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Case Report

Bridging *distances* in denture design: a global digital approach

Mdt. Antonello **Croce**

- With a six-year tenure as Digital Head at Ruthinium, Mdt. Croce was instrumental in pioneering research and development, focusing on novel materials and digital workflow enhancement. His close collaboration with software houses led to the creation of customised software solutions, improving production efficiency and user experiences.
- Founding Metadac FZE, he offers expert consultancy in digital dental transformations.
- He is the inventor of the DACOS system, awaiting patent approval, and an esteemed international speaker and trainer.
- His recent accreditation as a Blender For Dental Software Instructor further exemplifies his commitment to advancing dental education and practice.
- His role as a reviewer for the Dental Cadmos journal underscores his standing as a distinguished thought leader in digital dentistry.

INTRODUCTION

The evolution of removable dentures has taken a revolutionary leap forward with the integration of digital tools. In the past and even with current methods, designing and producing dentures have been limited by physical impressions and materials between the clinic and laboratory, often affecting the model dimensions and final denture results. However, today marks a new era where precision meets efficiency through digital innovation tools. This article explores a unique collaborative framework where a clinician in Ecuador and a technician in Dubai bridge the geographical gap using advanced digital tools, transforming the denture production workflow.

INITIAL CONSULTATIONS AND IMPRESSIONS

An 80-year-old female patient visited the clinic complaining that her dentures had poor retention. Her medical history was noncontributory, indicating no obstacles to undergoing dental procedures. She mentioned that she had been using the prostheses for over ten years but had never been able to eat properly.

During the intraoral examination, we found the presence of edentulous maxillae with minimal residual ridge, giving the case a guarded prognosis. At the first appointment, an intraoral scan of both maxillae was conducted using an intraoral scanner (Medit i700, Medit Corp; Fig. 1).

FIG. 1 *Digital impression taken with intraoral scanner.*

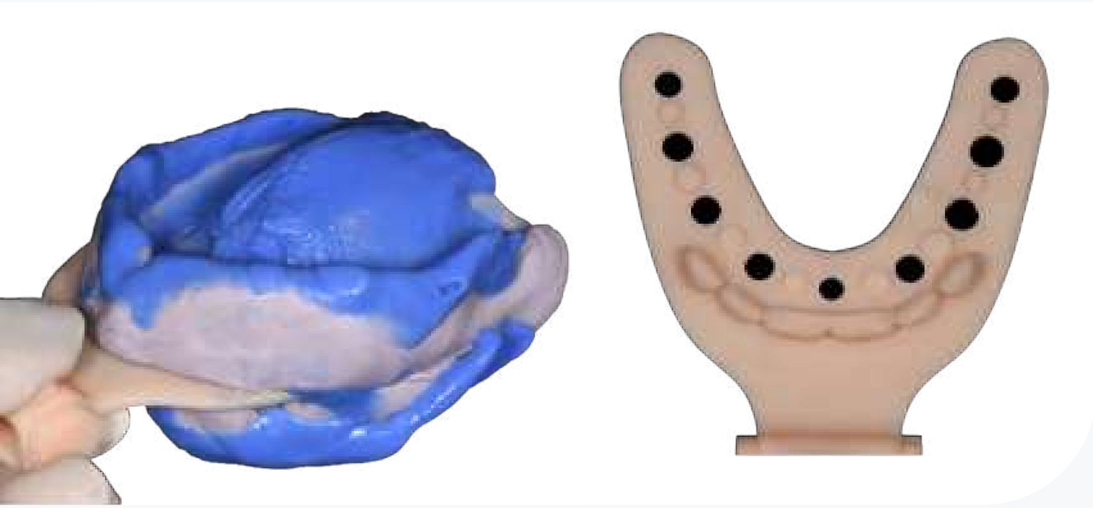

FIG. 2 *Preliminary Occlusal Vertical Dimension taken with printed centric tray.*

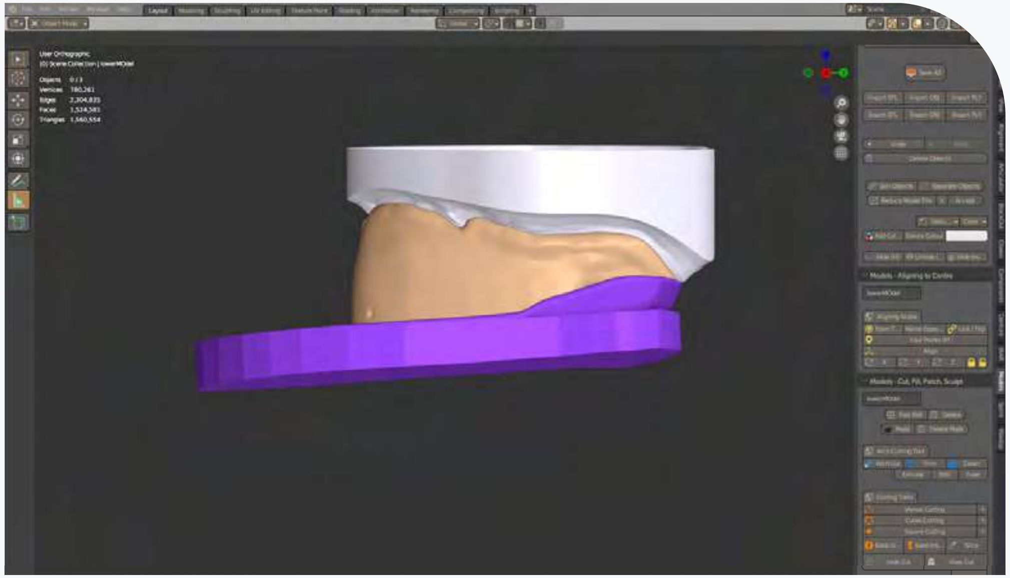

FIG. 4 *Occlusal plane check with Rim Former.*

A record was taken with a 3D printed centric tray to obtain a preliminary OVD record (Fig. 2), aiming to send a predictable interocclusal record to the laboratory for designing the prototypes with which the final impressions would be taken.

