

# CURRENT CONCEPTS OF DIGITAL SMILE DESIGNING

## Abstract

Digital Smile Design (DSD) in dentistry is a modern technique that facilitates the planning and visualisation of expected treatment outcomes by digitally simulating and previewing the final smile design. It has emerged as a transformative approach to treatment planning and visualization, allowing for a dynamic and patient-centred methodology. This digital technique involves active patient participation, enabling the customization of smile designs based on individual preferences and morpho-psychological characteristics. This collaborative approach establishes a psychological connection with the patient, fostering trust in the treatment process and boosting confidence in authorizing planned dental procedures. Dentists employ reference lines and shapes on both extra and intraoral photographic images to better assess the limitations, risk factors, and aesthetic principles of a case. This comprehensive perspective enhances diagnostic accuracy and contributes to improved outcomes across all phases of treatment. The incorporation of dynamic smile documentation in the Digital Smile Design protocol not only refines diagnostic precision but also ensures consistency in the treatment regimen. Digital Smile Design represents a paradigm shift in dentistry, offering a holistic and patient-centric approach that combines technology and artistry to achieve aesthetically pleasing and functionally sound results with minimal risks.

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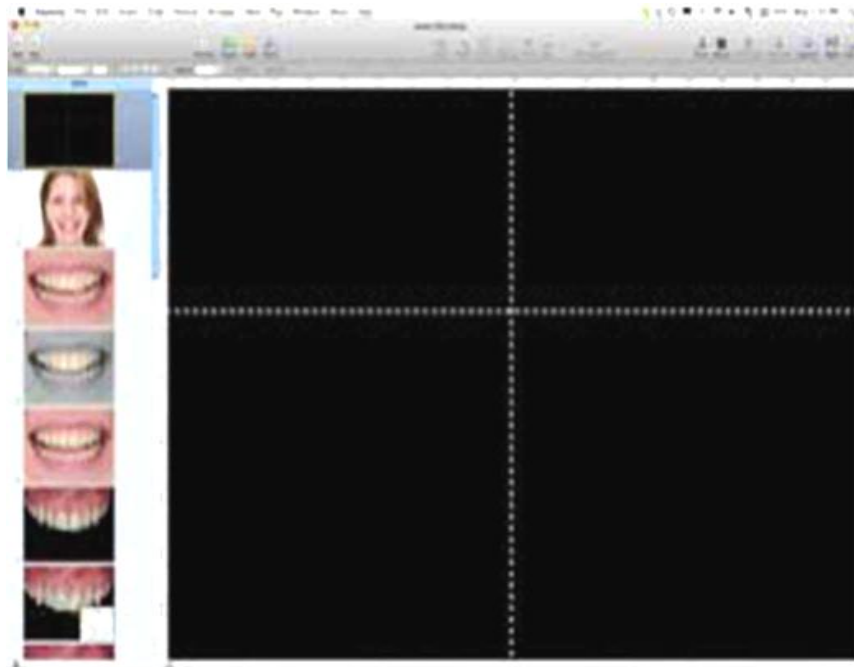
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## I. INTRODUCTION

When a patient desires a perfect smile but hesitates to undergo treatment due to uncertainty about the treatment's outcome, a dental professional can utilize the Digital Smile Design (DSD) tool. Digital smile design is a digital technique that helps in the planning and visualization of the anticipated results of the suggested treatment by simulating and previewing the final smile design. (1) An individual's natural smile is influenced by numerous components, encompassing factors such as the position of the incisal edge, buccal corridor, labiodental relationship, upper lip curvature, smile line, smile arc, and smile design. Moreover, factors like the gingival zenith's placement, symmetry, gingival display, and dental-facial midline alignment play crucial roles in determining the overall attractiveness of a smile. When embarking on a smile makeover, it is imperative to take all of these elements into account. (5) Digital smile design entails active patient participation in the smile design process, enabling the customization of their smile based on their unique preferences and requirements, aligning it with their morpho-psychological characteristics. This approach fosters a psychological connection with the patient, building trust in the treatment process and enhancing their confidence in authorizing the planned dental procedures. (1)

## II. DIGITAL SMILE DESIGN (DSD)

The Digital Smile Design (DSD) is a versatile conceptual tool that can elevate diagnostic precision, streamline interactions, and enhance treatment accuracy. It allows for a comprehensive assessment of both the patient's facial and dental attributes, uncovering details that traditional clinical, photographic, or diagnostic cast-based examinations might overlook. DSD illustrations can be created using presentation software such as Apple's Keynote (iWork) or Microsoft PowerPoint (Microsoft Office). (2)



**Figure 1:** Keynote Presentation Software

### III. EVOLUTION OF DIGITAL SMILE DESIGNING:

Over the last two decades, smile design has evolved from traditional analog methods to digital approaches, with the latest being 3D design. In earlier times, hand-drawn illustrations and printed representations were used to communicate and demonstrate the anticipated outcomes to patients. Today, it has progressed to the point where comprehensive digital drawings are created using specialized software like DSD on computers. This digital approach allows for easy adjustments and modifications at any stage, ensuring that the final design aligns perfectly with the functional and aesthetic requirements of the patients.

Christian Coachman proposed this evolution in 6 generations in 2017: (3)

1. **Generation 1** involved analog drawings on top of photographs with no link to the analog model. In this phase, manual sketches using pens were created on printed images to visualize treatment outcomes, but these drawings couldn't be precisely correlated with the patient's study model.
2. **Generation 2** involved digital 2D drawings with a visual link to the analog model. As the digital era emerged, there was a growing proficiency in using software like PowerPoint, which enabled digital drawings. While limited to two-dimensional representations and not exclusive to dentistry, this method offered greater precision and speed compared to hand drawing. It allowed for visual connections between the drawings and the study model, although there were no physical connections established.
3. **Generation 3** introduced digital 2D drawings with an analog connection to the model. This phase marked the beginning of a linkage between digital and analog components. The first dental-specific digital drawing software was introduced, bridging the gap between 3D wax-up and 2D digital smile design. Additionally, facial integration became part of smile design during this phase, although it was not yet integrated into the 3D digital environment.
4. **Generation 4** witnessed the transition from 2D to 3D in digital dentistry, where digital drawings were linked to the 3D model. This advancement allowed for the integration of facial aspects and the utilization of predefined dental aesthetic parameters in a 3D digital wax-up.
5. **Generation 5** marked the introduction of a comprehensive 3D workflow.
6. **Generation 6** introduced the innovative 4D concept, incorporating various motions into the design process, enabling a comprehensive view from all angles.

