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Journal of Cosmetic Dentistry

Tetracycline Staining Solved with Zirconia

Michael R. Sesemann, DDS, FAACD

Lee Culp, CDT

Lida Swann, DDS, MS

Managing Composite: Tips & Techniques

Utilizing Direct Resin for Worn Dentition—CE

Summer 2018

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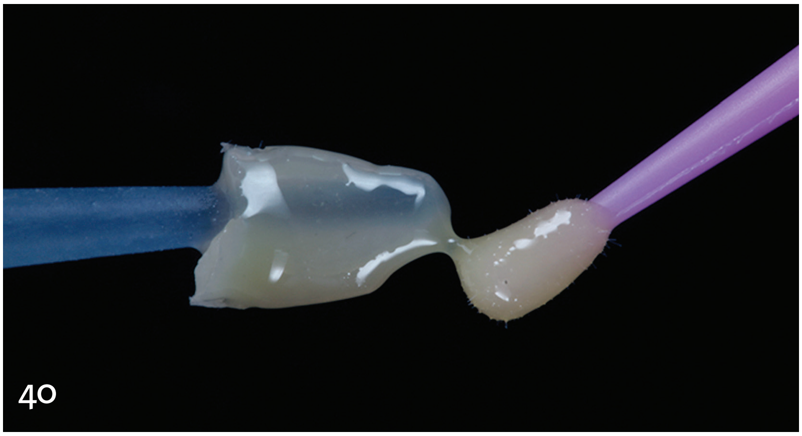

Column

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Impressive Teamwork!

> **When every team member is committed to working synergistically with a shared strategy and appreciation of how each contributes to the common goal, patient care will be enhanced.**

When teams collaborate purposefully it improves not only the work culture, but also patient care. A strong restorative dental team can accomplish even the most complex of cases. Most team members appreciate the virtues of collaboration because it makes each individual's job easier.

This issue of the *Journal of Cosmetic Dentistry* (*jCD*) features cases highlighting beautiful, lifelike restorations achieved by dentists and their restorative teams that have had profound effects on patients. Partnering with your dental technician as well as with other clinical specialists will help you to address the micro details that are crucial in the creation of natural-looking teeth. These interdisciplinary partnerships also can be highly effective in inspiring your office team by helping them to recognize the diverse set of skills each individual contributes. When every team member is committed to working synergistically with a shared strategy and appreciation of how each contributes to the common goal, patient care will be enhanced.

As advances in dental materials and technology enable us to solve different and more complex clinical scenarios, so too does the interdisciplinary team approach contribute to success. Uniting innovation and collaboration enhances the entire group's experience while restoring your patient's oral health esthetically and responsibly. In fostering this type of approach, colleagues experience success—building a strong restorative team as well as a strong restoration for the patient.

As with AACD members' practices and businesses, the *jCD*'s strength reflects the collective success of the many professionals from various disciplines who have made tremendous contributions to research and patient care. They have improved quality of life for patients while building a strong team.

How do you cultivate strong teamwork? I hope you will consider submitting a clinical case, how-to, or "tips" article describing how your internal team or interdisciplinary colleagues worked together to improve the quality of life for your patients. I'll bet it is impressive!

Edward Lowe, DMD, AAACD
Editor-in-Chief

"When our profession changes someone's life in such a profound way, everyone who contributed to the case feels the impact."

An Impactful Journey

By Michael R. Sesemann, DDS, FAACD

"My dental journey actually started before I had teeth" were the intriguing words of the patient featured on the cover of this issue. She went on to explain that she had been given tetracycline as an infant to treat an illness and, as a result, when her adult teeth erupted they exhibited deep gray and purple stains. All the dentists she had consulted over the years had told her that her teeth were the darkest or second darkest they had ever seen. Because of this she smiled with her mouth closed and sometimes she avoided smiling altogether.

Veneers had been applied to mask the discoloration when she was a teenager. Although she was pleased with their esthetics they chipped and broke frequently. The next step in her dental journey occurred while she was a college student in the mid-1980s, when crowns were placed on the eight upper teeth in her smile zone. Looking back, she said those original crowns were extremely opaque, very bulky, and thick, "almost like horse teeth."

In 2017, motivated by a root canal and her daughter's upcoming wedding, she sought a dentist in her hometown of Omaha, Nebraska, who could provide her with the beautiful, natural-looking smile she had always desired. Research led her to the author's practice… and to a new smile created with the help of renowned ceramist Lee Culp.

"When I first got my new teeth, I wanted to cry. They gave me the confidence that I've always been looking for. They're me! I love the shape, the color, the size—everything is authentic and natural," she exclaimed.

This patient had waited her entire life to have a smile that expressed her personality. The evolution of dental technology and materials united with clinical acumen and technical skill to finally fulfill her wishes as well as the restorative team's goals of strength, durability, lifelike texture, and natural color. When our profession changes someone's life in such a profound way, everyone who contributed to the case feels the impact.

Dr. Sesemann thanks Ms. Barbara Ruser for her help in developing this article; and the patient for her courage and positive attitude.

Turn to page 28 to read Dr. Sesemann's clinical cover article, co-authored by Lee Culp, CDT, and Lida Swann, DDS, MS.

Cover image: Photographer: Bryan Jamieson (Amherst, NY). Camera: EOS 5D Mark III (Canon; Melville, NY) with a Canon EF 70-200mm lens and four constant light sources.

Laboratory Dollars and Sense

An Interview with Leon Hermanides, CDT

Leon Hermanides, CDT, is the owner of Protea Dental Studio in Redmond, Washington. A clinical instructor at the Kois Center, he has served as president of the Board of Directors of the Washington State Dental Laboratory Association, published in both clinical and technical journals, and lectured throughout the U.S. and internationally on implant restorations, esthetics, and restorative failures. Mr. Hermanides will be presenting at AACD 2019 San Diego, on Friday, April 26. He will discuss strategies to manage laboratory profitability and share tips to boost finances. In this first part of a two-part interview, Mr. Hermanides answers questions from members of the jCD Editorial Board. Register today at www.aacd.com/sandiego

Introduction

As highly skilled dental technicians who have spent many years educating ourselves and honing our skills it often is difficult to understand how to effectively lead our companies and realize the lifestyle and financial rewards for which we have worked so hard. Our role requires us to brand our company, build a loyal customer base, deliver a consistent product, grow and inspire a team to support the strategy and ultimately, ensure our company's financial viability. For some of us these are not skills that come naturally or easily, but they are crucial for survival.

Our business skills require the same attention as the art of restorative dentistry; while often not the part of our job we enjoy the most, it can enrich our employees' and customers' experience when delivering life-changing treatments to patients every day.

Q: How do you attract new people in an era when skilled technicians are at a premium?

A: As with many small businesses it is easy to forget that team members are our customers, requiring the same dedication to marketing, retention, and goodwill as any client. The choice of places to work is endless for the right people and so I take my obligation to maintain the right environment for employees very seriously. I want them to be able to recommend our company as a good place to work. This does not mean I pay everyone beyond market rate, but we try our best to acknowledge everyone's contributions and develop their skills as much as possible. The "soft" skills have never been easy for me—I have given others free reign to contribute as much as possible—but it is still important for me to engage my team on a daily basis. We are most comfortable finding people that are the right fit for our team and developing them into great technicians.

However, even when you do everything right, employees' life circumstances may change and team members move on. Unfortunately, I believe our industry leadership has neglected to think long term and we are not training people in sufficient numbers or to an appropriate level to provide U.S. dental laboratories the means to thrive. I expect this problem to get worse long before it gets better and therefore I do as much as I can to contribute to the education of new dental technicians. To this end, our company funds a scholarship with the local dental laboratory program.

"We have realized the most important aspect of digital dentistry is having well-trained people operating the equipment."

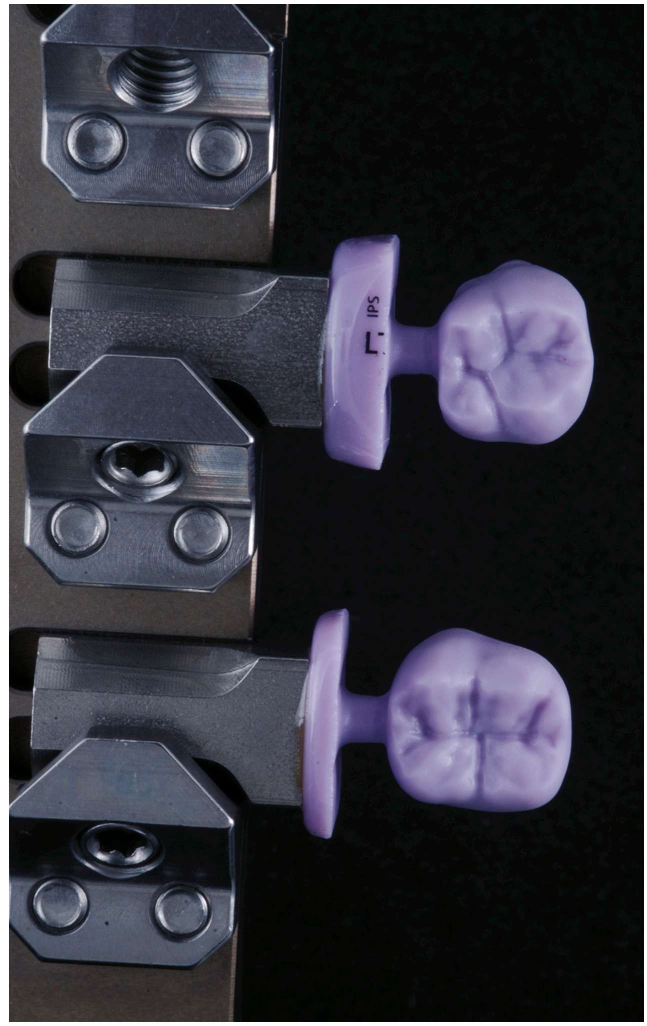
Full-contour CAD/CAM restorations.

Q: Do you train, or hire digital technicians?

A: I remember, probably 10 or 12 years ago, hearing from manufacturers and salespeople that technology would solve our employee issues because 1) it would allow us to employ unskilled people as the software would provide the knowledge and substitute the necessary skills and 2) it would never take a sick day or need a vacation. But we have realized the most important aspect of digital dentistry is having well-trained people operating the equipment. Our two newest CAD/CAM technicians both completed a two-year Associate's Degree program in dental technology; I believe this foundational education will drive their ability to fabricate highly individualized esthetic dentistry for many years to come. Preparing classically trained technicians to become digital technicians has given us more versatility and better results than hiring people who have been trained only in digital procedures.

Q: What is the correct labor percentage compared to sales?

A: I don't believe there is a correct labor percentage for every dental laboratory as this is so closely tied to a company's product and overall business strategy. We separate direct labor costs, those involved in making restorations from administrative labor, those involved in supporting our customers and business strategy. If your business is fabricating restorations for a highly demanding clientele, your team would have to spend more time on each restoration to achieve your expected quality. For the moment ignore all the other variables. I would therefore expect your labor cost to be higher than someone doing business in an environment where they produce more restorations for a less discriminating market. There may even be a difference in your business between various product lines. In our company, for example, there is a difference based on anterior versus posterior restorations. When we now consider other variables such as what you can charge for a restoration, your remake rate, how much an excellent technician earns in your area, and how much unused capacity your production team has, I believe it is better to track a range that is unique to your company. I am constantly evaluating our current numbers against historic numbers to ensure that we maintain our direct labor costs in line with our expectations and when I see any significant anomalies I know why. Our company's



Milled CAD/CAM ceramic.

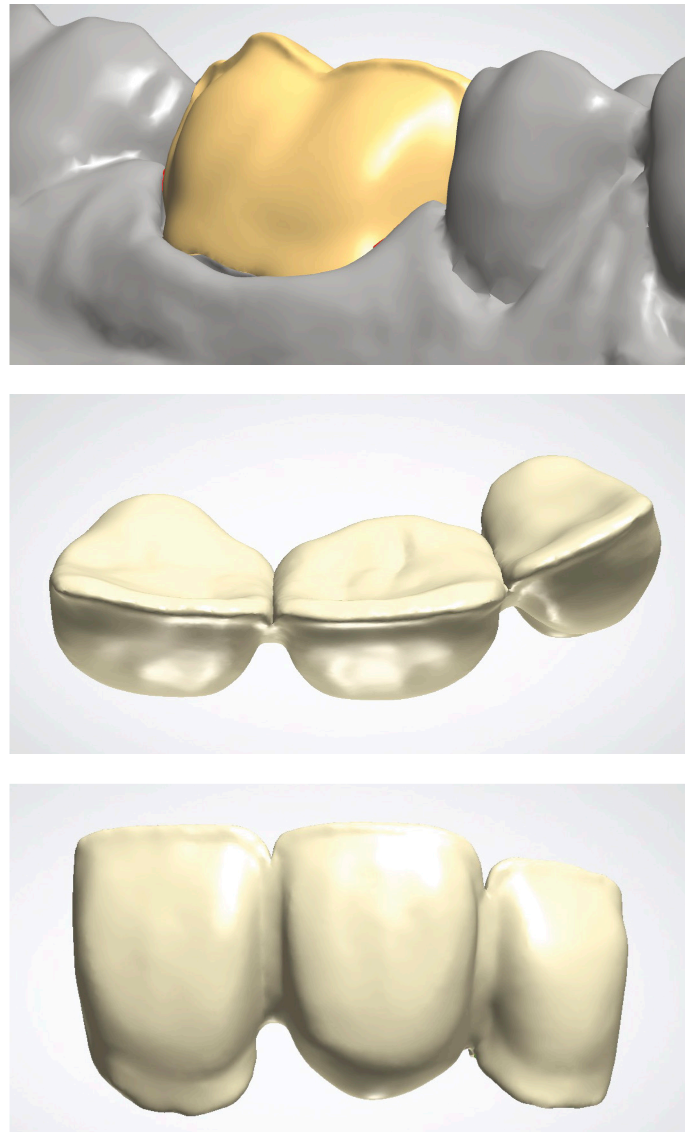
"Our company's direct labor costs range from 32% to 36%."

direct labor costs range from 32% to 36%. When our direct labor cost stays inside this window our company maintains a profit margin that allows us to meet all our current obligations, invest in new equipment/opportunities, and retain savings for future opportunities.

Q: With the advent of digital workflow, is there truly a savings in labor? Is there an increase in material expenses in the digital arena?

A: Yes, there is a labor cost savings, and within limits the material costs can be slightly higher; however, I feel that is not the whole story. First, without understanding the implications of funding large capital purchases many laboratory owners have struggled to meet the return on investment they expected investing in technology. I strongly suggest to never use a five-year option when making an investment in technology—by the fifth year most of it may be redundant, but you will still be paying! If the math doesn't work on a two- or three-year option don't buy it. In addition, I believe many people buy machinery beyond their scope of business. If you are processing 1-2 units a day and your machine has the capacity to do 48, there are 46 units on your expense tab that you have not billed out. Be realistic about your ability to grow a product line to fit your capacity when considering new equipment purchases. In our company, we research the costs associated with processing a given material, including capital funding, materials, maintenance, downtime, and consumables at a given volume of production. Until we can anticipate achieving an internal cost that is lower than (or within our acceptable cost differential) outsourced options we don't buy the equipment. We have consistently adapted the technology to fit our needs to a point where the labor savings has provided other opportunities for our team to develop.

In the second part of this interview Mr. Hermanides will discuss financial issues including pricing, expenses, and budget allocation. The Journal of Cosmetic Dentistry *thanks Mr. Hermanides for sharing his thoughts here and at AACD's Annual Scientific Session.*



Images of digital workflow.

"Be realistic about your ability to grow a product line to fit your capacity when considering new equipment purchases."

A Conservative Transformation with Composite Resin Veneers

Ramon A. Duran, DMD

Abstract

Composite resin can provide patients with a conservative option for diastema closures and other treatments needed to restore function and esthetics. Improvements in materials have enabled better placement techniques and enhanced final outcomes. This case report discusses a conservative direct resin treatment on youthful dentition and confirms the suitability of direct restorative material for anterior applications.

Key Words: direct resin, diastema closure, whitening, gingivectomy, Case Type V

Introduction

There is an overall awareness today of the value and impact an attractive smile has on the way we project ourselves to others as well as for our self-esteem. As a result, patients often ask us for options to improve the appearance of their front teeth. Composite resin materials can provide a conservative alternative to porcelain to modify shape, contour, and color; repair defects; and close spaces in the dentition. Materials have advanced to a level that allows us to restore a patient's full smile. Even though placing multiple resin veneers can sometimes be quite challenging, with the proper technique extremely natural results can be obtained in a very conservative way.[1] As Dr. Ronald Goldstein stated in a lecture some years ago, "direct composite veneers represent the art of dentistry in its fullest expression."

