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JPOR 440 No. of Pages 4

ARTICLE IN PRESS

journal of prosthodontic research xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Journal of Prosthodontic Research

journal homepage: www.elsevier.com/locate/jpor

Technical procedure

A fully digital approach to replicate functional and aesthetic parameters in implant-supported full-arch rehabilitation

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ARTICLE INFO

Article history:
Received 15 September 2017
Received in revised form 11 October 2017
Accepted 25 October 2017
Available online xxx

Keywords:
Dental implant
Digital impression
Emergence profile
Intraoral scanner
Peri-implant tissue

ABSTRACT

Purpose: The aim of this technical procedure was to use a fully digital technique (FDT) for full-arch implant support rehabilitation. The FDT was used to transfer the provisional restoration parameters to definitive restorations using intraoral scanners.

Methods: Three sets of digital impressions were obtained. Through the first set, standard tessellation language 1 (STL1), provisional restorations screwed to implants and the surrounding gingival tissue was captured. STL2 consisted of intraoral scans of standardized scanbodies screwed to implants to collect 3D positioning data of implants. STL3 included the digital impression of provisional restoration out of the mouth in order to capture the gingival architecture and the peri-implant soft tissue that was not possible to transfer with the previous impressions. STL1, STL2, and STL3 were combined using computer-aided design (CAD) functions into a single file, STL4. Thus, STL4 contained information on the 3D implant positions, soft tissue architectures, occlusal relationships, correct occlusal vertical dimension and aesthetic features. Using STL4, the master models with implant analogues were 3D printed. Computer-aided design and computer-aided manufacturing milled (CAD/CAM-milled) aluminium bars and a resin prototype were produced to test the accuracy and the functional and aesthetic parameters. Titanium frameworks were digitally designed using STL4, milled using CAD/CAM, and finalized with pink resin and resin teeth.

Conclusion: The FDT provided an effective fully digital protocol to capture all information for provisional full-arch implant restorations using an intraoral scanner and transfer that information to definitive restorations.

1. Introduction

The introduction of digital technologies to implant dentistry has improved the predictability of clinical and laboratory procedures [1]. When complete-mouth implant rehabilitation is required, digital approaches benefit the clinician by enabling prosthetic-guided planning of the implant position, the realization of the provisional restoration before fixture placement, the ability to perform flap-less surgery, and reduced time and costs [2]. Provisional restorations play a key role in the immediate implant loading protocol since certain characteristics like occlusal vertical dimension (OVD), tooth shape, and position are replicated in the final restorations [3]; however, no completely digital protocol has been described for a full-arch implant-supported fixed restoration that transfers information from the functionalized provisional restoration to the final restoration. In this scenario the application of the fully digital technique (FDT) described in single anterior restoration could be a useful implementation to reduce clinical and laboratory steps and to obtain a predictable aesthetic outcome [4]. However, full-arch digital implant impressions are challenging due to the increased difficulty for the intraoral scanner to correctly capture edentulous mucosa and standardized scanbodies [5–7]. This procedure describes the FDT that was applied to full-arch implant restorations to reduce the steps involved in defining the vertical dimension, occlusion relationship, and gingivngival architecture surrounding the prosthesis.

2. Materials and methods

A clinical case of an edentulous patient was used to illustrate the application of the FDT in a full-mouth fixed-implant restoration. After reviewing the aesthetic and functional parameters, the former dentures were duplicated to acquire radiographic

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https://doi.org/10.1016/j.jpor.2017.10.005
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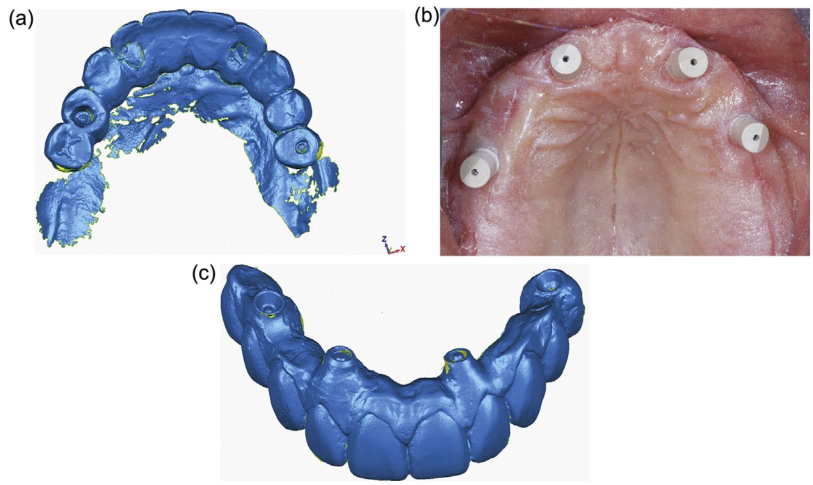