### IV. ADVANTAGES OF DIGITAL TECHNOLOGY

1. **Esthetic Diagnosis:** When a dentist initially evaluates a new patient expressing cosmetic concerns, critical aspects might go unnoticed. Through the use of digital photography and analytical techniques, dental professionals can visualize and assess issues that may not have been readily apparent during a clinical examination. Presentation software allows for the incorporation of reference lines and shapes into both intraoral and extraoral digital photographs

## 2. Communication

- Historically, dental technicians have been responsible for crafting smiles, working under the guidance of dentists to create aesthetic wax-ups, design tooth contours, and position dental prosthetics.
- To enhance predictability and meet patients' aesthetic expectations, four critical factors must be carefully managed: the horizontal reference plane, facial midline alignment, smile design encompassing tooth shape and arrangement, and color selection.
- The dental technician can effectively create a three-dimensional wax-up, focusing on developing anatomical features while adhering to specific criteria like reference planes, facial and dental midlines, suggested incisal edge placement, lip dynamics, fundamental tooth arrangement, and incisal plane. This information is subsequently transferred from the wax-up to the try-in phase through a mock-up or temporary restoration.
- In order to guide the treatment process, it is essential to design and test the final aesthetic restoration as early as possible.

## 3. Feedback

- The Digital Smile Design (DSD) offers a precise means to assess the progress at each treatment stage. In the presentation slides, the treatment sequence is arranged with visual aids like images, videos, remarks, graphics, and drawings.
- Team members have continuous access to the PowerPoint presentation, allowing them to observe and appraise the provided care. The digital ruler, sketches, and reference lines simplify the comparison of pre-and post-treatment photos.
- To streamline any required modifications, the lab technician also receives feedback pertaining to tooth shape, placement, and colour.

**4. Patient Management:** The clinician has the opportunity to discuss the prognosis, present treatment options, convey the seriousness of the condition, and provide recommendations for case management. DSD plays a crucial role in aiding patients to visualize and understand both past and future treatments, thereby enhancing patient acceptance of proposed plans. Additionally, DSD serves multiple functions, acting as a promotional strategy to engage patients, as an educational tool for clarifying treatment-related queries, and as an assessment tool by allowing comparisons between before-and-after photographs.

**5. Education:** To enhance its visual impact, DSD can benefit from incorporating slides featuring real-life clinical scenarios in a presentation. This approach facilitates a clearer understanding of the concepts being discussed for both the presenter and the audience. (2)

**6. Ease of Use:** Providing restorative dentists with a straightforward means of communicating with the dental lab responsible for creating the restorations. (4)

## V. PHOTOGRAPHY PROTOCOL – BASIC ARMAMENTARIUM

### 1. Digital Camera: (11,12)

- Compact point- and- shoot cameras
- Digital single-lens reflex –
  - More the pixels, the greater the detail of the image.
  - In dental photography, 10 Mega Pixels is required.
- Intraoral cameras

### 2. Camera Accessories

- Lens
  - Macro lens with fixed focal length of 85–105 mm.
- Light and ELECTRONIC FLASH SYSTEMS
  - Ring flash
  - Point flash
  - Twin flash
- Memory card
  - For storage of data
- Filter
  - Lens protection
  - Changing the lighting conditions if required
- Batteries

### 3. Clinical Accessories

- Cheek retractors
- Black background/contrastors
- Intraoral mirrors

**Photographic Views:** Six fundamental photographic angles are essential: (2)

- Frontal facial view with the smile and teeth apart.
- Frontal facial view with retraction and teeth apart.
- Side facial profile at rest.
- Side facial profile with a smile.
- An occlusal view using a mirror or taken from a model.
- A view from the top, akin to 12 o'clock, capturing the smile.



**Figure 2: Six Photographs**

It is also advisable for clinicians to capture a brief video where the patient articulates their treatment concerns and expectations in their own words. The video should encompass all feasible dental and smiling postures simultaneously, including a 45° view and a profile view.

## **VI. VIDEOGRAPHY PROTOCOL**

According to Coachman, when recording a video, the best frame, zoom, and exposure settings should be used to focus the lips and the mouth. (6)

1. A facial frontal video with a retractor and without a retractor smiling,
2. A facial profile video with lips at rest and a wide smile,
3. A 12 O'clock video above the head at the most coronal angle that still allows visualization of the incisal edge
4. An anterior occlusal video to record maxillary teeth from second premolar to second premolar with the palatine raphe as a straight line.

Additional videos should also be recorded to assess speech and functional aspects. These photographs and videos are then incorporated into the applications utilized for the design process.

