Digital dental workflow for a smile makeover restoration

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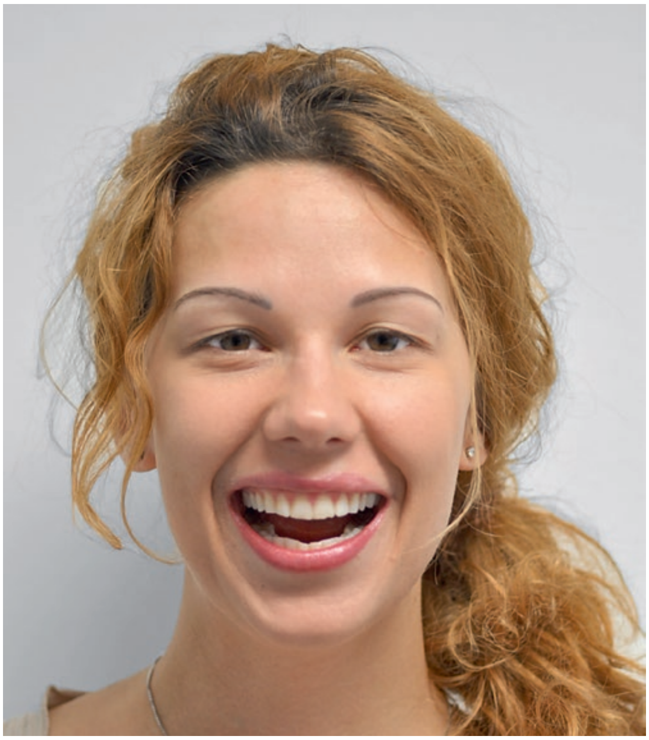

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Abstract

This article describes a novel concept for treatment planning and execution in the digital era. The aim of the presented workflow was to design, plan, communicate, perform, fabricate, deliver, and maintain a smile makeover restoration entirely through digital technology. The interdisciplinary treatment plan is described from the planning through the diagnostic mock-up to the final restoration. In digital designing, the dental morphology and tooth shape seen by the clinician and technician are interpreted by the computer as a 3D geometric mathematic model. Controlling the geometry provides freedom for the clinician to develop a restorative digital plan that can be followed throughout the patient's treatment. Moreover, new ceramic materials used with computer-assisted techniques have considerably broadened the choices for dental teams and have enhanced the results that can be achieved.
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Introduction

One of the main goals of dental treatment is to mimic the teeth and design a smile in the most natural and esthetic manner possible, based on the specific needs of the individual patient. The possibility of reaching that goal has improved significantly over the last decade due to rapid technological development, numerous new treatment modalities, and enhanced esthetic dental materials.[1] More specifically, the advances that have been made in the field of dental ceramics and adhesive technology allow for ultraconservative treatment methods to improve esthetics and function by modifying the morphology or shade of the anterior teeth.

Traditionally, it took several patient consultation appointments for the dental team to collect all the information needed to formulate an esthetic treatment plan, which required much time and effort on the part of the restorative team to develop wax-ups and put together a treatment plan.[2] Today, digital dentistry offers advantages from various perspectives to meet the esthetic needs of patients, which are driven in some part by current trends. Of particular interest in this regard is the ease of communication that digital methods allow. When utilizing the data provided by an intraoral scan and digital images, for instance, communication between the dental team and the technician about the prosthesis can take place through a software program and then be confirmed through an esthetic try-in. This entire process then leads to a digitally fabricated restoration.

In response to many requests by clinicians for support in prosthetic planning, designing, and fabricating procedures through the use of available innovative technologies capable of simplifying and accelerating the workflow, several new digital applications have been designed.[3]

Thanks to the latest-generation intraoral scanners and innovative applications such as the Digital Smile Design (DSD) app, all data collected are synthesized and assembled in 3D digitally for treatment planning.[4] In this way, digital medical and dental records are obtained, standard tessellation language (STL) files are generated by digital scanning of both arches and through the bite registration, periapical digital radiographs are acquired, a photo–video protocol is produced, and a face scanner is utilized to obtain a 3D face analysis of the initial patient situation.[5] This combination of data produces the 'virtual patient,' which eliminates the need for the patient to be present for numerous treatment planning appointments with various specialists that would otherwise delay the process.[6]

The virtual patient can be 'shared' digitally (Dropbox, cloud) among the restorative team and technicians, who then work in real time through dedicated CAD software to create a collaborative and ideal treatment plan both esthetically and functionally. This means that there are no boundaries between the restorative dentist, dental technician, periodontist, orthodontist and other specialists, which results in a more efficient treatment plan, workflow, and restoration delivery.[7]

Every tooth design created by nature is unique. Evaluating and restoring a patient's natural dentition could require many possible tooth designs and arrangements. The use of digital scanners in combination with dedicated 3D software allows for the creation of a new smile for patients based on their natural tooth design.

