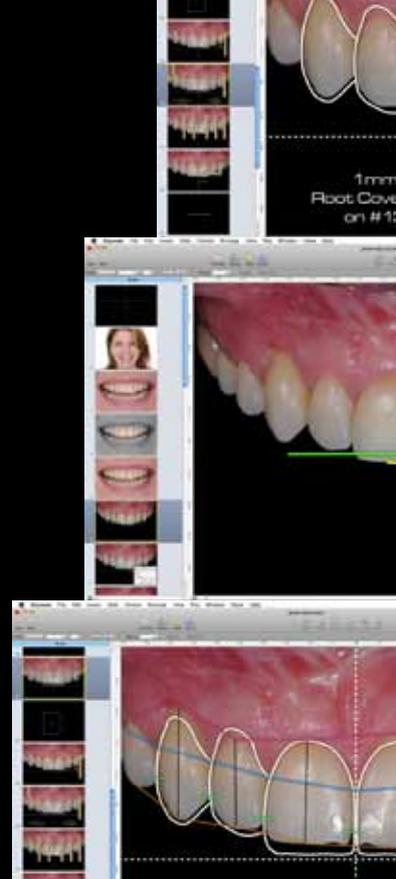


Digital Smile Design: A Tool for Treatment Planning and Communication in Esthetic Dentistry

Christian Coachman, DDS, CDT¹
Marcelo Calamita, DDS, MSD, PhD²



To obtain consistent esthetic outcomes, the design of dental restorations should be defined as soon as possible. The importance of gathering diagnostic data from questionnaires and checklists¹⁻⁷ cannot be overlooked; however, much of this information may be lost if it is not transferred adequately to the design of the restorations. The diagnostic data must guide the subsequent treatment phases,⁸ integrating all of the patient's needs, desires, and functional and biologic issues into an esthetic treatment design.^{9,10}

The Digital Smile Design (DSD) is a multi-use conceptual tool that can strengthen diagnostic vision, improve communication, and enhance predictability throughout treatment. The DSD allows for careful analysis of the patient's facial and dental characteristics along with any critical factors that may have been

overlooked during clinical, photographic, or diagnostic cast-based evaluation procedures. The drawing of reference lines and shapes over extra- and intraoral digital photographs in a predetermined sequence can widen diagnostic visualization and help the restorative team evaluate the limitations and risk factors of a given case, including asymmetries, disharmonies, and violations of esthetic principles.¹ DSD sketches can be performed in presentation software such as Keynote (iWork, Apple, Cupertino, California, USA) or Microsoft PowerPoint (Microsoft Office, Microsoft, Redmond, Washington, USA). This improved visualization makes it easier to select the ideal restorative technique.

The DSD protocol is characterized by effective communication between the interdisciplinary dental team, including the dental technician. Team members can identify and highlight discrepancies in soft or hard tissue morphology and discuss the best available solutions using the amplified images. Every team member can add information directly on the slides in writing or using voice-over, thus simplifying the process even more. All team members can access this information whenever necessary to review, alter, or add elements during the diagnostic and treatment phases.

[Au: Please provide professional affiliations for both authors.]

Correspondence to: Dr Christian Coachman, Oral Esthetic Rehabilitation, Well Clinic, Rua Bento de Andrade, 116, Sao Paulo, SP, Brazil, 04503-000. Email: ccoachman@hotmail.com; www.wellclinic.com.br

The adoption of the DSD protocol can make diagnosis more effective and treatment planning more consistent. The efforts required to implement DSD are rewarded by more logical and straightforward treatment sequencing, leading to savings in time, materials, and cost during treatment.

DIGITAL SMILE DESIGN

The DSD protocol offers advantages in the following areas:

- Esthetic diagnosis
- Communication
- Feedback
- Patient management
- Education

Esthetic Diagnosis

When the dentist first evaluates a new patient with esthetic concerns, many critical factors may be overlooked. A digital photography and digital analysis protocol enables the dentist to visualize and analyze issues that he or she may not notice clinically. Drawing of reference lines and shapes over extra- and intraoral digital photographs can easily be performed using presentation software.

