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DENTAL TECHNIQUE

Alignment of intraoral scans and registration of maxillo-mandibular relationships for the edentulous maxillary arch

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ABSTRACT

One of the main issues in using intraoral scans for the fabrication of removable dentures is that scans need to be aligned to each other. The workflow presented provides aligned intraoral scans of the arches and of the occlusion rim incorporating maxillo-mandibular relationships and information for tooth arrangement in a single procedure. Thus, after intraoral scanning, the clinician can proceed directly with the denture design. (J Prosthet Dent 2019;121:737-40)

The digitalization of design and fabrication of removable dentures[1] has numerous advantages[2] and is being increasingly used in dental practice.[3] Current computer-aided design and computer-aided manufacture (CAD-CAM) denture systems start by digitizing impressions or definitive casts[4] with a laboratory scanner. However, intraoral digital scans are possible. The production of removable dentures starting from intraoral scans is clinically sensible for the comfort of the patient (reduced number of visits, no unpleasant gag reflex, no potential allergies to impression materials); it is also advantageous from a technical point of view (reduced number of steps; no material expansion, shrinkage, or distortion to deal with; higher level of standardization) and for practice ergonomics (reduced number or visits). A technique to design and fabricate a functional single-arch maxillary denture starting from intraoral scans and using a digital protocol has been reported.[5]

Intraoral scanners can capture a truly mucostatic impression[6] of edentulous arches which is advantageous for treating patients with sharp, thin, flat, or flabby residual ridges. Digital scanning cannot currently incorporate functional movements, but this is not a disadvantage because under the mucostatic concept, denture retention is not achieved by the peripheral seal but depends on surface tension created by the intimate contact of the denture base with underlying tissues. This might permit shorter denture flanges without affecting retention, although excessive underextension of the denture flanges is not desirable because it may reduce secondary retention and stability and impair lip and cheek support.

One of the main issues in using intraoral scans for the fabrication of removable dentures is that scans of edentulous arches are not aligned in the correct relation to each other. Thus, before proceeding with the denture design, it is mandatory to modify the coordinates of the scans to obtain the proper position according to the maxillo-mandibular relationships. A technique for occlusal registration when treating single edentulous maxillary arch has been proposed[7]; nonetheless, it does not allow a registration of all information for tooth arrangement in the same procedure.[7] In addition, it cannot be applied when the patient has no remaining posterior mandibular teeth.

The present technique uses an intraoral scanner to make the intraoral maxillo-mandibular relationship registration and scan alignment and at the same time to register all information for tooth arrangement and transfer all these data into the digital workflow for denture design. In the treatment described, the maxillary arch was edentulous, and the patient wore a removable acrylic resin partial denture in the mandibular arch.

Patient was treated at Salus Oris Srl Dental Clinic, using equipment available in the clinic.