Design and planning phase – the esthetic try-in

Prior to initiating any treatment, it is recommended to collect the patient's information following the basic fundamentals of prosthetic dentistry to evaluate the risk profile (general, periodontal, endodontic decay, biomechanical, and esthetic) (Figs 1 to 7).

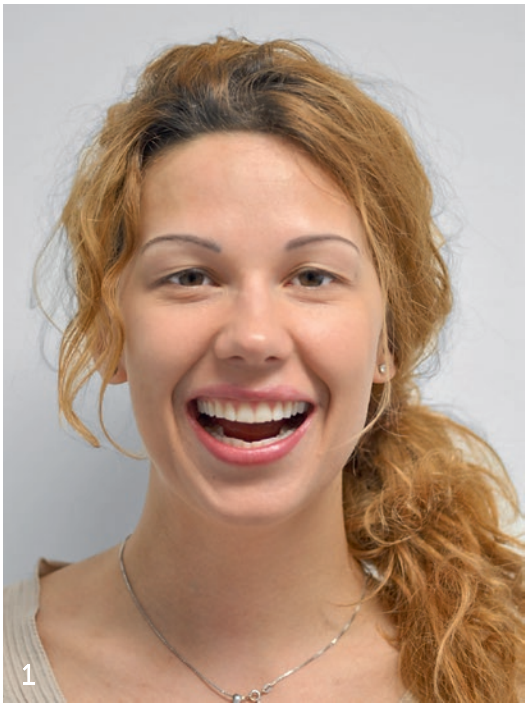


Fig 1 Patient with a high smile line presented to improve the esthetics of her smile. The dental midline was canted toward the left and the facial flow slightly toward the right. The incisal plane was flat.

Fig 2 The patient was concerned about the composite veneers on her incisors that were continually chipping off. Her smile width comprised 10 teeth. The teeth were of a regular shade, but tooth 11 was darker than the neighboring teeth. The critical interface exposure was evident.

Figs 3 to 5 Intraorally, the gingival margins were not symmetric. The patient presented with dental disproportion and soft tissue dehiscence on tooth 25 as well as a bulky tooth profile. Tooth 11 was buccally covered with composite and presented a low value. The overjet was 2.5 mm and the overbite 1.5 mm. The teeth also showed signs of chemical erosion, mechanical wear, and the presence of localised gingivitas.

Fig 6a to f Radiographs showed a regular interdental bone level, two endodontic teeth, and one crown in a patient with an average endodontic decay risk profile..

Fig 7 On the 12 o'clock image evaluation it was noted that the smile curve was not correct based on the lower lip indication. The tooth guide was considered in the buccal palatal orientation.

It is necessary and advantageous to digitally design and previsualize the new smile, which is the ideal way to communicate with the patient, formulating the diagnosis and treatment planning the case. The digital mock-up is the ideal way to communicate this to the patient.[8]

The initial 2D design is made from a facially driven perspective, allowing real-time feedback from the restorative team. Numerous tooth shapes are available on the DSD software, and, once chosen (following the indication of the software), the most appropriate shapes can be positioned in the area to be restored. The smile is then designed using the Smile Frame tool (Fig 10). Once the patient has been scanned (Fig 9), the 3D arches can be overimposed with the 2D patient images (Fig 10).[9]

It is possible at any time to render a preview through the software. Once the diagnostic design of the new smile is finalized, it can be shown to the patient with 'before' and 'after' mirroring. Subsequently, the final STL file is exported for 3D printing to produce a model (Fig 11). The clinician can easily transfer the design to the patient's mouth by making a silicone transfer index.[10] The harder this silicone, the more precise the transfer will be, duplicating all the details (eg, the line angles that give the ideal tooth shape, surface texture, etc), and, more importantly, eliminating the messy excess of material.[11]

The digital mock-up is an essential step that allows the patient to evaluate the esthetics and consent to the proposed treatment (Fig 12). Unlike traditional plaster casts, digital models are not fragile and can easily be retrieved and shared.[12,13]

The diagnostic smile design is generated over the existing patient smile, so the mock-up is additive (it is placed buccally onto the existing teeth). It may therefore be perceived by the patient to be slightly bulky. Patients should therefore be informed of