Case Presentation

Patient Complaint and History

A 23-year-old female who wished to improve the appearance of her smile was referred to the author's office by her orthodontist. Her chief complaint was that she had completed orthodontic treatment when she was 16 but diastemas had since appeared and she was unhappy with the appearance of her anterior teeth. She did not like their shape, and noted "grayness" (translucency) at the incisal edges. She wanted a whiter smile, without any spaces.

The patient was in excellent health and was not taking any medications. She had good oral hygiene and visited her dentist regularly for examinations and cleanings. She had a fixed lingual retainer from #22 to #27 and reported that she had also had a removable retainer in her upper arch for a few years but that she had lost it.

Findings and Treatment Plan

Her clinical exam revealed an overall healthy dentition. Periodontally, she presented with some calculus and mild inflammation. Her temporomandibular joints showed no signs or symptoms, and a stable Class I occlusion was noted. There were no occlusal problems and only minimal wear was noted on her lower incisal edges. No clinical or radiographic evidence of decay was present and minimal bone loss was observed on her radiographs. Her overall shade was close to a Vita A-2, with grayish, translucent enamel throughout the incisal one third of her upper incisors. The upper incisors had diastemas between them and were somewhat narrow relative to the size of her arch **(Fig 1)**. The gingival heights of her anterior teeth were irregular and the incisal edges presented with some unevenness.

Other than the need for regular prophylaxis, the rest of the patient's treatment would be elective, with the goal of improving her smile. Due to her youth and intact dentition, resin veneers presented an excellent option to achieve the desired changes.[2,3] With good care, these restorations can be expected to last 7 to 10 years and they eventually can be utilized for the initial design for very conservative, minimal-preparation porcelain veneers. The proposed treatment plan included the following:

- prophylaxis and oral hygiene instructions
- nightguard bleaching
- electrosurge gingivectomy, #8 and #11
- direct resin veneers, #6 to #11
- partial direct resin veneers, #5 and #12

"Even though placing multiple resin veneers can sometimes be quite challenging, with the proper technique extremely natural results can be obtained in a very conservative way."

Treatment

Preoperative: Prophylaxis was performed and oral hygiene instructions were reviewed with the patient. Probing to the osseous crest was performed under local anesthetic on #8 and #11, and a 1-mm gingivectomy was done on both teeth to achieve more ideal gingival levels in the anterior segment. Custom bleaching trays (Ultradent Products; South Jordan, UT) were fabricated with a reservoir and the patient was provided with eight syringes of carbamide peroxide (Opalescence PF 10%, Ultradent). She was evaluated after two weeks of use and excellent progress was noted. The patient was scheduled for the resin restorations two weeks after the bleaching procedure was completed.

Figure 1: The maxillary incisors had diastemas and were somewhat narrow relative to the size of the arch. Preoperative retracted frontal view (1:2).

A wax-up was completed with the proposed shapes of teeth #5 to #12 and a putty matrix (Sil-Tech, Ivoclar Vivadent; Amherst, NY) was fabricated and trimmed prior to the restorative appointment.[4]

Preparation: At the beginning of the restorative appointment, a finishing diamond (#8862, Brasseler USA; Savannah, GA) was used to roughen the enamel surfaces on #5 to #12. No local anesthetic was needed. Phosphoric acid 35% (Ultra-Etch, Ultradent) was applied for 20 seconds on #6 to #11 and rinsed thoroughly. An adhesive (Scothbond Universal, 3M ESPE; St. Paul, MN) was applied for 15 seconds and the solvent was evaporated with a stream of dry air for 10 seconds. A matrix strip (Mylar, Henry Schein; Melville, NY) was placed between the anterior teeth and the adhesive was cured for 10 seconds with a light-emitting diode (Valo, Ultradent).

Composite layering: A nanohybrid (Filtek Supreme Ultra, 3M ESPE) was selected as the restorative material because of its fracture resistance, sculptability and polishability, and esthetic/natural appearance when properly handled.[5] Using the putty matrix, an initial thin lingual wall was created for #8 and #9 with shade white enamel (WE), followed by a layer of A1 Dentin with mamelon shapes.[6] The desired contour was completed using B1 Body, B1 Enamel, and WE. Using similar layers, resin veneers were created for #10 and #11, followed by #6 and #7. In addition to B1 Body, A1 Body was used for the cuspids, creating a slightly higher chroma.

Finishing and polishing: Initial contouring was accomplished with coarse and medium discs (Sof-Lex, 3M), followed by diamond finishing bur #8862. Once the initial contouring was completed the final anatomy was created with diamond and carbide finishing burs (#8862, #368, #7901, #7408, Brasseler), followed by polishing with rubber points (FlexiPoints, Cosmedent; Chicago, IL) and regular Jiffy brushes (Ultradent).[7] The final luster was achieved with a flexible disc and polishing paste (FlexiBuff and Enamelize, Cosmedent). Floss was used to confirm adequate cervical interproximal margins. The patient received written and verbal instructions to help her maximize the "esthetic life" of her new restorations.

Enameloplasty: Minor enameloplasty was performed on #22 and #27 with a finishing diamond, carbide finishing bur, and a diamond-impregnated rubber cup (#8862, #H48L, and #W17DCHP, Brasseler) mounted in a slow-speed handpiece. The appointment was completed and the patient was scheduled to return one week later to finalize the case.

Modifications

At the second appointment, some modifications and minor additions were performed, and the partial veneers of #5 and #12 were created employing the same procedure used for the incisors. The secondary anatomy was completed with diamond finishing burs and occlusion was verified. Finishing was completed with FlexiPoints, fine Sof-Lex discs, and a regular Jiffy brush, followed by a final polish with FlexiBuff and Enamelize **(Fig 2)**. Floss was used to again confirm adequate cervical interproximal margins **(Figs 3 & 4)**.

The patient was scheduled to return one week later for a follow-up visit, during which slight modifications were made and some additional polishing was done. As the gingival tissues were not totally mature, final photographs were not taken until a few days later. The patient was very pleased with the final result **(Figs 5 & 6)**.

Figure 2: The maxillary incisors no longer have diastemas and are more proportional to the size of the arch. Postoperative retracted frontal view (1:2).

Figure 3: The patient was dissatisfied with the shape of her teeth. Preoperative maxillary anterior frontal retracted view (1:1).

Figure 4: The treatment was completed with finishing and polishing. Postoperative retracted frontal view (1:1).

Figure 5: The gingival heights of the anterior teeth were irregular and the incisal edges presented with some unevenness. Preoperative frontal view (1:2).

Figure 6: The gingival heights of the anterior teeth were corrected and the incisal edges were balanced in the final restorations. Postoperative frontal view (1:2).

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Dr. Duran practices in San Juan, Puerto Rico.

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> Due to her youth and intact dentition, resin veneers presented an excellent option to achieve the desired changes.

The Challenges of Case Type V

Brian J. Gilbert, DDS, AAACD

The restoration of six or more teeth employing direct resin is not a common procedure for most restorative dentists. As a result, Case Type V is usually one of the last cases to be completed by the typical candidate during the Accreditation process.[1] Due to its challenging nature, Case Type V can be an extremely valuable learning experience, particularly in terms of understanding the subtleties of tooth contour and the process of layering resins to create a natural smile. In addition to giving the clinician an opportunity to display his or her talents, the process of layering composites helps the clinician to understand the laboratory technician's analogous process of indirect layering of ceramics; this can aid the clinician in communicating with the technician in future indirect cases.[2]

Elements of smile design are extremely important in Case Type V. A high level of planning similar to an indirect case typically is involved. Case selection is of critical importance, due to the predictable need for significant chair time, multiple visits, positive patient attitude, and persistence through the process until the desired final result is achieved.

Dr. Duran's approach to Case Type V exemplifies the necessary attributes listed above. He carefully chose a case that would allow him to achieve ideal results **(Fig 1)**. He approached his preparations from an extremely conservative point of view. The description of layering in his article, along with his photographs of the layering process, shows his appreciation of the case's complexity and what was needed to achieve natural-looking restorations **(Fig 2)**.[3] When viewing the final results, Dr. Duran's knowledge of the anatomy of anterior teeth is evident. The shape, length, contour, and overall morphology of the treated teeth appear completely natural.

Dr. Duran's Case Type V passed unanimously. However, as stated in previous examiners' commentaries, there is no such thing as a perfect case. The examiners here noted three main criteria when discussing areas for improvement:

- **Criterion 35:** *Do the radiographs show problematic clinical issues (i.e. open, overhangs, pathology or other defects)?* Several of the examiners noted overhangs on the radiographs. This was considered a major fault (-4).
- **Criterion 44:** *Does the surface exhibit the appropriate finish, polish, and luster?* Two of the examiners observed finish issues in interproximal areas and along some of the margins. This was considered a minor fault (-2).
- **Criterion 53:** *Is the color (hue, value, chroma) selection appropriate/natural, not monochromatic?* Three of the examiners mentioned that they saw the restorations as mostly monochromatic. This was considered a minor fault (-2).

Despite the faults listed above, the majority of examiners gave the candidate a +1 based on the case's overall look **(Fig 3)**. Dr. Duran is to be congratulated on his fine work. Along with the beautiful esthetic result, with which the patient was extremely happy, Dr. Duran displayed a well-grounded understanding of the esthetics needed to achieve a successful Case Type V.

Figure 1: A near-ideal case selection for six or more direct restorations (preoperative natural smile, 1:2 view).

Figure 2: An understanding of composite layering aids the practitioner in understanding the layering of porcelain in indirect restorations (postoperative retracted frontal image, 1:2 view).

Figure 3: The beautiful final result (postoperative natural smile, 1:2 view).

> "Due to its challenging nature, Case Type V can be an extremely valuable learning experience..."

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Tips to *Prevent* and *Eliminate* Pits in Anterior Composite Restorations

(Accreditation Case Types IV & V)

James H. Peyton, DDS, FAACD
Brian J. Gilbert, DDS, AAACD

Introduction

You are restoring a Class IV on tooth #8 and everything is going well. But just when you think you have successfully created a flawless composite restoration, you are disheartened to realize that a void or "pit" is visible in the final product. If this has ever happened to you, do not become discouraged.

Tips to Avoid Pitting

Pits or voids can appear in any restoration, but steps can be taken to prevent these unsightly occurrences.

- When layering the composite, be sure to add enough material for each phase of the restoration. If you have to go back to keep adding composite, you are more likely to incorporate pits.
- Care should be taken to smooth out the restoration, especially the final layer. It often helps to use a brush moistened with a wetting agent (e.g., Modeling Resin [Bisco; Schaumburg, IL]; Wetting Resin [Ultradent Products; South Jordan, UT]; Brush & Sculpt [Cosmedent; Chicago, IL]) to shape the composite and eliminate folds or voids.
- When employing the brush technique, try using a #3 artist brush with just enough wetting agent to moisten the tip of the brush, to prevent the restoration from turning into "composite soup."
- Be sure that the operatory light is off (or has an amber shield) to avoid premature setting of the composite, which will result in a chalky, rough, or pitted restoration.[1,2]

Sometimes, even when you have attempted to perform all the steps correctly, you will still end up with a void. This might be due to air bubbles in the composite as it comes out of the syringe or compule. These voids can be eliminated by rolling the composite into a ball. If the void is extremely small, you may be able to simply add a small amount of bonding agent to the pinhole with a sharp explorer, then light-cure and polish and it will disappear.

On the other hand, a large void should be completely removed using a small round diamond bur. After acid-etching, rinsing, and drying the defect, place a coat of bonding resin. Before curing the bonding resin, place the composite, carefully smoothing it out. Once the composite is smooth and ideal, light-cure and polish. (Note: If you cure the bonding agent first, you might create a gray "halo" around the restoration.)

By taking these steps, you should be able to prevent voids and pits from appearing in your composite restorations **(Figs 1-2j)**.

> Pits or voids can appear in any restoration, but steps can be taken to prevent these unsightly occurrences.

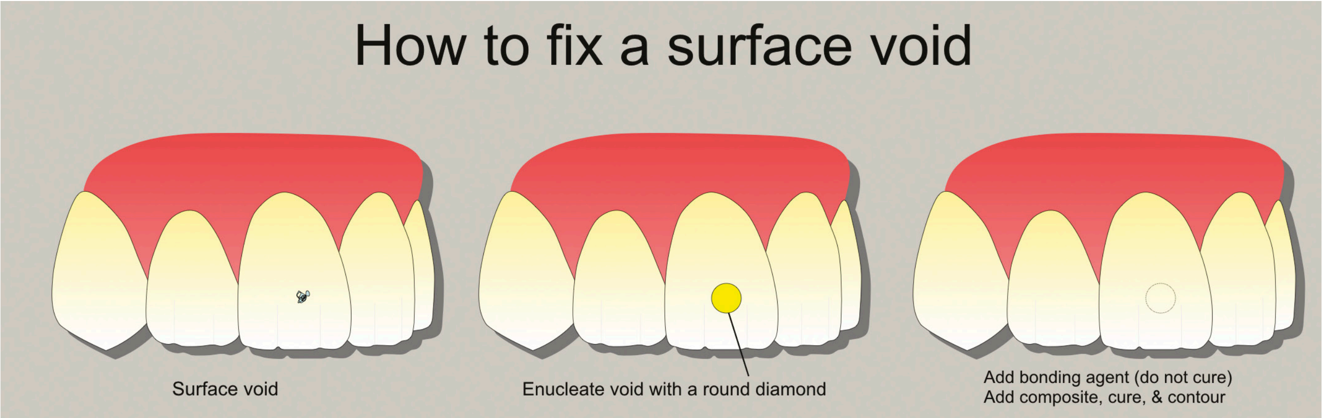

Figure 1: Illustration showing how to fix a surface void.

Figure 2a: A stain on composite veneer on #8 at the distogingival area and a small pit on #7.

Figure 2b: The stain on #8 was removed with a diamond bur and the surface of #7 was cleaned out.

Figure 2c: The surfaces of both teeth were abraded with a micro etcher.

Figure 2d: Acid-etch repair of both teeth.

Figure 2e: The bonding agent was applied.

Figure 2f: The composite was applied and shaped with an interproximal carver.

Figure 2g: A large disc was employed to remove the excess composite and recreate the correct anatomic contour.

Figure 2h: A polishing cup was used to create a polished surface.

Figure 2i: A flexible felt buff and polishing paste imparted a high polish.

Figure 2j: The final repaired composite restoration.

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Restoration of Extremely Dark Tetracycline-Stained Teeth with Monolithic Gradient Zirconia

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Abstract

The dentist-laboratory technician restorative team has been challenged over the last 50 years to find a suitable restorative material to treat the extensive tooth staining, born out of the late 1960s and early 1970s, from the ingestion of tetracycline. For milder cases, combinations of bleaching and/or a variety of direct and indirect materials could be effective. However, truly dark teeth necessitated finding a balance between blocking out the darkened tooth structure and the ability to provide lifelike dental restorations with suitable optical metamerisms. This article discusses the properties of dental zirconia and its performance in fixed dental prostheses. A case study illustrating how monolithic, gradient zirconia can provide beautiful, lifelike restorations for even the darkest tetracycline-stained teeth is provided.

Key Words: tetracycline staining, zirconia, monolithic lithium disilicate, veneers, crowns

Introduction

Clinicians and laboratory technicians are dedicated to fixing patients' functional and esthetic problems, the resolution of which can have a profound effect on a patient's quality of life. One of the common esthetic problems the restorative team has struggled with during the past 50 years is how to restore the effects of tetracycline staining of the adult dentition, especially cases that are extremely dark. The challenge lies in the conflicting objectives of adequately blocking out the unwanted darkness and color while providing optical characteristics that mimic natural teeth.

A recent evolution in the composition and technical handling of zirconium dioxide (ZrO_2), also known as zirconia, makes it possible to optimally restore even the darkest tetracycline cases.[1] Zirconia is a white crystalline oxide of the metal element zirconium. Its most naturally occurring form is the rare mineral baddeleyite, although zirconium metal used for dentistry is obtained from the zirconium-containing mineral ore called zircon. After being processed and purified these powders can be further processed to produce somewhat porous bodies that can be CAD/CAM-milled with great precision. Once densely sintered, a polycrystalline ceramic material is produced which, unlike most other dental ceramics, contains no glass phase.

"A recent evolution in the composition and technical handling of zirconium dioxide (ZrO_2), also known as zirconia, makes it possible to optimally restore even the darkest tetracycline cases."