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TECHNIQUE

1. Make the preliminary intraoral scan of the edentulous arch and the antagonist using an intraoral scanner (TRIOS 3 color; 3Shape A/S). Process and export scans (Fig. 1) with the TRIOS software. Use either TRIOS direct connection to export to a desktop or the '3Shape communicate' system. Use the TRIOS 3 also for the other scans.
2. Create digital casts with the specific workflow in the 3Shape Dental System software (3Shape A/S).
3. Design the baseplate for the occlusion rim (OR) and make a 3D print of it. Use the workflow for individual impression trays in the Dental System, setting the space for the material to zero so that the baseplate is completely adapted to the mucosa. The shape of the OR needs to leave uncovered most of the palatal area (Fig. 2A). Transfer the standard tessellation language (STL) file of the designed baseplate to the software application of the 3D printer (M200; Zortrax) and then print with a 0.09-mm thickness of the material (Z-Ultrat; Zortrax). This material is not Federal Drug Administration (FDA) approved for intraoral use, but an approved material with similar properties can be substituted.
4. Add wax (Bite Wax Rims; Henry Schein, Inc) to the baseplate for the definitive OR.
5. Record the vertical dimension, occlusal plane, lip support, maxillary incisor length, and midline by adapting the OR on the patient.
6. Make the facebow and jaw relation records. Use ARCUS Digma II (KaVo Dental GmbH) to record settings for the virtual articulator and centric relation (CR). Guide the patient into CR following the manufacturer's instructions and register CR in the OR previously heated in warm water (Fig. 2A).
7. Make the definitive intraoral scans.
   a. Copy the old order ('order' is how the scanning process is referred to in 3Shape TRIOS software) of preliminary scans. Change the new (copied) order settings as you would scan a "phantom crown" in the maxillary arch; this is aimed just at having access to the "Pre-preparation scan" function and activate this function.
   b. Follow the scanning workflow. Delete the scan of the maxillary jaw derived from the preliminary order. Put the registered OR in the mouth and scan it in the "Pre-preparation scan" step; all the palate should be scanned (Fig. 2A). The mandibular scan is already present in the order because it was copied from the preliminary scan.
   c. Ask the patient to close and guide the mandible into CR registered in the OR. Then, scan the right and left occlusal relationship according to the scanning workflow. At the end of this step, the OR scan is automatically aligned to the mandibular scan. If this is not the case, use the manual procedure available in the TRIOS software to carry out this task (Fig. 2B).
   d. Remove the OR from the mouth of the patient and scan the maxillary edentulous arch by activating the "Preparation scan" step in the scanning workflow. In this step, the TRIOS software presents, by default, the "Pre-preparation scan" of the maxillary arch, which is nothing other than the OR scanned in the step described at point 7b (Fig. 2A). Use cutting tools available in TRIOS software to delete the area of the scan corresponding to the OR and maintain the area of the palate (Fig. 2C). Complete the scan of the maxillary arch starting from the palate area; at the end, the completed scan of the edentulous maxillary arch (Fig. 2D) is nothing other than the "Pre-preparation scan" from which a part has been removed (the OR) and substituted with a new part—the edentulous arch. As such, the new scan is in the same position of the "Pre-preparation scan"; thus, it is already aligned to the antagonist arch (Fig. 3A). Alignment can be easily checked using cross sections (Fig. 3B).
8. Export scans (Fig. 4) and proceed with denture design.

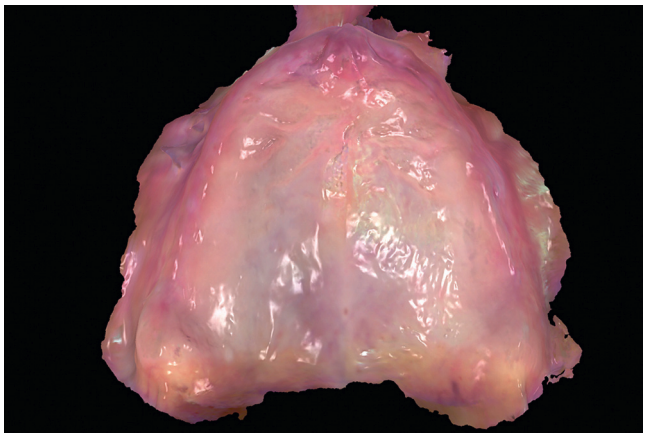

Figure 1. Preliminary intraoral scan of maxilla.

DISCUSSION

To date, although the treatment of edentulous patients with removable dentures can be fully digitalized, registration of the maxillo-mandibular relationship cannot; this task cannot be accomplished in a fully digital or virtual environment and still requires the use of some physical object. In the presented technique, an OR is used for the registration of both maxillo-mandibular relationships and all information for tooth arrangement.

