optimal adaptation to limited prosthetic spaces and contributing to improved clinical outcomes.
The described technique followed conventional protocols for the framework fabrication and denture processing procedures and used the digital

approach for the arrangement of the artificial teeth Customized artificial teeth significantly enhance the aesthetic integration of the prosthetic restoration while enabling precise adaptation to the individual anatomical characteristics of each patient.(5)

The selection and positioning of the prosthetic teeth are carefully planned and recorded on the digital model. Contemporary CAD software provides advanced functionalities, adjustments in tooth size and morphology can be made, and the harmonious alignment of prosthetic teeth within the arch can be optimized through functions such as duplication or mirroring based on the remaining natural dentition.(6)

The cervical margins of the prosthetic teeth can also be repositioned to achieve better alignment with adjacent natural dentition when necessary. Importantly, all modifications are made with consideration of the patient's maxillo-mandibular relationship.(7)

Following the design phase, the fabrication of denture teeth employs advanced manufacturing technologies, These processes are broadly categorized into two primary types: subtractive manufacturing, which involves the precise removal of material from a solid block using milling instruments such as burs, disks, or lasers; and additive manufacturing, wherein objects are constructed incrementally, layer by layer.(8)

In the present case, an additive manufacturing approach was selected through the use of 3D printing technology.

There is a large number of 3D printing technologies available for dental applications including Vat Polymerization (StereoLithography Appartus (SLA), Digital Light Projection (DLP)), Material Jetting, Inkjet Printing, Fused Deposition Modeling (FDM), and powder bed fusion (PBF) (Selective Laser Sintering (SLS), Selective Laser Melting(SLM), Electron Beam Melting(EBM)).(9)

Regarding the properties of 3D-printed denture teeth, several studies have evaluated their mechanical and functional performance. Chung YJ et al demonstrated through an in vitro study that the chipping and fracture loads induced by tensile stress in 3D-printed artificial teeth were comparable to those observed in various commercially available prefabricated teeth. (10)Similarly, Cha HS et al reported that the wear resistance of 3D-printed denture teeth, when tested against zirconia and metal antagonists, was within the range exhibited by several types of artificial teeth. (11).

Furthermore, Chen SG et al.showed that incorporating surface-modified titanium dioxide nano-fillers and PEEK micro-fillers into the 3D-printed PMMA composite resin enhanced both the flexural strength and antibacterial properties of the material.(12)

CONCLUSION

Digital advancements in design, materials, and production have expanded the therapeutic possibilities for partial dentures, offering greater efficiency and improved patient outcomes.

As the demand for removable partial dentures (RPDs) continues to rise, it is essential that RPD approaches evolve accordingly. The integration of new materials, digital technologies, ongoing research, will play a crucial role in enhancing the care of partially edentulous patients and ultimately improving their quality of life.

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