Tetracycline Staining

Clinical evidence of tetracycline-associated tooth discoloration began to emerge in the mid 1960s.[2,3] It was soon established that tetracycline chelated calcium orthophosphate to form a complex that was irreversibly incorporated into teeth during the calcification stage of tooth development. This resulted in permanent discoloration of the affected dentition. Unfortunately, these findings were significantly delayed because of the significant amount of time that passed between pregnant mothers' or young children's ingestion of the drug until the affected teeth erupted. The clinical presentation of the condition was found to be type-, dose-, and timing-dependent.[4]

Tooth discoloration is the main adverse effect associated with tetracycline taken during pregnancy, especially for exposure in the second and third trimesters during fetal tooth calcification. The drug exposure time-point during gestation defines which teeth will be stained. However, post-natal (from three months to eight years of age) exposure to tetracycline results in lifelong enamel discoloration of the primary and permanent dentition.

Zirconia

Biomaterials in dentistry must address several requirements, which include biocompatibility and strength related to intended purpose and esthetics. The history of dental prostheses reflects a progression from function to esthetics, with gold restorations largely being replaced by porcelain-fused-to-metal (PFM) restorations during the period from the 1970s to the 1990s. The introduction of various all-ceramic restorations beginning in the 1980s initiated a continuous transition from metal-based ceramics to different multilayered and monolithic all-ceramic restorations.

The central issue for all-ceramic restorations has been the balancing of esthetics (color and translucency) with strength or function. Different materials have been utilized and their esthetic value traditionally has been correlated inversely to strength. The basis for this clinical paradox is the use of glass phase ceramics to impart translucency to dental ceramics and the use of relatively opaque crystalline ceramics to achieve strength.

Despite the early esthetic limitations of zirconia-based restorations, it has seen remarkable penetration into the dental laboratory and clinical practice. The reasons for this replacement of metal and metal-ceramic restorations is attributable to several factors, including the relative cost of gold alloys, the integration of zirconia materials into the CAD/CAM workflow, and the esthetic value of "white" dental materials. This migration of clinical preferences from metal ceramics to all-ceramic materials suggests the satisfactory performance of the all-ceramic material.

Literature Review

The past 13 years of clinical research has provided some insight regarding the performance of zirconia prostheses. A systematic review by Raigrodski and colleagues looked at the survival and complications of zirconia fixed dental prostheses (FDPs). They reported survival rates ranging from 73.9% to 100% in 12 studies. Five of these studies reported 100% survival rates during the observation period. One study reported 73.9% survival of frameworks and the remaining six studies found survival rates ranging between 88.2% and 96.6%. The common complication reported was chipping and it was suggested that with the development of new layering porcelains, better clinical properties would be expected.[5]

A systematic review by Schley and colleagues[6] on the performance of zirconia-based FDPs evaluated not only the survival but also the complication rates for this type of prosthesis up to five years. The study followed 310 prostheses. The estimated five-year survival rate for all FDPs was 94.29%. The five-year complication-free rate for technical complications was 76.41%, with chipping being the most reported complication.[6] Very rarely do we seem to see fractures within the zirconia framework itself. For example, a systematic review by Sailer and colleagues[7] indicated that compared to chipping rates of 13.6%, framework fractures occurred at a rate of only 6.5%. Fractures were reported most commonly in connectors of multi-unit posterior restorations and/or second molar abutments.

Larsson's systematic review in 2014[8] suggested that the success rate of tooth-supported and implant-supported zirconia-based crowns is similar, and comparable to that of conventional PFM crowns. A laboratory study utilized indentation to induce chipping of monolithic zirconia and lithium disilicate materials. The results confirm that ceramic veneered-zirconia displayed high chipping and that monolithic lithium disilicate resisted this chipping; however, monolithic zirconia was most resistant to this induced chipping behavior.[9]

Characteristics

As revealed in the aforementioned reviews, one of the early significant observations made regarding the clinical performance of zirconia-based all-ceramic restorations was chipping of the veneering porcelain from the zirconia frameworks. While many different investigators have suggested fundamental reasons for this phenomenon,[9] the clinical response to chipping is a concern for layered zirconia restorations.

When used as a framework, zirconia has an inherent basic esthetic value due to the fact that it is white and can be alternatively colored to mimic surrounding dentin. Further, it can be provided with high opacity to cover discolored teeth and implant components.[10] This can be advantageous to the technician who is trying to conceal a dark underlying tooth structure, a metal post, or the remainder of amalgam restorations left after initial preparation.

Zirconia framework-based restorations, when veneered with an appropriate ceramic layering system, can result in exceptional esthetics and achieve an imperceptible match to the surrounding dentition (**Figures 1 through 3** show images of a 2006 case in which the prosthesis is still in service today). The talented technician may develop appropriate color and optical properties of the restoration within the veneering ceramics. However, the past decade of investigation has revealed that chipping within the veneering ceramic or at the framework/veneer interface frustrates higher clinical success and survival of these restorations. Veneer chipping, not framework fracture, appears to be the weak link in zirconia-based restorations.

Biocompatibility

Research on zirconia as a biomaterial began in the late 1960s with Helmer and Driskell.[11] Nearly 20 years later, Christel suggested the use of zirconia as an alternative to other materials used at the time, to manufacture the ball heads for total hip replacements.[12] Zirconia is still used today in this application and for other medical prosthetics. Studies show that zirconia was found to be superior to other ceramic biomaterials in use circa 1990 because it possessed higher strength and hardness.[7,13]

The interaction of zirconia with oral soft tissues may be central to the performance of tooth- and implant-supported restorations.[14] The formation of biofilm on dental prostheses, either natural tooth or implant-supported, is material-related. A 2014 investigation measured the colonization of dental implant abutments.[15] DNA checkerboard analysis revealed that, compared to zirconia abutment materials, higher total bacterial counts were greater on cast or machined titanium discs after 24 hours. This confirms the work of Bremer and colleagues, who showed that biofilm was lowest and thinnest on zirconia compared to lithium disilicate restorations.[16] The clinical impression that low biofilm formation and limited inflammation at zirconia restorations is supported by such in vitro and in vivo studies. Bacterial adhesion has proven to be slightly better that titanium. Scarano and colleagues reported a degree of coverage by bacteria of 12.1% for zirconia as compared to 19.3% on titanium.[17] Rimondini and colleagues confirmed these results with an in vivo study where y-TZP accumulated fewer bacteria than titanium in terms of total numbers of bacteria and presence of potential pathogens such as rods.[18]

Based upon the above-mentioned findings, it may be concluded that zirconia materials offer advantages of biocompatibility for use as endosseous and oral biomaterials due to their remarkable strength and durability, as well as their surface properties.

Strength

The introduction of zirconia-based ceramics as a restorative dental material has generated much interest in the dental profession. The mechanical properties of

Figure 1: Implant-supported zirconia framework used by the restorative team for a patient in 2006 to restore missing teeth #7 to #10 and accompanying osseous defect.

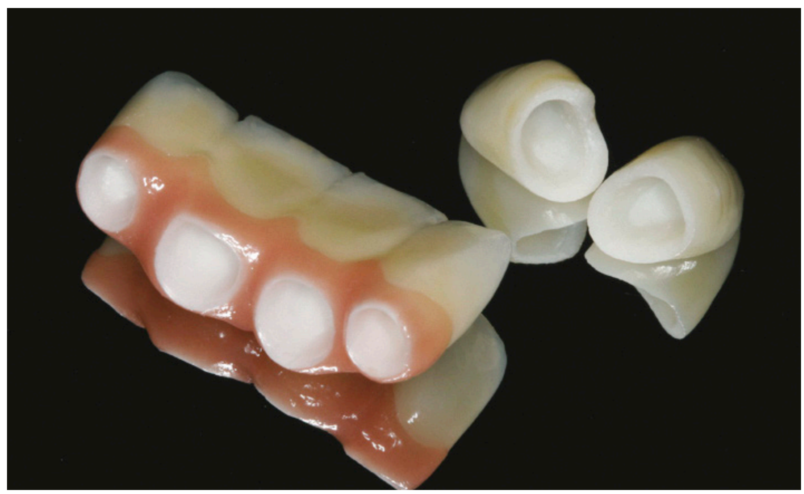


Figure 2: Completed implant-supported zirconia framework bridge with pressed leucite-reinforced ceramic (both pink and white) for final tooth and gingival form with ceramic layering to characterize the final appearance.

Figure 3: Prosthesis seated in 2006 still in service in 2018. Cuspid full-coverage restorations with pressed leucite-reinforced ceramic.

zirconia are the highest ever reported for any ceramic used in prosthetic dentistry and its strength has allowed the incorporation of high-strength all-ceramics into its use for posterior FDPs.[19] Its strength, coupled with its potential for high esthetics, enables zirconia to be an extremely valuable option in the prosthetic armamentarium.

The basis for zirconia's strength is its unique crystalline structure and its behavior under loads. Over the last decade or so, many high-strength ceramics have been developed for the construction of metal-free restorations.[20] Several studies have evaluated different all-ceramic systems and suggested where these systems may successfully be used in the oral environment. Lüthy and colleagues measured average load-bearing capacities for several ceramic systems and found 518 N for alumina-based restorations, 282 N for lithium disilicate-based restorations, and 755 N for zirconium restorations.[21] Raigrodski and colleagues also analyzed several different all-ceramic systems, concluding that those in their study were to be used only in the anterior, for single-crown restorations and possibly three-unit FPDs.[20] They also concluded that because of zirconia's higher strength it offers a wider area of restorative options in the oral cavity, including posterior single units, and multi-unit restorations.[20]

Another option is fracture-resistant, partially translucent monolithic ceramics. These monolithic all-ceramic restorations are becoming more accepted due to their higher strength, by avoiding weak veneer-core interfaces. Materials such as IPS e.max lithium disilicate and Wieland Zenostar zirconia (Ivoclar Vivadent; Amherst, NY), and Lava Plus zirconia (3M ESPE; St. Paul, MN) have acceptable esthetics and can eliminate the need for veneering ceramics altogether.

Wear

During the early 2000s it was believed that the use of zirconia would create high wear in the opposing dentition. That perception has since been challenged[22] and multiple studies have shown that zirconia can be a material gentle to opposing dentition,[23,24] in comparison to glass ceramics that are layered on PFM restorations. This low-wear property can be attributed to zirconia's microstructure and its small grain size, which allows for a "polished mirror" surface to be created that is kind to opposing enamel surfaces.[23,24]

An in vitro study by Yung and colleagues[25] evaluated the wear of enamel opposing zirconia surface. They found that zirconia surfaces appear to be less abrasive to enamel than feldspathic porcelains. They also found that polished zirconia without glazing is less abrasive than zirconia-glazed surfaces.[25] Janavula and colleagues also evaluated the wear of enamel by full-contour polished and glazed zirconia. A wear simulator producing a 4-mm slide at 20 N rate was applied and samples evaluated using a non-contact 3D profilometer. Although the wear of glazed zirconia was more than polished zirconia, it was still less than that of commonly used porcelains for PFM restorations.[26]

These results were investigated further in a six-month clinical study that evaluated the wear on opposing dentition for monolithic full-contour zirconia prostheses.[27] Twenty monolithic crowns were placed in patients and mean vertical loss for specimens, antagonists, and contralateral was recorded. Both mean and maximum enamel wear were significantly different between the antagonists of the zirconia crowns and the contralateral antagonists. Under clinical conditions, monolithic zirconia crowns seem to be associated with more wear of opposed enamel than natural teeth, but the amount of wear is comparable to if not less than that of other ceramic systems.

Esthetics

The difficulty in achieving predictable excellent esthetics with PFM restorations and the desire for metal-free solutions has led to the increased use of zirconia, whose unique optical properties require new and different understanding of how the materials are managed.[28] Translucency and color are important and often inseparable variables for dental restorations; and translucency may be an innate optical property of the zirconia material related to its crystalline structure. Over the past 16 years there has been a remarkable evolution in the esthetics of full-contour zirconia, as raw material manufacturers and ceramic companies work together to improve translucency and optical properties within this unique biomaterial.

At the beginning of dentistry's use of zirconia, with systems and materials from Cerec, Dentsply Cercon, Vita, Ivoclar Vivadent, and others, there were only two choices: white or opaque. Then 3M ESPE introduced dyeing liquids that allowed for the internal coloring of zirconia frames. However, ceramics were still being layered to achieve final tooth form and esthetics. It was not until full-contour solid zirconia restorations became popular that serious research into the material's esthetics became the focus of zirconia development. Since that time there has been significant research and development on this material's specifications and esthetics.

In the last few years zirconia technology has offered the technician both higher translucency and pre-shaded discs in all A-D shades. New multilayered zirconia milling discs offer a transition from dentin to enamel shades, along with proper translucency differences in those areas. These zirconia discs offer the dental technician, dentist, and patient a universal restorative option for both anterior and posterior applications that rivals the esthetics of traditional hand/brush-layered ceramics.

New Material

Zirconium oxide block IPS e.max ZirCAD medium translucency (MT) Multi offers excellent esthetics and high strength at over 850 MPa due to a blending of shade and translucency, but also a transition from less translucent at the cervical to more translucent at the incisal. Intraoral observations show that very esthetic restorations can be made with this material with a cervical/circular wall thickness of 1 mm and an opacity of approximately 68%. The MT raw material is employed in the cervical part; in the incisal part, where the wall thickness naturally increases to 1.5 to 2 mm, a higher translucency is achieved with the blending of a 5Y-TZP zirconia. Therefore, e.max ZirCAD MT Multi has a gradient of the composition from 4Y-TZP up to 5Y-TZP, which leads to a natural appearance in the oral environment. The incisal part in particular is characterized by natural light transmission so that this material can be used for anterior restorations without any layering and/or applying veneering ceramics.

Case Study

Patient Complaint and Findings

A 48-year-old female presented to the treating clinician's practice seeking options for the restoration of her front teeth. She wished to replace 30-year-old PFM restorations in the maxillary arch and fix very dark tetracycline-stained teeth in the mandibular arch **(Figs 4 & 5)**. A biomechanical, tooth-by-tooth analysis of the patient's existing restorations indicated that new restorations were necessary **(Figs 6 & 7)**. The results of the biomechanical analysis, in conjunction with an occlusal diagnosis of dysfunction, resulted in a treatment plan for a full-mouth rehabilitation to satisfy the patient's esthetic objectives while meeting the dentist's functional parameters. Clinical examination also determined that the patient had reticular lichen planus lesions of the attached gingiva and the buccal mucosa.

Treatment

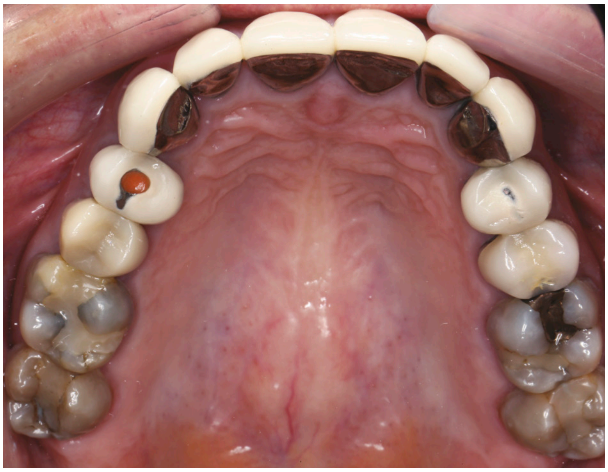
Endodontic procedures were completed for numerous teeth and an allograft (AlloDerm, BioHorizons; Birmingham, AL) was performed for #8 to treat recession and optimize the maxillary anterior gingival architecture for smile design purposes (the patient revealed the full length of #8 even with a guarded smile). The gingival grafting procedure was necessary to make the central incisors mirror images for an optimal esthetic result.

Monolithic lithium disilicate (e.max) posterior restorations were completed in the laboratory while the gingival graft healed. The clinician's preference is to utilize monolithic lithium disilicate for posterior restorations because it allows the capability to "see through" the restorations on radiographs at recare visits. While the posterior restorations were being fabricated, the restorative team decided to utilize a new gradient zirconia, e.max ZirCAD MT Multi, for the anterior restorations. The anterior teeth were prepared for these full-coverage zirconia restorations, images were taken to communicate the patient's stump color **(Figs 8 & 9)**, and provisionals were made from the diagnostic wax-up. After the provisionals were adjusted for functional occlusion and

Figure 4: Patient's natural smile, 1:2 magnification.

Figure 5: Retracted 1:2 view of the patient's PFM crowns in the maxillary arch and the deep tetracycline-stained teeth in the mandibular arch.

> "...post-natal (from three months to eight years of age) exposure to tetracycline results in lifelong enamel discoloration of the primary and permanent dentition."