Communication

Traditionally, smile design has been instituted by the dental technician. The technician performs the restorative wax-up, creates the tooth shapes and dental arrangements, and follows the instructions and guidelines provided by the dentist in writing or by phone. In many cases, however, insufficient information is given to the dental technician to utilize his or her skills to maximum potential. As a result, the final restoration is less likely to fully satisfy the patient's desires.

When the treatment coordinator or whichever member of the restorative team has developed a personal relationship with the patient takes responsibility for the smile design, the results are likely to be far superior.

This individual has the ability to better communicate the patient's personal preferences and/or morphopsychologic features to the technician, elevating the excellence of the restoration from acceptable to exceptional.^{7,8,11}

Successful restorative treatment involves controlling the four dimensions of treatment: esthetics, function, structure, and biology. In relation to esthetics, there are four main issues that must be controlled to improve predictability and meet patient expectations: the horizontal reference plane, facial midline, smile design (tooth shape and arrangement), and color. The question is how to precisely transfer this information from the face to the mouth, to the cast, and to the final restoration. The primary goal of the DSD protocol is to facilitate this process.

With this valuable information in hand, the dental technician can more efficiently fabricate a three-dimensional wax-up, focusing on developing anatomical features within the parameters provided, including the planes of reference, facial and dental midlines, recommended incisal edge position, lip dynamics, basic tooth arrangement, and incisal plane.

This information is transferred from the wax-up to the try-in phase through a mock-up or provisional restoration.^{4,6,12} The design of the definitive esthetic restorations should be developed and tried-in as soon as possible to guide the treatment sequence. Efficient treatment planning helps the entire dental team identify any challenges and reduce total treatment time.⁸

Feedback

The DSD allows for precise evaluation of the results obtained in every treatment phase. The sequence of treatment is organized on the slides with photographs, videos, notes, graphics, and drawings. At any time, team members can access the slide presentation to track and analyze the treatment provided. With the digital ruler, drawings, and reference lines, easy comparisons can be made between pre- and posttreatment photographs. These comparisons help determine whether the treatment has successfully followed the original plan or if other adjunctive procedures are necessary to improve the final outcome. The dental technician also gains feedback related to tooth shape, arrangement, and color to facilitate any necessary re-

finements. This constant double-checking ensures the excellence of the final result and provides a great learning tool for the entire interdisciplinary team. The DSD tool also serves as a useful library of treatment procedures. Clinicians can revisit treatments performed years ago and learn from past results.

Patient Management

The DSD can be used as a marketing tool to motivate the patient, an educational tool to help explain issues related to treatment, and an evaluative tool by comparing before and after photographs. Further, the library of slides from past treatments can be used to demonstrate treatment possibilities during patient consultation. The treatment planning presentation will be much more effective because the DSD allows patients to visualize the multiple factors responsible for their orofacial issues. The problems presented in each case can be superimposed in list form directly over the patient's own photographs. The clinician can express the severity of the case, introduce treatment strategies, discuss the prognosis, and make case management recommendations. In addition, DSD aids in patient acceptance by helping them visualize and understand both past and future treatments.

Education

This personal library of clinical cases can also be shared with patients and colleagues, and the most appropriate cases can be transformed into a slideshow for dental presentations and lectures. DSD can increase the visual impact of a lecture by incorporating the slides from clinical cases. The audience can better understand the concepts discussed, and the presenter can minimize the use of a laser pointer.

DSD Workflow

The authors carry out the DSD protocol using Keynote software (iWork); however, similar software such as Microsoft PowerPoint can be used with minor adjustments to the technique. Keynote allows for simple manipulation of the digital images and the addition of

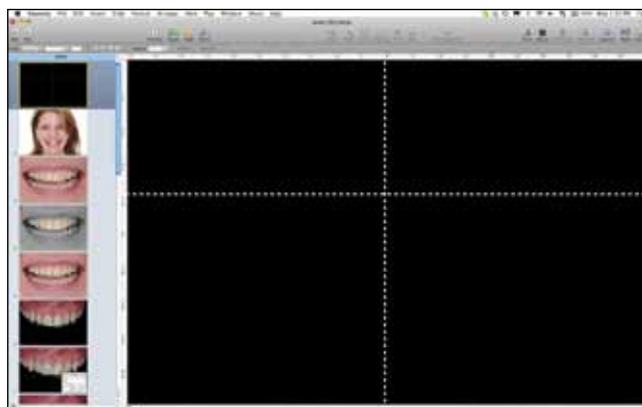


Fig 1 Slide presentation software (Keynote, iWork, Apple) with crossing lines placed on the middle of the slide.

lines, shapes, and measurements over the clinical and laboratory images.