## VII. DIGITAL WORKFLOW SOFTWARE

The digital workflow timeline can be divided into two distinct phases: a pre-case-acceptance phase, which involves planning, and a post-case-acceptance phase, which pertains to execution. Likewise, dental software platforms are categorized into pre-case-acceptance software (pre- software) and post-case-acceptance software (post-software), each designed to provide optimal features based on the specific phase in which they will be utilized. (4)

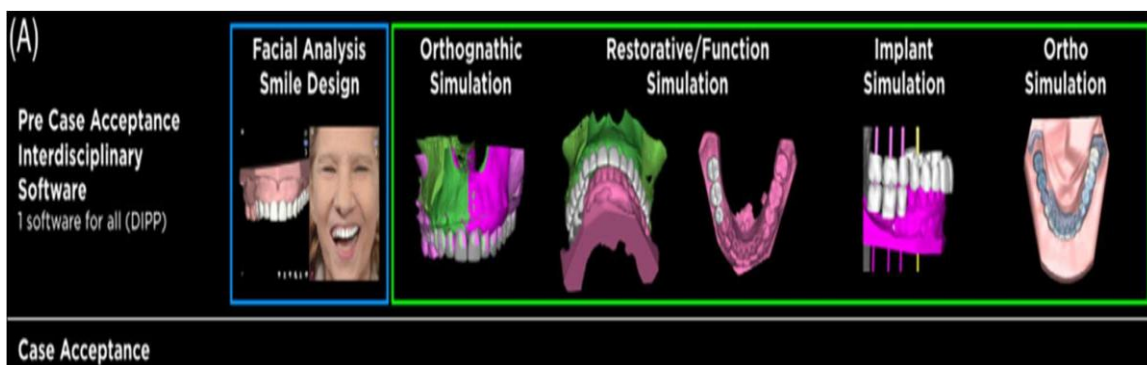
**1. Pre-Case Acceptance Software:** The pre-software needs to have two main characteristics

- Treatment planning guided by the face
- Interdisciplinary integration.

The software should serve several purposes, including diagnosis, initial ideal smile creation, and modelling various treatment options. This comprehensive functionality is essential to determine the most suitable combination of treatments for each patient. It should have the capability to perform all interdisciplinary simulations within a single program and facilitate facial analysis along with the incorporation of ideal smile design elements.

*The primary objectives of pre-case acceptance software include:*

- Data Acquisition
- Enhancing the process of identifying the patient's concerns and making diagnoses
- Simulating and comparing various treatment options, fostering collaborative brainstorming within the team to find solutions
- Enhancing the decision-making process and risk assessment
- Facilitating the explanation of treatment options to the patient, actively involving the patient in the decision-making process by using pre-software as a 3D visual communication tool. (4)



**Figure 3:** Pre-Case Acceptance Software

**2. Post-Case Acceptance Software:** The dental practitioner has the capability to export files from the pre-software and import them into various post-software applications after the treatment plan is finalized and the patient consents to the proposed course of action. The primary purpose of the post-software, which is specialized for specific areas, is to meticulously coordinate a particular disciplinary procedure while also **designing any**

necessary devices or components needed to execute the clinical procedure.

The primary objectives of post-case acceptance software include:

- Importing files from pre-software: incorporating the ideal design and initial specialty simulation recommendations.
- Seamlessly integrating files from pre-software with working files for disciplinary tasks.
- Designing the necessary devices or components required for specific procedures.
- Establishing connections with manufacturing systems like milling and 3D printing machines to bring the designed components into physical reality. (4)



**Figure 4:** Post-Case Acceptance Software

### VIII. COMMONLY USED DSD PROGRAMS: (1)

|   |
|---|
| Photoshop CS6 (Adobe Systems Incorporated)  |
| DSD App by Coachman ( <a href="#">DSDApp</a> LLC)   |
| Microsoft PowerPoint (Microsoft Office, Microsoft, Redmond, Washington, USA)              |
| Cerec SW 4.2 (Sirona Dental Systems Inc.)   |
| Planmeca <a href="#">Romexis</a> Smile Design (PRSD) (Planmeca <a href="#">Romexis</a> ®) |
| Smile Designer Pro (SDP) (Tasty Tech Ltd) <a href="#">NemoDSD</a> (3D)                    |
| VisagiSMile (Web Motion LTD)  |
| Exocad <a href="#">DentalCAD</a> 2.3  |
| DSS ( <a href="#">EGSolution</a> )  |
| Aesthetic Digital Smile Design (ADSD - Dr Valerio Bini)                                   |
| Guided Positioning System (GPS)   |
| Keynote (iWork, Apple, Cupertino, California, USA)  |

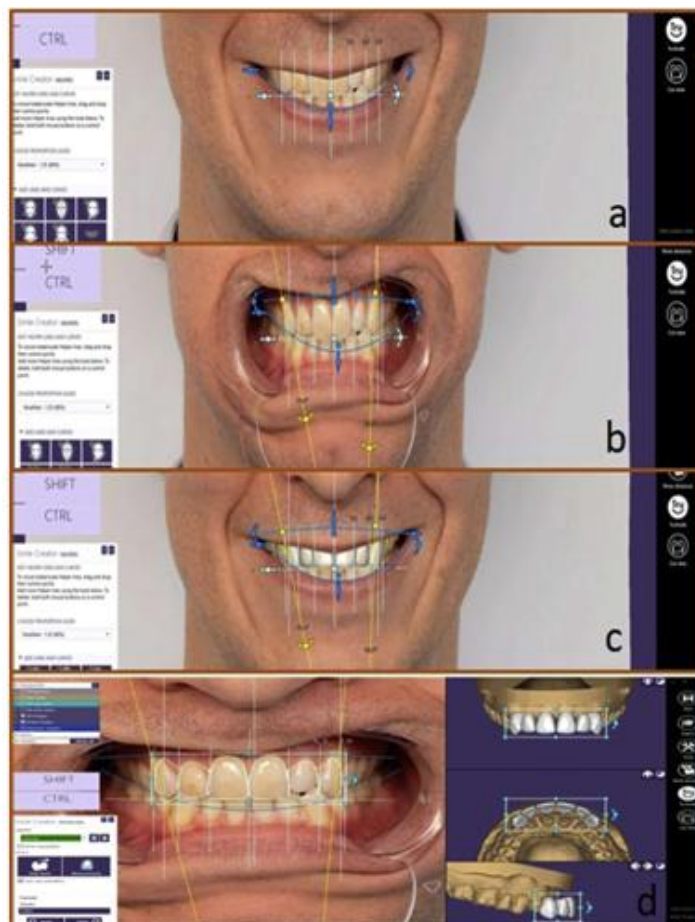
While not initially designed with Digital Smile Design (DSD) in mind, dentists and other dental professionals have found utility in software like Photoshop CS6 and Keynote for DSD purposes. Their suitability for cosmetic dentistry has been discussed in various literature reviews. Specialized digital design tools specifically marketed for the dental cosmetic industry include SDP and ADSD. Commonly used CAD/CAM programs like Cerec SW 4.2



and PRSD are employed to create anterior restorations, which typically involve designing ceramic restorations based on frontal photographs and intra-oral digital impressions. Two applications, the DSD App and VisagiSmile, incorporate the visagism theory, which posits that personality traits can serve as design components for smiles. Dr. Coachman, who has previously published numerous studies on the use of Keynote for digital smile design, is the creator of the DSD App. These programs originally designed for non-dental purposes are expected to have a broader scope due to their diverse range of functions and adaptability. (7,8)