DIGITAL DATA INTEGRATION

Upon receiving the digital impression and centric tray scanned with an intraoral scanner, we aligned the impressions accurately at an initial OVD with an approximately 40 mm interarch distance. The impressions were flipped from negative to positive to generate virtual models (Fig. 3). This digital step eliminates transitions from alginate to plaster, directly creating the base without losing any details.

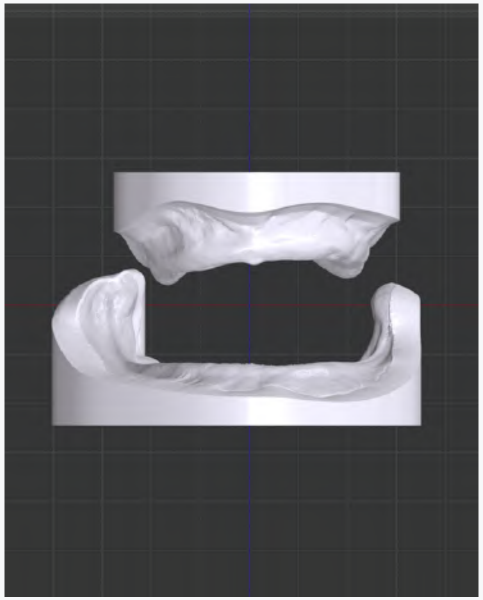

FIG. 3 *Digital models designed from the intraoral scans.*

Next, we designed the stabilised bases and occlusal bite rims using Blender for Dental (Blender For Dental, Australia) software. The design process began with cleaning the scans and generating the virtual model. On these models, we drew the peripheral borders of the bases, incorporating anatomical references and muscle dynamics for speech and mastication, such as the frenum, tongue, and cheeks.

Once designed, a preformatted bite rim STL file was imported and adapted to the upper base. We set the incisal edge height to 22 mm from the upper lip sulcus and 8–10 mm from the interincisive papilla, with a 10° sagittal plane inclination.

The upper occlusal plane was set using a digitised analogue tool, Rim Former (Fig. 4), positioned from the pterygomaxillary notches to the described measurements, creating an ideal upper rim plane.

The lower rim was then adapted to the centre of the alveolar ridge, aligned with the upper rim's plane. Finally, two negative dots were placed near the upper rim's incisal edge, 20 mm apart, which are crucial for smile design software calibration and future picture alignment (Fig. 5).

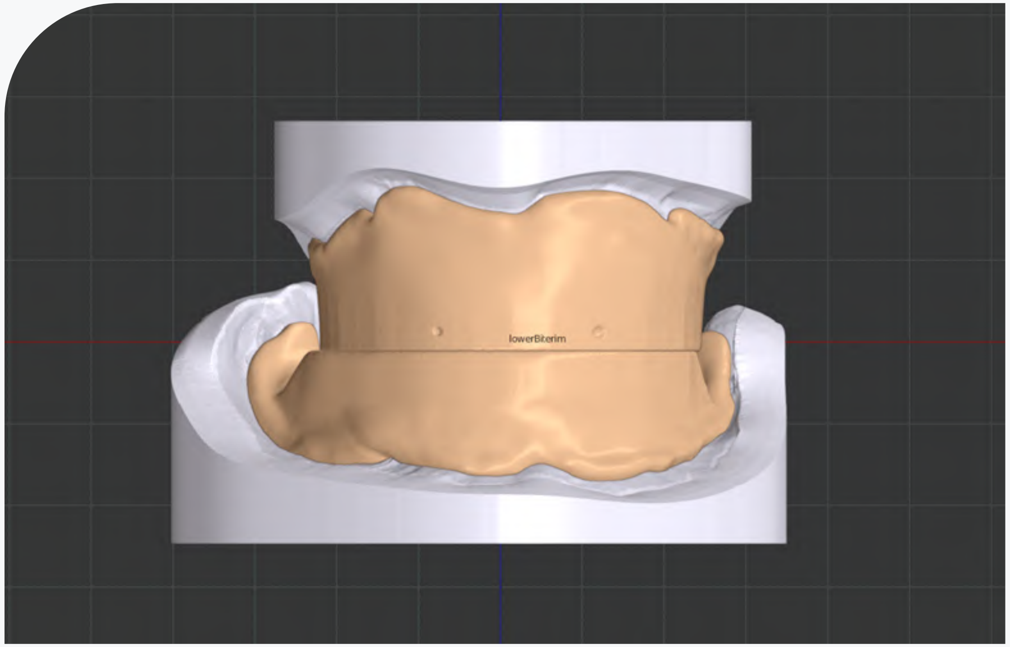

FIG. 5 *Bite rims designed and ready with 2 dots on the upper bite rim.*

FIG. 6 *Second functional impression taken*

SECOND APPOINTMENT FINAL IMPRESSIONS

The prototypes (Cozahn; Osstem Corp) were 3D printed and used to take our final impressions. The impressions of both maxillae were taken using the closed-mouth functional technique (Fig. 6), which was conducted in two stages: a peripheral seal was first created using heavy-body silicone (Heavy body VPS; PlastaCare USA, USA), and then the final impression was created using light-body silicone (Light body VPS; PlastaCare USA, USA). Once the impressions were taken, they were scanned outside the mouth using an intraoral scanner (Medit i700; Medit Corp).

