

# Advanced Smile Design Technologies



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Dentistry has certainly come a long way since the barber shop image of the past. Today, digital technology affects every aspect of the profession, and patients use the Internet to search for qualified dentists who specialize in smile design. *Bacon's Media Source* reports that the average monthly circulation of articles about cosmetic dentistry reached 40 million in 2004. And that includes only print media—not television.<sup>1</sup>

The computer has made smile design cosmetic simulations possible with exact color-matching capabilities, and new computed tomography (CT) images with 3-D views of the patient to help with virtual planning and surgery is a reality. Cone beam CT technology, which uses a different approach to conventional CT, is remarkable in its ability to acquire whole volume data during a single sweep of the scanner.

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For years, many dental offices have been using CAD/CAM systems such as Sirona CEREC technology to fabricate restorations during a single visit. Others have begun using the Cadent iTero system, which is the first all-digital solution for fabricating dental restorations using an intraoral scanner to create an accurate 3-D image of the prepared tooth. In recent years, dental laboratories have begun to acquire contact scanners such as the Procera (Nobel Biocare) to help design and mill a restoration using computer-assisted design.

Along with these scanner advancements, cutting-edge dental software has evolved to help dentists design a smile that allows patients to choose tooth shapes, sizes, colors, etc—all with just the software and a digital camera.

## THE AESTHETICS OF SMILE DESIGN

The creation of a smile design requires the dentist to prepare an aesthetic dental makeover by using several indispensable



Figure 1. Preoperative full facial view.

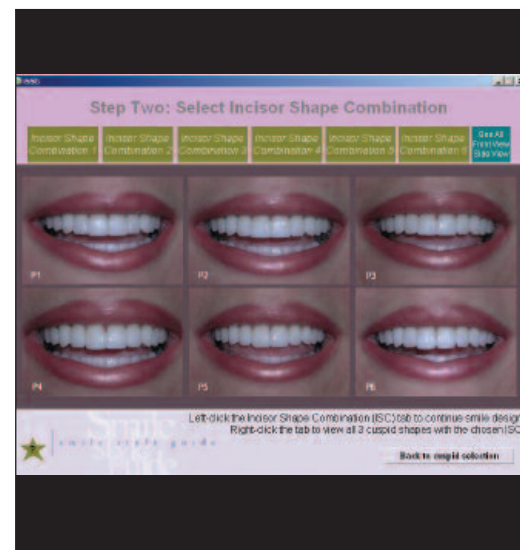


Figure 2. Interactive Smile Style Guide.

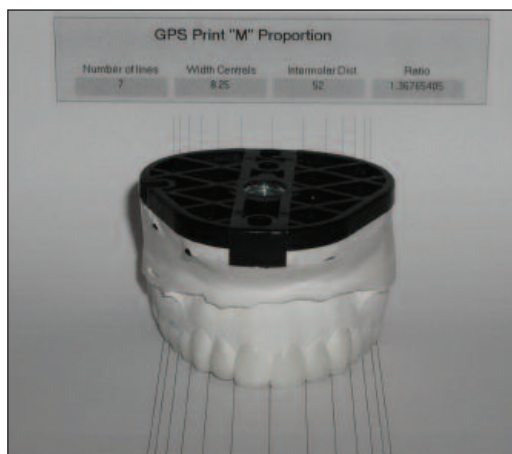


Figure 3. Modified Golden Proportion grid for diagnostic wax-up.

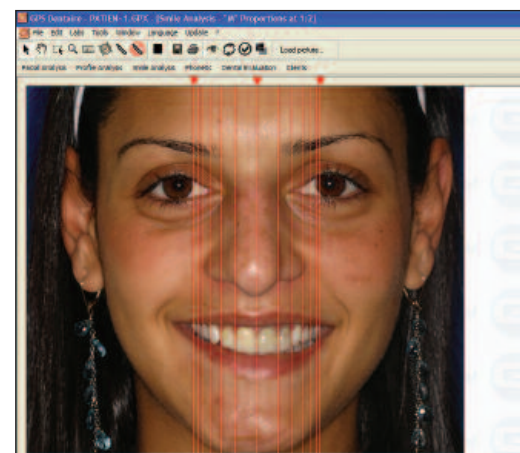


Figure 4. Facial analysis using GPS.

protocols. This involves proper planning of the aesthetic component in advance so that expectations are discussed and realized prior to any tooth preparation.