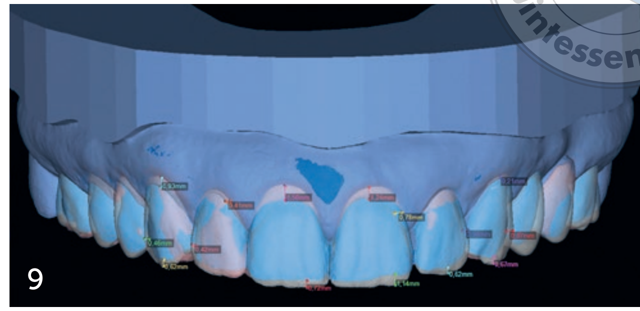
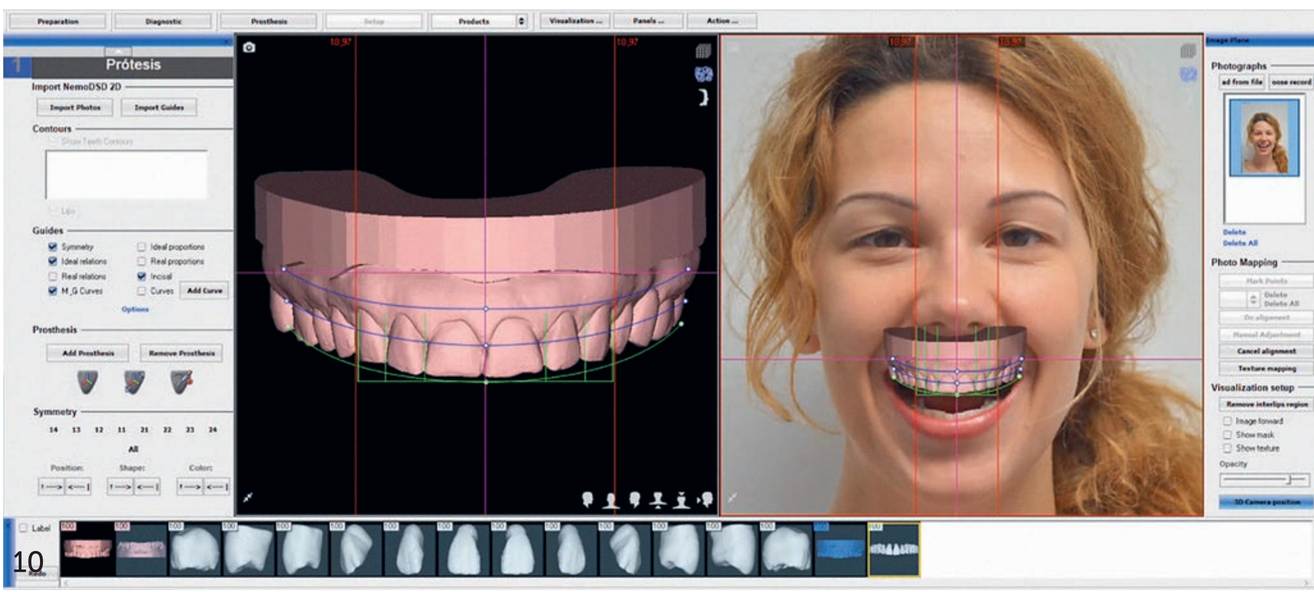


Fig 8 Functionally, the patient had an anterior skid due to a premature contact, which was removed before the rehabilitation began to stabilize the occlusion in centric relation. At this point, a digital impression was detected the iTero Element 2 scanner in the Prosthetic modality, which produces a free STL file that can be immediately sent, together with the video and photographic set, to the DSD Planning Center for the digital 3D design.



Figs 9 and 10 Nemotec software makes it possible to combine the 2D design with a 3D model, choosing the tooth shape, improving the proportion, reestablishing the proper function, and designing the new smile following a facially driven evaluation. Note the accuracy of the information available for the entire dental team.

Fig 11 Thanks to 3D-printer technology, a reliable and stable model can be made that helps the clinician to present the smile design to the patient through the mock-up. Nowadays, it is possible to outsource this process to a third party (DSD Virtual Lab, Madrid, in this case) or produce the model in-house with a 3D printer.

Fig 12 Seeing is believing – the power of the visual impact. The mock-up is the ideal tool to communicate with the patient, who in this way can experience the possibility of a new smile. Thanks to a silicone transfer index it is easy to transfer the digital design into the patient's mouth.

this difference between the mock-up and the final restoration. It is also advisable to take frontal photographs and/or a video of the patient before and after the placement of the mock-up in the mouth.[14]

Only once patients have accepted the diagnostic mock-up and given their formal written consent to the treatment plan should the interdisciplinary team become involved.

From the plan to the treatment

One of the greatest challenges in a smile makeover restoration is to reproduce exactly what has been digitally planned, previsualized, and presented to the patient. For example, in a case where a gingival recontouring is required, the challenge is to perform the gingivectomy or – depending on the biologic width evaluation – the crown lengthening exactly where it was planned.

Dedicated 3D software programs such as Nemotec facilitate the 3D diagnostic digital mock-up, which is used to design a gingivectomy guide and produce it by means of a 3D printer. This guide allows for the performance of the surgery exactly where it was planned, as it fits on the incisal margins and occlusal surfaces and guarantees stability during the execution (Fig 13).

After the soft tissue healing, the focus will shift to maintaining the same geometry as the 3D diagnostic mock-up on the final restoration design, the only difference being that the geometry of the final design is then revised over the prepared teeth. Thus, only the sagittal axis differs from the diagnostic design, since after soft tissue recontouring and tooth preparation, the final digital design can be repositioned slightly more palatally and the emergence profile revised.