Three basic photographic views are necessary: full face with a wide smile and the teeth apart, full face at rest, and retracted view of the full maxillary arch with teeth apart. A short video is also recommended in which the patient is prompted by the clinician to explain his or her treatment concerns and expectations. Simultaneously, the video should capture all possible dental and smile positions, including 45-degree and profile views. The photographs and videos are downloaded and inserted into the slide presentation. The DSD workflow then proceeds as follows:

1. **The cross:** Two lines must be placed on the center of the slide, forming a cross (Fig 1). The facial photograph with the teeth apart should be positioned behind these lines.
2. **Digital facebow:** Relating the full-face smile image to the horizontal reference line is the most important step in the smile design process. The interpupillary line should be the first reference line to establish the horizontal plane, but it should not be the only one. The face as a whole must be analyzed before determining the best horizontal reference to achieve harmony. After determining the horizontal reference line, the facial midline is outlined according to facial features such as the glabella, nose, and chin (Fig 2).

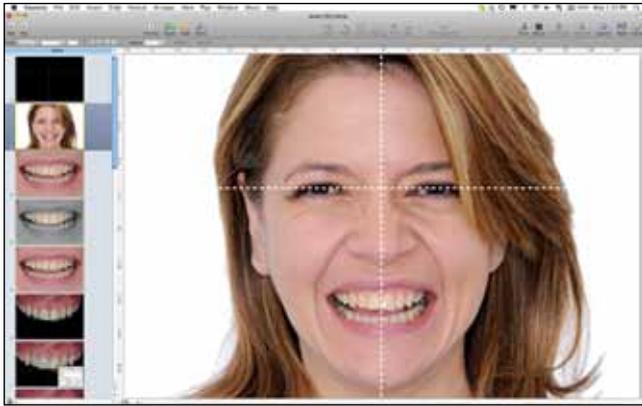


Fig 2 The facial photograph with a wide smile and the teeth apart is moved behind the cross to determine the ideal horizontal plane and vertical midline (ie, the digital facebow).

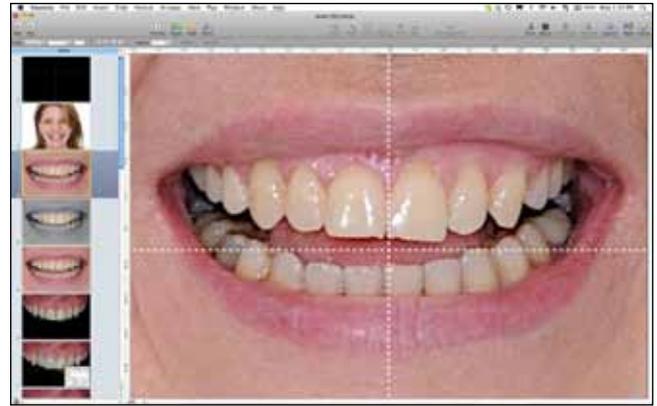


Fig 3 Transferring the cross to the smile: grouping the lines with the facial photograph and zooming in to analyze the relationship between the facial lines, lips, teeth, and gingiva.



Fig 4 Basic dental simulation performed by cropping the images of the teeth and placing them over the smile photograph, correcting the gingival levels, length, and the canting of the anterior teeth.

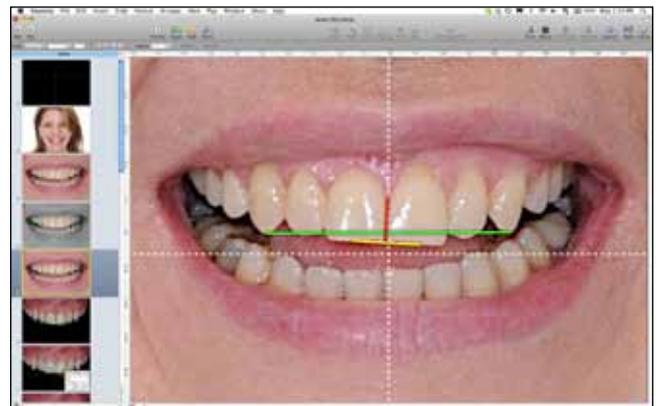


Fig 5 Drawing the three reference lines that will allow for transferring of the cross to the intraoral photograph.

