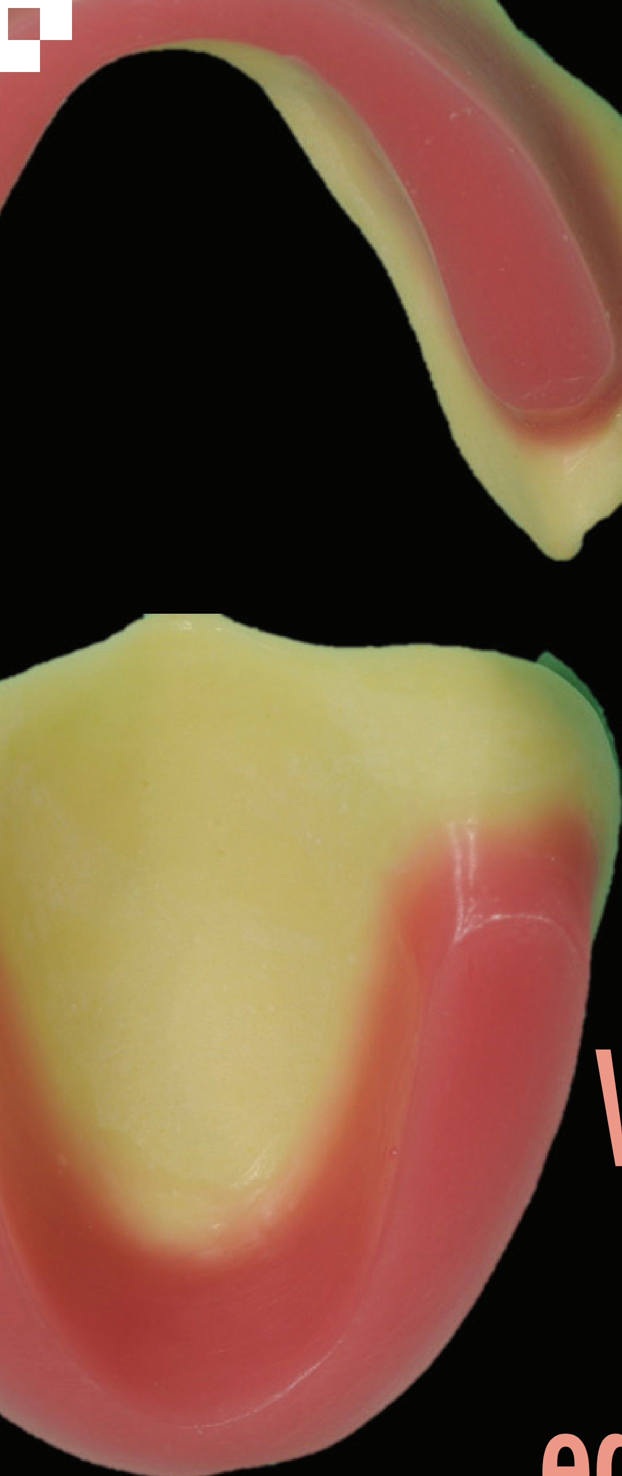


A digital Workflow for an edentulous patient

by *Luca Ortensi DDS, Tommaso Vitali DDS, Carlo Borromeo CDT, Cesare Chiarini CDT , Fabrizio Molinelli CDT, Marco Ortensi CDT, Massimiliano Rossi CDT.*

The development of digital technologies in dentistry has changed the therapeutic approach in the edentulous patient as well, both in the preliminary stage of the clinical case study and when supporting the actual fabrication phase. The purpose of this article is to illustrate a digital therapeutic protocol that reduces the operational phases and the processing stages, thus obtaining an improved final quality of the therapy carried out.

Introduction

For some years, modern prosthetic dentistry has been making use of digital technologies to support both the diagnostic and therapeutic stages of patient rehabilitation [1,2,4]. The traditional removable and implant-supported denture has also benefited from these innovations and has been further digitally developed both in the virtual planning of clinical cases and as support during the actual fabrication phase [7,8]. The aim of this article is to illustrate, through the description of a complex clinical case, how it is possible to perform the prosthetic reconstruction of an overdenture using existing implant fixtures and applying the new digital technologies in every step of the prosthetic therapy. In particular, by employing a digital pre-rendering software (Digital Smile System DSS and DSS CAD, Varese-Italy) not only as a means for dentist/patient dialogue, but also as a work tool for transferring to the dental technician

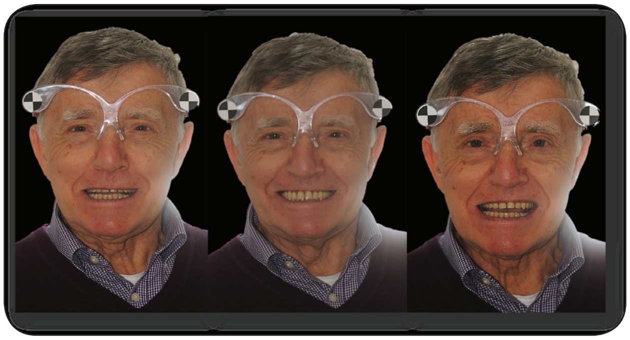


Fig. 1 — Initial state of the face: we observe a reduction of the vertical dimension with an increase in perilabial wrinkles. The smile is disharmonious and unpleasant due to incongruous occlusal planes.