While the diagnostic mock-up can serve as a tool for achieving the patient's consent for treatment and as a guide for the surgical template production, the ideal design post-gingivectomy mock-up is extremely important for tooth preparation and for the provisional restoration.

Fig 13 Thanks to dedicated 3D software, the 3D diagnostic digital mock-up can also be utilized to design and produce a gingivectomy guide by means of a 3D printer to perform the surgery exactly where it was planned. The guide fits on the incisal margins and occlusal surfaces, guaranteeing stability during the execution. This is a perfect example of so-called digitally driven dentistry.

Tooth preparation

Before tooth preparation begins, the patient must sign a form indicating approval of the esthetics, shape, and positioning of the ideal post-gingivectomy mock-up design.

Ultraconservative preparations are made over the mock-up to ensure maximum preservation of hard dental tissue (Fig 14).[15]

The tooth preparation should be performed based on the evaluation of the facial surface of the teeth, tooth alignment, angulation, color of the dental substrate, and need to create a path of insertion for all the ceramic veneers. In the case presented here, the tooth shade was favorable and there were no diastemata to manage. It was therefore possible to perform minimal tooth reduction according to the lithium disilicate parameters of the case.[16]

The goal is to be minimally invasive and maintain as much tooth enamel as possible; also because the dentin bonded interface is susceptible to hydrolytic and enzymatic degradation, which can cause margin discoloration, secondary caries, and veneer debunking over time.[17] Moreover, limiting the preparation surface on the enamel increases the success rate to 98.8%, compared with excessive tooth preparation with large amounts of dentin exposure or extending the limits over the root surface, which reduces the success rate to 68%.[18]

It is for these reasons that the teeth are prepared through the [a]esthetic pre-evaluative temporary (APT) technique; in this case, utilizing two different sizes of round burs, one for the cervical and the other for the axial portion of the tooth as well as a tapered bur to merge the preparation (Figs 15 and 16). APT, being a very solid reference for the depth cutter, will not only allow the optimal space for the ceramist's work, but will also enable the clinician to perform a minimally invasive preparation.[16]

After the tooth reduction is complete, the preparations should be polished to ensure maximum efficiency of the digital impression.

Fig 14a to c Ultraconservative preparations are made through the mock-up (a) to ensure maximum enamel preservation, utilizing two different-sized round burs, one for the cervical (b) portion (1.2-mm size that works 0.3 mm), and one for the axial (c) portion of the tooth (1.8-mm size that works 0.6 mm).

Fig 15a to c The APT technique offers a very solid reference for the depth cutter. It allows maximal space for the ceramist's work and facilitates a minimally invasive preparation. Minor changes should be made only when necessary, and the tooth reduction should be as minimal as possible maintaining the inner enamel throughout the entire preparation.

Fig 16 Tooth with a favorable dental shade and correct position and angulation, which only required enamel-guided recontouring. A minimal juxta gingival chamfer was performed following the gingival contour.

Digital impression phase

The scanning plan (Fig 17), executed with the iTero Element 2 scanner, was as follows:

- Maxillary arch scan with the mock-up in position.
- Mandibular arch scan.
- Bite registration.
- Maxillary arch scan of the prepared teeth.
- High resolution (8000 frames per second by means of confocal microscopy technology) of each prepared tooth to detect the details of the margin preparations.

The best scan strategy in order to take advantage of all the specific features and benefits of each system should be considered, which will depend both on the system itself and the experience of the operator. Moreover, not all digital systems deliver the same accuracy; some perform better in some clinical situations than in others. That is why it is critical to know the scan path, which means that the intraoral scanner must be used according to a specific movement to maximize the accuracy of the virtual models.[9]

For the iTero Element 2 scanner it is suggested to:

1. Scan the complete occlusal surface, beginning from either side of the third molar.
2. Roll over to the palatal/lingual side and scan the complete palatal/lingual surface.
3. Roll over to the buccal side and scan from the molar to the midline.
4. Move to the opposite side of the third molar and scan to the midline to complete the buccal surface.