The rules of smile design are the architectural blueprints for the dentist, the patient, and the laboratory. Smile design evaluates the deficiency of balanced aesthetic characteristics from an objective standpoint, but precise protocols allow the dentist to achieve a more subjective goal—the specific aesthetic wishes of the patient.

Collectively, the following aesthetic characteristics of smile design have been

proven to be predictable protocols that dentists must evaluate prior to performing the dental makeover.

1. Line angles: the area where the facial surface of the tooth turns interproximally into the contact area.

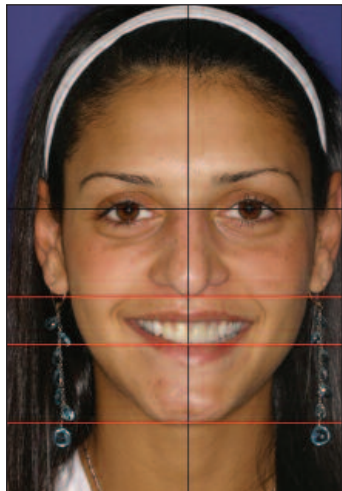
2. Outline form: the shape of each respective anterior tooth when mesial and distal line angles and the incisal and gingival aspects of a tooth are connected.

3. Embrasure spaces: these must be evaluated to determine if they increase slightly as the teeth go from central to canine.

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**Figure 5.** Facial/dental determination using GPS.



**Figure 6.** Preoperative photo of anterior teeth.



**Figure 7.** Post-bleaching of posterior maxillary and entire mandibular arch.



**Figure 8.** Stumpf shade determination.



**Figure 9.** Shade determination using Vita 3-D Master Shade Guide.

4. Axial inclination: the known fact is that all teeth have their own long axis alignment that compares to the vertical alignment of the

maxillary teeth. From central to canine, there should be a subtle increase in mesial inclination when viewing a patient's smile from the front.

5. Contact points: these gradually decrease from central to canine. The more youthful the teeth, the more apically positioned the interdental contact. The more incisal the contact is placed, the more mature the teeth will appear.

6. Gingival levels: does the upper lip follow the level of the upper gingival architecture? Do the incisal edges of the maxillary teeth follow the lower lip line?

7. Buccal corridor (vestibular space): this is the space between the maxillary posterior teeth and the inner cheek. Depending on arch width, soft-tissue patterns, and muscle, the most appealing smiles have little or no negative dark buccal corridor space.<sup>2</sup>

8. Incisal edge position: this is second in importance to centric relation, according to Dawson. The key controlling factors are the contour and position of the labial surfaces of each tooth. If the incisal edge is to be changed, it is best to first accomplish this with temporaries to evaluate controlling factors intraorally, and placement should be assessed in relation to the patient's lip mobility. Anterior guidance must also be maintained or developed where necessary.<sup>3</sup> The central incisor is approximately on the same plane as the tips of the canines and the buccal cusp tips of the premolars and molars. Spear tells us that the more mobile the lip, the less we can show the incisal edge at rest, while the less mobile the lip, the more we must show at rest to create the most appealing smile. Ideally, the incisal edge should just touch the dry side of the wet-dry inner vermilion border of the lower lip.<sup>4</sup>

9. Dental/facial midline: this is another important criterion because you want a cohesive succession of coincidental lines that are in balance with the dentition, dentofacial, and facial complexes. Is the facial midline

coincidental with the dental midline for the perception of symmetry? (ie, Is the vertical plane 90° to the horizontal plane that we determine from the eyes and lips?) If there is an imbalance, the aesthetic strength is reduced.