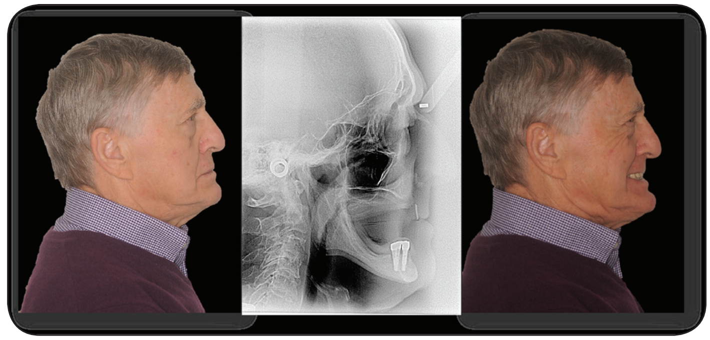


Fig. 2 — The study of the patient's latero-lateral radiography shows a mesofacial musculo-skeletal type with reduced occlusal risk.

Fig. 3 — The assessment of the face from a sagittal view highlights a posteriorly inclined occlusal plane with intraoral characteristics attributable to Kelly's syndrome.

Fig. 4 — The upper arch presents a complete removable denture, while the lower arch presents a removable denture held by 4 implants in intraforaminal position.

all the information needed to create the prosthetic artefact, limiting to a minimum both the clinical trials and the analogue laboratory stages.

Description of the clinical case:

Introduction

Patient A.F. is 73 years old and comes to us complaining of reduced chewing ability and loss of retention of both removable dentures present in the oral cavity. He furthermore asks to improve the esthetics of his smile and face, saying he is dissatisfied with the color and visibility of his teeth which, even when facial mimicry is more accentuated, are scarcely noticeable and feature unnatural slanted planes.

The medical history shows no pathology incompatible with dental therapies and an overall good state of health: the patient can be classified as ASA1.

The objective face examination shows a reduction of the vertical dimension with broadening of the naso-labial folds and a loss of tone of the perioral soft tissue with overall worsening of all the esthetic parameters of the face. The patient's smile appears disharmonious due to dental wear and the inclination of the occlusal planes, which makes the appearance unpleasant (Fig. 1). Assessment of the face from a sagittal view highlights a posteriorly inclined occlusal plane with intraoral characteristics attributable to Kelly's syndrome [5] (Fig. 2). The study of the patient's latero-lateral radiography shows a mesofacial musculo-skeletal type with reduced occlusal risk. The latero-lateral teleradiography is a means of diagnosis that the authors deem indispensable for framing a correct treatment plan in complex prosthetic rehabilitations. This radiographic exam makes it possible to study the hard and soft tissues of the patient's face, the relation between the upper maxillary, the spatial position of the upper central incisor and the labial filter. Furthermore, using an appropriate and simple cephalometric analysis, the musculo-skeletal class to which the patient belongs can also be identified (Fig. 3) [6].

The intraoral clinical exam reveals incongruous removable dentures in both arches (Fig. 4). The upper arch presents a complete removable denture, while the lower arch presents a removable denture held by 4 implants in intraforaminal position, joined by a bar obtained from lost-wax casting. All the retentive components of the bar are

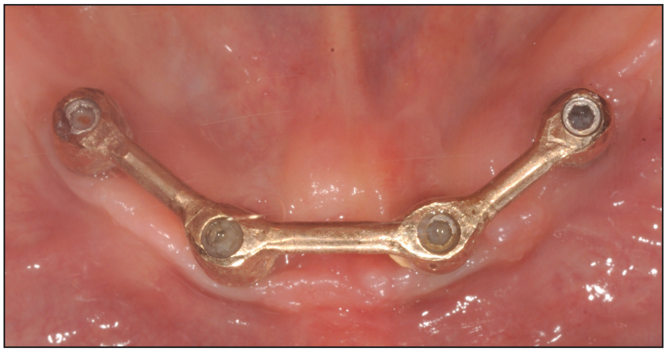


Fig. 5 — All the retentive components of the bar, made of precious alloy, appear worn.

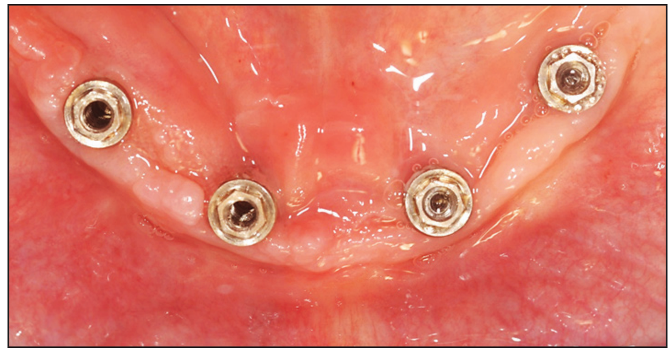


Fig. 6 — Removing the bar and the prosthetic components we can see a good state of the peri-implant soft tissues: the implants are osseointegrated.