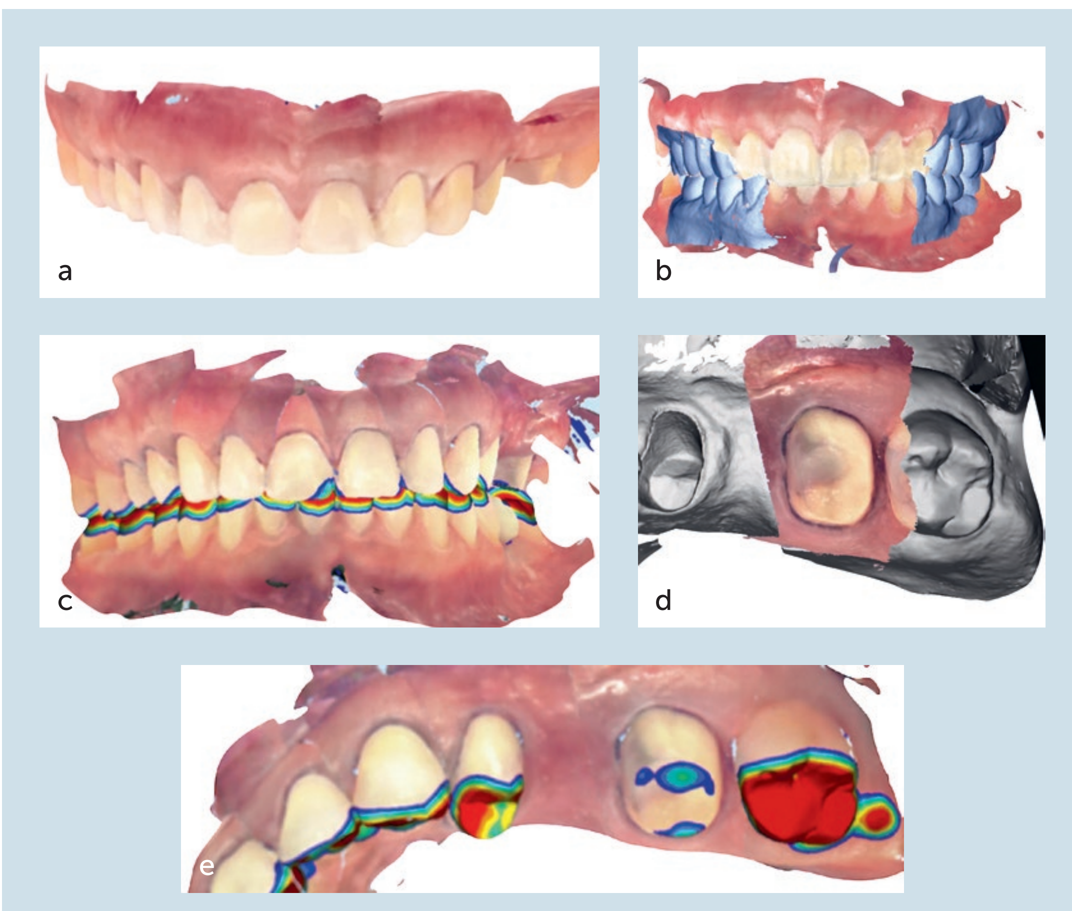


Fig 17a to e After tooth reduction, the preparations should be polished and rounded to ensure better intraoral scanning. In this case, the plan was to scan the maxillary arch with the mock-up in position, the mandibular arch, the bite registration, the maxillary arch of the prepared teeth, and a high-resolution image (8000 frames per second, by means of confocal microscopy technology) of each prepared tooth. This was executed with the iTero Element 2 scanner in Restorative mode. Note how the scanner read both finishing lines: horizontal for the veneers and vertical for the maxillary left bridge.

5. Finish the arch by rolling over the anterior teeth. Begin in the lingual area behind the canine and lateral incisor to the buccal side. Repeat on the canine and lateral incisor on the opposite side.
6. Scan each prepared tooth in high resolution.

One of the major challenges in the digital workflow is scan alignment. Lack of an accurate alignment can produce error factors that make the process more cumbersome and complex. Manual alignment can also be complicated and the results inadequate. Due to the iTero software's post-processing capability, the different scans are aligned. This reduces the possibility of making mistakes.

In a digital workflow it is common to have multiple different scans of the same region (initial scan, after the periodontal surgery, the mock-up design, and the final restoration in position) performed in the scanner's iRecord modality. These are all free STL files that can be overlapped at any time, thanks to the time-lapse software feature. The overlapped scans help the dental team to quality control during the treatment plan, as they allow the opportunity for fine tuning and adaptation of the guided changes to the planned clinical situation. The overlapped scans also assist during the maintenance protocol phase because they efficiently show the patient any minor changes that have occurred in the mouth.

Polymethyl methacrylate (PMMA) prototype

Following the tooth preparation and digital impression phases, the technician designed, based on the mock-up indication, and produced a PMMA prototype to 'test drive' esthetics, function, and the patient's perceptions (Fig 18). PMMA-milled restorations are an excellent alternative to bis-acryl provisional restorations because they provide a superior marginal fit and longevity, PMMA being an industrial material with superior mechanical and chemical properties. In addition, they allow the patient the opportunity to evaluate the final improved outcome.

Taking a digital impression of the patient at this point helps to compare the digital simulation with the final design of the prototype. As the geometry is identical, the two versions should look alike. The variation in the sagittal axis between the diagnostic and final designs is translated as an increase in interproximal space and a proper

Fig 18 From the digital impression data a PMMA prototype is produced to test drive esthetics, function, and the patient's perception. Note that the emergence profile of tooth 25 improved due to the new prosthetic design and the periodontal plastic surgery that was performed in the area.

