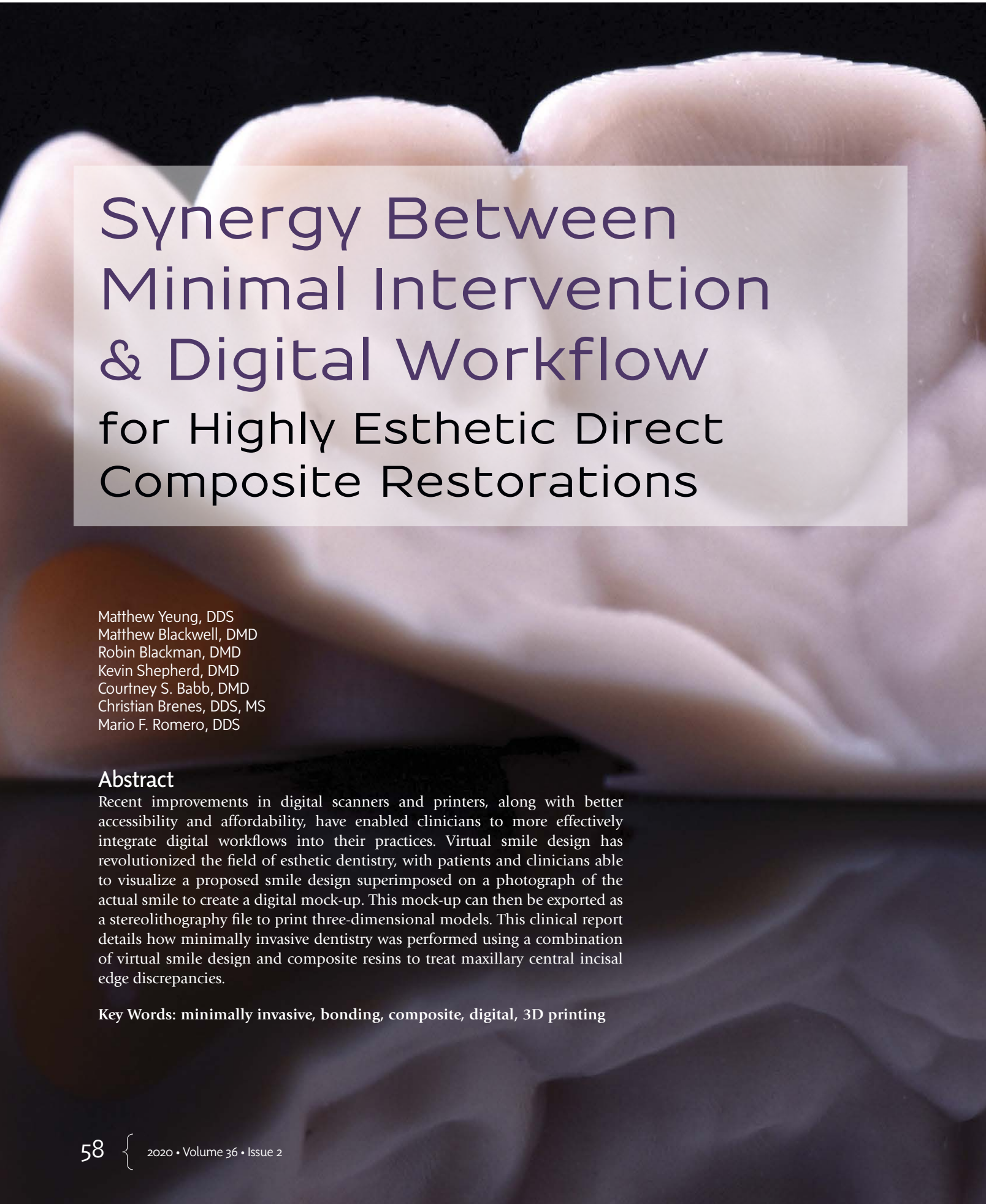

Synergy Between Minimal Intervention & Digital Workflow

for Highly Esthetic Direct Composite Restorations

Matthew Yeung, DDS
Matthew Blackwell, DMD
Robin Blackman, DMD
Kevin Shepherd, DMD
Courtney S. Babb, DMD
Christian Brenes, DDS, MS
Mario F. Romero, DDS

Abstract

Recent improvements in digital scanners and printers, along with better accessibility and affordability, have enabled clinicians to more effectively integrate digital workflows into their practices. Virtual smile design has revolutionized the field of esthetic dentistry, with patients and clinicians able to visualize a proposed smile design superimposed on a photograph of the actual smile to create a digital mock-up. This mock-up can then be exported as a stereolithography file to print three-dimensional models. This clinical report details how minimally invasive dentistry was performed using a combination of virtual smile design and composite resins to treat maxillary central incisal edge discrepancies.