Figures 6 & 7: Maxillary and mandibular occlusal views showing multiple restorations at the end of their useful service.

Figure 8: Shade guides next to the patient's lower anterior teeth illustrating the enormous change from the existing to the future shades.

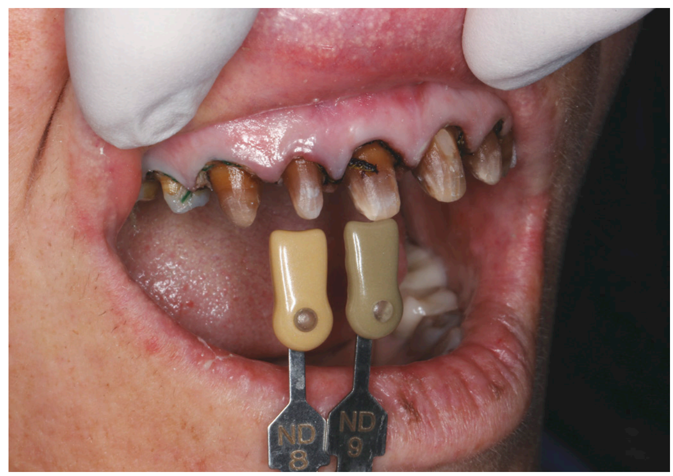


Figure 9: Stump shade revealing the extent of the darkened tooth structure that needed to be blocked out.

macro esthetic elements **(Fig 10)**, impressions and images were taken and sent to the dental laboratory to facilitate the fabrication of the zirconia restorations.

After fabrication, the zirconia restorations were returned to the clinician's office **(Figs 11-13)**. They were tried in to verify fit and occlusion, including compatibility with the patient's envelope of function. Upon verification the restorations were cleaned with Ivoclean; treated with MonoBond Plus; and cemented with Adhese, a universal bonding adhesive, and dual-cure Variolink Esthetic resin cement (all Ivoclar Vivadent) **(Figs 14-17)**.

"The difficulty in achieving predictable excellent esthetics with PFM restorations and the desire for metal-free solutions has led to the increased use of zirconia..."

Figure 10: Facial view of the patient in provisionals to illustrate the 3D macro smile design elements of the provisional cast.

Figures 11 & 12: Fabricated zirconia restorations on the maxillary and mandibular working models.

Figure 13: Restorations reflecting the intricate synergy between block-out capability and lifelike optical metamerisms needed to mimic natural teeth.



Figures 14-16: Frontal, right lateral, and left lateral post-seating natural smile, 1:2 magnification.

Figure 17: The seated zirconia restorations, retracted 1:2 magnification. Note the reticular lichen planus on the buccal mucosa and the posterior gingiva.

Summary

Due to recent advances in the composition, technical handling and optical properties of zirconia, the dentist-laboratory technician team can restore very dark, stained teeth with restorations that exhibit natural, lifelike optical properties. The ability to restore such a case can have a profound effect on the patient and the entire restorative team.

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"The ability to restore such a case can have a profound effect on the patient and the entire restorative team."

Maximizing Esthetics and Function of FRC Posts and Full Composite Crowns in Endodontically Treated Teeth

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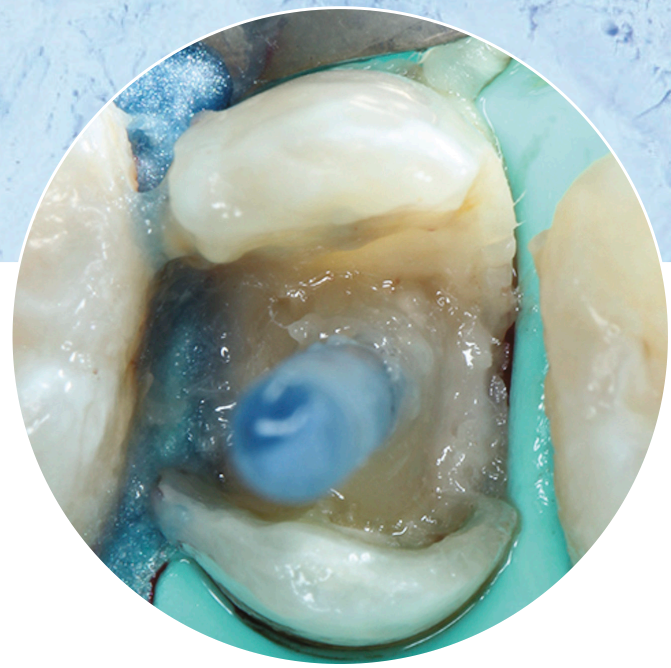
Ismael Henríquez, DDS
José Pablo Tisi, DDS
Abelardo Báez, DDS, MSc

Abstract

Ensuring the esthetics and functional longevity of endodontically treated posterior teeth can present dentists with complex challenges that, to date, have been addressed using various therapeutic alternatives. The best combination of materials for restoring endodontically treated premolars is an indirect anatomical fiber-reinforced post and a dual-cure cement with a self-etching adhesive. For cases in which there is a substantial loss of tooth structure, full-coverage composite crowns have been indicated as long-lasting restorations. This article details a conservative, step-by-step technique for rehabilitating an endodontically treated premolar with wide root canals, using an indirect method for creating an anatomical fiber-reinforced composite post in combination with a full-coverage composite resin crown restoration.

Key Words: endodontically treated tooth, anatomical post, composite crown



> To optimize the stability of endodontically treated teeth, adhesive procedures at the root canal level and in the coronal portion of the teeth have been advocated.

Introduction

Ensuring the esthetics and functional longevity of endodontically treated posterior teeth can present dentists with complex challenges that, to date, have been addressed using various therapeutic alternatives.[1] Complexities have included loss of pulp vitality, resulting in biomechanical changes that directly affect the elastic modulus and proportional limit of the dentin (e.g., moisture reduction).[2,3] Therefore, to optimize the stability of endodontically treated teeth, as well as the retention of the subsequent restoration, adhesive procedures at the root canal level and in the coronal portion of the teeth have been advocated.[4-8] Such protocols inherently require clinical management to ensure minimal reduction of healthy tooth structure, particularly in areas where the ferrule effect can be achieved.

Unfortunately, it is not uncommon for dentists to encounter clinical situations in which less than half of the coronal tooth structure remains. In such cases, findings by Dietschi and colleagues support the placement of fiber-reinforced composite (FRC) posts to increase the retention surface,[3,4] improve mechanical behavior through adhesive cementation, and reduce the potential for root fractures.[4]

FRC posts, which demonstrate the same mechanical properties as dentin (e.g., elastic modulus),[2,3] have been specifically indicated for the restoration of endodontically treated teeth when remaining coronal tooth structure is insufficient to ensure restoration retention.[4] Although an adhesive protocol can be undertaken with FRC posts, their ability to be conventionally cemented reduces stress around the dentin within the root canal in the apical portion of the tooth. This contributes to survival rates superior to those of metallic restorations, as well as fewer adhesive failures.[5-8]

To improve adaptation of the FRC post to the internal walls of the canal and reduce the likelihood of interphases, an indirect technique for copying the anatomical shape of wide root canals has been employed. According to Gomes and colleagues,[9] the indirect method is ideal for premolars with wide canals, particularly in terms of enhancing adhesive strength. Although similar results have been achieved compared to a direct technique (i.e., 8,8±2,3 y 8,8±2,5 MPa, respectively), better fracture resistance values are observed with the indirect method (1156±229,4N).[9] Adhesive resistance studies by Faria-e-Silva and colleagues employing a push-out test methodology confirmed these findings, showing that FRC posts obtained higher values than those without an anatomical shape.[10]

Overall, the best combination of materials for restoring endodontically treated premolars is an anatomical (i.e., indirect) FRC post and a dual-cure cement with a self-etching adhesive. According to Duc and Krejci, this combination produces lower interphases and failure rates.[11]

Further, for cases in which there is a substantial loss of tooth structure, full-coverage composite crowns have been indicated as long-lasting restorations. Their clinical application is based on improvements to their mechanical and optical properties, which increasingly approximate those of natural teeth.[12] Additionally, indirect full-coverage composite resin restorations are simple to fabricate and are considered an effective option in the posterior region.[13]

However, Burke and Sands believe these restorations should be used as long-term provisionals.[14] Their previous limitations as permanent restorations were due to failure rates and bacterial plaque accumulation over time.[15] Fortunately, developments in polishing materials and instrumentation have facilitated the creation of smooth surfaces, thereby reducing plaque accumulation and contributing to better clinical success rates.[16,17] Surface roughness Ra values of more than 0.2µm produce bacterial colonization,[18] but various studies have shown that different polishing techniques result in roughness values of less than 0.2µm.[19-23]

The following case report describes a conservative, step-by-step technique for rehabilitating an endodontically treated premolar with wide root canals. In particular, the indirect method for creating an anatomical FRC post in combination with a full-coverage composite resin crown restoration is discussed.

Case Report

Initial Appointment

Examination and findings: A 28-year-old male presented with a fractured mesial-occlusal-distal composite resin restoration in tooth #4, with residual decay beneath the restoration. Radiographs were taken, and no apical lesion was observed. The restoration was removed with a probe during the examination. A glass ionomer base was found under the defective composite, along with caries around the interphase of the cavity base **(Figs 1-3)**. Under rubber dam isolation, the glass ionomer and the caries lesion were completely removed until a clean dental substrate was revealed **(Fig 4)** and clear access to the endodontic filling was achieved. Because only half of the coronal tooth structure remained, the decision was made to place an anatomical FRC post created using the indirect method. Due to the patient's financial constraints, an indirect full-coverage composite resin crown restoration was planned.

FRC post: Following partial removal of the endodontic filler **(Figs 5 & 6)**, a silicone impression of the root canal was taken (Panasil Initial Contact X-Light and Panasil Putty Soft, Kettenbach GmbH; Eschenburg, Germany) **(Fig 7)**. Cast models were obtained and isolation liquid (Acryfoil, Laboratorio Farmodental S.A.C.I.; Santiago, Chile) was applied to duplicate the canal anatomy in the FRC post with composite resin **(Fig 8)**. The fiber post selected for this case was D.T. Light-Post Illusion X-RO #3 (RTD Dental; St. Egrève, France). The post was cleaned with 97% alcohol and covered with a thin layer of adhesive (Optibond Solo Plus, Kerr; Orange, CA), then polymerized with an LED curing unit for 60 seconds (Coltolux 4, Coltene/Whaledent; Mahwah NJ) **(Figs 9a-9c)**. After treating the post surface, dentin composite resin (UD4, ENA Hri, Micerium S.p.A.; Genoa, Italy) was placed inside the canal of the cast model, securing the post into position. It was then polymerized for one minute **(Figs 10a-10d)**. A post-curing procedure was performed to increase the monomers' degree of conversion (Lampada Plus,

Figure 1: Preoperative view of tooth #4.

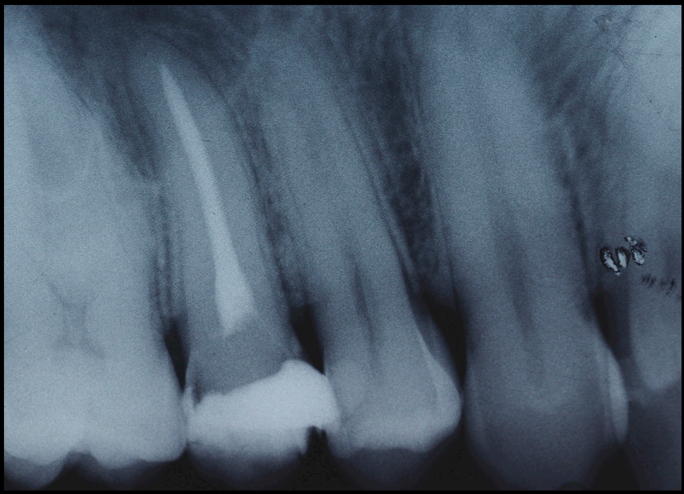


Figure 2: No apical lesion was revealed in the initial radiograph.

Figure 3: The old composite resin restoration was dislodged during the clinical examination, revealing a glass ionomer base and caries.

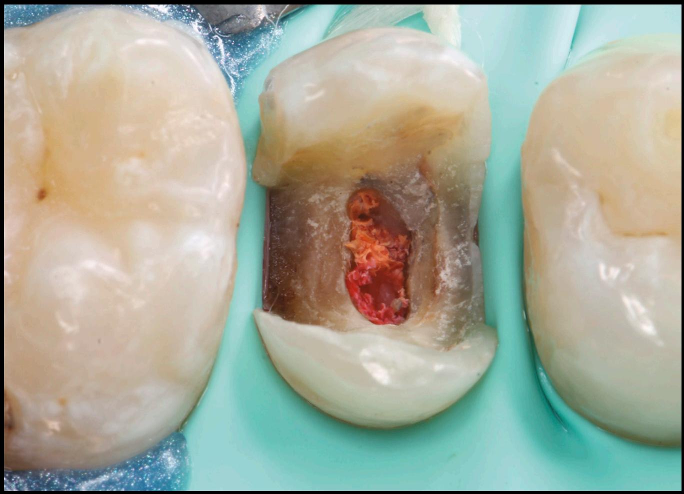


Figure 4: The remaining tooth substrate was cleaned under rubber dam isolation to eliminate all caries lesions, remaining defective composite, and glass ionomer base material.

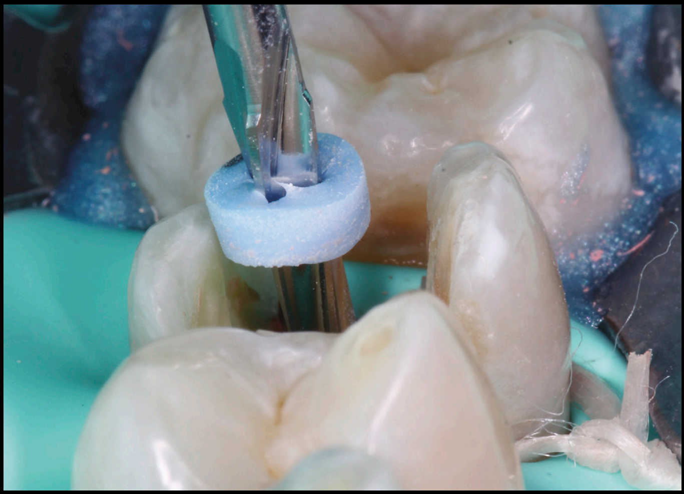


Figure 5: The endodontic filling material was partially removed.

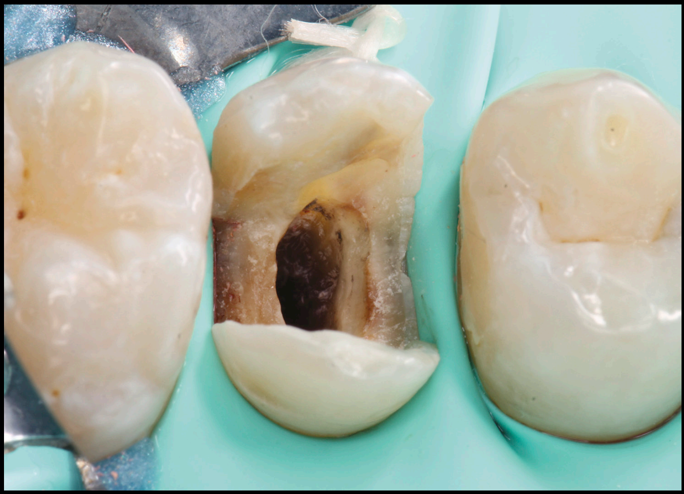


Figure 6: Access to the root canal was achieved after removing the endodontic filling material.

Figure 7: A silicone impression of the root canal was taken.