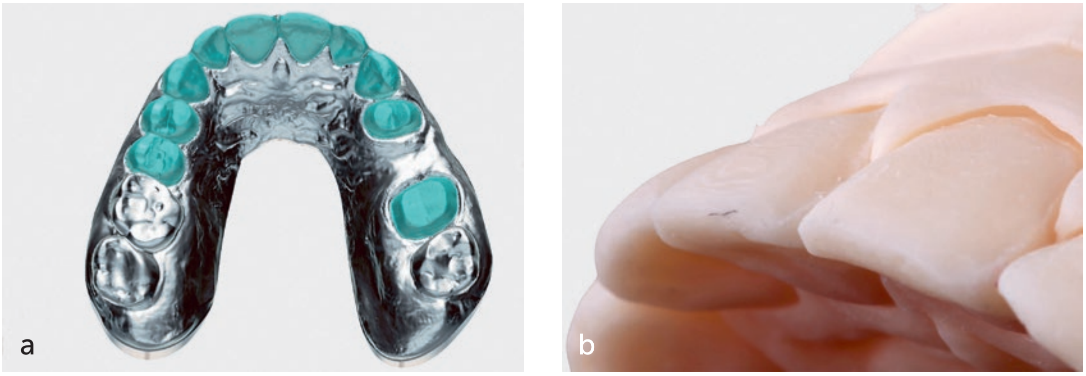


Fig 19a and b The digital alveolar model is created from the intraoral scan using the model builder software. Models are printed with a digital 3D printer (Sheraprint 40). Note the tooth preparation details replicated in the master model.

emergence profile. These details are usually not perceived by the patient.

If any details of the PMMA test-drive prototype need correcting or altering or if the patient requests any changes, the design will require modification, after which it is necessary to scan the area again so that the technician has the opportunity to copy and paste it in the final restoration within the CAD software.

Digital master model production and materials selection

In the present case, the digital alveolar model was created from an intraoral scan using the model builder software (Fig 19). Separate colors can be used for the dies and the base. Models were printed with a digital 3D printer (Sheraprint 40). The advanced technology of 3D printing shortens manufacturing lead time, reduces costs, and allows for the printing of items with a complex structure. The accuracy observed with 3D printing averages around 25 µm and can serve as a definitive working model. 3D-printed model production is required for occlusal adjustments, contact points, surface texturing, staining, marginal adjustments, and polishing (Figs 20 and 21).

Today, the continual improvements in ceramic materials have broadened the options and applications, providing the possibility of achieving a highly esthetic result in challenging cases. The optimal compatibility of ceramics with the oral cavity and their biologic stability gives them a high success rate over time.

In the present case, lithium disilicate was used (IPS Empress e.max CAD; Ivoclar Vivadent) for the production of the ultrathin CAD/CAM veneers with up to 0.2-mm thickness. Tetragonal zirconia was utilized for the maxillary left fixed partial denture (FPD), given its flexural strength and toughness.

It is relatively easy to mill CAD e.max ceramic blocks since they are milled in the green stage. If a margin of 0.2 or 0.3 mm is desired, the block should be milled thicker and then adjusted on the third printed die model. Surface texture is given to the veneers on the 3D-printed model before crystallization. The main advantage of using ultrathin ceramic restorations is maximum enamel preservation, which ensures the long-term success of the restorative treatment.

One of the strengths of lithium disilicate is the excellent quality of the soft tissue response. In vitro, this material exhibits high levels of biocompatibility, not only due to its low plaque retention but also to the adhesion and proliferation of human epithelial cells and human gingival fibroblasts, especially when the surface is polished.