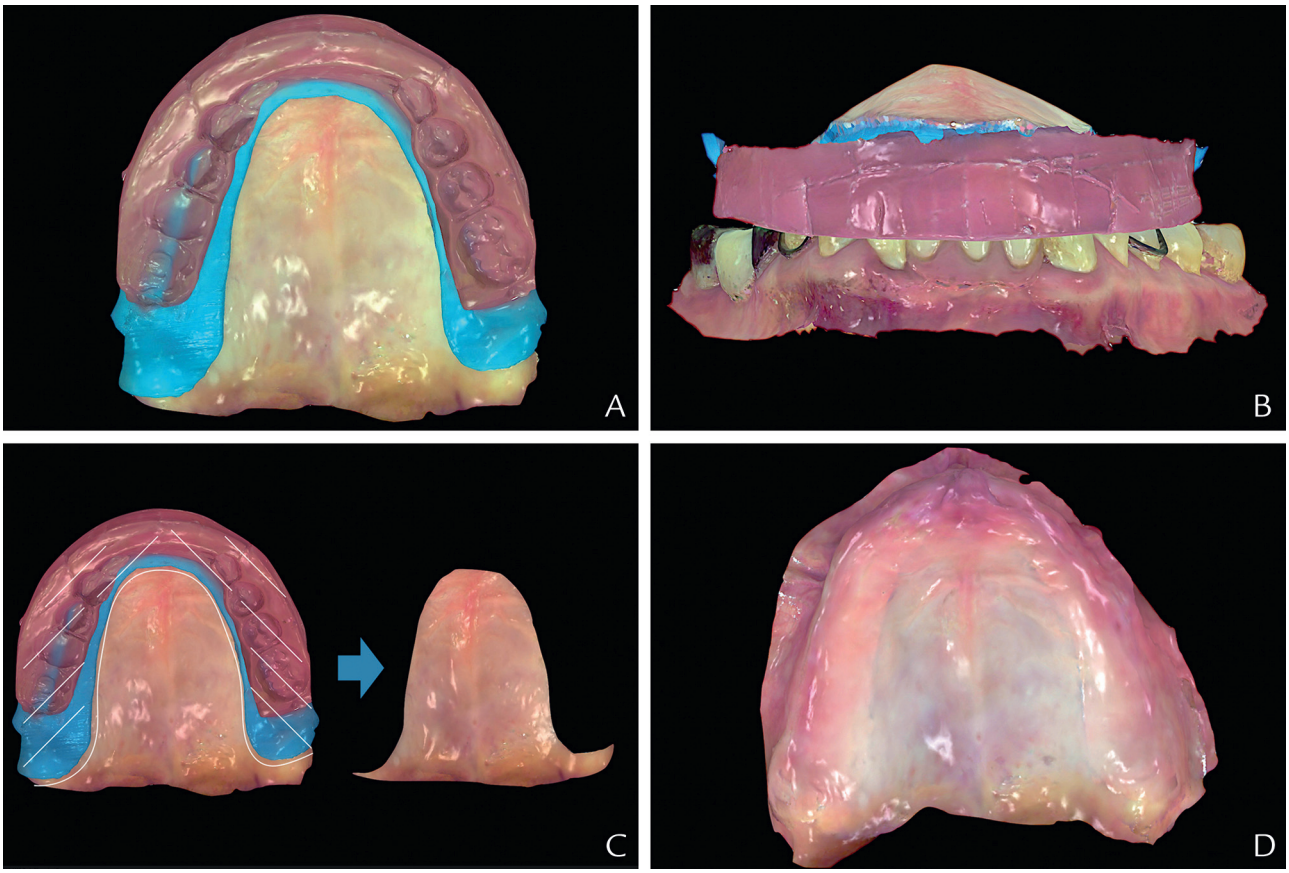

Figure 2. Capturing definitive intraoral scans. A, Intraoral scan of occlusion rim made with wax mounted on baseplate obtained with 3D printing and adapted to patient to register information for tooth arrangement and maxillo-mandibular relation. Occlusion rim leaves most of palatal area uncovered. B, Occlusion rim scan aligned to antagonist arch. C, Area of scan corresponding to occlusion rim deleted, whereas palate is retained. D, Starting from palatal area, scan of edentulous maxillary arch completed.