10. The Rule of Golden Proportion: a mathematical rule that defines a specific ratio between dimensions of a larger length to a smaller length. As you look straight at an anterior situation, the width of the central has a mathematical relationship to the width of the lateral to the smaller width of the cuspid. The ratio of the Golden Proportion has long been considered to create an aesthetically perfect appearance of harmony and balance. If the laterals are a factor of 1, then the centrals are 1.618, with the size of the laterals looking straight on from the front, and the cuspids 0.618 of the size of the laterals. While the Golden Proportion cannot always be achieved, we strive to get as close to it as possible. For example, closing a diastema may require a slight deviation from the Golden Proportion—something that Stephen Snow, DDS, calls the Golden Percentage. By using percentages to help design a balanced smile, the analyses of symmetry, dominance, and proportion of each tooth within the anterior segment can be evaluated for their contribution to the entire smile.<sup>5</sup>

11. Occlusal plane: Is there an acceptable occlusal plane especially with an emphasis on the incisal plane of the anterior teeth? Does the imaginary line touching the incisal edges of the maxillary anterior teeth and the interpupillary line appear level when using the simple rule of aligning the face-bow with the eyes? Dawson tells us that there are few mistakes that affect aesthetics more negatively than a slanted incisal plane. Is the labial surface of the central to the occlusal plane near or about 90 degrees to the occlusal plane, which is the most pleasing angle? How are the curve of Spee and the curve of Wilson? Properly mounted casts are a must for determination of these variables.

12. Facial assessment: this is necessary to determine if there are asymmetries that make it difficult to use certain facial anatomic landmarks to establish spatial relationships for the teeth. We often use the nose, chin, and eyes to help us determine midline placement, but the entire dento-facial complex must be weighed because the features and facial forms of each patient are unique.<sup>6</sup> The first consideration is the outline form of the patient's face (facial shape)<sup>7</sup> and what outline form, therefore, should be created for the teeth.

a. A round face can be made narrower by elongating the teeth.

b. A narrow face will appear wider with a flatter smile line.

c. An oval face can accept many different smile designs.

d. A square face can be made to look more oval with proper smile design. Long, narrow teeth, for example, will elongate the face, while square teeth will accentuate the square facial appearance.

e. A heart-shaped or tapering face can be de-emphasized with flatter teeth.

13. Phonetics: the sounds produced when speaking are shaped mechanically by the combination of teeth, lips, and tongue. The F sound helps to guide us in placing the upper incisal position in the correct plane. Pre-evaluating the position of the incisal edges with the speech pattern of your patients can help you assess where to correctly place the edge in wax and then intraorally in the temporaries for the final aesthetic determination.

#### A CHALLENGING CLINICAL EXAMINATION AND DIAGNOSIS

A 20-year-old woman came to my office complaining of an unbalanced smile with discolored teeth and aged composite and porcelain veneer restorations. She had been in a severe automobile accident a few years earlier, which had caused extensive facial and dental trauma, and teeth Nos. 7 to 10 had been restored with direct bonding and porcelain crowns.

She wanted a more ap-

*By using percentages to help design a balanced smile, the analyses of symmetry, dominance, and proportion of each tooth within the anterior segment can be evaluated for their contribution to the entire smile.*

pealing, youthful smile that included whitening her teeth and replacing the old, discolored restorations. First, I reappointed her for a comprehensive medical/dental examination that consisted of a functional analysis of her TM joints, including load testing, palpation of her muscles of mastication, range of mandibular motion/doppler auscultation, a full series of digital radiographs/panorex, 12 American Academy of Cosmetic Dentistry preoperative digital photos, soft- and hard-tissue evaluation, periodontal probings, face-bow (Rotofix [Jensen Industries]) mounted study models on a semiadjustable articulator (Artex [Jensen Industries]) with CR bite records using a lucia jig (Great Lakes Orthodontics), and an evaluation of her entire dento-facial complex using the Dr. Jose-Luis Ruiz aesthetic diagnosis form. This form helps to diagnose the patient's existing dento/facial problems, as well as determine her desires and expectations.<sup>8</sup>

Upon clinical examination, we discovered that the patient had trauma to her face, especially to the left cheek area immediately under the eye, chin, and lower left border of her lip. A permanent scar was apparent to the lower lip, both at the wet and dry border, which gave it a swollen appearance. Her lip and chin also had permanent deviations (Figure 1).

Radiographic evidence revealed that she had had endodontic therapy to teeth

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**Figure 10.** Final glazed indirect Luxatemp temporaries.