Key Words: minimally invasive, bonding, composite, digital, 3D printing

Learning Objectives

After reading this article, the participant should be able to:

1. Better understand how digital dentistry can positively impact minimally invasive techniques.
2. Effectively integrate a digital workflow into his or her daily practice.
3. Employ a simplified digital approach to treat incisal edge discrepancies.

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Introduction

Once viewed as merely an adjunct to traditional analog workflows, digital dentistry has emerged as a solution that can offer efficiency without a compromise in quality. Assuming an appropriate case is selected, modern intraoral scanners will deliver more accurate results than conventional impressions. In addition, intraoral scanners reduce patient discomfort, eliminate plaster models, and are more time-efficient.[1-3] The wide range of applications includes—but is not limited to—orthodontics, orthognathic surgery, facial reconstruction, maxillofacial prosthodontics, and dental implants.[2,4,5]

Minimally invasive dentistry is "a philosophy that attempts to ensure that teeth are kept functional for life" and is "therefore, not restricted to the management of dental caries but also applicable to other areas of oral health such as oral rehabilitation."[6] In many cases, composite restorations qualify as minimally invasive dentistry, as they require very little to no tooth preparation.

A digital workflow can maximize the benefits of minimally invasive dentistry. The superimposition of photographic images over the patient's actual smile to three-dimensional (3D) scans is being increasingly utilized in virtual smile design. By employing set landmarks and specific software, clinicians and technicians can present patients with digital mock-ups.[7-10] Taken one step further, a 3D wax-up can be generated, and digital wax-ups can then be fabricated using affordable 3D printers.[2,4,5] The digital approach to completing a diagnostic wax-up differs very little from a wax-up completed by hand, the exception being that the digital approach facilitates a more efficient generation of natural-looking proposed smile designs. This allows for preservation of the patient's existing envelope of function and in turn the lingual anatomy, therefore minimizing occlusal alterations.

Composite resins offer a solution when restoring teeth in the esthetic zone; their benefits include strength, esthetics, and a lower cost than glass ceramic restorations. When used as an additive type of restoration, the greatest advantage is that they are almost completely reversible; if the patient is not satisfied with the restorations, they can be removed with minimal damage to the natural tooth structure.[11] Nonetheless, these restorations can be challenging for clinicians who lack experience or the correct armamentarium.

This clinical report illustrates improvement of a patient's smile through the use of a digital workflow with a no-preparation design in combination with incrementally layered dentin and enamel composite shades.

Clinical Report

Chief Complaints and History

A 34-year-old male presented to the Advanced Education in General Dentistry program clinic of the Dental College of Georgia at Augusta University; his chief complaints were worn/fractured incisal edges of teeth #8 and #9 and an unesthetic smile **(Fig 1)**. The patient's medical history was noncontributory, and clinical examination revealed a slight discrepancy of incisal edge length between teeth #8 and #9 as well as irregularities due to childhood trauma **(Fig 2)**. The patient's hygiene was ideal, and probing depths were within normal limits with no bleeding on probing. A periapical film revealed no caries and no periapical pathology.

Digital Imaging

After reviewing the risks, benefits and alternatives to treatment, the patient opted for an additive direct restorative approach. An intraoral scan (i500, Medit; Seoul, South Korea) and full-face portrait photographs **(Figs 3 & 4)** were imported into dental design software (DentalCAD, Exocad; Woburn, MA). The case was planned as two single wax-up restorations, and the Exocad Smile Creator module wizard was used to analyze tooth proportions and to generate the wax-up proposal **(Figs 5 & 6)**. Based on an 80% height-to-width central incisor proportion, the virtual wax-up proposed a 1.0-mm increase in length to both central incisors **(Fig 7)**. Occlusion was verified on a virtual articulator, accounting for both maximum intercuspation and eccentric occlusion **(Fig 8)**. The diagnostic wax-up did not alter the envelope of function; however, the facial contours and

Figure 1: Preoperative smile.