**Figure 5:** The Cerec Software



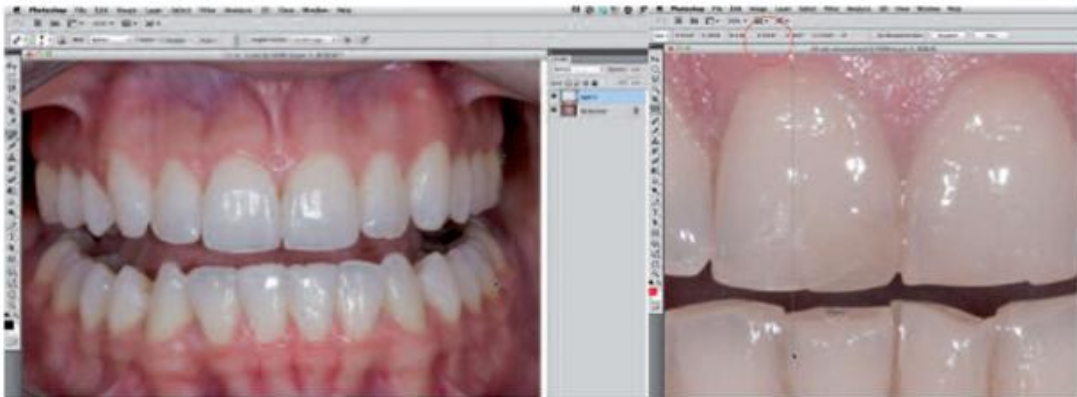
**Figure 6:** Exocad 3D software

## IX. THE PHOTOSHOP SMILE DESIGN TECHNIQUE

Converting of the actual tooth length and width into the software is the first stage in the PSD approach. Next, the recommended new length and proportion of the teeth are determined digitally. (10)

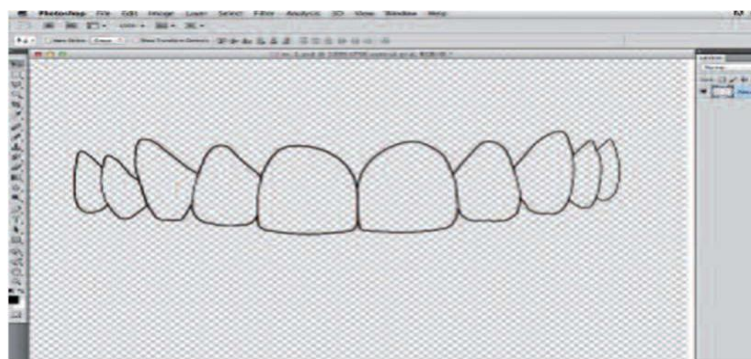
### 1. Determining Digital Tooth Size

- To establish a conversion factor, divide the anticipated tooth length by the current tooth length.
- Launch the full-arch cheek-retracted view using Photoshop software, and zoom in on the central incisor.
- Choose the eyedropper palette. A new menu will appear. Opt for the ruler tool.



**Figure 7:** Open an image of an attractive smile in Photoshop in a separate transparent layer.  
**Fig 8:** Measure the digital length of the central incisor using the ruler tool.

- Employ the ruler tool to create a vertical measurement from the top to the bottom of the tooth. Multiply the number of pixels by the previously determined conversion factor to calculate the digital tooth length. Use the same formula to determine the digital tooth width.
- Establish a new layer, ensure it's transparent, and utilize the pencil tool to annotate the measurement. (10)



**Figure 9:** A Two-Pixel Stroke Black Line Used to Trace Tooth Selection.

- 2. Applying A New Proposed Tooth Form:** Following the completion of the smile analysis and digital measurements, opt for a custom tooth grid that suits the patient. Select a tooth grid that aligns with the planned teeth's width- to-length ratio.



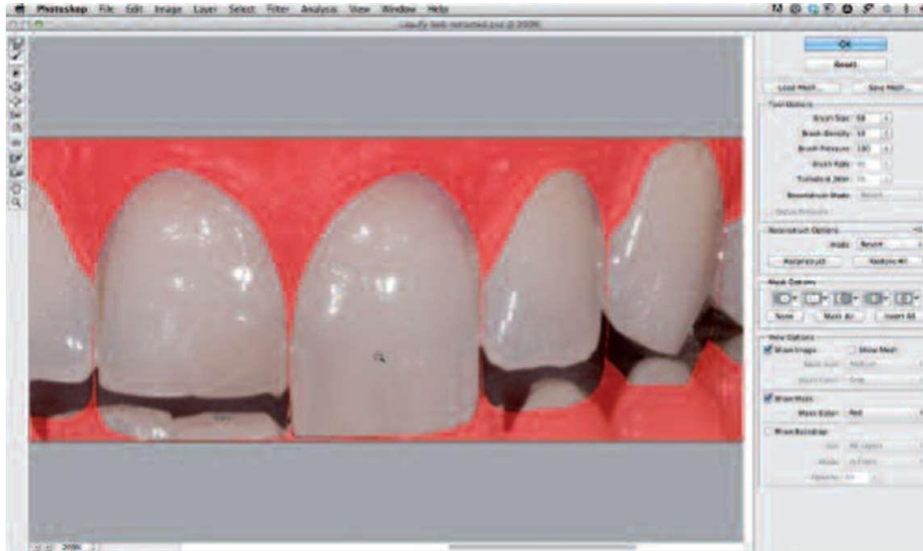
**Figure 10:** Image of the ideal teeth traced up to the second premolar to create a tooth grid.