Fig. 1. (a) File generated from an intraoral digital impression of the upper provisional restoration with the surrounding mucosa (STL1). (b) Following the removal of the provisional prosthesis, standardized scanbodies were screwed to implants and sprayed slightly with scan powder to obtain digital impressions (STL2). (c) File generated from digital impressions of the upper provisional restoration executed out of the mouth (STL3). Supra-implant emergence profiles and pontic elements were captured to collect information about the soft tissues surrounding the restoration.

templates for the cone beam computed tomography (CBCT). Guided surgery was planned using the certified Nobel Guide, as described previously [8], and the surgical templates were fabricated. Provisional restorations were digitally designed based on the implant virtual plan and then computer-aided design and computer-aided manufacturing (CAD/CAM) milled. Guided implant insertions were performed and the provisional prostheses were luted to the provisional abutments and loaded. Four months after surgery, three sets of digital impressions were obtained to collect information for the provisional restorations (STL1), the 3D implant positions (STL2), and the soft tissue architecture surrounding the restorations (STL3). Impressions were obtained using wavefront intraoral scanners (True Definition Scanner — Lava Cos; 3M ESPE, St. Paul, MN, USA) with uniformly applied scan powder (3 M ESPE, Seefeld, Germany). The first set of digital impressions (STL1) consisted of intraoral scans of the provisional restorations screwed to implants. Restorations were fully captured within the surrounding gingival tissues (Fig. 1a). Arches were initially scanned separately, and then scanned in the maximal intercuspal position to obtain information regarding the functionalized OVD, tooth shape, and positioning. The restorations were then unscrewed, and screwed scanbodies (Elos Medtech AB, Lidköping, Sweden) were added to the implants (Fig. 1b). The second set of digital impressions (STL2) were executed, and implant 3D positions were registered in both arches. The impression protocol consisted of uninterrupted scans from each arch extremity to the other executing circle paths around scanbodies [9]. In this phase it was not possible to determine the occlusal relationship between arches due to a lack of landmarks. Finally, to collect information about peri-prosthetic soft tissues (PPST; i.e., supraimplant soft tissues and gingival shapes surrounding the pontic elements), the upper and lower provisional restorations were completely scanned out of the mouth and a new set of files was created (STL3) (Fig. 1c). The STL1, STL2, and STL3 files were imported into Geomagic Studio 12 inspection software (3D Systems, Rock Hill, SC, USA) and merged using the best fit algorithm. Since the gingival tissues that were scanned during the intraoral impression process were identical in the STL1 and STL3 files, the Geomagic software identified a good automatic match. Following this, STL2 files were also combined (on STL2, the restoration shape was identical to STL3), creating the STL4 file. STL4 contained the following: 3D-positions of the implants, PPST, occlusal parameters, and aesthetic features. The STL4 file was imported into Dental Software (Dental Wings, Montréal, QC, Canada) to detect implant positions from scanbodies (Fig. 2). Two stereolithographic cast models with implant analogues were 3D-printed. Upper and lower screwable CAD/CAM aluminium bars were produced to check on the patient the accuracy of implant impression (Fig. 3a). Two resin prototypes were designed and fabricated to verify the patient's occlusion and aesthetics (Fig. 3b). The most convenient frameworks supporting acrylics were designed, elaborated, and fabricated. The design procedure was aided by the virtual wax-up (from STL4 files), which allowed the technician to model the shape and anchor pins based on the future positions of the teeth (Fig. 4a). Grade 5 extra-low interstitial titanium was chosen as the material for the frameworks and was milled using a numerical control milling machine with a five-axis computer. The frameworks were assessed using the Sheffield test and X-rays of each implant (Fig. 4b,c). Prostheses were finalized using conventional procedures, and teeth were chosen following the shape and dimensions of the virtual wax-up. The final restorations were screwed at 35 N/cm^2 torque, and the occlusal and lateral contacts were checked using a 20-μm double-sided occlusal marking strip. Each tooth was checked with 8-μm Shimstock foil (Fig. 5).

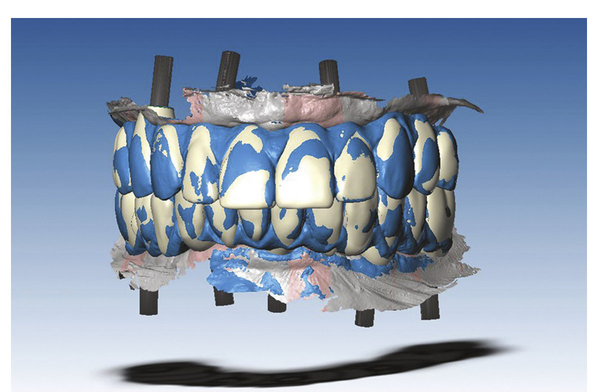

Fig. 2. The STL1, STL2, and STL3 were superimposed and imported into Dental Software to determine implant locations.