**Figure 11.** Final Empress crowns/veneers.



**Figure 12.** Final Empress restorations showing internal effects.



**Figure 13.** Postoperative 1:1.



**Figure 14.** Postoperative right lateral view showing canine guidance.



**Figure 15.** Postoperative left lateral view showing canine guidance.

Nos. 8, 9, and 10, and teeth Nos. 9 and 10 had been replanted after the endodontic therapy. Large, prefabricated posts and porcelain crowns were present, and when the new radiographs were compared to an old series, she unfortunately was found to

have periapical pathology. Initially, she was referred to her endodontist to evaluate the large radiolucencies, and the endodontist felt that due to the large posts and reimplantation, there would be a risk of fracture if we tried to remove the posts and retreat the teeth.

Therefore, we offered to have an endodontist treat her with apicoectomies or have her teeth removed and replaced with implants. She opted to try to save her teeth, and I advised her that when metal posts are present, the natural transmission of light through all-porcelain crowns and down to the tooth's root is impossible. Since I believe it is often preferable to articulate possible problems before treatment is initiated, I wanted her to understand that she would probably have dark discoloration around the gingival margin as compared to her other teeth. Therefore, we discussed exactly what she wanted versus the realistic results I could provide her.

We discussed her dissatisfaction with the overall color of her teeth, the existing aesthetic concerns I felt I could improve, and the smile design that she preferred. My goal was to create proportionate, symmetrical dimension to her incisors and transform her smile into a softer, more youthful, feminine appearance. Using new software called the Interactive Smile Style Guide (iSSG {Digident.com}) co-developed by Drs. Lorin Berland and David L. Traub, I discussed cuspids, lateral, and central incisor tooth shapes and sizes with the patient. I wanted to get a feel for her tooth dimension preferences. By using this cutting-edge technology on my computer monitor, we could easily show her specific tooth shapes and sizes step by step (Figure 2).

I spent considerable time with her to get a sense of her expectations. We discussed tooth color, her speech pattern (especially when she spoke words with *F* and *V* sounds), and her overall facial appearance. This gave me an understanding of not just her personality, but her

dental personality. I find that this co-discovery with the patient is invaluable for the success of the aesthetic case. Once I feel that the patient's expectation is within my reach, I can proceed with the smile design.

## Preparation

Thankfully, we have many modern tools to help us diagnose an aesthetic case using the above parameters of smile design. First and foremost, the visual information that digital dental photography provides to the patient, dentist, ceramist, and any other specialist involved is indispensable. Instant digital images can allow the photographer to immediately evaluate the desired image that will be used with the advanced technologies that follow.

New and innovative software called the Guided Positioning System (GPS [mydentalgps.com]), developed by Dr. Alain Methot,<sup>9</sup> takes digitized images of the patient's facial view at 1:10 ratio and studies them using a step-by-step system for dental aesthetics. This system allows the restorative dentist to utilize specific parameters of smile design with technological accuracy. The values that are entered, which are obtained clinically during the photography session, are the interpupillary distance, the width of the central incisors, and the intermolar distance.

The software determines what Methot calls the Modified Golden Proportion Formula, which is specific for each patient. It establishes the correct guidelines, protocols, and dimensions to ensure that the postoperative simulation results will match the desired balanced smile as closely as possible. Using the photographic protocol in the dental GPS, axial inclinations, length of teeth, soft-tissue levels, contact points, midline placement within the full facial complex, buccal corridor space, etc, are all determined. The software also prints out a grid of the modified Golden Proportion ratio, which you can forward to the laboratory in order for the dimensions of the teeth

to be waxed up to this proportion (Figure 3). The project can also be digitally emailed to the laboratory or periodontist. Figure 4 shows the simulation of the patient's pre-existing smile. The vertical bands show the existing midline, buccal, and vestibular space.

Figure 5 shows the true interpupillary, midline, and occlusal level for this patient. You may simply want to move the midline 1 mm, adjust the occlusal level to correct any canting, and alter incorrect tissue levels and contact points with this software.

The software takes you through a step-by-step process to answer certain questions according to the desires of the patient and dentist, and your answers can be adjusted as necessary.

