Case Report

A Clinical Report of Digital Assisted Full Mouth Rehabilitation Using Zirconia Inner Crowns and SLM Titanium Framework for Fabrication of Telescopic Denture

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Running title: digital assisted telescopic denture

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Abstract

Patients with poor occlusal support suffer from unequal bone resorption, leading to an uneven occlusal plane. A telescope overdenture could be a promising treatment option for full mouth reconstruction to maintain healthy teeth and balance the unfavorable occlusal pair. Interest in fabricating digitally assisted removable dentures has focused on using intraoral and extraoral scanners, computer-aided design software, and computer-aided manufacturing machines since they may offer faster treatment, better prosthesis fit, and ease of denture duplication. This clinical report describes a method combining digital scanning devices and a 3D milling/printing process with conventional procedures to fabricate telescope dentures for a 66-year-old male patient. The intraoral scanner helped capture the detailed surface structure of the natural abutment teeth and edentulous ridge. Interim dentures could be scanned and converted into 3D data for superimposing digital models to duplicate intermaxillary relationships. Multiple materials were applied during treatment, including zirconia inner crowns, a selective laser melting manufactured titanium metal framework, 3D-milled polymethylmethacrylate artificial teeth, and conventional denture base resin. This digitally assisted method and packing procedure provided a more efficient and precise way to fabricate telescopic overdentures. During the 1.5-year follow-up period, the patient was satisfied with his dentures, masticatory function, and improved physical appearance.

Key words: Telescopic denture, loss of occlusal support, digital assisted prostheses, zirconia, selective laser melting

Introduction

Removable prostheses are a common treatment for patients who have lost many teeth or with poor occlusal support. A telescope denture is a common option for patients with a compromised periodontal situation who wish to preserve as many healthy teeth as possible and pursue better prosthesis stability and retention.[1] A telescope denture consists of inner and outer crowns, a metal framework, artificial teeth, and a denture base. The advantages of these attachments are decreased denture size, increased retention and support, slower ridge resorption, and improved comfort.[2]

Digital dentistry has recently become popular. The use of digital equipment and computer-aided design/computer-aided manufacturing (CAD/CAM) technologies has significantly improved precision and reduced the treatment period. 3D milling has developed extensively over the last decade to produce zirconia prostheses and is commonly used for dental crowns, bridges, and copings.

Regarding metal manufacture, casting difficulties have led to the limited use of titanium in dental prostheses in the past. The selective laser melting (SLM) method has recently been developed to fabricate biomedical components from titanium alloys. Polymethylmethacrylate (PMMA) resin discs can be milled into artificial teeth previously designed and adjusted in CAD software.

A new type of telescope denture can be fabricated by combining these materials. This clinical report describes and evaluates a digitally assisted process to manufacture a telescope denture for the full mouth rehabilitation of a 66-year-old male patient.

Case report

A 66-year-old male patient who attended the Department of Prosthodontics at KMU Hospital requested full mouth evaluation and rehabilitation to improve his masticatory function. The patient stated that the original upper fixed 11-X-22-23 prostheses were highly mobile, and he suffered from gingival swelling due to severe periodontitis. The bridge was removed at a local dental clinic about one month before. Clinical and radiographic evaluations revealed poor oral hygiene, multiple teeth with severe bone loss and malposition, an upper torus palatinus about 2.0 × 3.0 cm in size, an ill-fitting 45-X-47 metal bridge, unfavorable occlusal support with Eichner B3 classification, and complete anterior deep bite (Figs. 1, 2, and 3). The patient hoped to retain as many healthy teeth as possible and looked forward to good functional and esthetic outcomes. However, the patient rejected implant surgery and considered removable denture prostheses a more acceptable option. After detailed evaluation and discussion, it was decided that the telescopic type of dentures with natural teeth abutments would be a suitable treatment option.

His prosthetic treatment began by removing the 45-X-47 metal bridge and extracting the hopeless teeth (31, 32, 41, and 42). Next, a study cast and detailed wax-up were created for occlusal

Figure 1. The patient's initial intra-oral condition. (A) Frontal view. (B) Occlusal view of the upper arch. (C) Occlusal view of the lower arch.