3. **Smile analysis:** Dragging the horizontal line over the mouth will allow for initial evaluation of the relationship of the facial lines with the smile. Grouping the lines and the facial photographs will allow the clinician to zoom in on the image without losing the reference between the lines and photograph. Midline and occlusal plane shifting and canting can be easily detected (Fig 3).
4. **Smile simulation:** Simulations can be performed to fix the incisal edge position, canting, shifting, tooth proportions, and soft tissue outline (Fig 4).
5. **Transferring the cross to the intraoral images:** To analyze the intraoral photographs in accordance with the facial references, the cross must be transferred to the retracted view using three transferring lines drawn over the smile view as follows (Fig 5):

- a) *Line 1:* from the tip of one canine to the tip of the contralateral canine.
- b) *Line 2:* from the middle of the incisal edge of one central incisor to the middle of the incisal edge of the contralateral central incisor.
- c) *Line 3:* over the dental midline, from the tip of the midline interdental papillae to the incisal embrasure.

It is necessary to calibrate four features on the photograph: size, canting, incisal edge position, and midline position. Line 1 will guide the two first aspects (size and canting), line 2 will guide the incisal edge position, and line 3 will guide the midline position (Fig 6).

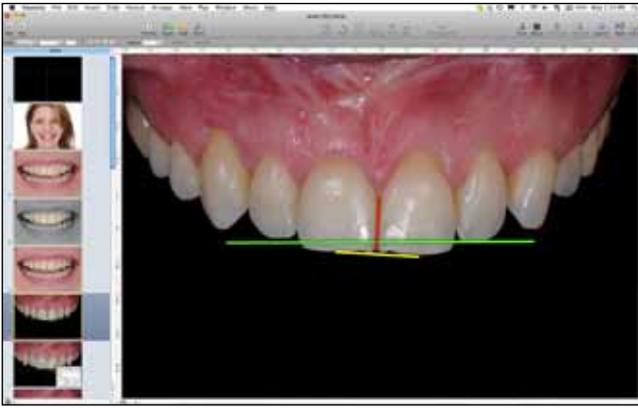


Fig 6 Intraoral photograph adjusted to the three reference lines.

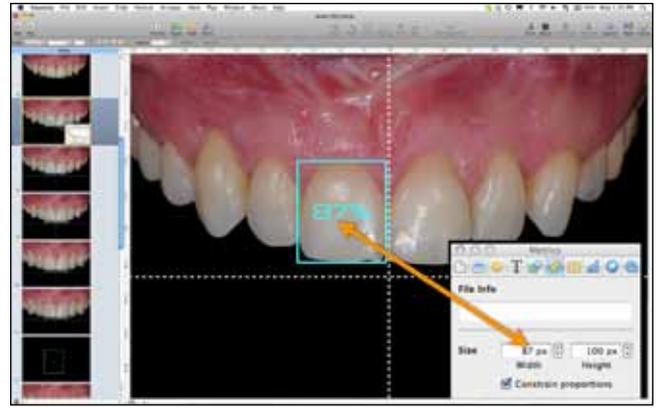


Fig 7 Intraoral photograph with the cross used to measure the actual length/width proportion of the right central incisor.

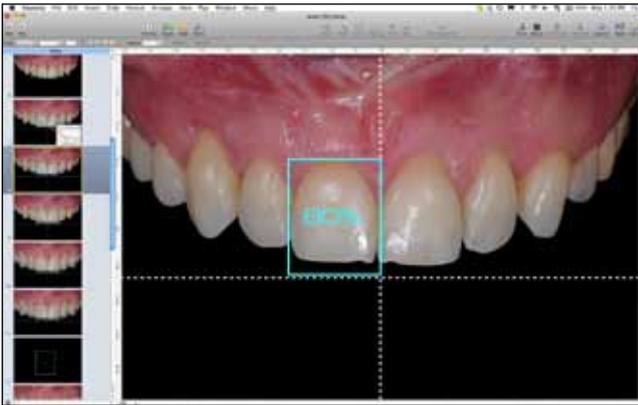


Fig 8 A rectangle with ideal length/width proportion (80%) is placed over the central incisor to compare the actual pretreatment proportion with the ideal one.