- Launch the image of the selected tooth grid in Photoshop and drag it onto the image of the teeth that need smile designing.
- Depending on the original image size, the tooth grid might appear either proportionally too large or too small. To resize the created tooth grid (with the layer activated), press the command (or control) and "t" keys to activate the free transform function. While holding down the shift key (which ensures proportional transformation), click and drag a corner either left or right to enlarge or reduce the size of the custom tooth grid.



**Figure 11:** Adjust the grid as required while maintaining proper proportions

- Modify the size of the grid to match the outlines of the central incisors' new proposed length. Use the move tool to shift the grid as required, ensuring that the incisal edge of the tooth grid aligns with the new proposed length.



**Figure 12:** Shape One Tooth at a Time Using the Wand Tool

- Areas of the grid can be individually altered using the liquify tool. (10)

### 3. Digitally Creating New Aesthetic Teeth

- Activate both the new tooth grid layer and the magic wand tool, and then click on each tooth to select all the teeth within the grid.
- Widen the selection by two pixels by going to the "Select" menu and choosing "Modify" and then "Expand." Activate the layer containing the teeth (cheek-retracted view) by clicking on it.
- Activate the liquify filter (you'll notice a red mask outlining the shapes of the proposed teeth). This mask serves as a digital boundary that restricts any alterations to the teeth beyond its limits, similar to using tape to create a masking boundary when painting a shape.



**Figure 13:** Once all of the teeth have been shaped, use the liquify tool.

- Utilize the forward warp tool by selecting an area of the current tooth and dragging it to reshape the tooth according to the new proposed outline.
- Repeat this process for each tooth in the grid.
- Opt for the dodge tool to lighten and enhance the appearance of the teeth. (10)

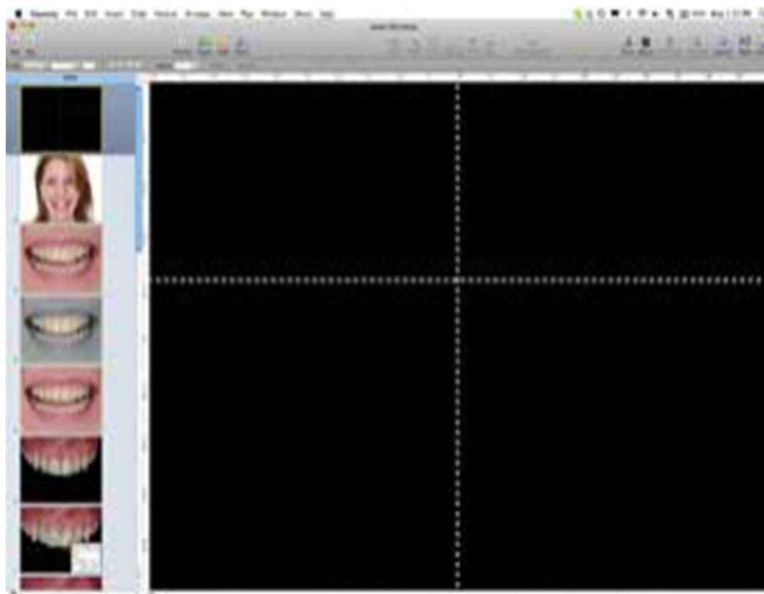


**Figure 14:** Teeth Whitened Using the Dodge Tool.

## **X. COACHMAN'S DSD APP**

The DSD workflow by Coachman proceeds as follows: (2)

1. **The Cross:** Position a cross on the slide, formed by two intersecting lines, at the center. Place a facial image with well-defined teeth behind these lines.



**Figure 15:** Cross Lines Placed in the Middle of the Slide

- Digital Facebow:** The pivotal step in smile design involves aligning the full-face smile image with the horizontal reference line. While the interpupillary line should be the primary reference for the horizontal plane, it's important to note that it shouldn't be the sole reference line. Before determining the ideal horizontal reference to achieve harmony, a thorough examination of the face is necessary. Once the horizontal reference line is established, the facial midline is defined in accordance with facial features such as the glabella, nose, and chin.



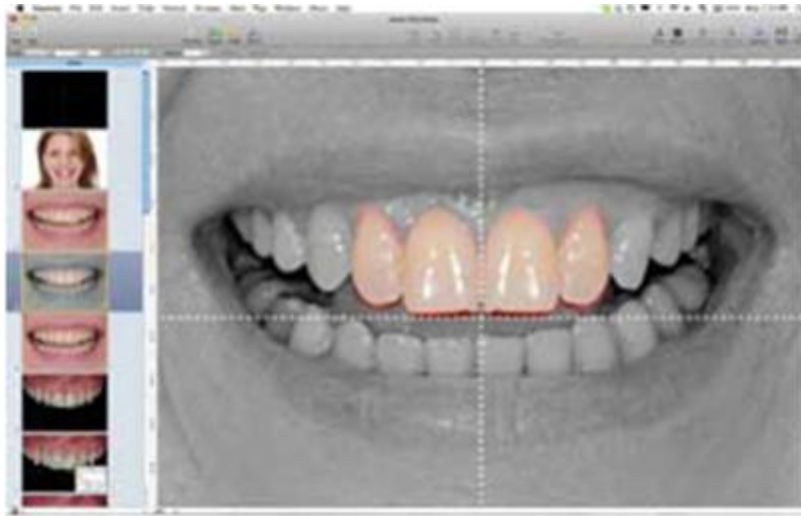
**Figure 16:** The facial photograph is moved behind the cross to determine the ideal horizontal plane and vertical midline

- Smile Analysis:** To begin assessing the connection between facial lines and the smile, you can start by positioning the horizontal line over the mouth. By grouping the lines with the facial images, clinicians can zoom in on the image while ensuring that the lines maintain their connection to the facial shots. This approach simplifies the identification of midline discrepancies and occlusal plane misalignments.