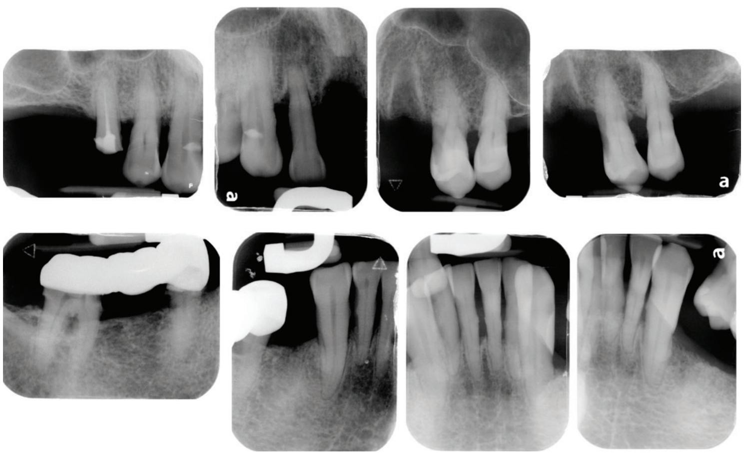

Figure 2. Periapical radiographic films showed unfavorable crown/root ratio for the remaining natural teeth and a poorly fitted 45-X-47 metal bridge

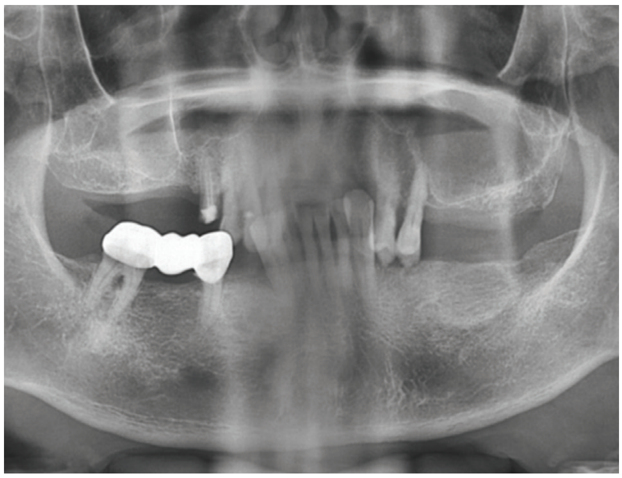

Figure 3. The patient's initial panoramic radiograph film.

space and occlusal plane analysis to evaluate the reduction volume of individual abutments. Then, all his other remaining teeth underwent emergency endodontic therapy followed by preparation and reduction to about 3~4 mm to attain a more ideal crown/root ratio and adequate space for prostheses material (Fig. 4). After the standard impression taking, vertical dimension and centric relation recording, and wax denture try-in, the upper and lower interim overdentures were delivered to meet basic chewing and esthetic demand (Fig. 5). It took the patient about three months to adapt to using removable dentures. The endodontic therapy for all abutment teeth was completed during this period. A thorough assessment was made to ensure those abutment teeth maintained good periodontal condition and the interim dentures worked well.

When fabricating the definitive prostheses, the inter-arch relationship, incisal display, and occlusal plane for tooth arrangement were based on the morphology of the interim dentures. An intra-oral scanner (3-shape Trios 3; 3Shape, Copenhagen, Denmark) was used for the final impression of the abutment teeth and edentulous ridge (Figs. 6A and 6B), and an extra-oral scanner (3-shape E4; 3Shape, Copenhagen, Denmark) was used to duplicate the interim dentures for the jaw relationship record. The digital data were superimposed and designed in Exocad DentalCAD (Exocad GmbH, CA, USA) software. The upper and lower digital model was "mounted" in Exocad to evaluate inter-arch space for all components needed for the definitive prostheses (Fig. 7). A digital wax-up of the upper and lower dentures was made to analyze inter-arch space and predict the future outcome of the definitive denture (Figs. 8A–B).

Zirconia was chosen for the inner crown material due to its strength, tooth-like color, and biocompatibility. The inner crowns were fabricated using a CAD/CAM milling procedure and showed identical long axes for the insertion path and a good fit under clinical examination (Fig. 9A–B). The outer crowns and denture framework were designed as a combined structure to achieve consistency and a strong connection. They were manufactured by 3D printing from metal with the SLM method and showed good accuracy in try-in appointments (Figs. 10 and 11).