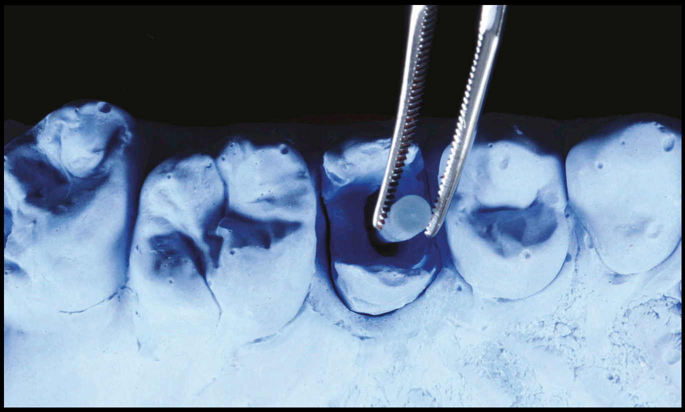
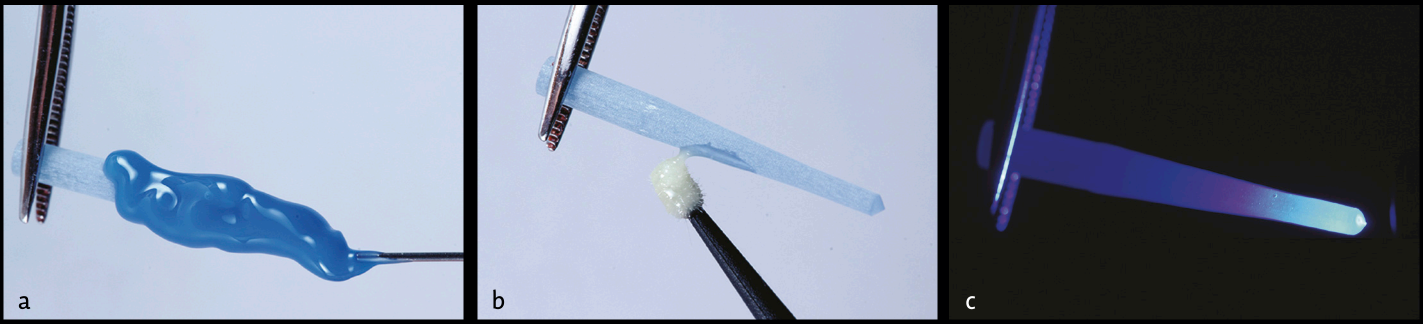
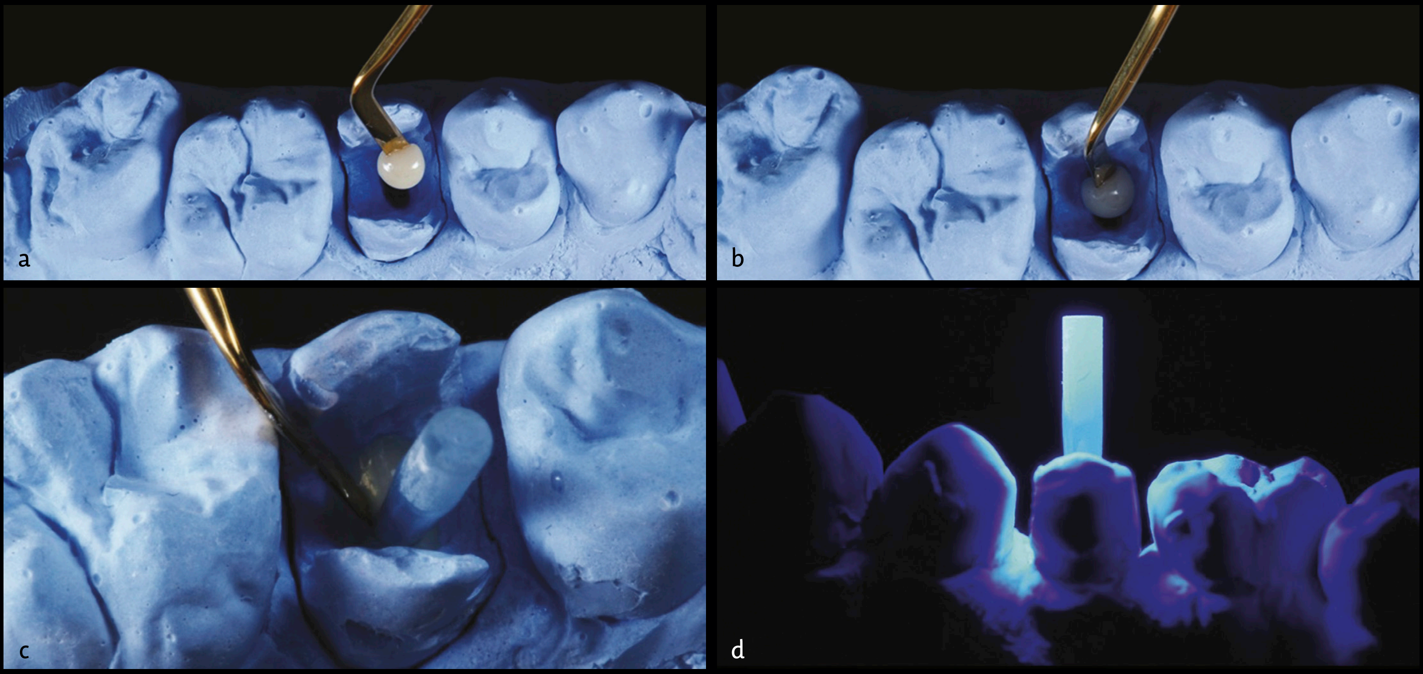


Figure 8: View of the FRC post selection on the cast working model for anatomical contouring with composite resin.



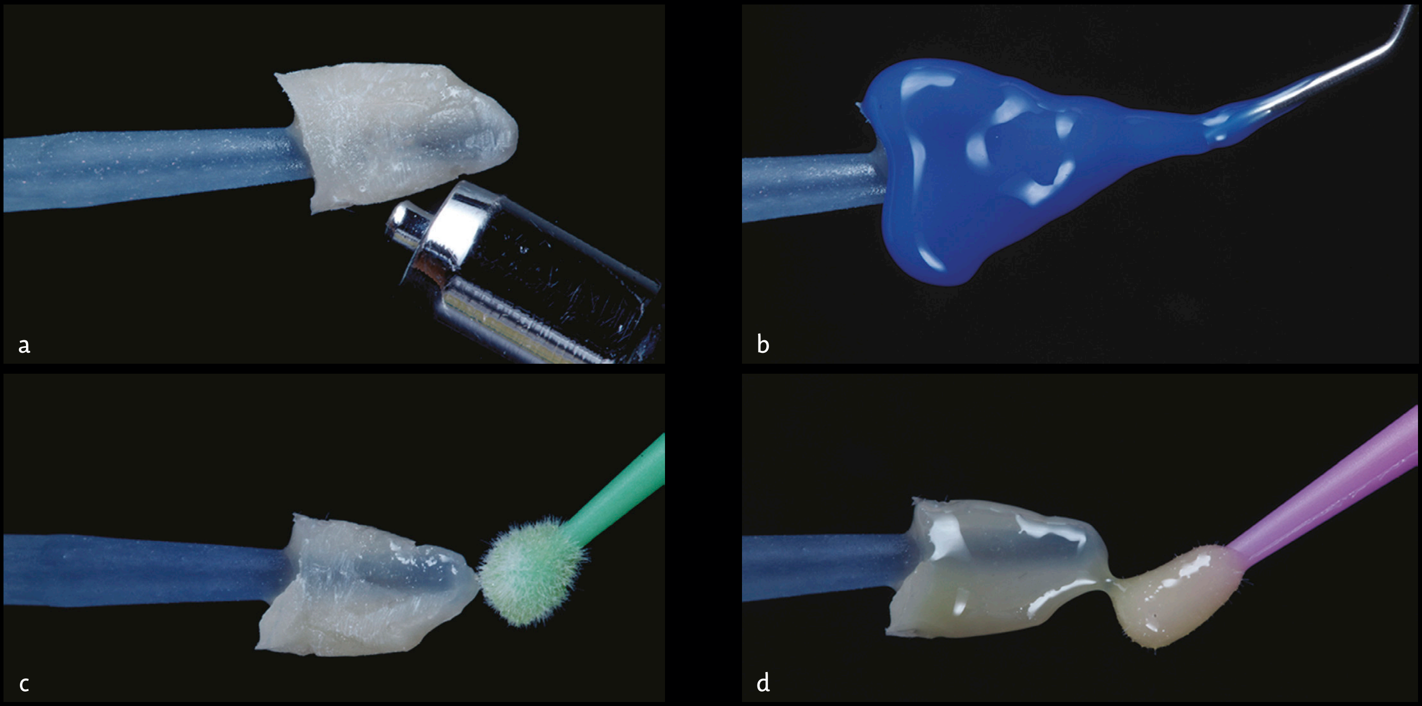
Figures 9a-9c: Surface treatment of the FRC post after cleaning with alcohol. (a) Cleaning with 37% phosphoric acid. (b) Adhesive application. (c) Light-curing of the adhesive.



Figures 10a-10d: After surface treatment of the post, the post was anatomically contoured. (a, b) A small amount of composite resin was placed in the deepest portion of the root canal in the cast model. (c) Correct insertion of the fiber post was determined. (d) The composite resin around the post was light-cured while verifying the post's correct axis.

Figure 11: The anatomical post underwent a post-curing process to increase the monomers' degree of conversion.

Figure 12: The post was inserted to verify fit and evaluate any necessary adjustments.



Figures 13a-13d: Surface treatment of the anatomic post. (a) Sandblasting with 30-μm aluminum oxide. (b) Chemical cleaning with 37% phosphoric acid for 30 seconds. (c) Silane application. (d) Adhesive application.

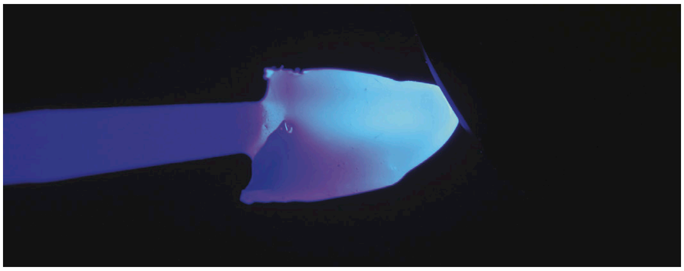
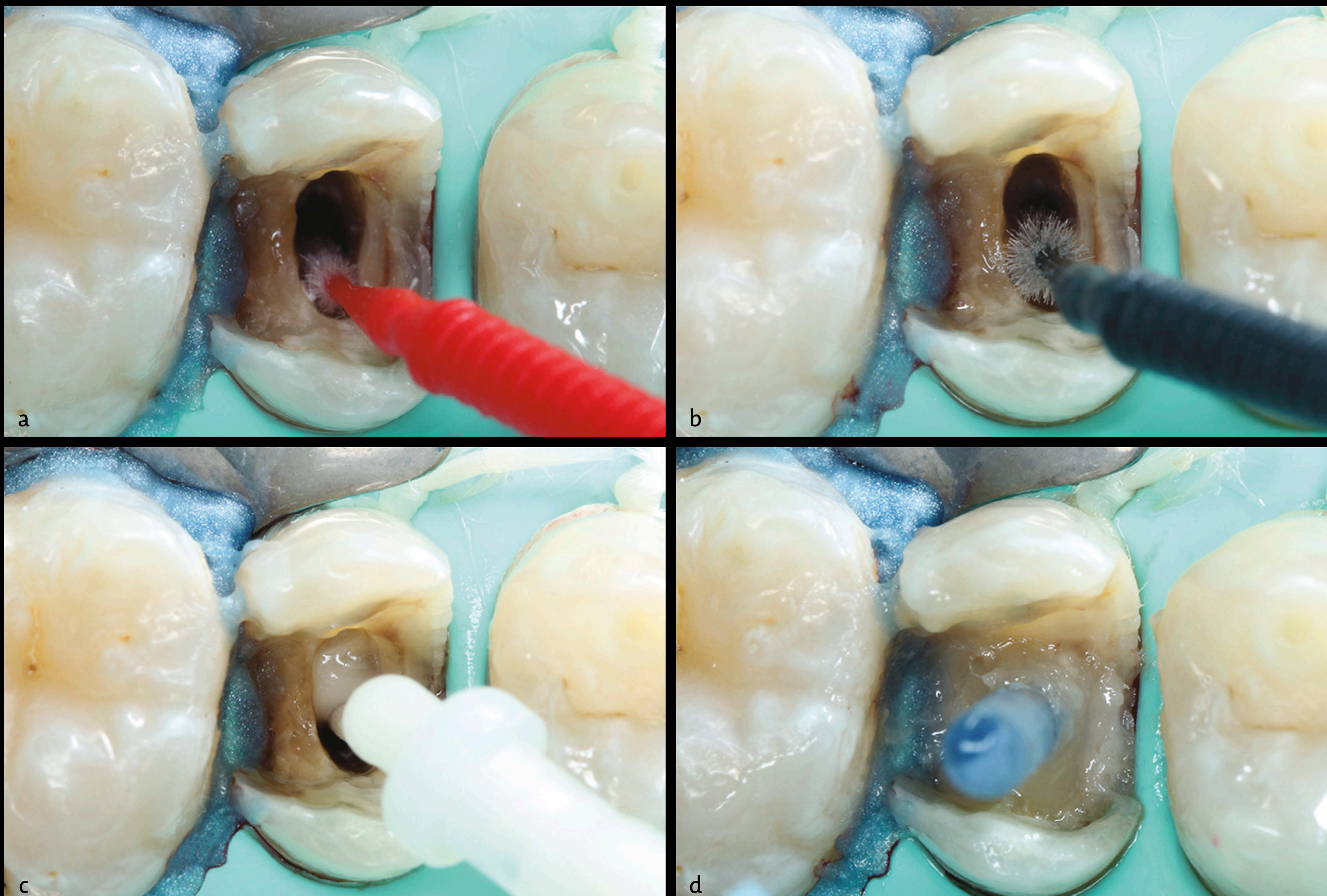


Figure 14: The adhesive layer of the anatomic post was light-cured.

Micerium S.p.A.) **(Fig 11)**. The post was then placed into the root canal intraorally under rubber dam isolation to test fit and stability **(Fig 12)**.

Surface treatment of the anatomical FRC post began by sandblasting with 30-μm aluminum oxide (CoJet Sand, 3M ESPE; St. Paul, MN). The post was then cleaned with 37% phosphoric acid for 30 seconds, after which silane (Monobond S, Ivoclar Vivadent AG; Schaan, Liechtenstein) was applied, followed by a thin layer of bonding adhesive (Optibond FL) **(Figs 13a-14)**.



Figures 15a-15d: Surface treatment of the root canal. (a) Application of a self-etching primer. (b) Application of dual-curing adhesive. (c) Insertion of the resin cement. (d) Insertion and adaptation of the anatomical post.

Cementation: The anatomical FRC post was cemented inside the root canal using a dual-curing, self-etching adhesive core and resin cement (ParaBond and ParaCore, Coltene/Whaledent) under rubber dam isolation. First, a non-rinse conditioner was applied for 30 seconds using an endobrush, after which it was dried with soft air for 2 seconds. Then, a chemically cured two-bottle adhesive was applied by rubbing the canal with a brush for 30 seconds and then air-thinned for 2 seconds. The dual-cure resin cement was loaded into the root canal, taking care to keep the automix tip at the deepest position; it was then slowly withdrawn until the canal was completely filled with cement **(Figs 15a-15d)**. After waiting 60 seconds to ensure complete chemical polymerization, excess cement was removed using a microbrush. Finally, light-curing was performed for 30 seconds according to the manufacturer's instructions.

Bonding and layering: Coronal reconstruction of the tooth was accomplished using a nanohybrid composite resin (ENA Hri) and a metallic matrix band system (Palodent, Dentsply Sirona; Bensheim, Germany) **(Fig 16)**. The build-up procedure was performed using a three-step etch-and-rinse adhesive system **(Figs 17 & 18)** and composite layering technique **(Figs 19 & 20)**. Each composite layer was light-cured for 40 seconds. The FRC post extension was then removed using diamond burs, and occlusal contact points were checked **(Figs 21 & 22)**.

In this particular case, considering the extensive destruction of the tooth substrate, the proximal area cervical margins could have been compromised. Therefore, relocation and elevation of the distal margin was accomplished with composite resin to avoid periodontal surgery and improve tooth preparation.[24-26] This would facilitate impression taking, restoration adjustment, and—with accurate rubber dam positioning—improve adhesive cementation.[27,28]

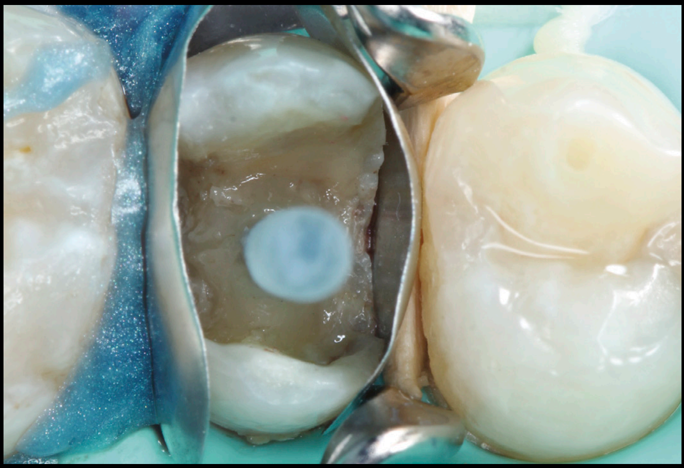


Figure 16: Metallic matrices in the proximal areas were placed to reconstruct the premolar marginal ridges with composite resin.