**Figure 17:** Transferring the Cross to the Smile

- 4. Smile Simulation:** Simulations can be carried out to capture critical factors such as incisal edge position, tooth inclination, tooth proportions, and soft tissue contours.



**Figure 18:** Simulation performed by cropping the images of the teeth and placing them over the smile photograph

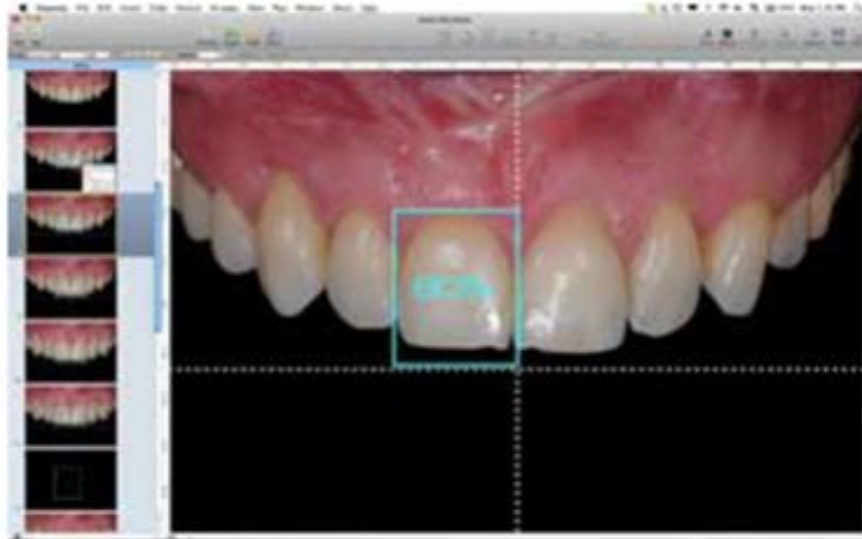
- 5. Transferring the Cross to Intraoral Images:** To analyze intraoral images based on facial references, the cross must be transferred to the retraction view using three transferring lines drawn over the grin view in the following manner:

- The first line runs from the tip of one canine to the tip of the opposite canine.
- The second line extends from the midpoint of the incisal edge of one central incisor to the midpoint of the incisal edge of the opposite central incisor.
- The third line goes from the tip of the interdental papilla at the midline to the incisal embrasure above the dental midline.



**Figure 19:** The Three Reference Lines

- 6. Measuring Tooth Proportion:** The first step in determining how to remodel the grin is to measure the width/length proportion of the central incisors. After that, a rectangle is put over the fronts of the two central incisors. The central incisors of the patient's mouth can be compared to the recommended proportions mentioned in the literature.



**Figure 20:** Box with Ideal Length and Width Proportion is Placed over the Central Incisor

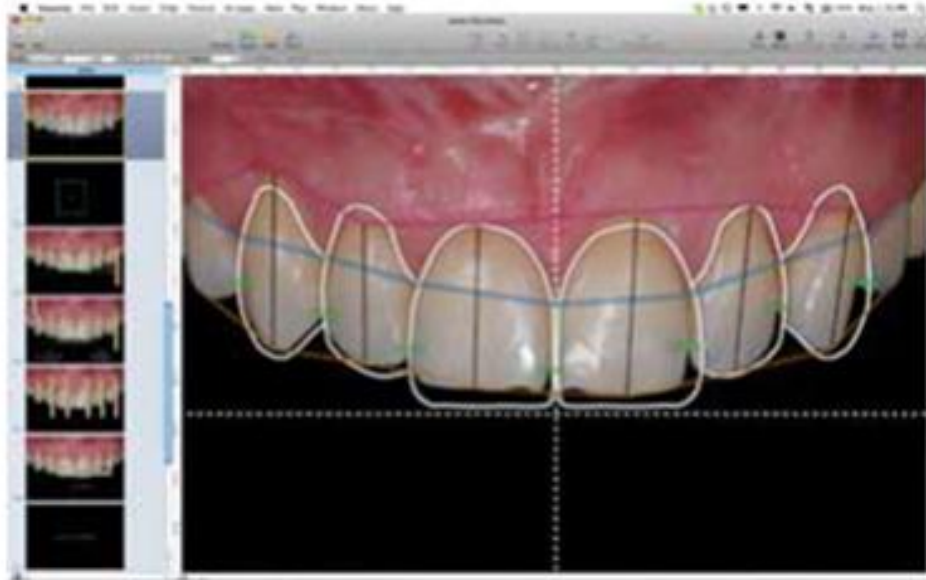
- 7. Tooth Outline:** Markings can be applied as needed, depending on the specific visualization or communication requirements for each case. For instance, the dentist can create tooth outlines directly on top of the photo or incorporate pre-made tooth outlines through copying and pasting. The selection of tooth shapes should take into account factors like the patient's preferences, aesthetic desires, and how well they complement their facial features.



**Figure 21:** Final Teeth Outline Showing the Preoperative Situation and the Ideal Design.

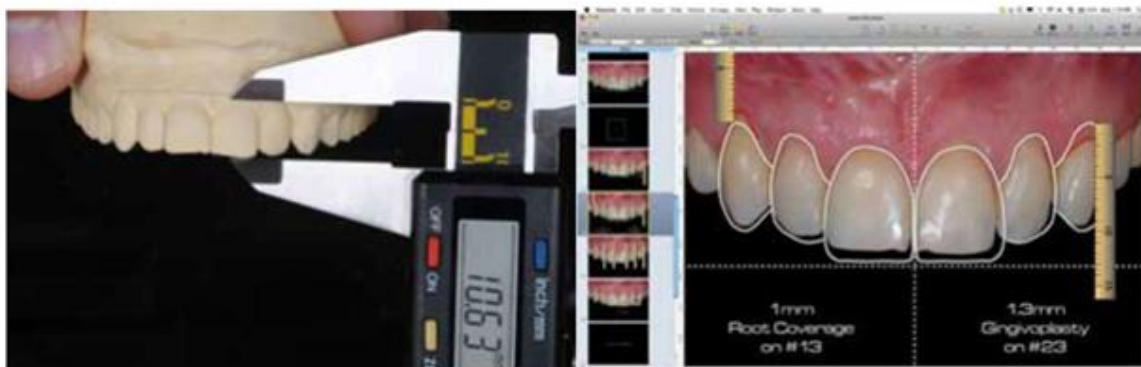


- 8. White and Pink Esthetic Evaluation:** After establishing all reference lines and drawings, the clinician should conduct a comprehensive assessment of the aesthetic aspects related to the maxillary arch. This assessment encompasses factors such as tooth proportions, interdental relationships, alignment between teeth and the smile line, disparities between facial and dental midlines, canting of the midline and occlusal plane, soft tissue harmony, alignment between soft tissues and teeth, papillary heights, gingival margin levels, incisal edge design, and tooth axis.