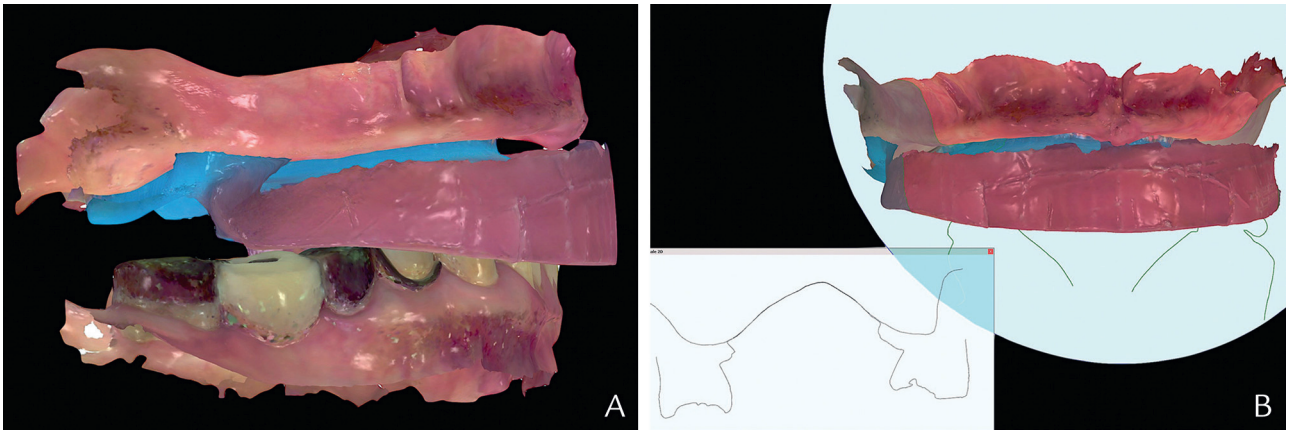

Figure 3. Aligned scans. A, Scan of edentulous arch aligned to occlusion rim and antagonist arch. B, Alignment can be easily evaluated using cross sections.

The scanning of the OR, edentulous arch, and antagonist arch is made intraorally. In addition, the alignment of all these scans is obtained with TRIOS software and is easily transferred into the design workflow. Thus, in a single procedure, it is possible to go from intraoral scan to denture design, guided by all information incorporated into the OR and the scans (or digital models) in the correct position.

In a previous described technique,[5] OR was scanned extraorally and then used to align digital casts with

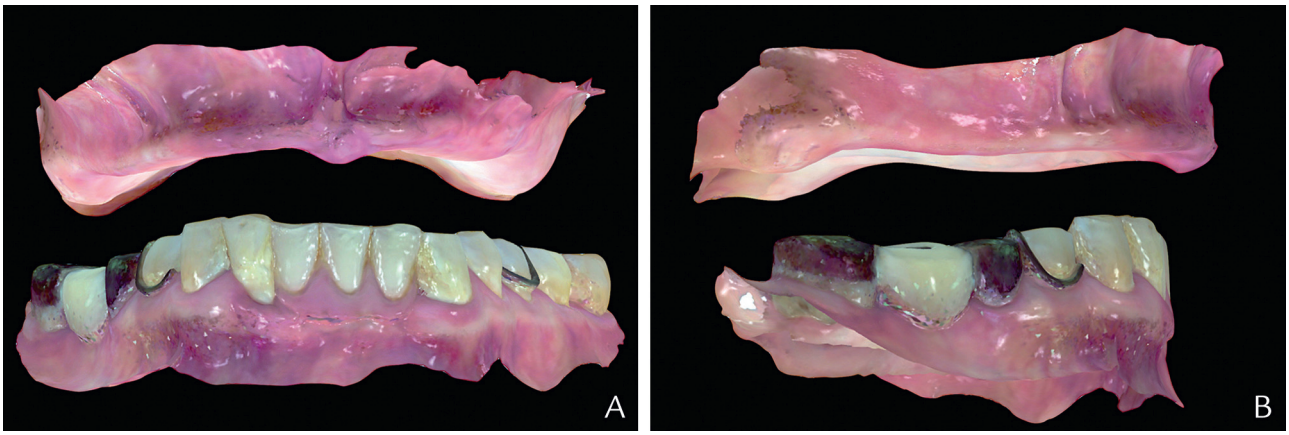

Figure 4. Definitive scans. A, Frontal view. B, Lateral view.

software; this procedure is effective but is more time-consuming because it requires several additional steps and implies the acceptance of some tolerance in alignment.

The technique presented cannot be used for mandibular edentulous arches or completely edentulous patients, but in comparison with the technique of Fang et al,[7] it can be applied when the patient has no remaining posterior mandibular teeth. In addition, the presented workflow makes it possible to obtain, in a single procedure, intraoral scans of the arches, as well as of the OR incorporating maxillo-mandibular relationships and information for tooth arrangement (Fig. 3A). All scans are aligned in the same coordinates system, which means they have the correct interocclusal relationship and can be directly used for denture design. This significantly simplifies the workflow for digital denture fabrication. Studies are required to address the issue of scan alignment in completely edentulous patients.

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