> Full-coverage composite crowns have been indicated as long-lasting restorations for cases in which there is a substantial loss of tooth structure.

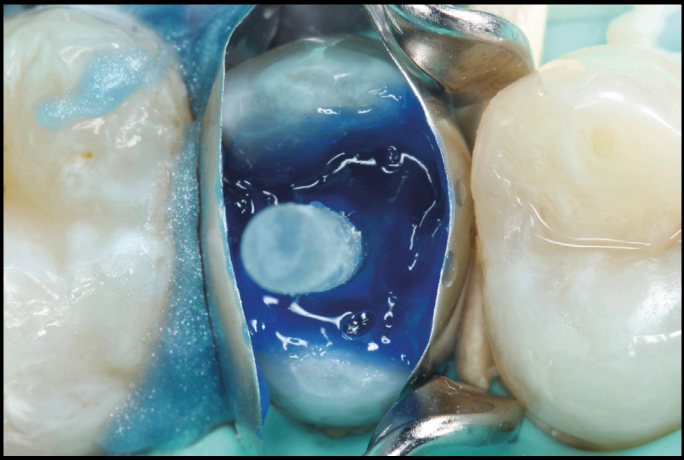


Figure 17: The preparation was etched with 37% phosphoric acid.

Figure 18: The bonding adhesive was applied.

Figure 19: View of the mesial marginal ridge with composite resin.

Figure 20: Composite resin was applied until the total volume of the tooth's coronal aspect was complete. Reconstruction was performed using a composite layering technique.

Figure 21: Layering with composite resin is complete. The occlusal contact points must be checked to maintain periodontal health. Note the correct axis and location of the post.

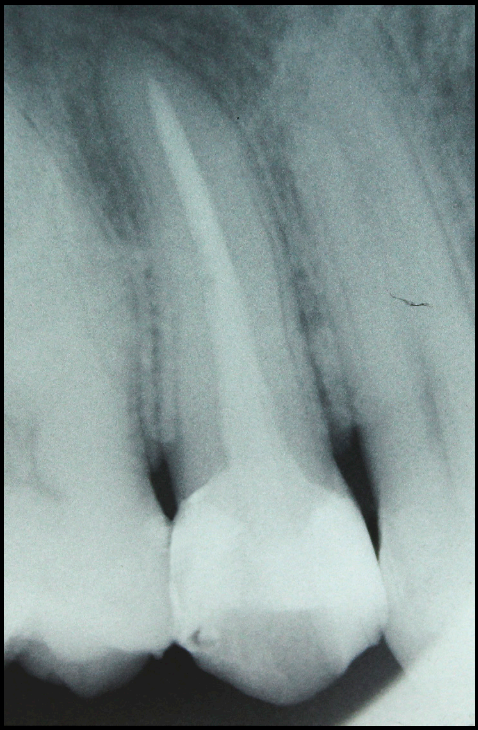


Figure 22: Radiograph following cementation of the anatomical FRC post and reconstruction with composite resin material. A perfect fit of the restoration in the proximal areas can be appreciated.

Second Appointment

Preparation and impressions: During the second appointment, a biological preparation for a single composite crown was performed using diamond burs (850.314.016, Komet/Gebr. Brasseler GmbH & Co.; Lemgo, Germany). Retraction cord was placed to finish the cervical margins of the tooth preparation and facilitate smooth surfaces (8856.FG.021, Komet/Gebr. Brasseler GmbH & Co.) **(Figs 23 & 24)**.

Silicone impressions were made (Panasil Initial Contact X-Light with Panasil Putty Soft), after which the tooth was provisionalized with an acrylic crown placed with temporary cement (TempBond, Kerr). Cast working models were obtained for use in fabricating the full-coverage composite resin crown. A first layer of dentin-like composite resin (UD4) was used, followed by a second layer of enamel-like resin (UE2), until the correct anatomy was achieved **(Figs 25a-25d)**.

Third Appointment

Finalizing the case: During the third appointment, once the provisional restoration was removed the definitive crown restoration was tried in to evaluate necessary adjustments, stability, and occlusion **(Figs 26 & 27)**. After establishing rubber dam isolation, the adjacent teeth were isolated with plumber's tape. The premolar surface was then sandblasted with 30-µm aluminum oxide (CoJet Sand), cleaned with 37% phosphoric acid for 30 seconds, washed with water, and air-dried. A thin layer of adhesive primer (Optibond Fl) was applied to the tooth preparation surface, followed by a layer of adhesive (Optibond Fl) **(Figs 28a-28d)**. No light-curing was performed to facilitate proper insertion of the restoration. The internal surface of the composite crown was first treated by sandblasting with 30-µm aluminum oxide, then rinsed with water and air-dried. Silane coupling agent (Monobond S) was then applied and allowed

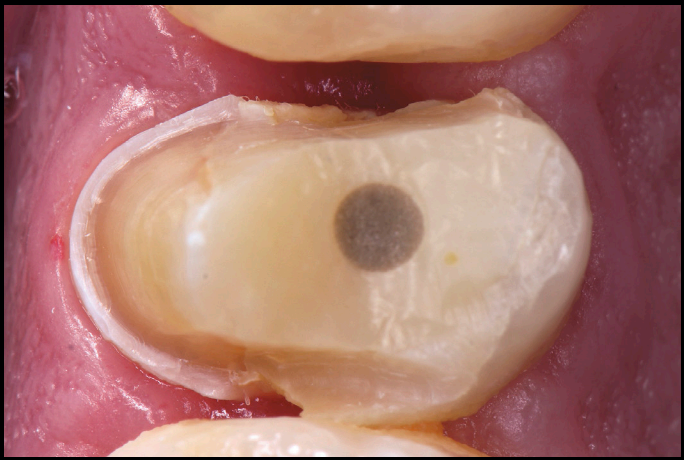
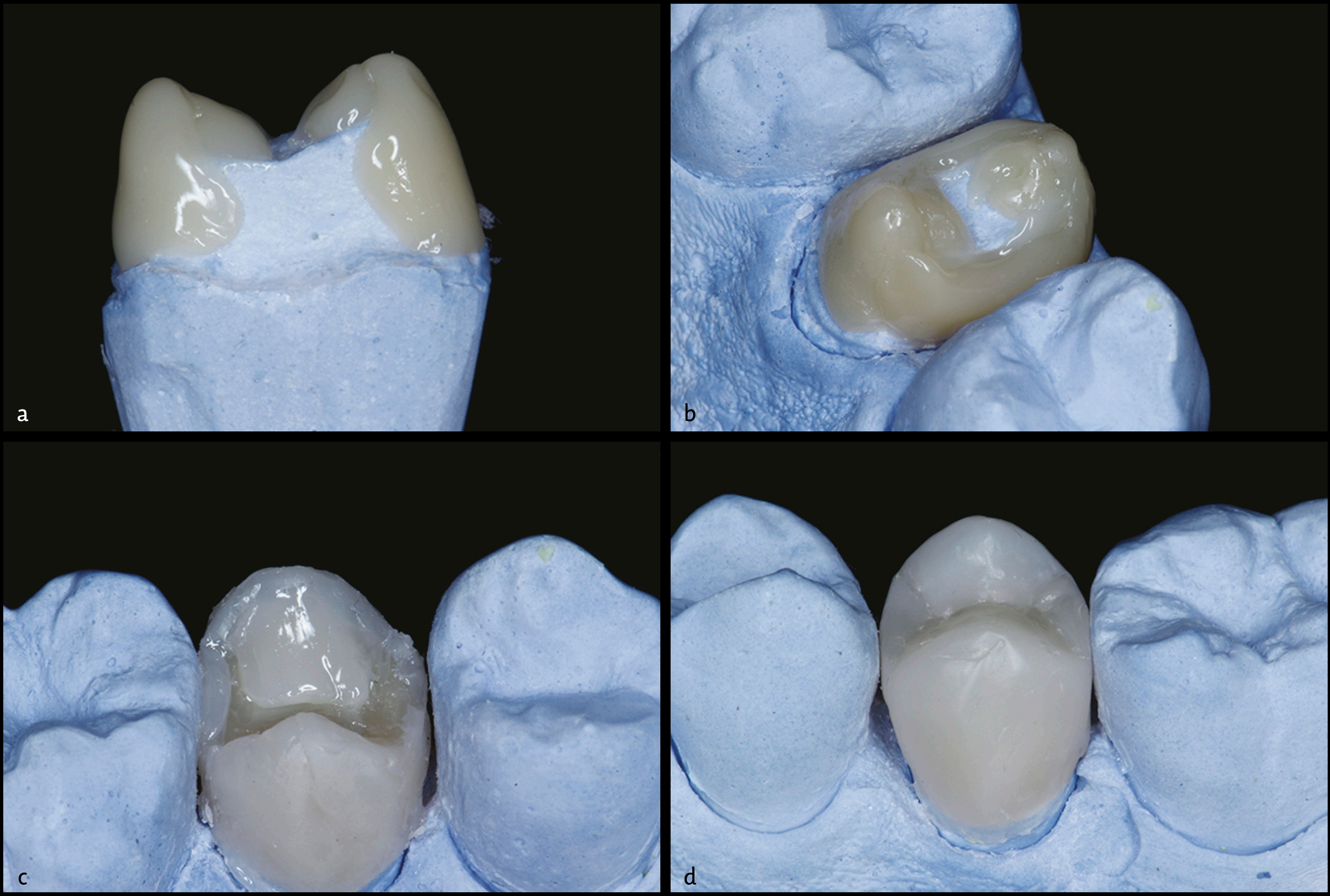


Figure 23: Initial biological tooth preparation performed in the palatal aspect of #4.

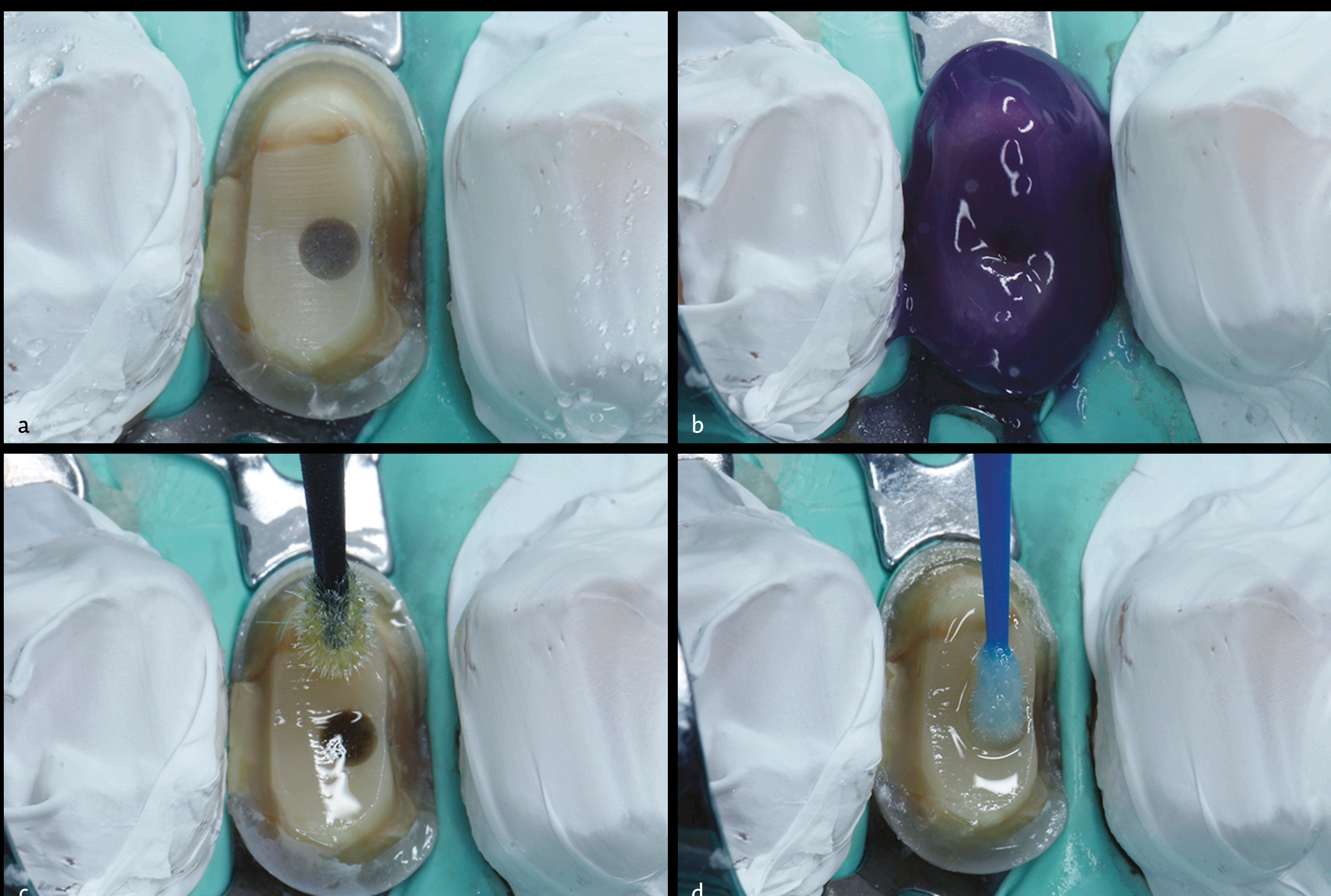
Figure 24: Retraction cord was placed into the sulcus to improve the cervical finishing lines before impression taking.



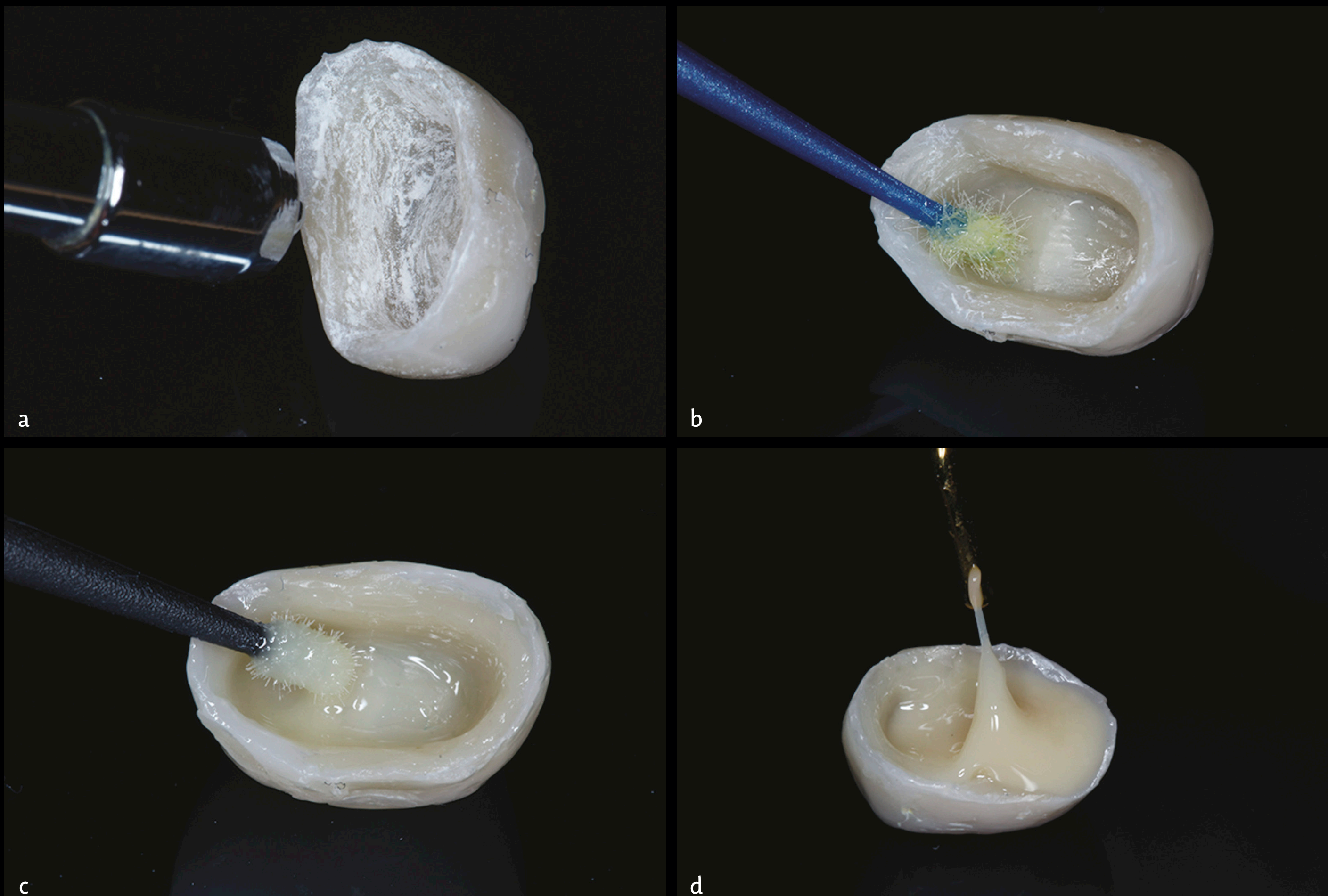
Figures 25a-25d: With a working cast model, the reconstruction with composite resin was performed. (a) Initial layering with dentin-like material. (b) The proximal areas were layered with enamel-like resin material. (c) After the proximal area was complete, the palatal and vestibular aspect were added. (d) A final occlusal sculpting was performed to restore the correct anatomical shape of #4.