Figure 2: Preoperative retracted view.

Figure 3: Preoperative intraoral scan.

Figure 4: Preoperative full-face view.

Figure 5: Preoperative tooth proportion analysis.

Figure 6: Virtual wax-up proposal with increased length on both central incisors.

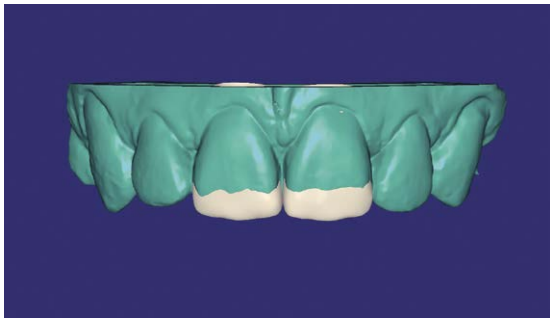

Figure 7: Intraoral view of the virtual proposed 1.0-mm length increase.

Figure 8: Verification of occlusion.

"A digital workflow can maximize the benefits of minimally invasive dentistry."

Figure 9: Frontal view of printed model.

Figure 10: Lingual view of printed model. Note the well-defined lingual embrasure.

Tips

BEGINNER

- Always use a matrix fabricated from your printed (or analog) wax-up for the first lingual layer.

INTERMEDIATE

- White opaque characterization is needed only when adjacent natural teeth have a "halo" effect on the incisal edge.
- Extending the facial composite layer toward the middle third is crucial for increased micromechanical retention provided by the etched enamel.

ADVANCED

- The buccal/lingual thickness of the final restoration should be at least 1.0 mm at the incisal edge for added strength.

incisal edges were extended slightly to allow for finishing and polishing the restorations to ideal contours. The virtual wax-up and portrait photographs were superimposed, and new tooth proportions were verified and approved by the patient **(Fig 6)**, then exported as a stereolithography file. A model was then printed in resin (Die and Model Tan, SprintRay; Los Angeles, CA) using a wireless 3D printer (SprintRay) **(Figs 9 & 10)**.

Treatment

Verbal and written consent for the proposed treatment was obtained, and rubber dam isolation (Hygienic; Akron, OH) was completed for teeth #5-#12 **(Fig 11)** with two clamps (W2, Hu-Friedy; Chicago, IL). The extent of this isolation allowed full seating of the putty matrix guide during the procedure. Polytetrafluoroethylene (PTFE) tape was placed on the adjacent teeth to protect them from acid etching. Approximately one-third of the facial and lingual surfaces of tooth #9 was etched with 37% phosphoric acid (Uni-Etch, Bisco; Schaumburg, IL) **(Fig 12)**. A universal dental adhesive (Optibond Universal, Kerr; Brea, CA) was applied to the lower half of the facial surface as well as the lingual aspect of the incisal edge **(Fig 13)**. The bonding agent was thinned out with a micro brush and light-cured for 20 seconds (Valo, Ultradent Products; South Jordan, UT). A putty matrix was fabricated with the 3D-printed model and used to create the lingual aspect of the restoration with approximately 0.5 mm of composite (dentin shade A2, Harmonize, Kerr) **(Fig 14)**. Characterization was added via a 31-mm stainless steel endodontic file (Flexofile, size 010, Dentsply Sirona; Charlotte, NC) with resin tint (White, Kolor + Plus, Kerr) to create a "halo" effect **(Fig 15)**. A layer of enamel shade composite (A1, Harmonize) was then used to create the final facial layer **(Fig 16)**. The restoration was completed to ideal contours with a fine diamond bur (8888, Brasseler; Savannah, GA) and abrasive discs (Sof-Lex, 3M; St. Paul, MN) **(Fig 17)**. The same protocol was followed to restore tooth #8 **(Figs 18-20)**. The rubber dam was removed, and occlusion was checked (AccuFilm II, Parkell; Edgewood, NY) to ensure no premature contacts existed. High gloss was achieved with composite polishing wheels (Shape-Guard, Coltène; Cuyahoga Falls, OH) **(Fig 21)**.