Finally, the impressions were placed back in the patient's mouth, and the occlusion record was made intraorally.

Before removing the bite rims, two pictures were taken with the bite rims in place (Fig. 7). The first used an intraoral retractor, and the second captured the patient's natural smile. The face should be straight, viewed from the front and sagittal perspectives, without tilting. The camera should be in vertical mode.

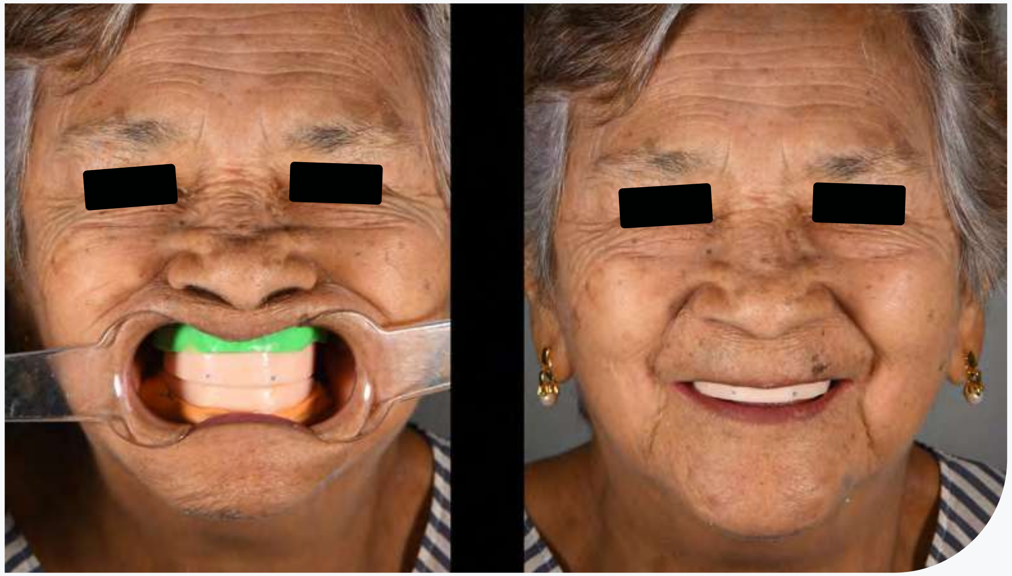

FIG. 7 *Two pictures taken for the Smile Design: one with intraoral retractor and the other with natural smile.*

AESTHETIC 2D SMILE DESIGN: RUTHINIUM DIGITAL PREVIEW

The next crucial step involved importing the two pictures into specific software, such as Ruthinium Digital Preview (Dental Manufacturing S.p.A., Italy; Fig. 8), which allows us to analyze the patient's facial features, identify discrepancies in the smile line and midline and make necessary corrections (Figs. 9 and 10).

After this analysis, we finalised the aesthetic project to share with the clinician and patient. This phase ensured a comprehensive evaluation of the design, selection of suitable teeth and greater patient involvement in decision-making (Figs. 11 and 12).

If mistakes were identified, such as issues with the midline or occlusal plane smile line, we corrected them immediately. We ensure these corrections are followed until the project's completion.

FUNCTION 3D SMILE DESIGN: 3D DENTURE GUIDE

Once the aesthetic project was approved by both the dentist and the patient, considering teeth positioning, dimensions, and colour, we exported an image from the 2D software (Fig. 11), which serves as the link between the 2D and 3D software, containing the upper teeth outlines as project guidelines.