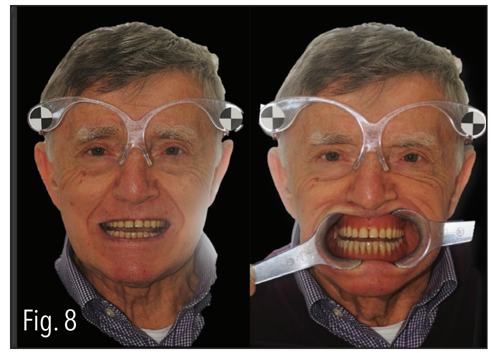


Fig. 7 - 8 — Dedicated glasses used to calibrate the digital pre-rendering software that the patient wears when taking the facial photographs.

worn (Fig. 5). The artificial teeth of both dentures show evident signs of wear so great that it is impossible for the patient to maintain a stable and repeatable mandibular-cranial relation.

When the bar and the prosthetic components are removed we can see a good state of the peri-implant soft tissues. The implants are osseointegrated and present correct parallelism, which will make the reconstruction of the prosthetic bar easier (Fig. 6).

At the end of the visit, facial and intraoral photographs are taken as an essential aid for completing the treatment plan, according to a coded technique for the DSS software (3). It is important to take photos of the face keeping the patient in a position that is stable and repeatable over time, trying not to change the enlargement ratio between shots. For this purpose, the patient is invited to sit comfortably keeping his back erect while the operator uses a camera set on a tripod to stabilize its position with respect to the individual being photographed.

The subject must be positioned so that his Frankfurt Plane (the line that joins the Porion and the Orbital Point) is parallel to the horizon.

Once the spatial position of the cranium has been identified, it must stay unchanged with respect to the camera and tripod. The patient may wear dedicated glasses used to calibrate the digital pre-rendering software (DSS) (Fig. 7).

The first facial photo is taken asking the patient to smile and show as many teeth as possible. This shot makes it possible to assess how the incisal plane is developing with respect to the lower lip and the width of the lateral corridors. The second facial photograph is taken with cheek retractors. This photo makes it possible to correctly assess both the parallelism between the bipupillary plane and the occlusal plane as well as the consistency between the median and the interincisive line (Fig. 8).

The photographic status is completed with facial profile shots and with intraoral photos, with and without the existing dentures.

The photos of the face allow us to make further diagnostic assessments regarding the overall esthetics of the face and the physiognomic traits, which we can address with our prosthetic therapy (11).

Clinical and laboratory procedures.

The first clinical stage of the new prosthetic therapy is to make the preliminary alginate impressions. This is in no way a marginal step in the process as it is essential to completely record the anatomy of the endoral structures of both

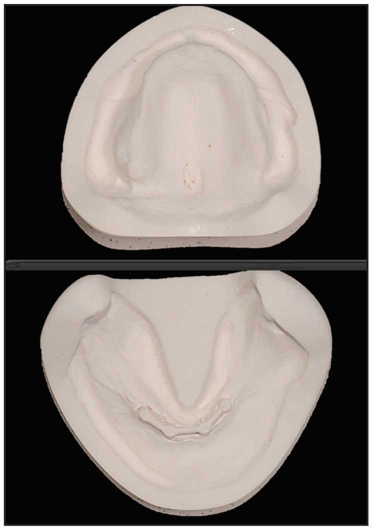


Fig. 9 — Extra-hard plaster impressions, obtained from preliminary molds, on which the constructive limits of the individual impression tray are designed.

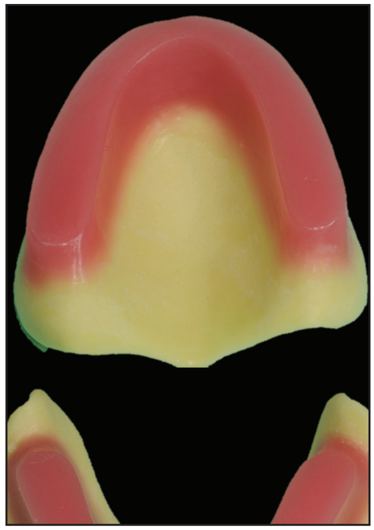


Fig. 10 — The resin occlusal bases with an occlusal rims for recording the mandibular-cranial relation and the esthetic and functional determinants, necessary for fitting the teeth.

Fig. 11 — Photos of the patient's face with the rims inserted in the oral cavity and the glasses for the DSS software.

maxillaries. Usually a high-precision alginate is used in two phases: the first impression is made using a mixed, high-consistency alginate, which is then dried and modified using a sharp instrument to eliminate the undercut, and then rebased with the same material but in a more fluid form to read all the details of the anatomical tissues.