Regarding wear and abrasiveness, lithium disilicate shows reasonably favorable

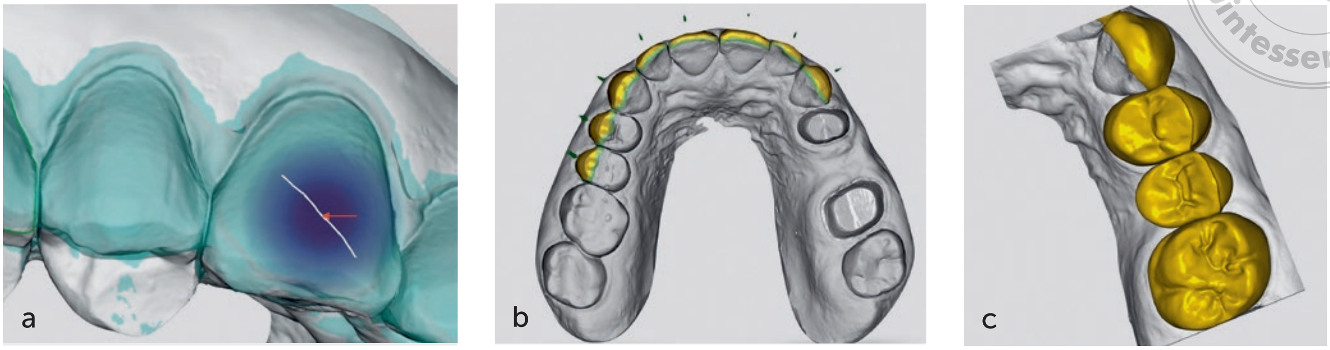


Fig 20a to c The CAD elaboration strategy follows the basic fundamentals of dentistry, integrated into the quality and parameter control allowed by the latest-generation software. For the three-unit zirconia FDP, a tetragonal zirconia layered with ceramic was chosen only for tooth 7 on the buccal side monolithic in the occlusal and palatal areas.

Fig 21 The ultrathin milled veneers with a thickness of up to 0.2 mm in position on the 3D-printed master model.

properties that are highly dependent on the surface characteristics of the restoration. Furthermore, it has an abrasiveness that is close to enamel and exhibits very good esthetic features, especially as regards translucency, which is about 30% higher than conventional zirconia.

Cementation phase

This phase plays a pivotal role in the longevity and predictability of the restoration, depending on the selected material. The luting agent bonds and stabilizes the two surfaces.[19]

In this case, luting was performed on the veneers following a multistep protocol. n esthetic try-in was performed utilizing a try-in paste the same shade as the dedicated cement. Following this, the operative field was isolated with rubber dam to inhibit any contamination by gingival fluid during the bonding procedures. Two clamps were used to retract both the rubber dam and the gingiva, exposing the gingival margins, and the adjacent teeth were protected with a transparent matrix (Fig 22).[20]

The tooth surfaces were cleaned with glycine powder. The bonding procedure must be performed according to the dental substrate; in this case, a three-step etch-and-rinse adhesive was used. The intaglio surface of the veneers was cleaned with a steam jet to remove the try-in paste and

Fig 22a to c Luting performed on the veneers following a multistep protocol. The operative field was isolated with rubber dam to prevent contamination by gingival fluid during the bonding procedures. A clamp was used to retract both the rubber dam and the gingiva, exposing the juxta-gingival cervical margins, and the adjacent teeth were protected with a transparent matrix.

other debris. All veneers were etched with 4.5% hydrofluoric acid (Porcelain Etch; Ultradent) for 20 s, rinsed under running water for 60 s, and then cleaned with 35% phosphoric acid (Ultra-Etch; Ultradent) for 60 s to remove any crystalline precipitates that had accumulated in the microporosities.[21]

The intaglio surfaces were air-dried, and a universal primer for conditioning glass-ceramic restorations (Monobond Plus; Ivoclar Vivadent) was applied two to three times for 60 s. Any remaining excess primer was dispersed with a strong stream of air, and bonding was applied without light curing.[22]

A low-viscosity photocured resin cement was used for the cementation to guarantee the undisturbed seating of the restorations. After the veneers were seated, the excess cement was removed using a microbrush, then each surface was light cured for 60 s (Fig 22).[23]

The next step was to apply a layer of glycerin gel on the bonded interface to prevent an oxygen-inhibited layer of resin cement, followed by the final polymerization of each surface for 60 s. After rinsing off the glycerin gel, any remaining cement was removed from the margin using a surgical scalpel blade.[24,25]

The final polishing was carried out using rubber silicone burs, and the restoration was then brushed with ceramic polishing.

For the zirconia FPD, the abutments showed good retention, and tooth primer was applied for 20 s. The FPD was then cleaned with Katana Cleaner (Kuraray Dental), and zirconia primer was positioned for 60 s. It was then cemented with Panavia V5 (Kuraray Dental).

Fig 23 Final dentolabial view 1 week after cementation.

Fig 24 Final intraoral view with a night guard produced through a fully digital workflow.

Fig 25 Closeup of the final patient smile at 2 years.

Careful occlusal adjustments were performed once the cementation procedures were completed, both in static and dynamic occlusion.

Conclusions

A successful smile makeover has a positive, deeper, and intangible impact on a patient's life, and this should be the goal of any dental restoration (Figs 23 to 25). Careful planning, tooth preparation according to a minimally invasive approach, and the correct choice of materials for both the restoration and the luting are crucial to assure a successful and long-term restorative outcome.

Although computers run the existing connections and are better at copying than humans, they never design by themselves.

Design implies the creativity of the dental technician. In the present case, the clinician and the dental technician had to be particularly creative to remain in tune with their steps and procedures such as abutment preparation, veneer design, milling, and 3D-printed model fabrication. Technical procedures such as creating particle surface textures, staining, and adjusting the occlusion and margins must be performed manually. For this reason, the human element is always present, even in a fully digital workflow. To unleash the true power of digital dentistry, we need to teach ourselves to see design in a different way when working digitally.