The next step was to fabricate the artificial teeth. The morphology and occlusal scheme of the dentition were designed in the Exocad software and milled from a PMMA resin disc. An analysis of a digital wax-up showed that the prosthetic spaces for abutment areas 24, 25, and 47 were limited for PMMA artificial teeth. Therefore, the external surface of the outer crowns was covered with a layer of veneered hard composite resin (crea.lign light-curing veneering composite; Brendent, Senden, Germany) to construct the morphology of the premolars and second molar. Hard composite resin was superior to veneering porcelain due to its flexibility and similar hardness to opposing artificial teeth.

Then, the wax dentures were manufactured for the patient's try-in step. Finally, after the conventional packing and polishing procedure, the definitive dentures were fabricated and delivered for long-term use (Fig. 12A–F) . The patient was satisfied with the outcome of the final denture and returned for three monthly follow-ups. A panoramic radiograph showed a stable periodontal condition and tooth structure (Fig. 13). No complications occurred during the 1.5 years of use and follow-up.

Figure 4. The old 45-X-47 metal bridge was removed, and the remaining teeth were prepared and reduced to 3~4 mm for a better crown/root ratio.

Figure 5. The upper and lower interim dentures gave the patient basic chewing and esthetic function.

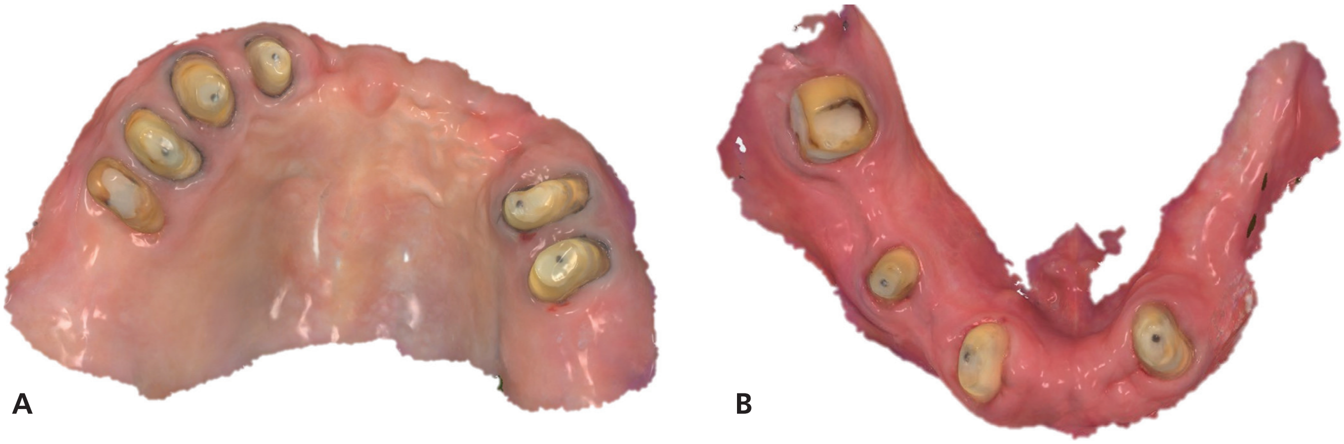

Figure 6. An intraoral scanner (3-shape Trios 3) captured the abutments and edentulous ridge morphology. (A) Upper arch. (B) Lower arch.

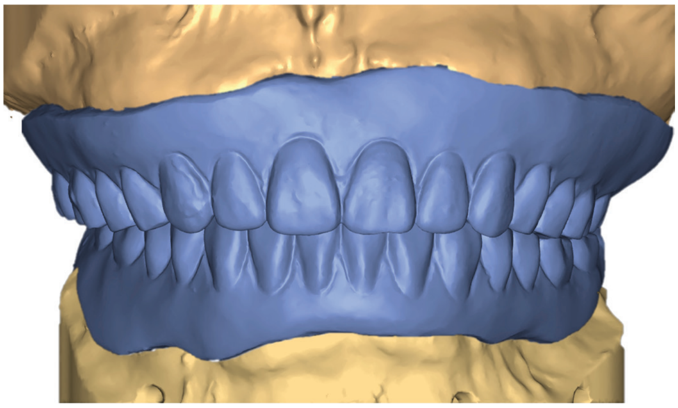

Figure 7.
Interim dentures were scanned with an extraoral scanner (3-shape E3) to record the vertical dimension and jaw relationship. The digital data of the interim denture and bimaxillary arch were superimposed in the Exocad software to display the patient's jaw relationship and design the definitive prostheses.