From the preliminary impressions we obtain extra-hard plaster models on which the constructive limits of the individual impression tray are designed (Fig. 9). The authors believe that the plotted design is one of the most important aspects of this initial stage, which can determine the success of the therapy. Both the dentist and the dental technician

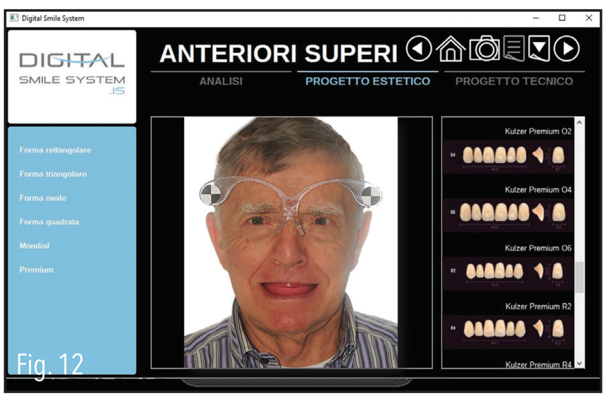


Fig. 12 - 13 — Digital pre-rendering with the DSS program consists of creating an actual virtual fitting with commercial teeth contained in the software library.

Fig. 14 — The library teeth are positioned using the occlusal rims as a fitting guide.

Fig. 15 — The final esthetic view of the patient after performing virtual fitting.

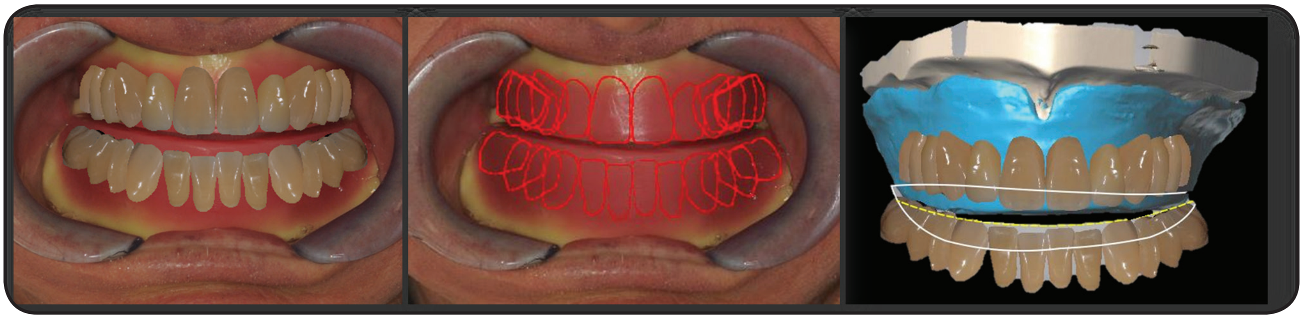


Fig. 16 — Data contained in the DSS file which will be transferred to the dental technician's laboratory to be imported in the DSS/CAD 3D software.

Fig. 17 a, b, c, d — It is possible to describe the "pairing" of the two software products simply by considering that the final image of the fitting obtained in the 2D version represents one face of the volumetric solid corresponding to what is present in the 3D version.

must equally be familiar with the anatomical components and the muscle dynamics that are at the basis of an ideal prosthetic design, regardless of the presence or lack of the implant screws. In the case at hand, resin occlusal bases with a wax wall for recording the mandibular-cranial relation and the esthetic and functional determinants, necessary for mounting the teeth, are constructed directly onto the initial models (Fig. 10) (12).

These occlusal rims are functionalized in the oral cavity starting from the top one. It is important to mark a few landmarks in the upper wall: the median line, the canine line and the smile line. The facial median is the line that runs through the glabella, the tip of the nose, the labial filter and the tip of the chin and should be perpendicular to the bipupillary line, forming an imaginary T. These reference lines will be used by the DSS software during the wall aligning phase.

At this point new photos are taken of the patient's face with the occlusal rims inserted in the oral cavity, using the photography technique described earlier (3). This will make it possible to import the photos in the DSS and proceed with the esthetic pre-rendering of the future prosthetic therapy (Fig. 11).

Digital pre-rendering with the DSS program consists of creating an actual virtual fitting with commercial teeth contained in the software library (Fig. 12-13). The library includes upper and lower teeth in various shapes and sizes. The front and back teeth are positioned using occlusal rims, suitably adapted in the oral cavity beforehand, as a fitting guide (Fig. 14). The teeth are chosen according to esthetic and functional parameters and can be replaced with others of different shapes or

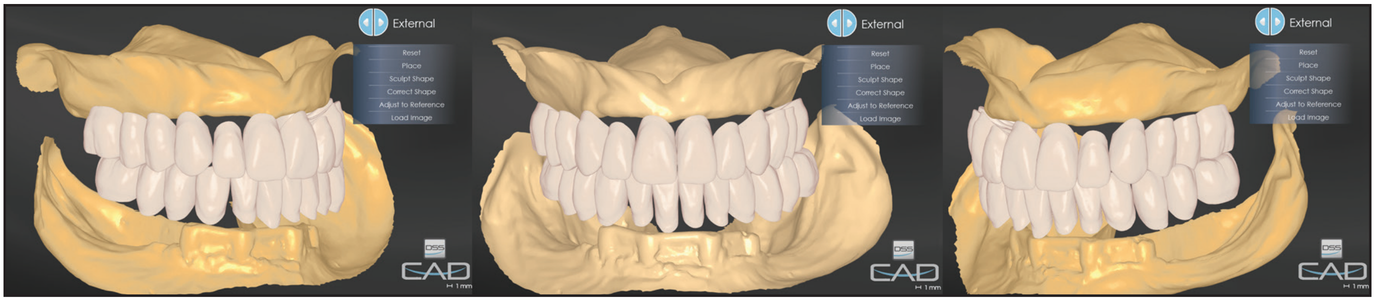


Fig. 18 — Teeth available in the 3D library used for the virtual fitting.