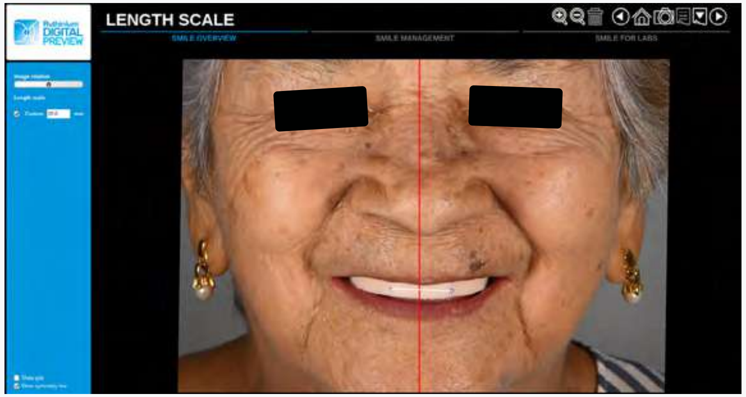

FIG. 8 *Import and calibration of the pictures in the software.*

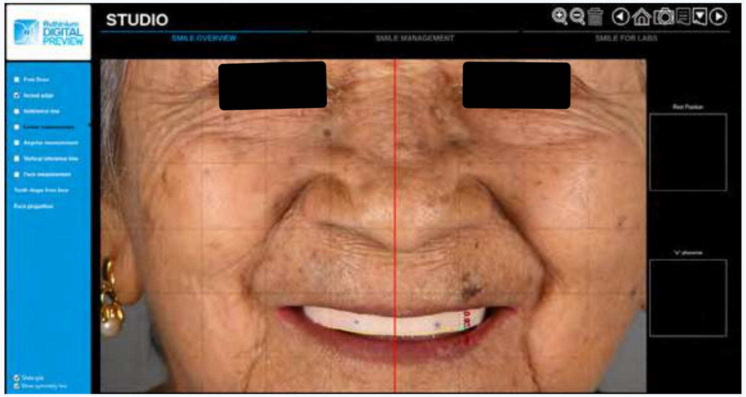

FIG. 9 *Analysis of the case and correction of mistakes on the patient's left side occlusal plane.*