Figure 26: The cervical finishing lines were checked to ensure adequate rubber dam isolation.

Figure 27: The composite crown was tried in to verify fit and proximal contact points, and evaluate any necessary adjustments.



Figures 28a-28d: Surface treatment of the core of #4. (a) Surface after sandblasting with 30-μm aluminum oxide. (b) Etching with 35% phosphoric acid. (c) Primer application. (d) Bonding application.



Figures 29a-29d: Surface treatment of the internal surface of the composite crown. (a) Sandblasting with 30-μm aluminum oxide. (b) Silane application. (c) Adhesive application. (d) Preheated composite application into the internal surface of the crown.

Figure 30: Note the viscosity of the preheated composite, which permits correct adaptation of the restoration to the tooth surface and resin.

to sit for 60 seconds. A thin layer of adhesive was applied, after which composite resin (UD4) preheated (ENAHeat) to 59°C was used as a luting agent **(Figs 29a-30)**.

The full-coverage composite resin restoration was placed over the core with slight and constant pressure until it adapted completely. Excess cement was removed and a layer of glycerin gel was applied prior to light-curing for 60 seconds on each side of the tooth, thereby eliminating the oxygen-inhibited layer **(Figs 31 & 32)**.

Figure 31: Occlusal view, immediately after cementation.

Figure 32: Palatal view, immediately after cementation.

Figure 33: Occlusal view, two years postoperative.

Figure 34: Palatal view, two years postoperative.

Summary

Dentistry has evolved considerably since the introduction of resin-based composite materials. The advent of increasingly conservative, minimally invasive procedures allows preservation of tooth structure and maintenance of pulp vitality, thereby increasing the time between restoration cycles.[29-31]

Among such procedures is the use of FRC posts in conjunction with full-coverage composite resin crowns. Anatomically customized FRC posts increase surface retention to the root canal through adhesive bonding, thereby enabling restoration of endodontically treated teeth with severe coronal destruction. Full-coverage composite resin crowns, likewise, can esthetically and functionally resolve issues surrounding an absence of coronal tooth structure and provide a long-term therapeutic solution for patients who cannot afford a metal-free ceramic restoration.

Although the case presented here demonstrates the utility of an indirect anatomical FRC method for a premolar tooth, Alonso and Caserio have demonstrated favorable long-term success rates when applying this technique through direct restoration of anterior teeth.[32]

Overall, potential advantages of the indirect anatomical FRC technique include more conservative procedures, less clinical time, fewer laboratory procedures, transferal of responsibility for the restorations to the clinician, ease of reparability, and lower patient cost. Some disadvantages of the technique include less wear resistance than ceramic restorations,[33] as well as the need for repolishing due to loss of gloss and increasing roughness over time.[34,35] It has been reported that composite crowns without fiberglass reinforcement demonstrate less wear resistance than porcelain-fused-to-metal crowns, but are still clinically acceptable after three years[33] **(Figs 33 & 34)**.

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“Full-coverage composite resin crowns can esthetically and functionally provide a long-term therapeutic solution for patients who cannot afford a metal-free ceramic restoration.”

"CPR" for the Worn Dentition:

from Concept to Prototype to Restoration

Dennis Hartlieb, DDS, AAACD

Abstract

Management of the patient with worn dentition is a challenge faced by many restorative dentists. The etiology of wear appears to be multifactorial and the occurrence of wear cases seems to be increasing. The traditional strategy of employing a preoperative wax-up followed directly by preparing the teeth for definitive restorations means the dentist is not able to test the planned occlusal and esthetic changes until after tooth preparation is completed. Unfortunately, in this scenario, patients may be dissatisfied with irreversible changes in tooth length, form, and contour. This article discusses a treatment technique that employs direct resin bonding in a no-preparation, reversible manner. The direct bonded restorations serve as a prototype, permitting the dentist to work out esthetic, occlusal, functional, and phonetic issues with the patient before the teeth are irreversibly prepared, thus allowing far more predictable definitive restorations. The philosophy of concept to prototype to restoration (or "CPR") enables the restorative dentist to treat the wear patient in a safe, reversible manner. The uses for a prototype restoration and how it differs from a temporary or provisional restoration are addressed, a clinical case is described, and an algorithm for treatment options following prototype bonding is shared.

Key Words: prototype, concept, erosion, wear, transitional bonding

CE CREDIT

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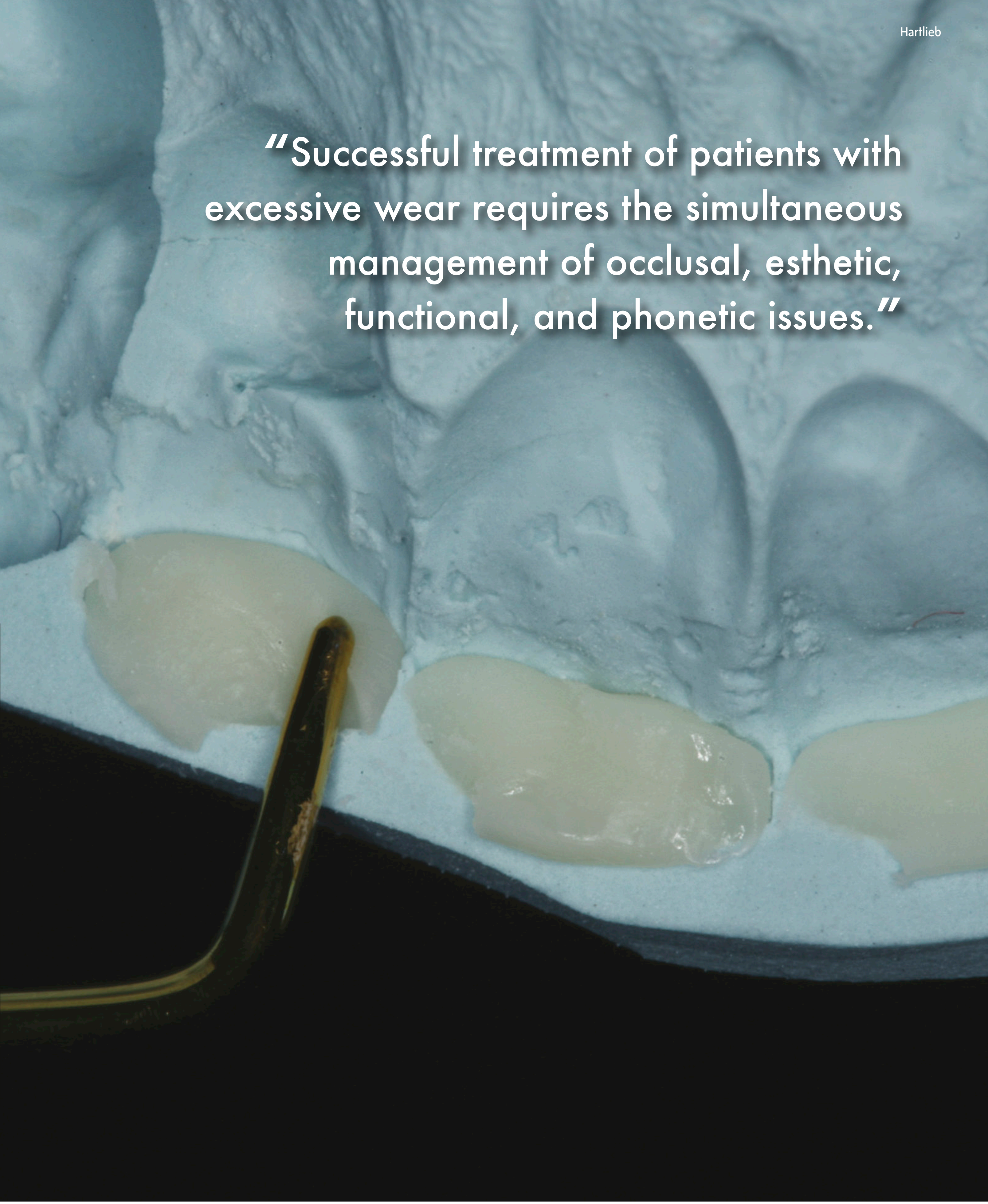
Learning Objectives

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

1. Better understand how to use a direct bonded restoration as a prototype for the final restoration.
2. Define and explore how a prototype restoration differs from a temporary or a provisional restoration.
3. Visualize opportunities presented in minimal- to no-preparation designs in the restoration of occlusal wear cases.



"Successful treatment of patients with excessive wear requires the simultaneous management of occlusal, esthetic, functional, and phonetic issues."

Introduction

Patients often present to dental practices with worn and eroded teeth that require restorative intervention. In fact, the number and severity of these cases seems to be increasing.[1] The etiology of the wear and erosion may be multifactorial, including but not limited to bruxism, highly acidic diets, and gastric acid reflux. Successful treatment of patients with excessive wear requires the simultaneous management of occlusal, esthetic, functional, phonetic, and airway issues. Given the complexity of the treatment to restore such patients, strategies to optimize predictability should be employed.

Traditional Management

Traditional management of the worn dentition case requires a diagnostic wax-up of the appropriate tooth form, maxillary and mandibular incisal edge position, and lingual and occlusal contours. Typically, after the patient and the dentist accept the wax-up, the teeth are prepared for the definitive restorations, impressions of the teeth are made, bite registrations are taken, and provisional restorations are fabricated. It is during the provisional period that the dentist and patient first have an opportunity to evaluate tooth length and form, overjet and overbite, and myriad other issues related to esthetics, function, and phonetics. Some patients may be dissatisfied with the proposed reconstruction but many of their objections also can be modified during the provisional phase. However, once the teeth have been prepared there is no going back; unknowns, such as how the patient will tolerate a change in his or her vertical dimension, cannot be determined until after irreversible preparation has occurred. In an effort to reduce the occurrence of such patient dissatisfaction there has been an emphasis on developing minimally invasive—or even reversible—procedures.

Transitional Bonding

The successful utilization of direct resin as a transitional restorative material has been well documented in recent years.[2-4] This technique, often referred to as *transitional bonding*,[5] can be used to add length to maxillary anterior teeth, open vertical dimension, and make other esthetic and functional changes. With transitional bonding there is an implied sense that there will be a sequence of treatment, from preoperative to transitional to the final definitive dentistry. The challenge the author has seen when treating patients with worn dentition is that the many esthetic, phonetic, occlusal, and functional issues being treated need to be tested during the transitional phase. Therefore, he believes that the term *prototype* is a more accurate descriptor of these “test” restorations.

Prototype Phase

It is critical that prototypes be tested for success and evaluated for possible limitations before the definitive restorations are designed and created. Employing the philosophy of "concept to prototype to restoration" (CPR), the dentist is able to test the provisionals in a safe manner prior to tooth preparation for the definitive restoration.

The information obtained from the development of the prototype is essential for the success of the final product. In dentistry, there is a belief that the laboratory technician’s wax-up (concept) will work successfully for the final crowns or veneers (restoration). Without a prototype phase, the testing of the concept occurs during the definitive restorative phase. Failures, whether esthetic, functional, or phonetic, can be modified only minimally once the definitive restorations are placed. The patient should understand that prototype bonding is to test and evaluate the restorative treatment and that the definitive restorations will be based on the prototypes, dependent on the patient’s satisfaction and approval.

The author’s main objectives during the prototype phase are to:

- involve the patient in treatment decisions
- perform reversible (no or minimal preparation) dentistry
- effect esthetic improvements
- make occlusal changes
- test the planned esthetic and occlusal changes
- modify prototype to achieve patient satisfaction.

Reversibility and Other Advantages

It is the author’s experience that some patients will be dissatisfied with or unable to adapt to the changes effected during the prototype phase. Therefore, it is essential that the treatment be reversible. As a reversible procedure, the prototype bonding can be removed with care, essentially returning the patient to his or her original situation. Knowing that the treatment is reversible can help patients feel more comfortable about proceeding.

Beyond the technique’s reversibility, there are several other advantages of prototype bonding when treating patients with worn dentition. These advantages include the ability to improve dialogue between the patient, the dentist, and the laboratory technician regarding the patient’s esthetic goals. Because the patient is able to fully experience the esthetic and functional changes proposed, he or she is better able to visualize the anticipated definitive restorations. Overjet and overbite, tooth shape and contour, vertical dimension of occlusion (VDO), and the esthetic display of the teeth can be adjusted and modified

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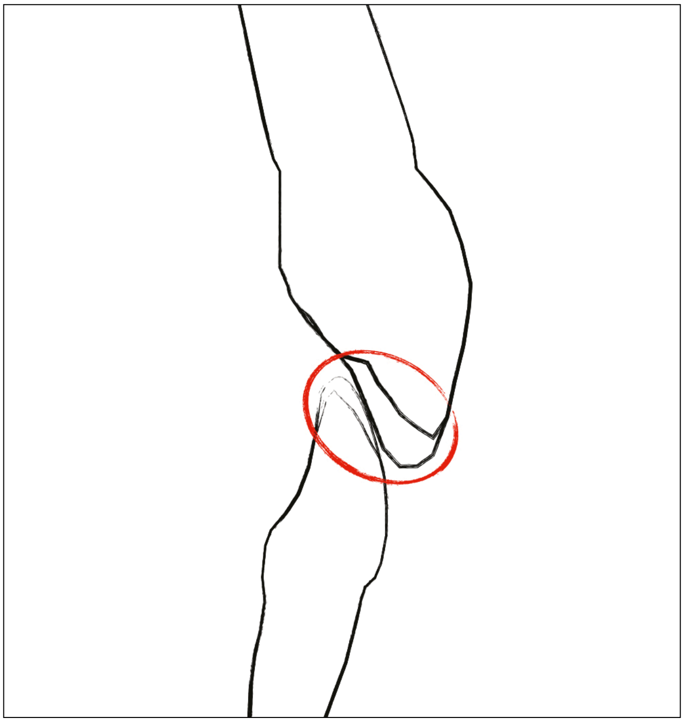

Figure 1: Loss of palatal maxillary anterior tooth structure and facial mandibular anterior tooth structure from wear.

based upon the patient's needs and desires. Limitations of the patient's existing dental situation may help the patient understand the need for additional procedures, such as periodontal crown lengthening, grafting, or orthodontic tooth movement.

Another significant advantage of prototype bonding is its ability to allow for long-term sequencing of the definitive dentistry, given that the prototype bonding has reestablished appropriate occlusal and functional form. Patients with financial constraints can opt for more limited definitive restorative treatment, including single-tooth or quadrant-based dentistry, once the occlusal and esthetic parameters have been created and tested for success. In fact, some patients may determine that the prototype restorations themselves satisfy all of their esthetic and functional needs and decide to maintain these restorations indefinitely.

Finally and critically, prototype bonding allows for decreased treatment time and costs due to predictability in creating the final restorations based on the prototypes. The dental laboratory can utilize an impression (scanned or analog) of the tested and accepted prototype restorations as a guide for the definitive restorations. This replica of the successful prototype restorations reduces the likelihood that remakes will be necessary, thereby also reducing the possibility of patient dissatisfaction.

Limitations

There are several limitations with prototype bonding, as there often are esthetic compromises with no-preparation or minimal preparation bonded restorations. Tooth shine-through is a common esthetic issue when direct resin bonded restorations are placed on teeth that are dark, discolored, or have severe rotations. Prototype bonding also can be monochromatic in nature. Given that the definitive incisal edge position is in question during the initial prototype experience, it is risky to include incisal translucency in the bonding as material may need to be added or length removed for the "ideal" position. Finally, to minimize patients' financial costs, prototype bonding lacks the ultimate surface polish and morphology that is expected with the definitive restorations.