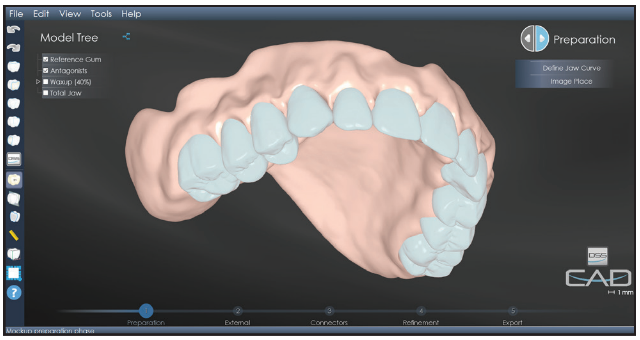


Fig. 19 — Completed virtual fitting: the digitally modelled flanges are visible.

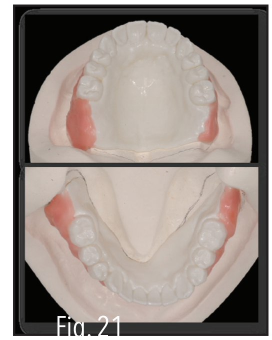


Fig. 20 - 21 — Resin prototypes of the virtual fitting produced in the milling center.


Fig. 22 — Prototypes positioned in the oral cavity to check the mandibular-cranial relation


Fig. 23 — Face of the patient with prototypes inserted in the mouth to check the esthetics.

color, if necessary (13). This allows us to show the patient the possible aesthetic result so that he can participate in the therapeutic project together with the entire dental team (Fig. 15).

Once the complete virtual fitting has been obtained - and approved by the patient - we proceed with transferring the file containing the patient's information, the photographic alignments, the libraries chosen and the work process to the dental technician laboratory where the file will be imported in a 3D software (DSS CAD, Varese, Italia) to convert the virtual 2D fitting into a 3D fitting (Fig. 16). It is possible to describe the "pairing" of the two software products simply by considering that the final image of the fitting obtained in the 2D version represents one face of the volumetric solid corresponding to what is present in the 3D version (Fig. 17 a-b-c-d). Therefore, thanks to the compatibility between the DSS and the DSS CAD software it is possible to export a file that is immediately useable for 3D modelling: the teeth used in the 3D library are the actual size of the corresponding commercial teeth (Fig. 18).

The dental technician will complete the 3D phase by improving the occlusal relation between the teeth and producing a prosthetic base that will support the artificial dental elements (Fig. 19). At the end of this CAD work stage, it is possible to produce a simulation of future dentures that correspond entirely to the project done using DSS and processed three-dimensionally with DSS CAD.

The clinician is provided with two prototypes of the virtual fittings corresponding to what was produced during the CAD phase. The prototypes are tried in the oral cavity checking the intraoral adaptation, the mandibular-cranial relation, and the esthetics of the smile and face (Fig. 20-21-22-23).

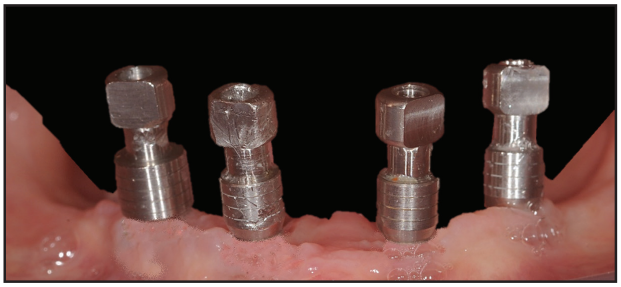


Fig. 24 — Implant transfers screwed into the fixtures at a set torque.

Fig. 25 — Final upper and lower impressions: note that the implant transfers have been joined together using composite resin.

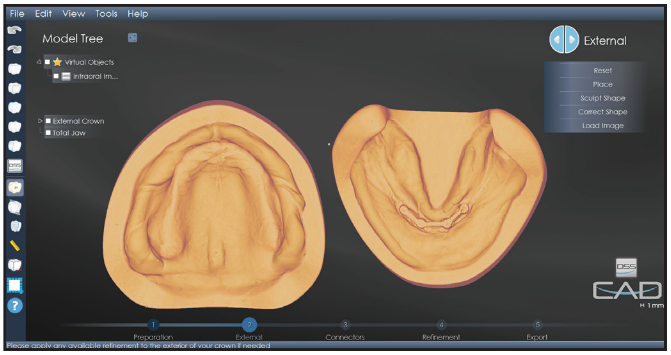


Fig. 26 — The master plaster models are developed and digitally acquired from the impressions.