**Figure 22:** Other Drawings and Lines Added To Help Visualize the Aesthetic Issues

- 9. Digital Ruler Calibration:** To calibrate the digital ruler over the intraoral image, one of the central incisors on the cast can be measured, and this measurement is then entered into the computer. Once the digital ruler is calibrated, the dentist can take any required measurements over the anterior region of the image.



**Figure 23:** Measuring the Length of the Cast And Calibrating the Digital Ruler on the Slide

- 10. Transferring the cross to the cast:** First, the gingival margin of the six anterior teeth should be adjusted to be above the horizontal line spanning the intraoral photograph. Using the digital ruler, the distance between each tooth's gingival margin and the

horizontal line is measured, and these measurements are recorded on the slide. Subsequently, a calliper is employed to transfer these measurements to the cast. Next, the vertical midline transfer is carried out. Only one reference point is needed to precisely locate the vertical line since it must be perpendicular to the horizontal line. The computer is used to measure the distance between the dental and facial midlines at the incisal edge, and this measurement is then transferred to the cast using a calliper. (2)



**Figure 24:** These Digital Measurements are Transferred To The Cast

**11. Evaluate the precision:** The next pivotal phase involves a clinical try-in, which serves as a critical validation step for assessing the precision of both the DSD technique and the wax-up. Depending on the level of complexity, you may opt for either a direct mock-up or a provisional restoration during this clinical evaluation. (2)



**Figure 25:** Temporization Made Using Bis-Acrylic Resin

**12. Tooth preparation:** After ensuring patient satisfaction, keep the tooth preparation minimal, providing just sufficient clearance to accommodate ceramic restorations appropriately.



**Figure 26:** Tooth preparation guided by the silicone indexes.

Manufacturing the ultimate restorations through a carefully managed procedure, requiring minimal post-production adjustments. (2)



**Figure 27:** Final ceramic veneers

## XI. CEREC - SIRONA SMILE DESIGN TOOL

The "Smile Design" software program was developed by Sirona for the aesthetic assessment and evaluation of virtually designed restorations. It is compatible with both Cerec and inLab software platforms. (8)

- To begin, the three-dimensional clinical condition of the patient's dentition is scanned. This can be accomplished either by using an intraoral scanner to directly capture an optical impression or by digitizing cast models with a laboratory scanner.
- Once the virtual model is designed, the Smile Design process can commence.
- This necessitates a portrait-format photograph of the patient. It's crucial to ensure that the patient's teeth, and potentially even portions of the gingiva, are visible in the image.

The patient's smile should be captured in a natural state, with the lips being kept at an average degree of openness.



**Figure 28:** The Patient with the Aesthetic Problem.

- The photograph is then chosen using a file explorer and imported.
- On the monitor, a patient's photograph is displayed alongside a virtual head.
- In the next step, 16 distinct feature points must be sequentially marked on the patient's photo, corresponding to where they are positioned on the avatar generated by the software. This ensures the patient's image is projected onto the virtual head with the highest possible accuracy. These points include the corners of the eyes, the tip of the nose, and the chin, which are distinct and prominent facial features.
- Subsequently, the actual distance between the two lateral corners of the eyes needs to be recorded. This measurement can be accomplished using a calliper.
- The computation of the actual size of the virtual head, onto which the results of the jaw scan will later be overlaid, is contingent on this measurement.
- Now visible within the mouth is a three-dimensional representation of the jaw that was created during the scanning process.



**Figure 29:** Characteristic Feature Points Marked on the image.

- Presently, achieving a precise fit when inserting the "dentition" into the avatar remains a challenge for the software.
- In many instances, manual adjustments are necessary to address this issue. To facilitate this, it is useful to use the teeth from the scanned photograph (also displayed) as a reference guide.



**Figure 30:** The completed trial restoration is given a final check in the virtual articulator.

- m. After completing this process, the Smile Design Tool is ready for use. It can be accessed through the "Display Objects" menu item at any point during the digital design procedure.
  - n. The current status of the virtual process is promptly displayed alongside the patient's face.
  - For this purpose, there are several applications,
- 1. Planning and Virtual Wax-Up/Mock-Up:** The digital images are captured right from the beginning. The patient can observe the procedure's results on the monitor. A restoration can be created from a polymer block and temporarily placed on the patient's teeth as a Snap-On. This provides the patient with a highly realistic preview of the upcoming restoration.
  - 2. Intermediate Assessment and Long-Term Provisional Restoration:** Following the preparation, the anatomical situation is digitized. It's also possible to mill the restoration from polymer blocks after digital design. In addition to offering a realistic preview of the potential treatment outcome, the resulting restoration serves as an excellent long-term temporary restoration.
  - 3. Verifying the Results of Designing the Definitive Restoration:** This step is particularly valuable when assessing aspects such as tooth length, sectioning, midline alignment, and horizontal plane alignment, among others. (8)



**Figure 31:** After Completion of the Design Calculations, the Restoration can now be Milled.

Omar et al in 2017 did a systematic review comparing some of the most popular DSD programmes in their capacity to evaluate and digitally alter parameters affecting the aesthetic appearance of the face, teeth, and the smile. A set of parameters for dentofacial esthetic evaluation was used. (7)