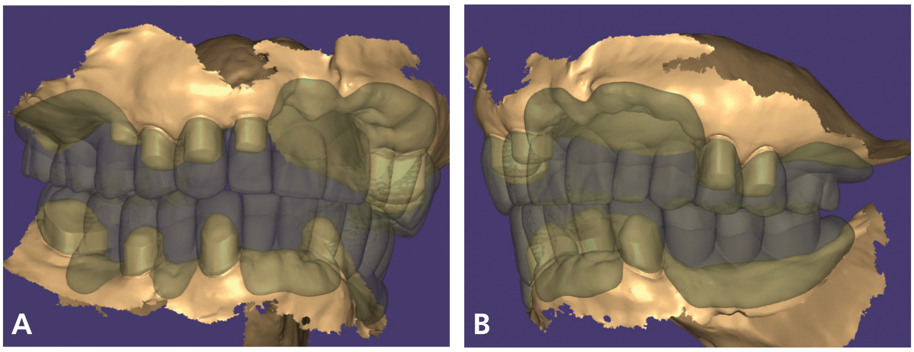

Figure 8. A digital wax-up of the upper and lower dentures was made to analyze inter- arch space and predict the future

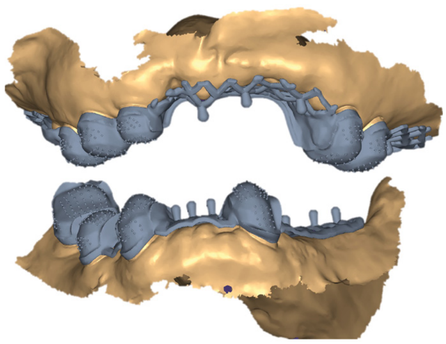

Figure 10. Digital design of the outer crowns and frameworks.

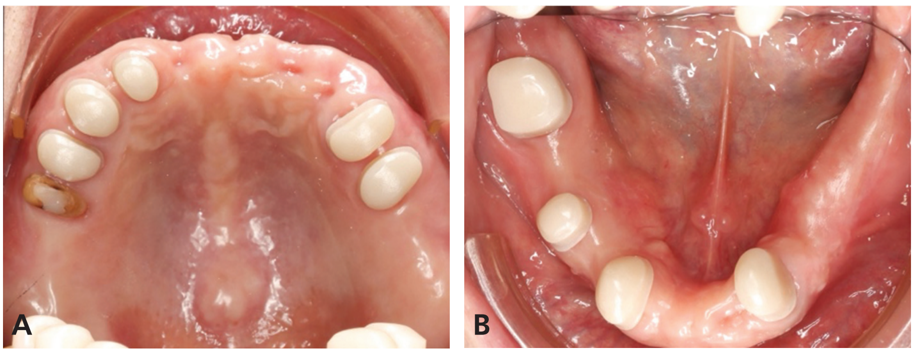

Figure 9. Clinical examination for the try-in step of zirconia inner crowns. (A) Occlusal view of the upper arch. (B) Occlusal view of the lower arch.

Figure 11.
Outer crowns and frameworks were fabricated from titanium by SLM. The images showed a good fit and stable structure at this try-in appointment.

Figure 12. After the conventional packing procedure, the definitive dentures were fabricated and delivered for long-term use. (A) The upper and lower telescopic dentures after the packing and polish procedure. (B) Frontal view of the final prostheses. (C) Occlusal view of the upper denture. (D) Occlusal view of the lower denture. (E) Right side lateral view. (F) Left side lateral view.