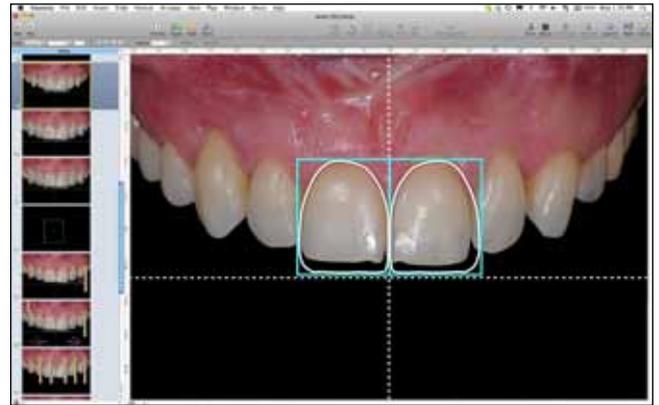


Fig 9 Drawing the tooth outline, as guided by the cross and by the rectangle proportion.

6. **Measuring tooth proportion:** Measuring the width/length proportion of the central incisors is the first step toward understanding how to best redesign the smile. A rectangle is then placed over the edges of both central incisors (Fig 7). The proportions of the patient's central incisors can be compared to the ideal proportions described in the literature (Fig 8).²⁻⁸
7. **Tooth outline:** From this step on, all drawings may be performed depending on what needs to be visualized or communicated for each specific case. For example, tooth outlines can be drawn over the photograph, or premade tooth outlines can be copied and pasted. The selection of tooth shape will depend on factors such as the morphopsychologic interview and the patient's desires, facial features, and esthetic expectations (Figs 9 and 10).^{11,13}



Fig 10 Final teeth outline showing the relationship between the preoperative situation and the ideal design.

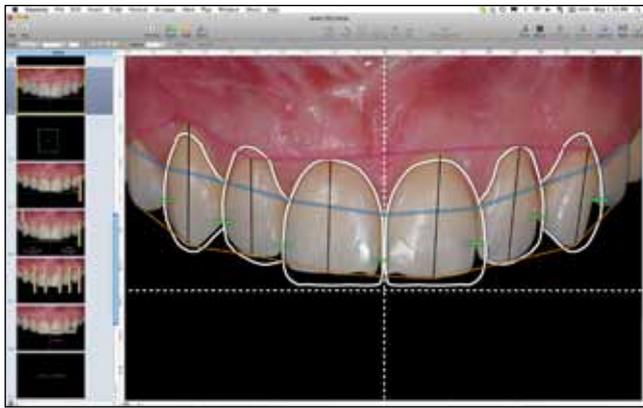


Fig 11 Other drawings and lines can be added as needed to help visualize the esthetic issues and improve the efficiency of communication.



Fig 12 Measuring the length of the left central incisor (10.6 mm) on the cast. This measurement will be transferred to the computer for calibration of the digital ruler.



Fig 13 Calibrating the digital ruler on the slide by shrinking/stretching until it matches the measurement done on the cast. The digital ruler is a photograph of a ruler (JPEG file) that is dragged on top of the slide and can be positioned as necessary.



Fig 14 Measurements can be taken of the difference between the preoperative location of the cervical areas of the canines compared to the ideal location. In this case, one maxillary canine needed crown lengthening and the other required root coverage.

8. **White and pink esthetic evaluation:** After all reference lines and drawings have been provided, the clinician should have a clear understanding of the esthetic issues involved in the patient's maxillary arch, including the tooth proportions, interdental relationship, relationship between the teeth and smile line, discrepancy between facial and dental midlines, midline and occlusal plane canting, soft tissue disharmony, relationship between the soft tissues and teeth, papillae heights, gingival margin levels, incisal edge design, and tooth axis (Fig 11).
9. **Digital ruler calibration:** The digital ruler can be calibrated over the intraoral photograph by measuring the length of one of the central incisors on

the cast (Fig 12) and transferring this measurement to the computer (Fig 13). Once the digital ruler is calibrated, the clinician can make any measurements needed over the anterior area of the image (Fig 14).