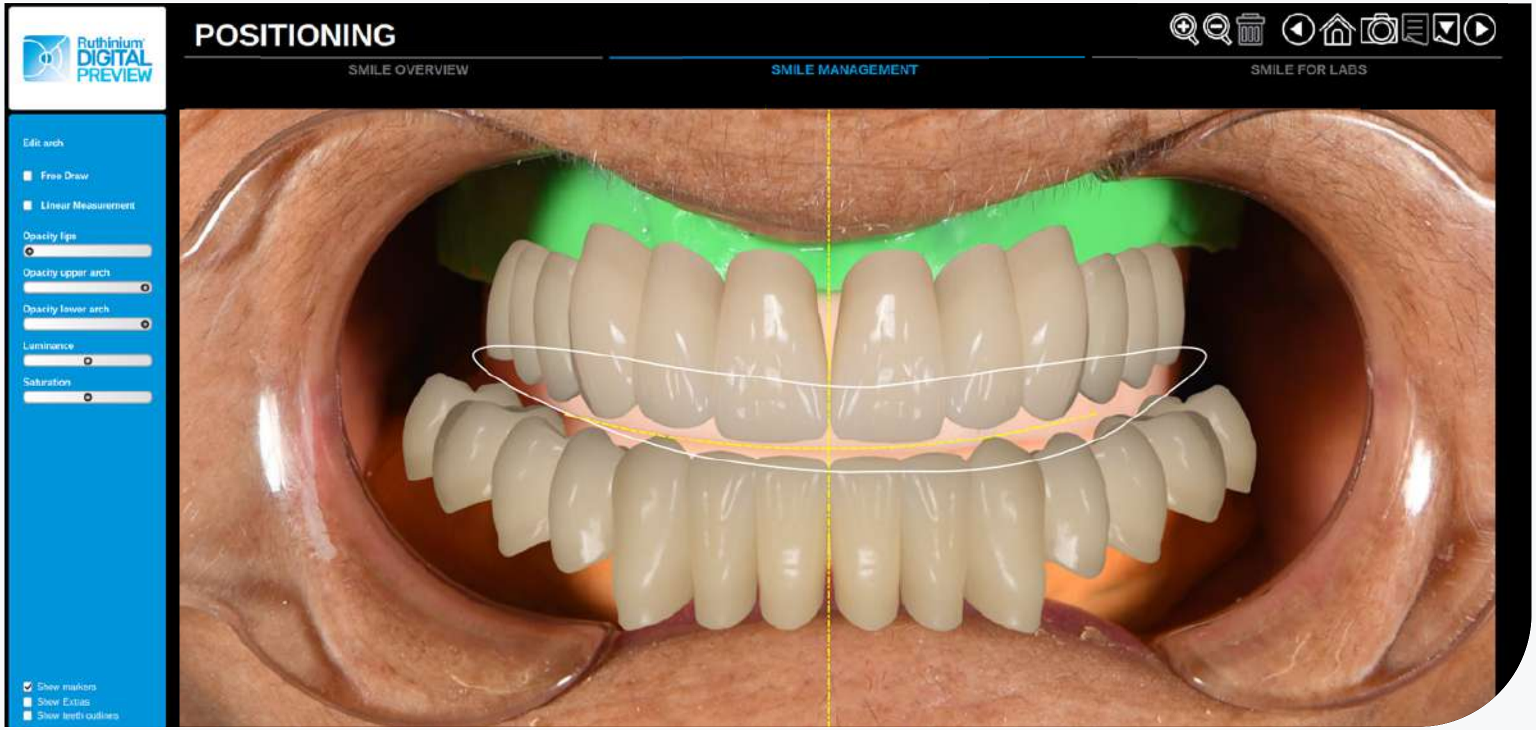

FIG. 10 *Setup of the teeth for preview purposes only.*

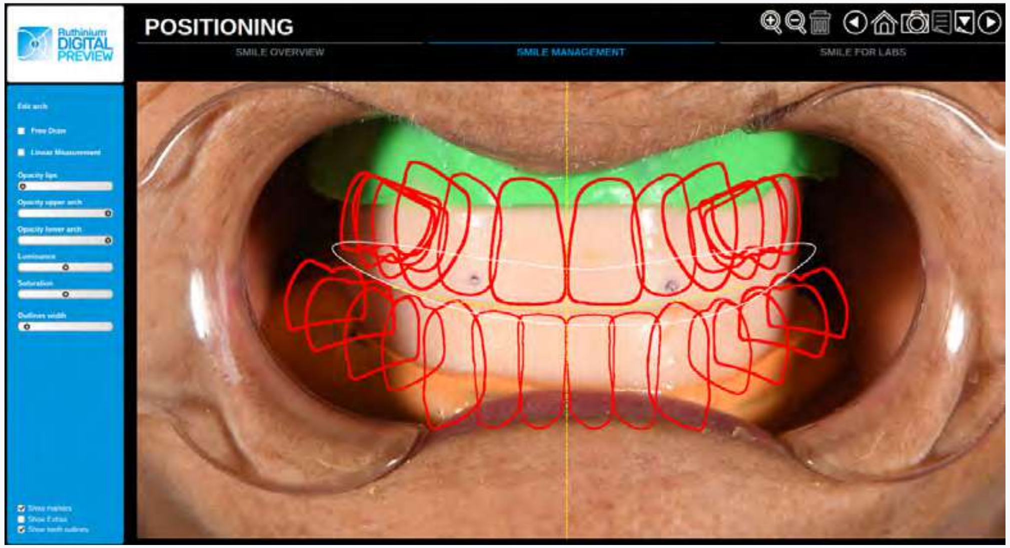

FIG. 11 *Linking 2D picture to 3D: the outline of the teeth.*

FIG. 12 *Final result of the 2D aesthetic project.*

We then imported this image into the 3D CAD software, 3D Denture Guide (Dental Manufacturing S.p.A., Italy), along with the STL files (Fig. 13). After a detailed analysis of the model, focusing on the anatomical points of the upper and lower arches, we proceeded with the dynamic assembly of the teeth using the same libraries from the aesthetic project. The project guideline image serves as a visual reference during tooth placement in the 3D software.

In the digital setup, we imported the teeth in one standard configuration and adjusted them according to the anatomy of the arches (Fig. 14).