Immediate **(Fig 22)** and six-month **(Figs 23 & 24)** postoperative photographs were obtained, demonstrating excellent marginal adaptation, and the transition from natural tooth structure to restoration material was undetectable.

Figure 11: Rubber dam isolation.

Figure 12: Tooth #9, acid etching of uncut enamel.

Figure 13: After application of a universal adhesive.

Figure 14: Lingual dentin layer.

Figure 15: White tint applied to create a "halo" effect.

Figure 16: Final enamel layer.

Figure 17: Finishing and polishing completed.

Figure 18: Tooth #8 isolated from adjacent teeth.

Figure 19: Acid etching of uncut enamel.

Figure 20: Tooth #8 ready for final enamel increment.

Figure 21: High gloss achieved on both restorations using composite polishing wheels.

"Highly esthetic outcomes require fine attention to detail."

Figure 22: Full smile immediately after treatment.

Figure 23: Close-up view of the smile six months after treatment. Note the "halo" effect obtained in the incisal edges of both central incisors.

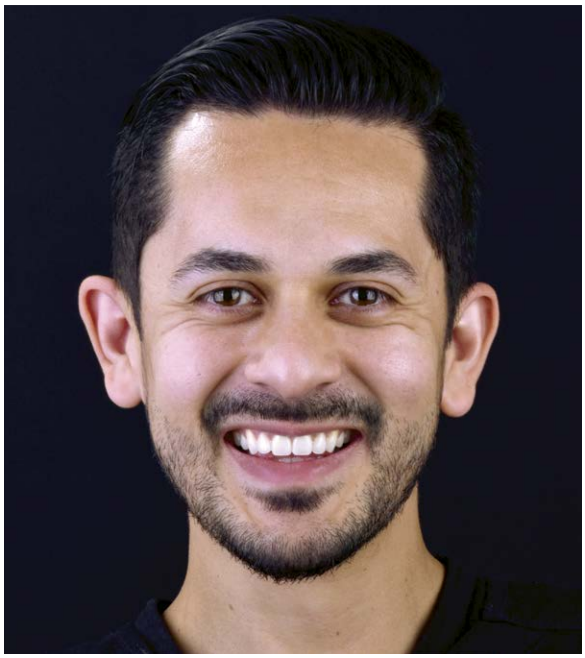

Figure 24: Full-face portrait for smile evaluation at six months.

Discussion

Digitally planning a smile makeover has gained popularity in recent years and is becoming more powerful as the integration of two-dimensional images (e.g., photographs and radiography) with 3D outcomes continues to advance. Correcting tooth proportions to improve a smile has been a standard within esthetic dentistry for years. Combining these two treatment modalities allows clinicians to obtain objective measurements and provides patients with a final visual outcome prior to rendering any treatment.

The term *minimally invasive* is commonly used to describe dental procedures ranging from bleaching to porcelain veneers that require minimal to no tooth reduction. One of the benefits of porcelain veneers is the increased availability of enamel, which is considered to be the best substrate for bonding.[12] On the other hand, nanohybrid composite resins are an excellent alternative restorative material due to their optical and physical properties. Acid etching plays a key role in the success of these restorations. Additive procedures with no preparation of enamel are, by definition, minimally invasive. The literature supports the use of dynamic etching, in which the clinician scrubs the etch onto the surface of uncut enamel. This enables dissolution of the surface enamel and is an effective, predictable way to bond to the tooth without roughening the surface with a bur.[13] It is the authors' opinion that prolonged etching times of up to 30 seconds also aids in the retention of these minimally invasive restorations.

Highly esthetic outcomes require fine attention to detail. Differences between layers of 0.5 to 1.0 mm, dentin versus enamel shades, and characterization employing tints can all drastically alter final restorations. In an unpublished experiment performed at the Dental College of Georgia using Harmonize esthetic composite resins, the opacity of the dentin alone and its combination with enamel was studied with a layered composite technique. In this particular case, the patient desired natural-looking teeth that included incisal translucency. Based on photographs of the different combinations of composite increments and shades, it was determined that the dentin layer would approximate 80% of the thickness (1.0 mm), and the enamel would complete the remaining 20% (0.5 mm) in order to achieve optimal esthetics. Combining this knowledge with the use of flowable tints can enhance restorations, and, in this case, a "halo" effect was created at the incisal edge.