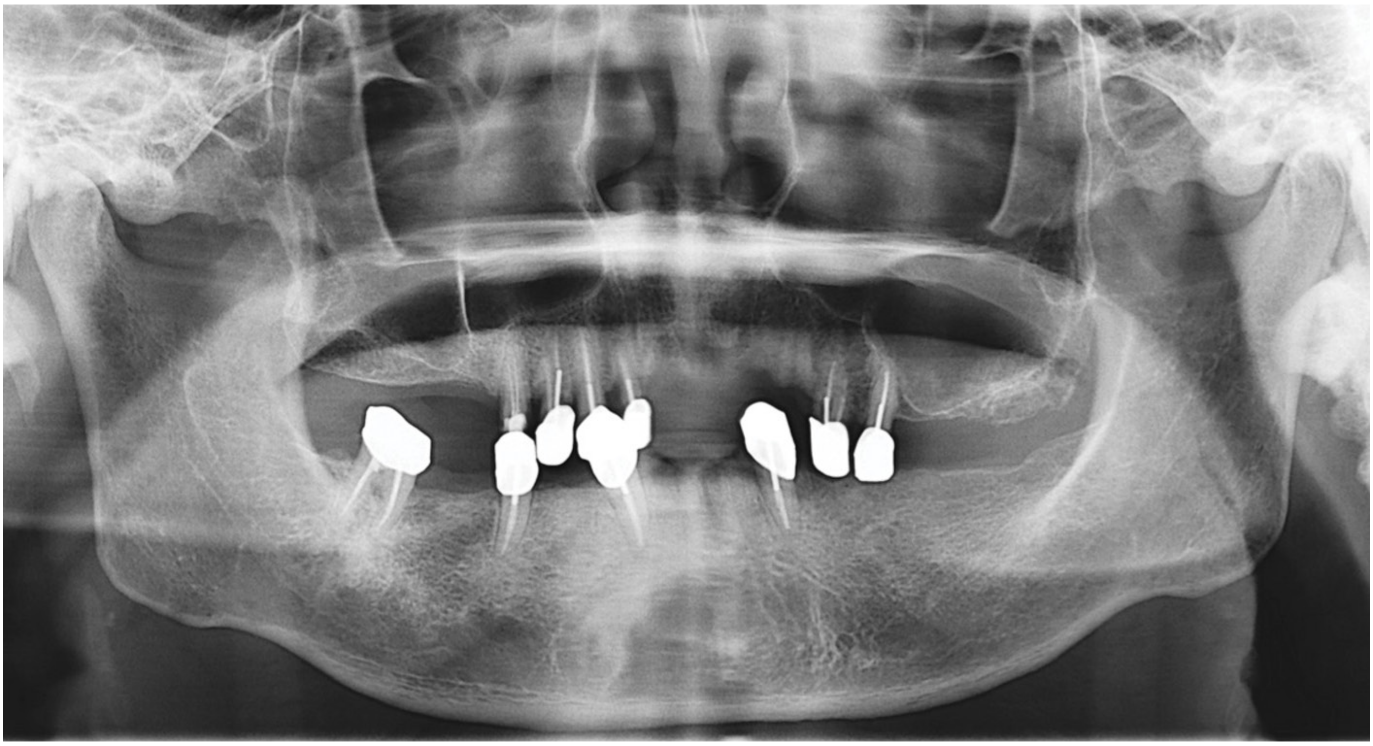

Figure 13. The panoramic radiograph film taken after three months of follow-up.

Discussion

Patients with poor occlusal support, such as missing adjacent teeth and the presence of opposing teeth, suffer from unequal bone resorption, leading to an uneven occlusal plane, bite collapse, periodontitis, and even an increased risk of tooth loss.[3, 4] A telescopic denture is defined as "an overdenture which is a dental prosthesis that covers and is partially supported by natural teeth, natural tooth roots, and/or dental implants." The term "double crowns" was first used by an American dentist over 100 years ago.[5] This treatment is indicated when a few unfavorably distributed abutment teeth remain within the arch.[6] It uses the existing abutment teeth as retainers, which consist of two crowns—the primary or inner crown, which is cemented to the abutment, and the secondary or outer crown, which is attached to the denture—where these additional attachments serve to increase the retention and stability of the prosthesis.[7, 8] With the double-crowns attachment system, clinicians can design a "clasp-free" denture to improve the esthetic demand. In summary, the benefits of telescopic overdentures include preventing bone loss,[9] enhanced esthetic appeal, improved speech (compared to other denture types), proper jaw alignment, and improved chewing efficiency.

Many double-crown systems have been reported in the literature. Retention of the telescopic denture relies heavily on the frictional surfaces between the double crowns. The inner crowns and secondary denture components should have high shear strength and wear resistance. The use of ceramics in dentistry and dental technology has increased in recent years. Among other materials, zirconia has been used to manufacture coping frameworks due to its good mechanical and biocompatible properties. Its use is supported by some studies that examined removable dentures retained on natural teeth or implants using zirconia as copings and/or implant abutments.[10, 11, 12] Almost no fractures of the zirconia copings were observed in this study. These copings or inner crowns proved a successful alternative to classic noble metal alloy copings, especially since the patient had high esthetic demands.