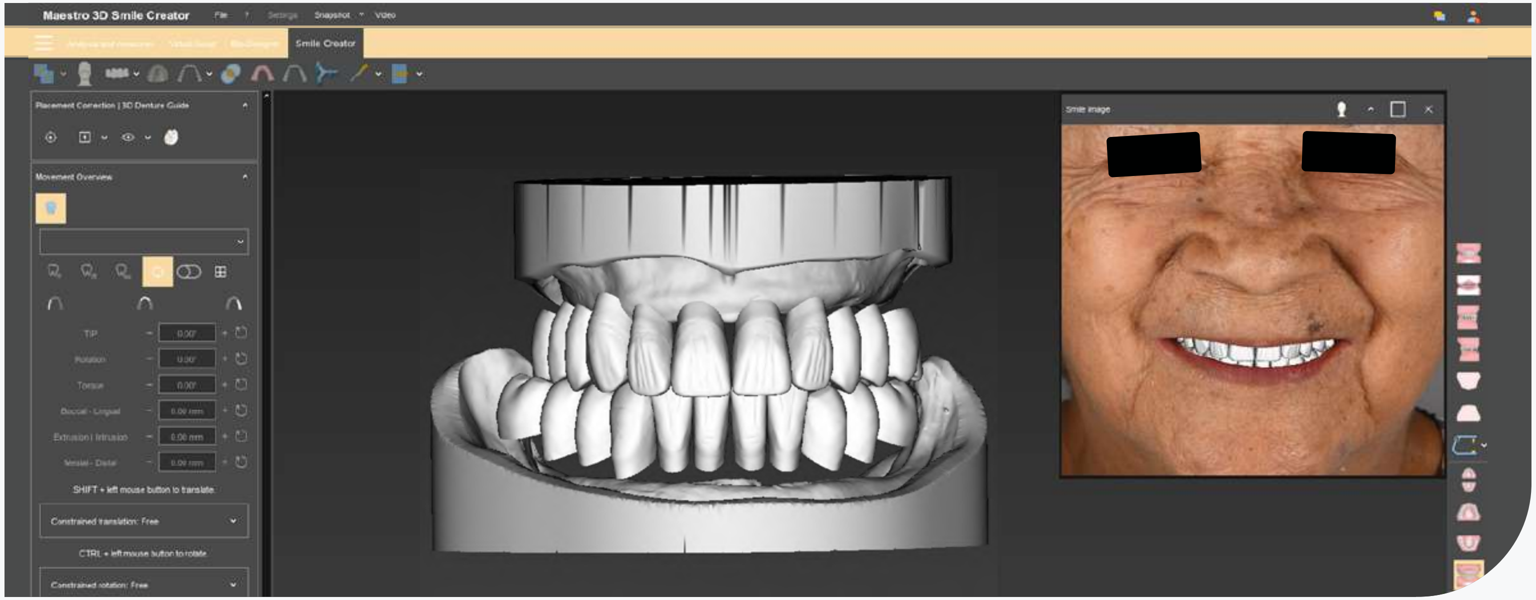

FIG. 13 *Setup of the teeth in 3D software with the patient's picture.*

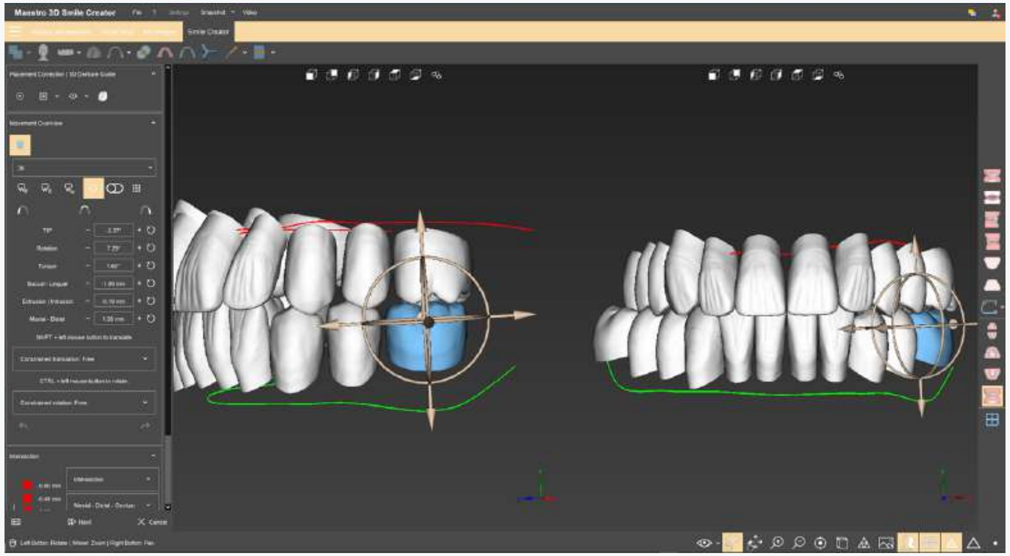

FIG. 14 *Dual screen setup for tooth positioning available in the software.*

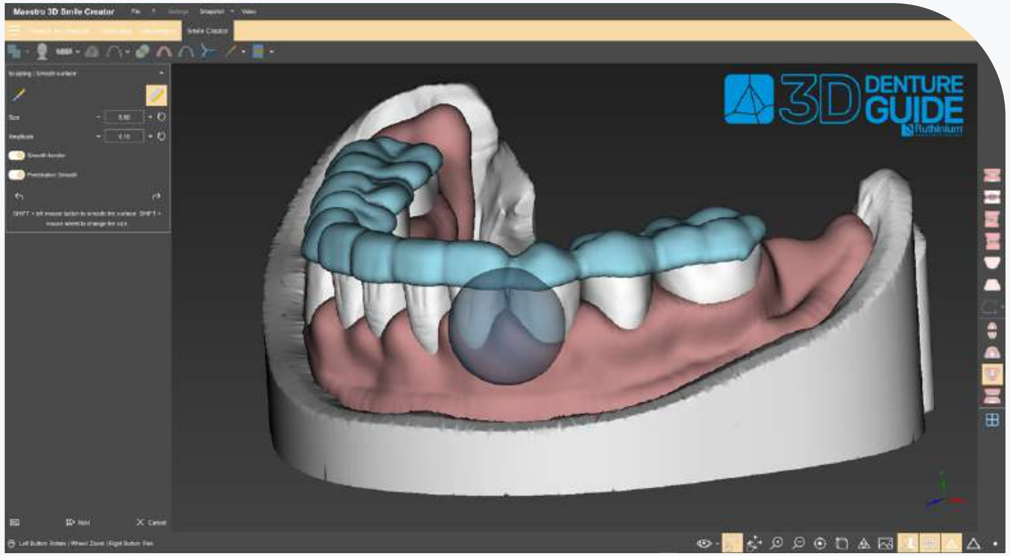

FIG. 15 *Designing of the 3D Denture Guide system.*

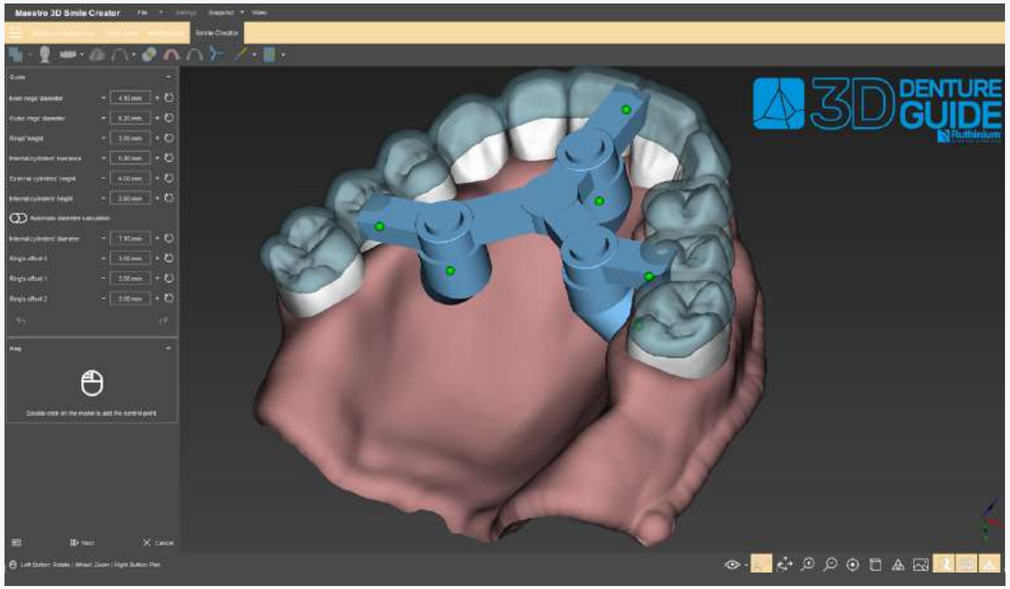

FIG. 16 *Designing of the 3D Denture Guide system.*

Firstly, we checked the correspondence with the outline image and then positioned all teeth as a block, starting with the central incisors. Next, we focused on the position of the posterior teeth on the gingival crest and adjusted the arch connection between the first bicuspids and central incisors. Finally, we personalised the setup by moving each tooth individually.