10. **Transferring the cross to the cast:** First, the horizontal line over the intraoral photograph should be moved above the gingival margin of the six anterior teeth. The distance between the horizontal line and the gingival margin of each tooth is measured using the digital ruler, and these measurements are written down on the slide (Fig 15). The measurements are then transferred to the cast with the aid of a caliper. Pencil marks are made on



Fig 15 The horizontal line is placed randomly above the gingival margin of the anterior teeth. This distance is then measured and transferred to the stone cast using the digital ruler.

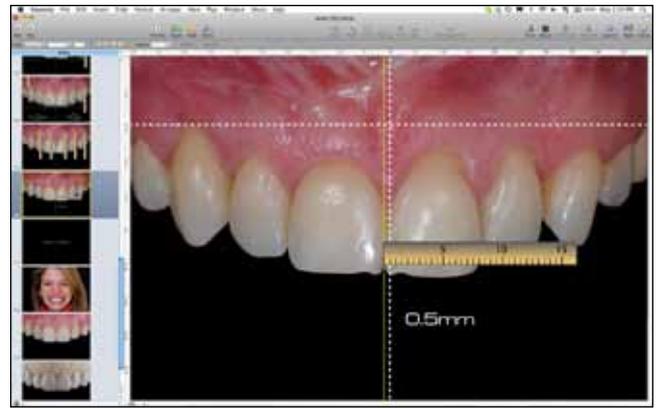


Fig 16 Measuring the discrepancy between the facial midline and dental midline.

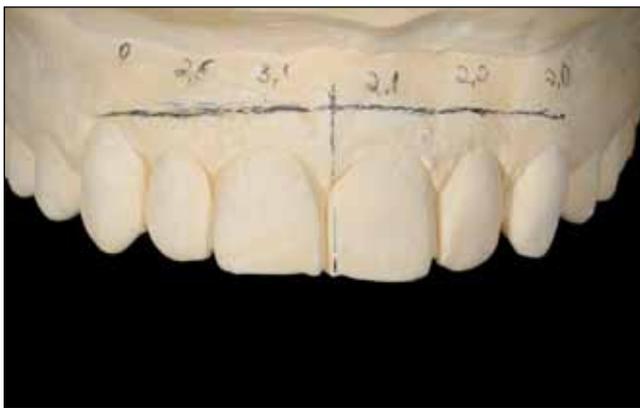


Fig 17 All the measurements are transferred to the cast, and the cross is drawn.



Fig 18 The diagnostic wax-up is fabricated using the cross and morphopsychologic design as guides. The new incisal length is measured on the computer and transferred to the wax-up with a caliper.

the cast at the same distances above the gingival margins as shown on the digital images. Those dots are then connected, creating a horizontal line above the teeth. The next step is to transfer the vertical midline. Because the vertical line must be perpendicular to the horizontal line, only one point is necessary to determine its location. The distance between the dental midline and the facial midline at the incisal edge is measured on the computer, and the distance is then transferred to the cast with the caliper (Fig 16). Subsequently, the line can be drawn perpendicular to the horizontal line passing over this reference point. After drawing the cross on the cast (Fig 17), it is possible

to transfer any necessary information, such as gingival margins, root coverage, crown lengthening, incisal edge reduction, and tooth width. At this stage, all information the technician will need to develop a precise wax-up is available on both the slides and cast (Fig 18).

The guided diagnostic wax-up will be an important reference for any surgical, orthodontic, and restorative procedures. Several guides can be produced over this wax-up to control the procedures, such as surgical stents, orthodontic guides, implant guides, crown lengthening guides, and tooth preparation guides. The next important step to evaluate the precision of



Fig 19 Try-in provisional made with bis-acrylic resin is obtained from a silicone index fabricated on top of the diagnostic wax-up.



Fig 20 Final minimally invasive tooth preparation guided by the silicone indexes.