The SLM technique was recently developed to fabricate biomedical components from metals such as gold, cobalt-chromium, and titanium (e.g., Ti-6Al-4V) alloys.[13, 14, 15, 16] Titanium alloys are known for their attractive properties for dental restorations, including corrosion resistance, good mechanical properties, excellent biocompatibility to surrounding tissue, low allergenic potential, and low cost compared to noble metals. Titanium use in dental prostheses is relatively limited in the conventional method because of casting difficulties. Titanium alloys are easily oxidized at high temperatures and react with the investment material required for casting, eventually leading to shrinkage, rough surfaces, and internal defects in the framework.[17] The SLM fabrication method provides the multi-functional capabilities of layer manufacturing and the ability to build complex custom metal structures from any 3D CAD design, which takes advantage of conventional manufacturing processes.[18]

Many factors influence the retentive force of a telescope denture, including the width and height of the inner crown, axial taper angle, adaptability of the outer crown, and gap width in the occlusal region between the inner and outer crowns.[19, 20] Due to digital manufacturing, the axial taper angle and gap width required for outer crowns can be accurately printed using the SLM method. Double crowns made with different materials exhibit different retention forces because of the different friction coefficients between the contact surfaces of the inner and outer crowns.[21] Ideally, the telescopic dentures should be designed to retain stable retention without over- or under-retention. The minimum required retention is preferred to allow the patient to easily remove the denture while ensuring that the denture remains seated during physiologic activities. The over-retention of a telescopic denture can loosen the inner crown or abutments, cause trauma or fracturing of the root, or damage the denture. Therefore, telescopic dentures with more than five abutments are not recommended.[22] In our case, the retentive force between zirconia and the SLM titanium alloy was adequate for telescopic dentures with 4~5 abutments.

Several materials (and combinations of materials) have been used to make telescopic crowns, including precious and non-precious metal alloys, zirconia, and polyether ether ketone.2 The inner and outer crown will wear during long-term use in patients with good mastication function. The materials typically combined in telescopic dentures create a metal-metal, zirconia-metal, or metal-polymer contact, which has different surface wear patterns and, therefore, variable resistance to repetitive removal-insertion cycles.21 A hard material with high resistance to wear is generally chosen for the inner crown and a more flexible material for the outer crown.[23]

Zirconia is often a modified yttria (Y_2O_3) tetragonal zirconia polycrystal, a relatively hard material used in dentistry. Zirconia and titanium alloy show different mechanical properties in compression tests.[24] While zirconia is harder than titanium alloy, their wearing interactions in telescopic dentures were unclear in recent studies. While zirconia is harder than enamel, highly polished zirconia is more wear-friendly to the opposing teeth than other materials.[25] Wearing between inner and outer crowns is inevitable in telescopic denture systems. Some clinical procedures can regain retention force. The wedge effect and retention force could be increased by creating an occlusal gap between the inner and outer crowns. Some reline material (Friktions Geschiebe Passung FGP; Brendent, Senden, Germany) could be applied to the inner surface of the outer crowns to increase friction and regain retention force.[26]

Recording the jaw relation is a fundamental and crucial step in providing a well-functioning restoration. Many devices can record the patient's inter-arch relationships. The occlusal vertical dimension can be registered digitally by scanning the bite record. In this case, the patient was adapting well to his interim dentures. After three months of function and adjustment, the vertical dimension and jaw relationship were very stable, and no parafunction was noted. The interim denture was scanned and duplicated as a bite record to accurately duplicate the jaw relationship. The upper and lower digital data could be precisely set in the design software by superimposing the intra-oral scanning models and bite records. Due to the precise jaw relationship and digital devices, the inner and outer crowns, framework, and artificial teeth could be well designed and fabricated in the following steps.

In this clinical report, multiple digital methods and materials were used for full mouth reconstruction. This digitally-assisted method provided a more efficient and precise way to fabricate telescopic overdentures.[27,28,29] During the 1.5 years of follow-up, the patient was comfortable and continued wearing the dentures, and his masticatory function and physical appearance were improved. However, further studies and research are worthwhile, and long-term follow-up should be considered.

Summary

This clinical report described the treatment procedure of a patient with poor occlusal support. Digitally-assisted methods and multiple materials were used in this case. The definitive prostheses were manufactured using digital scanning devices, CAD software, zirconia inner crowns, SLM titanium outer crowns and framework, PMMA artificial teeth, and conventional packing resin. More studies and follow-ups are needed.

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Conflict of Interest Statement

The authors declare no conflicts of interest related to this article.

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