Once the assembly was completed, we started designing the gum on the teeth using the latest tool available in the Expert Version of the software. After designing the gum, we proceeded to design the teeth positioning guide. With an easy process, we designed a layer on the teeth and connected it with the plaque (Figs. 15 and 16), allowing us to export different devices for the try-in and finishing phases.

For the try-in, we exported a monoblock file in STL format to be sent to the clinician. For the definitive part, we exported a plaque with teeth sockets and an incorporated tripod, along with the guide for the teeth and the female part of the attachment.

FUNCTION OR AESTHETIC TRY-IN DENTURE

The prototype represents a significant advantage over the conventional protocol. Previously, there was no way to send a trial of the tooth arrangement home with the patient, meaning the time available for them to decide on the shape and size of the teeth was very limited. This limitation often leads to patients wanting changes to the aesthetic aspect of their prosthesis, many of which are no longer possible. In this case, the patient took the prototypes home for a few days to test them (Figs. 17 and 18). After two days, they contacted us to report that they felt very comfortable with the proposed prototypes and approved proceeding to finalise the prosthesis.

PRODUCTION AND FINALISATION

In the production phase, traditional acrylic teeth optimised for a digital workflow were selected. These teeth, AcrySmart Digital (Dental Manufacturing S.p.A., Italy), feature a modified neck for digital workflow, free of sharp angles or raised numbers, facilitating easy placement in gingival sockets.

The collaboration between Metadac FZE and Ruthinium Spa focuses on adapting the classic AcrySmart tooth for digital use, ensuring a reduced and smoothed neck for better bonding. We used a tooth repositioning guide, part of the patented 3D Denture Guide system, for precise teeth positioning, ensuring predictable results. Fabrizio Molinelli invented this system to provide predictable repositioning from the digital to the analogue system.

The guide, designed post-plaque, was attached to the gum using a repositioning tripod. Depending on the technology, the files were ready for additive or subtractive CAM pathways. After evaluation, we chose 3D printing with Ruthinium AcryPrint 3D Denture HI resin for its dimensional stability and impact resistance (Fig. 19). The repositioning guide can be printed with various resins since it is only used for teeth repositioning (Fig. 20).

FIG. 17 *Monoblock try-in.*

FIG. 18 *Monoblock try-in.*

FIG. 19 *3D Denture Guide plaque and template printed.*

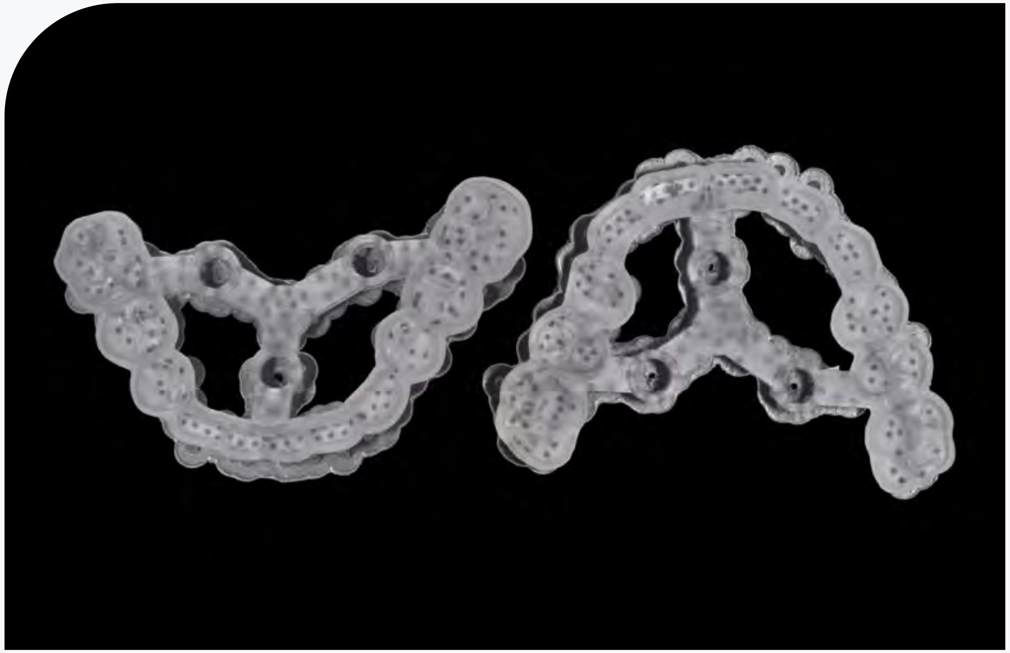

FIG. 20 *3D Denture Guide plaque and template printed.*

FIG. 21 *Bonding of the acrylic teeth to the plaque.*

The teeth were cleaned of wax, sandblasted, and then cemented using a dual-cure cement (Panavia SA), known for excellent adhesion. A visio.link primer was applied and polymerised before bonding. This dual-cure cement was chosen for its handling ease and speed, though alternatives are available (Fig.21-22).