After you have entered all of the necessary information in the software, the laboratory can provide you with a diagnostic wax-up of the case. Obviously, a wax-up is an educated guess, and the intraoral temporaries are the best means of evaluating the proposed smile design. Once the patient approves the case, you can proceed with the permanent smile design. With this particular patient, she needed slight tissue augmentation to provide a more desirable level (Figure 6).

The patient's next wish was to brighten her teeth. Using a take-home 16% bleaching system (Nite-White ACP [Discus Dental]) for several weeks, she attained her desired shade (Figure 7). This bleaching system combines the benefits of carbamide-hydrogen peroxide with a patented amorphous calcium phosphate (ACP) technology, potassium nitrate, and fluoride. This has allowed for an increase in patient comfort and compliance. Note how wonderfully the posterior and lower mandibular teeth bleached. Due to the existing restorations, of course, the maxillary central incisors did not bleach.

Bleaching is probably the most requested elective dental procedure, and obtaining such nice results

instills a level of confidence in the patient for the rest of the treatment sequence. Once the patient was satisfied with the bleaching results, I waited a few weeks because vital bleaching with even 10% carbamide peroxide causes a significant reduction in the natural amounts of calcium and phosphorus found in enamel. Haywood states that we should allow for color stabilization and remineralization in order to ensure sufficient bond strength before continuing with restorative therapies.<sup>10</sup>

Tooth preparation began with the removal of the old restorations and all evident decay, which was unfortunately excessive in teeth Nos. 9 and 10 (Figure 8).

There was an excessive degree of discoloration, and the stump shade guide revealed an even darker color than the St.3 shade tab at the gingival one third of tooth No.10. Although most dentists use this guide for prepared teeth, I have had equal success simply using the classic Vita shade guide (Vident) with digital photography to assist me in closely matching the existing stump shade and relaying this information to my ceramist.

Two images are very important for shade communication. The first involves taking the 2 closest value shade tabs to the teeth. One is a bit higher in value, while the second is a bit lower. The second image is for chroma—again, one tab providing a shade higher and one lower. Taking the images of the shade tabs in the same vertical plane allows the quantity of surface light reflection to be equal.<sup>11</sup> I chose the excellent aesthetic dental team that Daniel Materdomini, MDT, has put together at daVinci Dental Studios, using IPS Empress-pressed veneers (Ivoclar Vivadent). Over the years, they have provided my practice with extraordinary aesthetic results. Empress is a lucite-reinforced pressable glass ceramic with a long, successful track record. It provides excellent fit, translucency, and vitality, and the correct brightness value of the final shade is exclusively



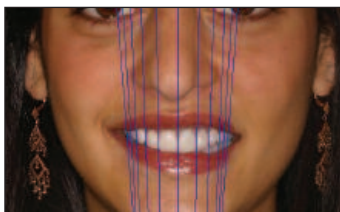
**Figure 16.** Postoperative 1:2 right lateral view.



**Figure 17.** Postoperative 1:2 left lateral view.



**Figure 18.** Postoperative 1:2 frontal view. Using the GPS system, an evaluation of the final smile can be seen in Figure 20.



**Figure 19.** Postoperative facial/dental midline evaluation using GPS.



**Figure 20.** Final full facial appearance with new smile.

determined by the ingot material. Masking of a dark die is usually achieved by using an ingot that exhibits both a high degree of opacity and low color intensity. The correct final shade of the veneer

is a combination of the die shade, the ingot material, and the layering material, as well as the staining procedure and the cementation material that is used.<sup>12</sup> Studies have also demonstrated strengths between 160 and 180 MPa.<sup>13</sup>

The shade guide chosen for the final restorations was the Vita 3-D Master system (Vident). The OM-1 shade was quite accurate to the existing shade seen in Figure 9, but I wanted to verify that it was as accurate as it appeared. While many practitioners find it challenging to determine the correct color, I have had success using the ClearMatch software-based system (Clarity Dental), which easily analyzes color measurement of shade and value with no need for proprietary hardware. A standardized black and white tab, along with a specified Classic Vita (Vident) shade tab (in this case A2), is placed adjacent to (incisal edge to incisal edge) an existing tooth that is to be closely matched. A high-resolution digital image is then taken. The ClearMatch software adjusts the hues of the image to compensate for any color imbalances that may have occurred while taking the image.