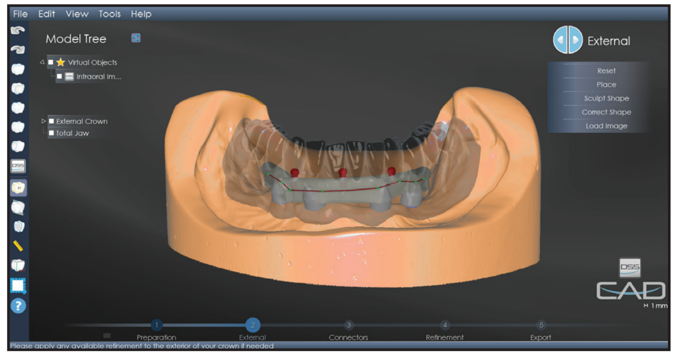


Fig. 27 — Digital designing of the bar: see how it is possible to assess the dimensions in relation to the final volume of the dentures.

These prototypes serve as dental trays with which, after any required beading, the final impressions are made of both arches, the mandibular-cranial relation and the already checked vertical dimensions. In our case a pick-up impression is made of the implant transfers previously screwed into the fixture, with a set torque (Fig. 24-25).

The master plaster models are developed and digitally acquired from the impressions (Fig. 26). In addition, the final volumes of the two prototypes are also reacquired so as to digitally superimpose the images to each other.

Using a dedicated software (DSS CAD) the project is executed to create the lower retentive bar, using the fixture scan transparencies to assess the available spaces and the position of the teeth with respect to their analogues, and identify the type of prosthetic structure and anchorage (Fig. 27). In the designed bar there are five anchorage areas: three in the front and two located distally (Fig. 28).

The structure project is sent to the milling center (New Ancorvis, Bologna, Italy): indication is given of the retentive system anchorage areas, using a dedicated threading, the type of metal and the execution technique (e.g. CAD/CAM or LASER sintering technology).

After being checked in the dental technician lab, the artefact is sent to the dentist to clinically test the structure, verifying its precision and passivity. Then the technician proceeds with an initial polishing of the artefact and the screwing in of the retentive systems (micro screwed-in OT cap attachments, Rhein 83 Bologna) (Fig. 29-30). The process later continues with further polishing and shining of the bar and the digital acquisition using a scanner (Fig. 31-32). The dental technician digitally designs the counter bar using dedicated software, always checking the available spaces, using final volume superimposition and inserting retentive pins in the project for the mechanical tightness of the teeth. Fabrication is carried out using laser-melting technology that makes it possible to obtain an accurate artefact to which the acrylic resin adheres tightly thanks to the presence of a retentive surface (Fig. 33-34).

Using the digitally acquired upper master model, the plate is designed according to the anatomical limits of the maxillary and creating in the digital artefact the opening for fitting the chosen commercial teeth. Using the digital software, it is possible to reproduce the paradontal anatomy with extreme precision (Fig. 35-36).

We then proceed with the complete application of the teeth onto the CAD-fabricated bases, using the prototype as a fitting plane, according to the crossed fitting technique. The joining of the

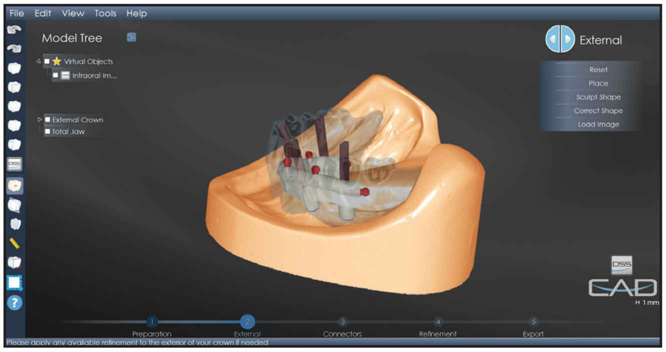
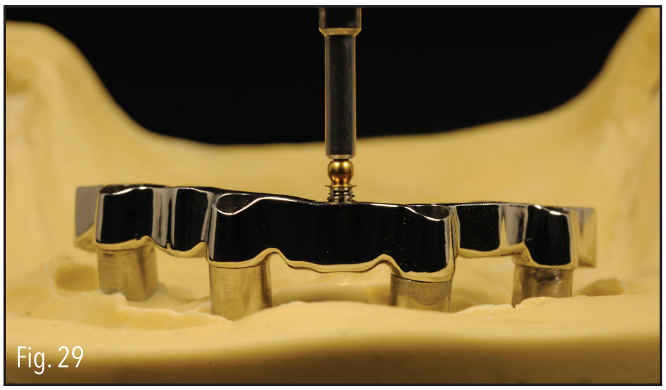


Fig. 28 — In the designed bar there are five anchorage areas: three in the front and two located distally.

artificial teeth and the milled resin base is done using a small amount of acrylic resin, thanks to the precision of the opening (Fig. 37).

The dentures and the finished and perfectly polished retention structures are sent to the dental office. The authors prefer modelling of the prosthetic flanges that respect the anatomy but allow easy cleaning of the artefacts by the patient (Fig. 38-39).