Once cement polymerisation was completed, we finished the prostheses mechanically using traditional systems and materials to achieve a result comparable to traditional prostheses.

FIG. 22 *Bonding of the acrylic teeth to the plaque.*

DACOS SYSTEM: OCCLUSAL CHECK

The lack of physical models is a notable shift in our fully digital workflow. Antonello Croce developed the Digital Antonello Croce Occlusal System (DACOS) to bridge this gap. This innovative tool allows for precise repositioning of prostheses in an articulator at the project's end by drawing on the negative part of the designed prosthesis and considering all undercuts (Fig. 23). The printed device connects to a physical splint sharing the same geometry and dimensions, enabling traditional movements, before sending the prostheses to the articulator.

FIG. 23 *DACOS system checking of the occlusal contact.*

The DACOS is a patent-pending project owned by Ruthinium, and its software was developed by Blender For Dental. This tool ensures the final fitting is optimised, maintaining traditional techniques in a digital environment and guaranteeing prostheses meet exact specifications for optimal functionality and patient comfort.

FINAL DELIVERY OF DENTURES

During the insertion appointment, the occlusal contacts were verified for intensity using articulating paper (Articulating Paper Blue BK 17 Extra Thin Horseshoe 40µ; Bausch, Germany). Additionally, areas with potential excessive pressure were identified using a pressure-indicating paste (Mizzy Paste Indicator; Keystone Industries, USA). The patient reported feeling comfortable and was satisfied with the aesthetic outcome.

The final dentures were delivered to the patient (Figs. 24 and 25).

RESULTS

This study highlights the benefits of digital tools and effective collaboration with a decentralised team. All team members, including the patient, gain advantages from this workflow.

FIG. 24 *Denture finished and polished.*

Digital Impressions and Workflow Optimisation

Intraoral scanners capture distortion-free digital impressions, eliminating errors from physical impressions. The immediate sharing of digital data optimises the workflow between the clinic and the laboratory, saving time and reducing potential errors. Digital assembly of teeth, simplified by preset tools, reduces production times and minimises aesthetic errors through photographs, avoiding remounting.

Aesthetic and Functional Quality

The digital removable dentures achieve exceptional aesthetic results comparable to traditional methods. Digital photographs enable detailed facial analysis, error identification and predictive corrections, enhancing patient involvement and satisfaction. Precision in managing the vertical dimension prevents future adjustments.

FIG. 25 *Final result on patient.*

Error Minimisation

The digital approach minimises production errors. Repositioning guides ensure predictable bonding and precision in tooth assembly. Teeth optimised for digital workflows eliminate sharp angles, ensuring trouble-free gingival placement. This meticulous digital workflow improves prosthesis quality and enhances the overall patient treatment experience, confirming the effectiveness and reliability of digital methods in dental prosthetics.

FIG. X *Dr. Edgar David Garcia Zea, co-author and doctor who performed the treatment.*

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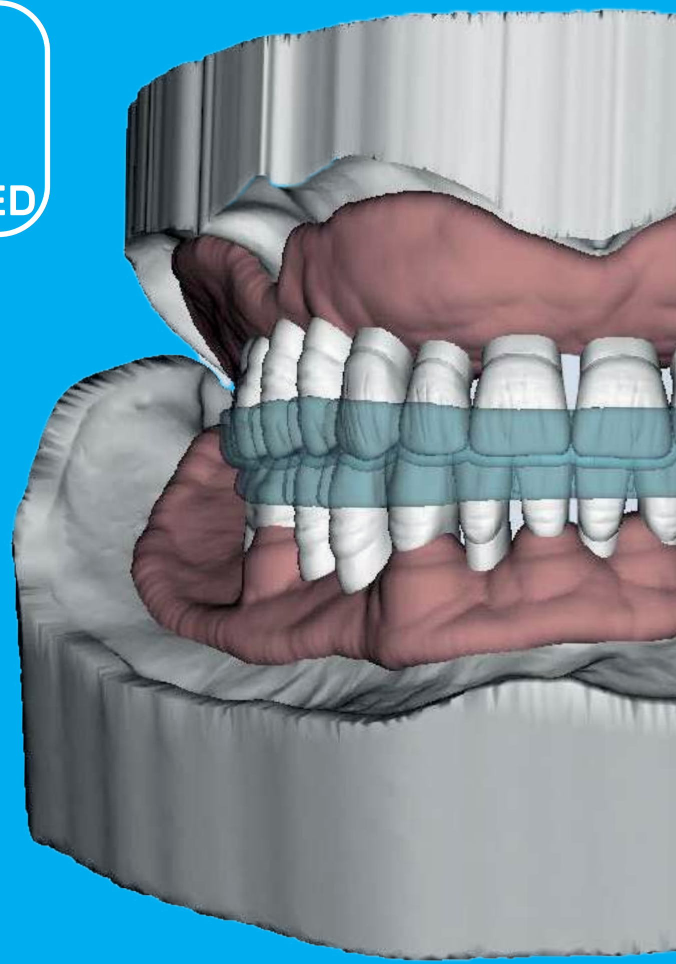

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allows the dental technician to **virtually place acrylic teeth into the denture design** of an edentulous patient, showing the result of the placement directly **on the face and in the patient's mouth**.
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