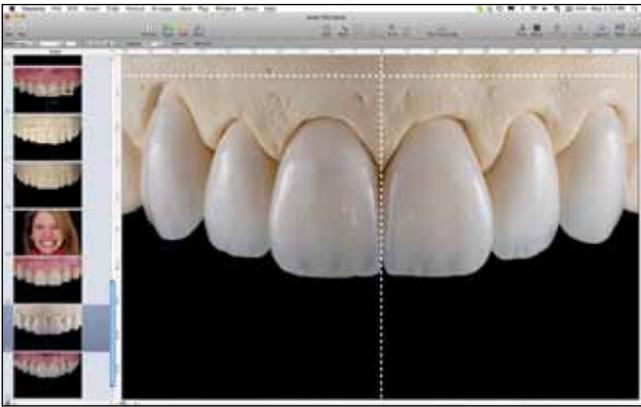


Fig 21 Final ceramic veneers (IPS e.max, Ivoclar Vivadent, Schaan, Liechtenstein) fabricated according to the silicone indexes.



Fig 22 Ceramic veneers after bonding.



Fig 23 Final outcome after 6 months.

the DSD protocol and the wax-up is to perform a clinical try-in (Fig 19). The clinical try-in can be carried out using a direct mock-up or a provisional restoration depending on the complexity of the case. After patient approval, the restorative procedures can be adjusted as necessary. Tooth preparation should be minimally invasive, allowing just enough clearance to create proper space for ceramic restorations (Fig 20). Fabrication of the final restorations should be a controlled process with minimal final adjustments (Fig 21). If all of these steps are carried out properly and carefully, the final result will likely exceed the patient's expectations (Figs 22 and 23).

CONCLUSIONS

The Digital Smile Design is a multi-use tool that can assist the restorative team throughout treatment, improving the dental team's understanding of the esthetic issues and increasing patient acceptance of the final result. The placement of reference lines and other shapes over extra- and intraoral digital photographs widens the dental team's diagnostic vision and helps to evaluate the limitations, risk factors, and esthetic principles of a given case. These critical data will lead to improved results in all phases of treatment.

ACKNOWLEDGMENT

The authors would like to thank Dr Marcos Pitta, Oral Surgeon; Dr Milton Missaka, Orthodontist, and Adriano Shayder, CDT, members of the interdisciplinary team, for their remarkable contributions to the results obtained and for all dental laboratory support.

REFERENCES

1. Coachman C, Van Dooren E, Gürel G, Landsberg CJ, Calamita MA, Bichacho N. Smile design: From digital treatment planning to clinical reality. In: Cohen M (ed). *Interdisciplinary Treatment Planning. Vol 2: Comprehensive Case Studies*. Chicago: Quintessence, 2012:119–174.
2. Goldstein RE. *Esthetics in Dentistry. Vol 1: Principles, Communication, Treatment Methods*, ed 2. Ontario: BC Decker, 1998.
3. Chiche GJ, Pinault A. *Esthetics of Anterior Fixed Prosthodontics*. Chicago: Quintessence, 1996.
4. Magne P, Belser U. *Bonded Porcelain Restorations in the Anterior Dentition: A Biomimetic Approach*. Chicago: Quintessence, 2002.
5. Fradeani M. *Esthetic Rehabilitation in Fixed Prosthodontics. Vol 1: Esthetic Analysis: A Systematic Approach to Prosthetic Treatment*. Chicago: Quintessence, 2004.
6. Gürel G. *The Science and Art of Porcelain Laminate Veneers*. Chicago: Quintessence, 2003.
7. Rufenacht CR. *Fundamentals of Esthetics*. Chicago: Quintessence, 1990.
8. Dawson PE. *Functional Occlusion: From TMJ to Smile Design*. St Louis: Mosby, 2007.
9. Spear FM. The maxillary central incisor edge: A key to esthetic and functional treatment planning. *Compend Contin Educ Dent* 1999;20:512–516.
10. Kois JC. Diagnostically driven interdisciplinary treatment planning. *Seattle Study Club J* 2002;6:28–34.
11. Paolucci B. Visagismo e Odontologia. In: Hallawell P. *Visagismo Integrado: Identidade, Estilo, Beleza*. São Paulo: Senac, 2009:243–250.
12. Gürel G, Bichacho N. Permanent diagnostic provisional restorations for predictable results when redesigning smiles. *Pract Proced Aesthet Dent* 2006;18:281–286.
13. Paolucci B. *Visagismo: A Arte de Personalizar o Desenho do Sorriso*. São Paulo: VM Cultural, 2011.