The bar is inserted in the oral cavity by the clinician and tightened to the implant fixtures with preset torque. The dentist must check that there are no areas where the soft tissues are compressed and that there is room for the



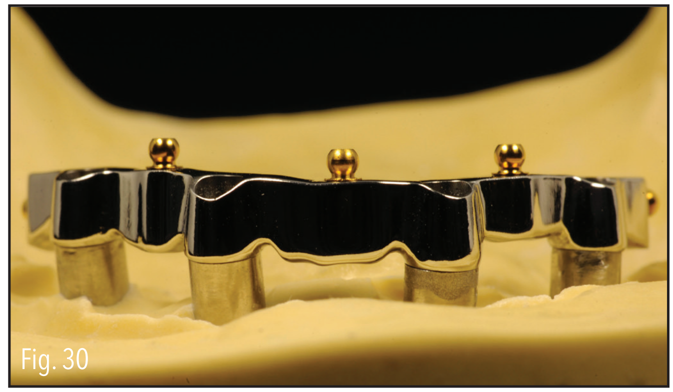


Fig. 29 - 30 — Micro OT cap retentive systems are screwed into the bar using the threading located on the metal artefact.

Fig. 31 — The bar is further polished and finished before digitally acquiring the image for fabricating the counter bar.

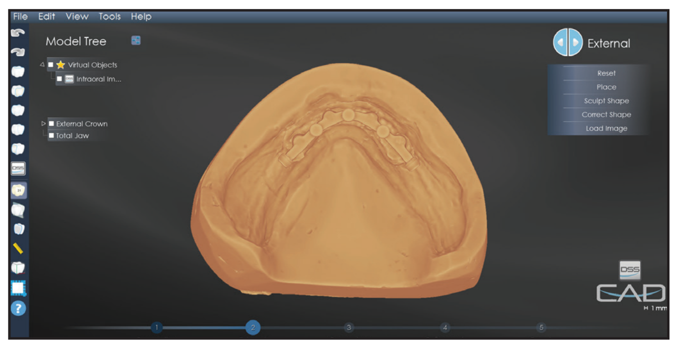
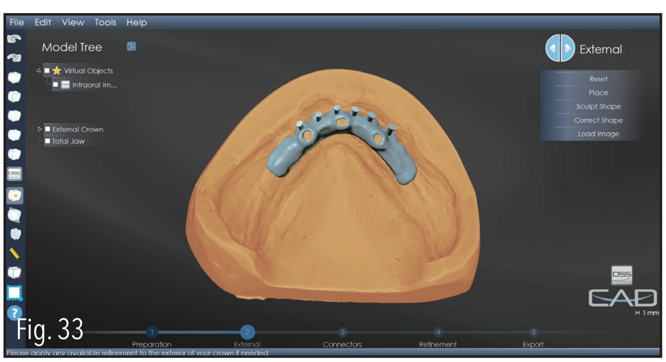


Fig. 32 — Image of the finished bar acquired digitally for the fabrication of the counter bar.



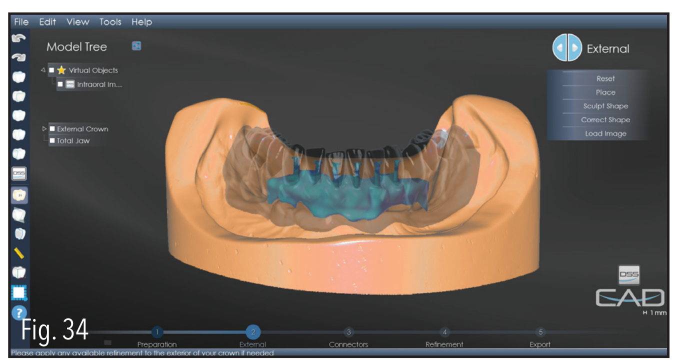


Fig. 33 - 34 — Digital fabrication of the counter bar: see how the spaces are controlled in relation to the final prosthetic volume.

Fig. 35 — Design stage of the final prosthesis: aspect of the artificial gum.

use of dental devices: interdental brushes and flosses. Notice the parallelism of the retentive components which is synonymous with hold and maintainability over time (Fig. 40-41).

Once the prosthetic therapy is completed, the patient displays an improved situation from the esthetic viewpoint. The soft tissues of the face appear firm and toned. We notice a reduction in the naso-labial folds and peri labial wrinkles, both frontally and laterally. The vertical dimension, which has been slightly increased, appears adequate and well tolerated esthetically. During phonation and smiling dynamics the patient displays natural looking teeth that are perfectly integrated with the face (Fig. 42-43).

Even laterally we can see how the naso-labial angle falls within the correct values and the patient shows a firm labial filter supported by the prosthetic flange (Fig. 44).

These last images fully represent the therapeutic philosophy followed by the authors when planning and carrying out complex prosthetic therapy: the face is a guide to the therapy for restoring esthetics and function (9-10).