**Table 1** Facial analysis components found in computer programs used for DSD.

| Esthetic parameters      | Photoshop CS6 | Keynote | ADSD           | Cerec SW 4.2   | DSD App        | SDP            | Visagi-SMile | PRSD |
|--------------------------|---------------|---------|----------------|----------------|----------------|----------------|--------------|------|
| Intercommissural line    | ✓             | ✓       | ✓              | ✓              | ✓              | ✓              | X            | X    |
| Interpupillary line      | ✓             | ✓       | ✓              | ✓              | ✓              | ✓              | ✓            | ✓    |
| Facial midline           | ✓             | ✓       | ✓              | X              | ✓              | ✓              | ✓            | ✓    |
| Smile cant               | ✓             | ✓       | ✓              | ✓              | ✓              | X              | X            | X    |
| Dental midline deviation | ✓             | ✓       | ✓              | ✓              | ✓              | ✓              | ✓            | ✓    |
| Mandibular midline       | ✓             | ✓       | ✓              | X              | X <sup>c</sup> | X <sup>c</sup> | ✓            | ✓    |
| Horizontal proportions   | ✓             | ✓       | ✓              | X              | X              | X              | ✓            | X    |
| Vertical proportions     | ✓             | ✓       | ✓              | X              | X              | X              | X            | X    |
| Facial profile angle     | ✓             | ✓       | ✓              | ✓ <sup>b</sup> | X              | X              | X            | X    |
| Nasolabial angle         | ✓             | ✓       | ✓ <sup>b</sup> | ✓ <sup>b</sup> | X              | X              | X            | X    |
| E-plane                  | ✓             | ✓       | X              | X              | X              | X              | X            | X    |
| H-plane                  | ✓             | ✓       | X              | X              | X              | X              | X            | X    |

**Table 2** Dento-gingival analysis components found in computer programs used for DSD.

| Esthetic parameters | Photoshop CS6 | Keynote | ADSD | Cerec SW 4.2 | DSD App | SDP | Visagi-SMile | PRSD |
|---------------------|---------------|---------|------|--------------|---------|-----|--------------|------|
| Gingival line       | ✓             | ✓       | ✓    | ✓            | ✓       | ✓   | ✓            | ✓    |
| Lower lip line      | ✓             | ✓       | ✓    | ✓            | X       | ✓   | ✓            | ✓    |
| Buccal corridor     | ✓             | ✓       | ✓    | X            | X       | X   | X            | X    |

**Table 3** Dental analysis components found in computer programs used for DSD.

| Esthetic parameters          | Photoshop CS6 | Keynote | ADSD | Cerec SW 4.2   | DSD App | SDP | Visagi-SMile | PRSD |
|------------------------------|---------------|---------|------|----------------|---------|-----|--------------|------|
| Tooth dimension              | ✓             | ✓       | ✓    | ✓              | ✓       | ✓   | ✓            | ✓    |
| Tooth shape modification     | ✓             | ✓       | ✓    | ✓              | ✓       | ✓   | X            | ✓    |
| Tooth characterization       | ✓             | X       | ✓    | ✓              | X       | X   | ✓            | X    |
| Tooth shade                  | ✓             | ✓       | ✓    | ✓ <sup>a</sup> | ✓       | ✓   | ✓            | ✓    |
| Occlusal plane/Incisal curve | ✓             | ✓       | ✓    | ✓              | ✓       | ✓   | X            | ✓    |

**Figure 32:** Comparison of DSD programs by Omar et al, 2017

## Drawbacks of Digital Technology

- **Startup Costs:** The initial investment required for digital dentistry equipment remains significant. Many systems operate on a platform with subscription-based licensing. For example, various Digital Smile Design Apps necessitate an annual subscription. Additionally, some intraoral scanners impose monthly or annual fees, similar to cloud-based data storage for backups.
- **Lack of Standardized Workflows:** Digital dentistry lacks universally standardized workflows that can be seamlessly integrated into any practice. Interoperability is a challenge due to the variety of data-gathering devices from different manufacturers, each exporting various file formats.
- **Limited Access to Digital Partners:** A primary obstacle in transitioning to digital dentistry is the difficulty in finding other dental team members who are proficient in digital technology. This is because many smaller-scale dental facilities, especially those on the higher end, have yet to fully embrace digital technologies.
- **Intraoral Scanners and Scanning:** Incorporating digital impressions can come with challenges like a learning curve and adjustments for scanning techniques, scanning sequences, and digital workflows. There are three main categories of digital impression systems:
  - **Stand-Alone Systems:** This category includes scanners like Cerec Primescan, Carestream CS, iMedit 500, iTero, and Trios. Each of these scanners is capable of producing high-quality digital impressions and comes with specific features designed to enhance the user experience.
  - **Scan, Design, and Output to a Third-Party Mill:** In this category, you have systems like Trios by 3Shape. These systems are primarily used for scanning the patient, but they also have the option to incorporate chair-side design software for creating restorations before sending the data to a third-party milling machine.
  - **All-in-One Ecosystem:** Examples of systems in this category are Planmeca Emerald and Sirona Cerec. These devices allow dentists and their staff to complete the entire digital workflow within the dental office. This includes digitally capturing the patient's impression, creating the restoration using internal design software, and milling the restoration using an integrated in-office milling machine. (9)

## XII. CONCLUSION

Digital Smile Design is a versatile tool that can benefit the aesthetics team at every stage of the procedure, enhancing the dental professional's understanding of aesthetic concerns and increasing patient acceptance of the final result. By placing reference lines and other shapes on extra- and intraoral photographic images, dentists can better evaluate a case's limitations, risk factors, and aesthetic principles. This expanded perspective aids in diagnostic purposes, leading to improved outcomes throughout all treatment phases. The use of dynamic

smile documentation in the Digital Smile Design protocol enhances diagnostic accuracy and treatment regimen consistency. Furthermore, it streamlines treatment sequences, reducing risks and ultimately improving results.

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