Thanks to the 'copy-paste' dentistry solutions and the power of digital dentistry, it has become possible to capture beauty, including morphology and shapes that never repeat themselves, and store and reproduce it in an unlimited number of designs and materials, involving the patient every step of the way. , and delivering a restoration that what very close to what was digitally planned.

References

1. Blatz MB, Chiche G, Coachman C, Heymann HO. Evolution of esthetic dentistry. J Dent Res 2019;98:1294–1304.
2. Cofar F, Gallard C, Popp I, Hue C. Skyn concept. A digital workflow for full mouth rehabilitation. QDT 2016;39:47–56.
3. Coachman C, Calamita M. Digital Smile Design: a tool for treatment planning and communication in Esthetic Dentistry. QDT 2012;3:1–9.
4. Coachman C, Calamita MA, Coachman FG, Coachman RG, Sesma N. Facially generated and cephalometric guided 3D digital design for complete mouth implant rehabilitation: a clinical report. J Prosthet Dent 2017;117:557–586.
5. Cofar F, Van Dooren E. Raw: a digital workflow. QDT 2016;21:8–24.
6. Coachman C, Paravina R. Digitally enhanced esthetic dentistry – from treatment planning to quality control. J Esthet Restor Dent 2016;28(suppl 1):S3–S4.
7. Shin JH. Digital communication in three perspectives. QDT 2018;4:135–159.
8. Gurel G. The Science and Art of Porcelain Laminate Veneers. London: Quintessence, 2003.
9. Agnini Al, Agnini An, Coachman C. Digital Dental Revolution: The Learning Curve. Quintessence, 2015.
10. Gurel G, Morimoto S, Calamita MA, Coachman C, Sesma N. Clinical performance of porcelain laminate veneers: outcomes of the aesthetic pre-evaluative temporary (APT) technique. Int J Periodontics Restorative Dent 2012;32:625–635.
11. Gurel G, Sesma N, Calamita MA, Coachman C, Morimoto S. Influence of enamel preservation on failure rates of porcelain laminate veneers. Int J Periodontics Restorative Dent 2013;33:31–39.
12. Kirschneck C, Kamuf B, Putsch C, Chhatwani S, Bizhang M, Danesh G. Conformity, reliability and validity of digital dental models created by clinical intraoral scanning and extraoral plaster model digitalization workflows. Comput Biol Med 2018;100;10:114–122.
13. Kröger E, Dekiff M, Dirksen D. 3D printed simulation models based on real patient situations for hands-on practice. Eur J Dent Educ 2017;21:e119–e125.
14. Bertazzo D, Conti A. Esthetic veneers for an orthodontic restorative case. QDT 2019;21:147–163.
15. Agnini Al, Apponi R, Dondi L, Dondi M, Dondi D, Agnini An. Il ruolo delle nuove tecnologie e dei nuovi materiali in una riabilitazione adesiva full mouth di una dentizione affetta da erosione chimica. Implantologia 2019;21:9–26.
16. Gurel G, Shayder A, Paolucci B, Bichacho N. Anterior esthetics with APT: are CAD-CAM systems ready for the high-end anterior esthetics challenge? QDT 2013;36:77–95.
17. Tuğcu E, Vanlıoğlu B, Özkan YK, Aslan YU. Marginal adaptation and fracture resistance of lithium disilicate laminate veneers on teeth with different preparation depths. Int J Periodontics Restorative Dent 2018;38(suppl):s87–s95.
18. Fradeani M, Redemagni M, Corrado M. Porcelain laminate veneers: 6- to 12-year clinical evaluation – a retrospective study. Int J Periodontics Restorative Dent 2005;25:9–17.
19. Duarte S Jr, Sartori N, Sadan A. Adhesive resin cement for bonding esthetic restorations: a review. QDT 2011;34:40–66.
20. Breschi L, Mazzoni A, Ruggeri A, Cadenaro M, Di Lenarda R, De Stefano Dorigo E. Dental adhesion review: aging and stability of the bonded interface. Dent Mater 2008;24:90–101.
21. Tian T, Tsoi JK, Matinlinna JP, Burrow MF. Aspects of bonding between resin luting cements and glass ceramic materials. Dent Mater 2014;30:e147–e162.
22. Sartori N, Alsamman R, Bocabella L. The adhesive restorative complex (ARC) concept. QDT 2017;40:48–65.
23. Mazzoni A, Angeloni V, Sartori N, et al. Substantivity of carbodiimide inhibition of dentinal enzyme activity over time. J Dent Res 2017;96:902–908.
24 Clavijo V, Sartori N, Pharl JH, Duarte GF, Soares LM. Novel guidelines for bonded ceramic veneers: Part 1. Are tooth preparations truly necessary? QDT 2016;39:7–25.
25. Sartori N, Peruchi LD, Phark JH, Duarte S Jr. The influence of intrinsic water permeation on different dentin bonded interfaces formation. J Dent 2016;48:46–54.