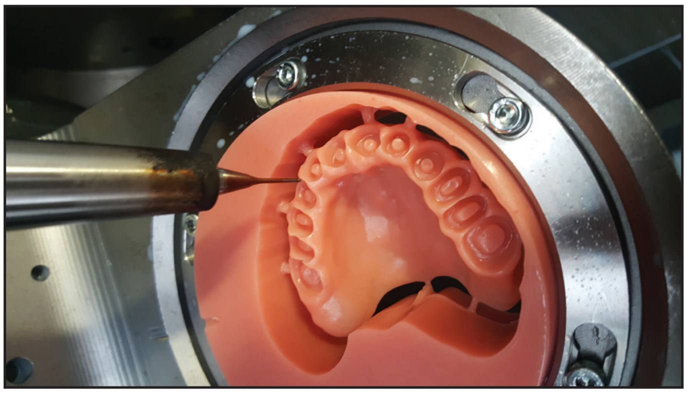


Fig. 36 — Fabrication stage of the resin base done at the milling center (Ancorvis, Bologna, Italy).

Fig. 37 — Teeth fitted on the bases to check the occlusal relation and the digitally designed esthetics.

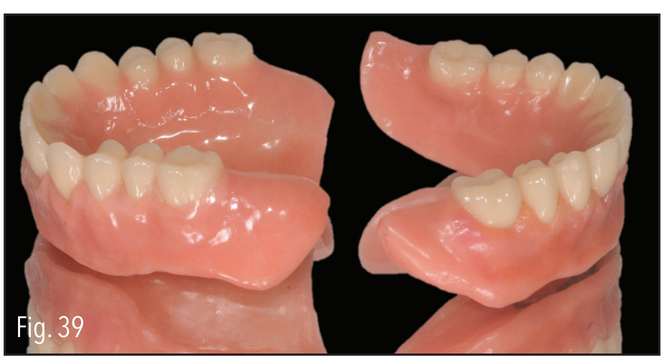
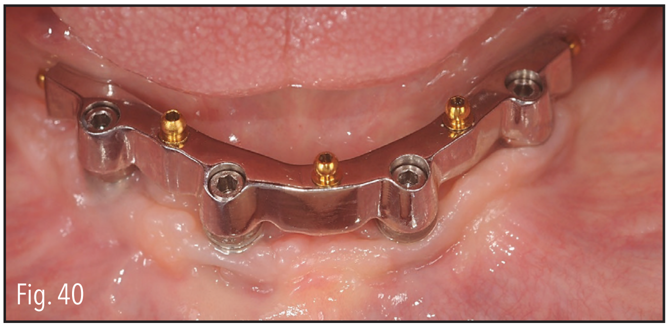


Fig. 38 - 39 — Completed dentures ready to be sent to the dental office.

CONCLUSIONS

The use of digital technologies is now vastly widespread in the field of dentistry and in prosthetic therapy, particularly. We feel that in removable, traditional and implant support prosthetic therapy digital technology can play an essential role. The clinical case described has been resolved, almost entirely, with an innovative digital workflow, both from the clinical and technical



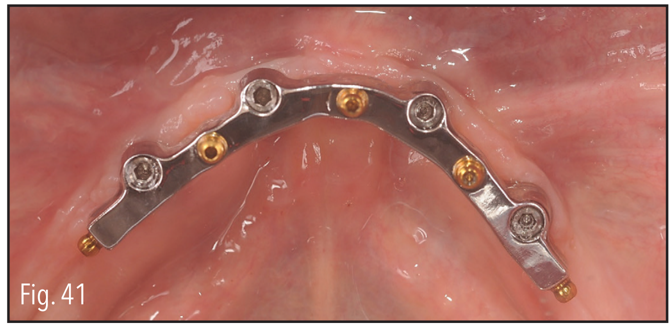


Fig. 40 - 41 — Bar inserted in the oral cavity: notice the parallelism of the retentive components which is synonymous with hold and maintainability over time.

Fig. 42 — Dentures inserted in the oral cavity with good esthetic integration.

Fig. 43 — Patient's face at the end of the therapy: notice a reduction in the naso-labial folds and peri labial wrinkles.

viewpoint. The human component is still fundamental and not all stages can be carried out digitally. However, we are convinced that technical evolution will rapidly lead to more and more digitalized therapies with an increase in the end quality of the therapy and less conditioned by the skills of the individual operator. Sd

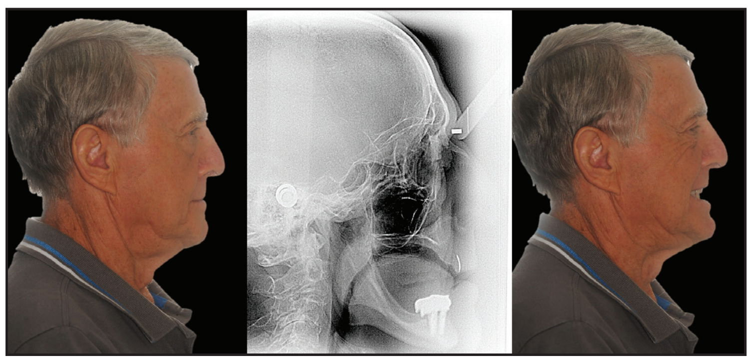


Fig. 44 — Patient's face in lateral view: the lip support appears correct.

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