After the color was chosen that closely matched the unprepared teeth, digital photos were taken to aid the ceramist in closely matching the teeth color. A new stick-bite, face-bow, and CR bite were also taken to assist in mounting the case.

The stick-bite record helps verify any shift in the face-bow that could result from lateral auditory meatus discrepancies. If these discrepancies occur when taking the face-bow, the intercondylar axis could result in a significant change in the functional and aesthetic planes of occlusion.<sup>14</sup> The incisal edges of the anterior teeth should be parallel to the interpupillary line and perpendicular to the facial midline, and the patient's chin must be parallel to the horizon. Use of a miniature level gauge for correct alignment is very helpful in helping to avoid a skewed incisal plane,

which can result from skeletal issues and can create a canted, unattractive smile. Note, too, that if the patient's head is incorrectly postured, the ceramist may position the incisal edges incorrectly. Digital images of the stick-bite allow the ceramist to view the position of the interpupillary/incisal edge position.

Temporaries were fabricated by using a putty matrix that was duplicated from the diagnostic wax-up. Luxatemp shade BL (Zenith/DMG) was the material of choice, which is a syringable bis-acryl temporary material that is very aesthetic and accurate (Figure 10). I chose to use the indirect method of temporary fabrication in order to have more control over embrasure spaces, the thickness of material, and marginal fit. Certainly, if I had found thin areas within the temporary, I would have performed additional preparation in those areas.

The prepared teeth were scrubbed clean with a chlorhexidine gluconate rinse (PerioRx [Discus Dental]), and each individual tooth was spot-etched with 35% phosphoric acid, followed by a coating of a desensitizing agent (Acquaseal [Acqua-Med Technologies]). Acquaseal contains HEMA, which helps seal open dentinal tubules, and contains fluoride and benzalkonium chloride, which act as antimicrobial agents. Once this material is air-dried, a flowable composite such as Revolution 2 (Kerr) can be lightly flowed within the intaglio surface of the temporaries. Since all bis-acryl materials are partly composite and partly resin, the flowable composite binds to the temporary itself and strengthens it. Only where the teeth have been slightly etched does the temporary/flowable combination actually adhere, however. When the patient returns for the final seating of the definitive restorations, the temporaries and cured flowable material are removed with little, if any, flowable material adhered to the teeth.

Once the temporaries were in place, the patient

and I could evaluate the aesthetics, occlusion, and function of the new smile. She was told to return in one week to discuss how the teeth felt, at which time we talked about color mapping in terms of the level of incisal translucency, problems with speech patterns, and any other concerns. Once the temporaries were accepted, an impression of the approved provisionals was taken for the lab to use in designing the porcelain restorations. The final restorations were then fabricated and returned to the office for evaluation (Figures 11 and 12).

### The End Result

For the final restorations, anesthesia was administered, and a dry field was obtained using the OptraGate system (Ivoclar Vivadent). Patients find the OptraGate more comfortable to wear over longer periods of time, as it is 3-dimensionally flexible. The temporaries were removed, the teeth were re-disinfected, and water was used to try the veneers in place.

The patient was allowed some time to evaluate how they felt before the bonding procedure began. The final results are seen in Figures 13 to 15. Lateral views show the incisal edge levels, although there was a great deal of trauma to the lip from the automobile accident (Figures 16 to 18).

Although this was a quite difficult case, especially with the loss of natural translucency with teeth Nos. 9 and 10, the harmonious balance we achieved is evident in Figure 19. The final smile reveals a very happy patient (Figure 20).

### CONCLUSION

Although the protocols we use daily in aesthetic dental makeovers have been tested successfully for many years, cases that are less than ideal provide us with special challenges. Extensive planning and dialogue with the patient are essential. Hippocrates said, "without diagnosis there can be no treatment." Today's new technologies can guide us in obtaining the desired results by

helping us properly diagnose each individual case. Patient expectations can be obtained with accuracy via computers and software, as long as they fit scientifically into the protocols of our original, tested systems. ♦

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