Arguably the most important aspect of these restorations is the finish. To create a high-shine restoration with a natural finish, the restoration must not be rough. Surface roughness is directly correlated with the longevity of composite resin restorations. Increased surface roughness can lead to staining and plaque accumulation, both of which can lead to restoration failure. Highly polishing restorations, independent of the polishing system, greatly impacts restorations' lifespans. Introducing a one-step polish into a multi-step finishing process can decrease surface roughness of restorations.[14] Incorporating a silicone-based polisher into a multi-step finishing protocol resulted in the final restorations' high luster and an undetectable finish line.

Summary

With a mastery of simple composite resin layering and finishing techniques, combined with the technology of virtual smile design and 3D printing, this patient's chief complaint was addressed with no sacrifice of tooth structure. The authors hope that increasing awareness of digital dentistry in the profession will help lead to a greater impact on minimally invasive dental techniques.

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Dr. Yeung is a resident in the Advanced Education in General Dentistry (AEGD) program at the Dental College of Georgia at Augusta University, Augusta, Georgia. He can be reached at myeung@augusta.edu

Dr. Blackwell received his dental degree as well as his AEGD certification from the Dental College of Georgia at Augusta University, Augusta, Georgia.

Dr. Blackman is a resident in the AEGD program at the Dental College of Georgia at Augusta University, Augusta, Georgia.

Dr. Shepherd is a resident in the AEGD program at the Dental College of Georgia at Augusta University, Augusta, Georgia.

Dr. Babb is a clinical instructor in the Department of General Dentistry at the Dental College of Georgia, Augusta University, Augusta, Georgia.

Dr. Brenes is an associate professor in the Department of Oral Rehabilitation at the Medical University of South Carolina.

Dr. Romero is an associate professor and director of the AEGD program at the Dental College of Georgia, Augusta University, Augusta, Georgia.

jCD Self-Instruction

Operative (Restorative) Dentistry (CE) Exercise No. jCD42 AGD Subject Code: 250

3 Hours Credit

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1. Combining two-dimensional treatment planning with three-dimensional outcomes

a. gives subjective measurements of the final visual outcome.
b. provides a subjective visual outcome with definitive measurements.
c. allows for objective measurements with a preoperative visual objective.
d. supports a definitive objective visual outcome with subjective general measurements.

2. Highly effective outcomes require

a. polychromatic composites for monolithic restorations.
b. layering of equal thickness.
c. variable etching times depending on the size of the restoration.
d. a fine attention to detail.

3. In a study performed at the Dental College of Georgia, optimal composite esthetics in a clinical trial were provided by

a. an 80% thickness of dentin (1 mm) and a 20% thickness of enamel (.5 mm).
b. an 85% thickness of dentin (1.2 mm) and a 15% thickness of enamel (.3 mm).
c. a 66% thickness of dentin (1 mm) and a 33% thickness of enamel (.5 mm).
d. variable thicknesses of both enamel and dentin layers.

4. With composite restorations, in order to create a high shine with a natural finish,

a. the surface must not be rough.
b. a one-step polishing and finishing process is required.
c. a multi-step polishing and finishing process is required.
d. a flat, anatomical surface is desirable.

5. The longevity of composite restorations

a. correlates directly to surface roughness.
b. is not dependent upon surface roughness.
c. Is the same when comparing highly polished and unpolished restorations.
d. is in direct correlation to their esthetic value.

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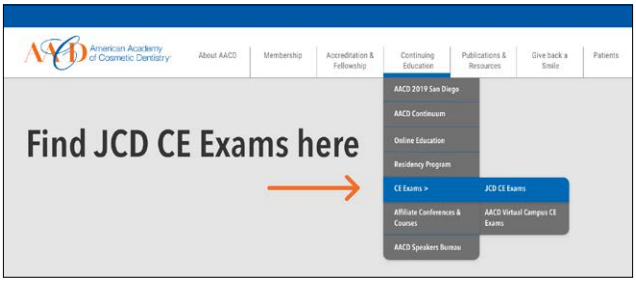

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