Wear

It is not the intent of this article to delve into the reasons for the significant wear and erosion seen in many patients today. The causes likely are multifactorial; however, there is evidence that suggests the likelihood of a link between airway disturbances and secondary bruxism and gastric reflux.[6,7] Dietary and other individual patient habits also are probable key contributors.

The restorative dentist's challenge when treating the wear patient is to create the space necessary for the teeth to be restored. Due to the compensatory super-eruption of the teeth during the loss of occlusal tooth structure, there typically is a lack of space to create appropriately contoured teeth **(Fig 1)**.[8] Three commonly accepted ways to create the lost restorative space include **(Fig 2)**:

- orthodontic intrusion of the teeth
- seating the condylar joints in centric relation (CR)
- opening the VDO.

Orthodontic Intrusion

Orthodontic intrusion can be used to gain restorative space for both anterior and posterior teeth. For patients with excessive anterior wear and limited posterior wear, intrusion of the maxillary and/or mandibular anterior teeth is an ideal treatment modality **(Fig 3)**.[9,10] Repositioning only the teeth that need restorative treatment can minimize the number of teeth to be restored, thereby reducing the patient's time and monetary costs.

With anterior intrusion, the esthetic parameters are evaluated for gingival margin leveling rather than incisal edge positioning. Intrusion of the maxillary anterior teeth to align the gingival margins will allow for optimally contoured restorations with the appropriate incisal edge positions **(Figs 4 & 5)**. This anterior tooth repositioning maintains the preoperative occlusal situation while allowing for esthetic and functional improvement with the prosthetic enhancement.

Seating Condyles in CR

Seating the condyles in CR often can provide the necessary space for additive dentistry to replace worn tooth structure **(Fig 6)**. If the wear is limited to the anterior dentition, positioning the joints in CR can reduce the number of teeth requiring restorative treatment.[11,12] It is important for the restorative dentist to understand that there are limitations when using CR only as an opportunity to gain restorative space. Seating of the con-

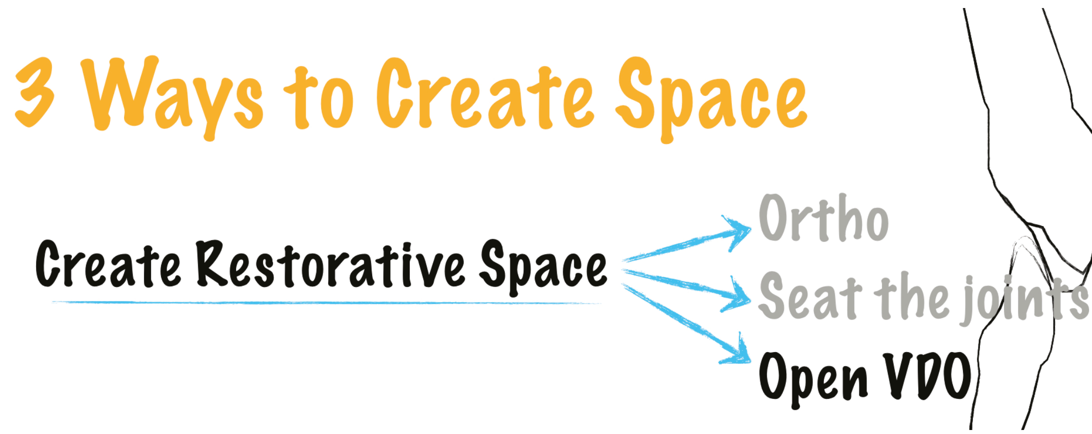

Figure 2: Three treatment options to create restorative space: orthodontics, seating condyles in CR, and opening vertical dimension.

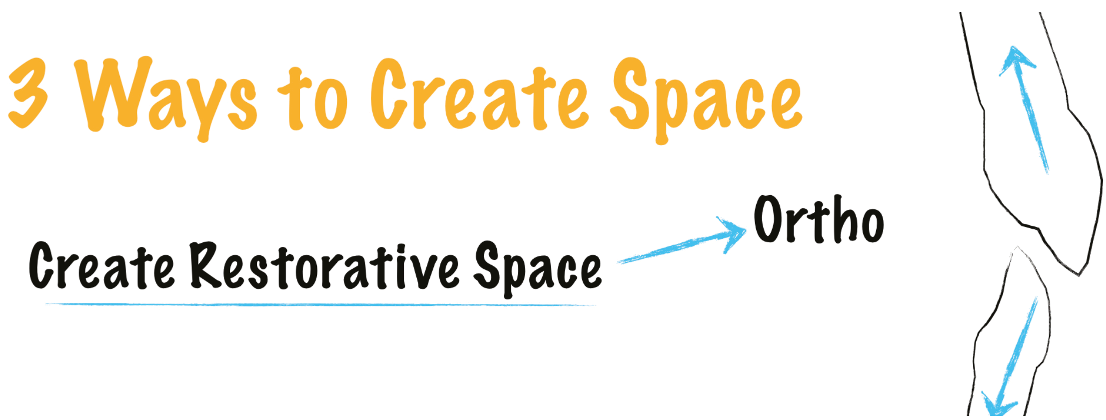

Figure 3: First option for creating restorative space: orthodontic intrusion of anterior teeth.

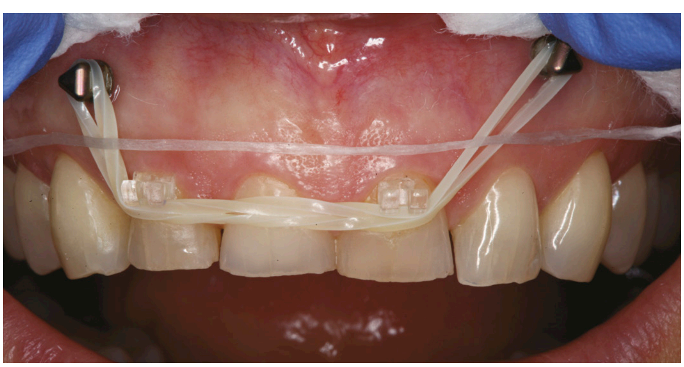

Figure 4: A patient with intrusion of maxillary anterior teeth (retracted view). Floss positioned to demonstrate optimal cementoenamel junction positioning.

Figure 5: Smile view of the patient utilizing temporary implant anchorage devices and orthodontic elastics.

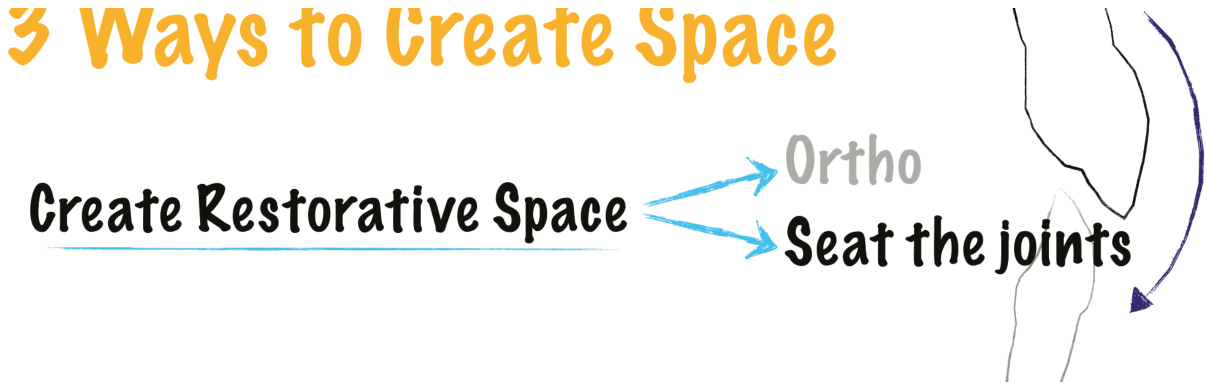

Figure 6: Second option for creating restorative space: seat the condyles in CR.

Figure 7: Retracted image of a patient with teeth in maximum intercuspation (retracted view).

Figure 8: Image of the patient showing the restorative space available with condyles seated in CR utilizing bilateral manipulation technique.

dyles may create anterior space, but if there is posterior wear that needs to be restored seating the condyles in CR often will create initial contacts on the worn posterior teeth. However, if there is an absence of, or minimal posterior wear, utilization of CR may provide sufficient space to restore the worn anterior dentition **(Figs 7 & 8)**. Critically, there exists the possibility that if the reason for the wear and erosion is secondary to airway obstruction issues, seating the joints in CR may cause a decrease in airway patency, potentially creating an increase in airway stress.

Opening VDO

For patients who have both anterior and posterior wear or patients for whom orthodontics may not be an option, it may be necessary to create restorative space by opening the VDO **(Fig 9)**. The principal advantages of increasing the VDO in wear cases are to gain the restorative space necessary to create naturally contoured teeth as well as the ability to manage the occlusal surfaces in one or both arches **(Fig 10)**. Increasing VDO can allow the dentist to better control occlusal forces in functional and parafunctional jaw movements.

Disadvantages: There are several disadvantages to opening the vertical dimension, the most obvious being that it increases the number of teeth to be treated (with subsequent increases in treatment time and costs). In addition, some patients may be sensitive to the changes in their occlusion and find it difficult to adjust to the new vertical dimension. The typical challenge when opening vertical dimension is related to the downward and posterior rotation of the mandible as the vertical dimension is opened. It is important for the restorative dentist to recognize that as the VDO is opened, the mandible does not open only in the vertical axis. The common misconception that there is a straight downward movement of the mandible as VDO is opened is depicted in **Figure 11**. Instead, the condyles are seated superiorly and anteriorly, as there is a rotation of the condyles within the joint space.[12] The

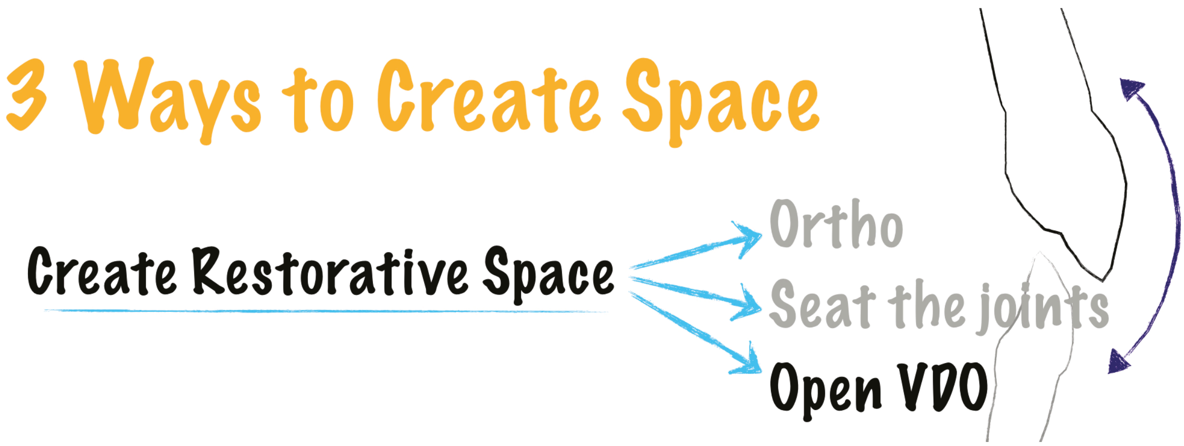

Figure 9: Third option for creating restorative space: increase the VDO.

Figure 10: The patient shown in Figures 7 and 8; restorative buildup of lower anterior teeth with condyles seated in CR.

subsequent rotation of the mandible creates a repositioning of the lower anterior teeth in both the horizontal and vertical axes **(Fig 12)**.

Although opening the vertical dimension can create the necessary space to add to the posterior occlusal surfaces and develop more ideal tooth form for anterior teeth, there might be challenges in gaining anterior guidance, particularly in patients with Class II occlusal skeletal relationships. The lower incisors may need not only to be lengthened, but also broadened buccolingually. Restorative treatment to the palatal of the maxillary anteriors may be necessary to gain occlusal contacts and anterior disclusion. Due to this increase in the anterior teeth overjet, some patients will be unhappy with the new occlusal relationship and real or perceived changes in their facial appearance. Phonetic issues also may occur due to the increased palatal thickness of the maxillary anterior teeth.

With skeletal Class II patients, it may not be possible to gain anterior contacts after opening the vertical dimension. The facial-palatal distance between the maxillary and the mandibular anterior teeth might be too significant to close the space restoratively without creating excessive contour in the restorations **(Figs 13 & 14)**.

Prototype Bonding—Clinical Technique

Patient Complaint and Treatment Options

A 57-year-old male presented at the author's practice for esthetic improvement of his smile. He was displeased with the dark color of his natural teeth and the mismatch of the existing porcelain restorations. Following a clinical examination that included evaluation of the biological and structural health of his teeth, periodontium, and temporormandibular joints, two preliminary treatment options were reviewed with the patient. The first option included orthodontic intrusion of the lower incisors and leveling of the occlusal planes with subsequent restorative treatment (veneering of unesthetic teeth and replacement of existing dentistry). The patient was not willing to consider orthodontic treatment, either through the use of conventional braces or with a removable clear retainer system. The second option, which the patient selected, was to manage the irregular occlusal planes restoratively to create an improved foundation for the proposed esthetic work. The patient was informed that forgoing orthodontics would necessitate compromise in the final treatment and that both dental arches would need treatment with the restorative-based solution, which might not be the case if orthodontics were utilized.

Treatment

Preoperative data: Preoperative study cast impressions and a facebow record were taken for mounting the upper cast to an articulator **(Fig 15)**. Although there is debate over the necessity of employing a facebow for maxillary cast mounting on an articulator, the author favors its use to designate the appropriate facial esthetic plane to set the maxillary cast to the level ho-

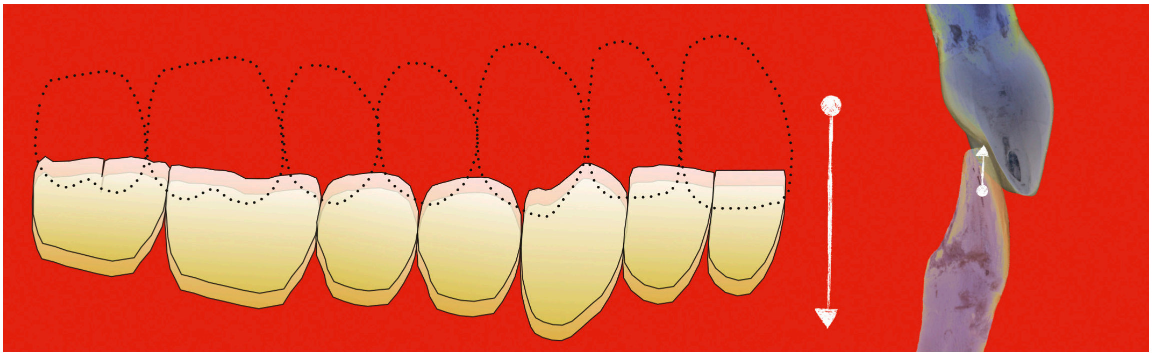

Figure 11: There is a common misconception that there are only vertical changes on anterior bite space with opening of the VDO.

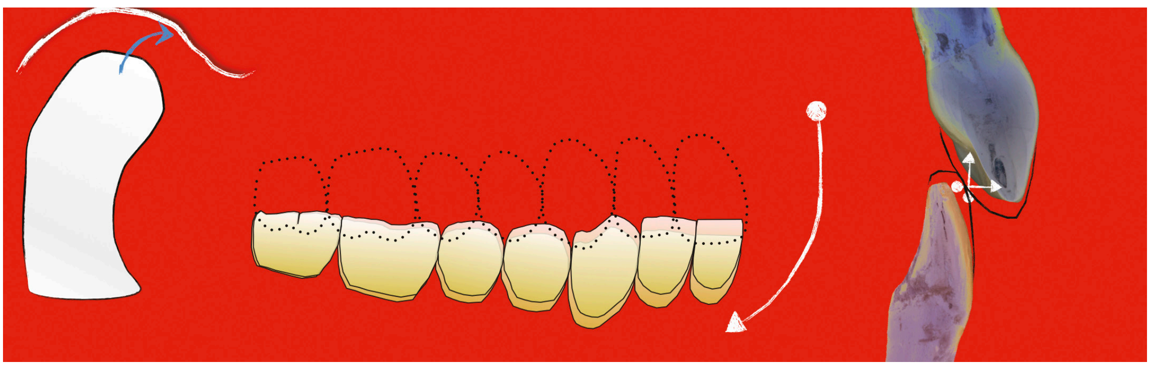

Figure 12: Changes in both horizontal and vertical space witnessed with anterior superior positioning of condyles in increased VDO.

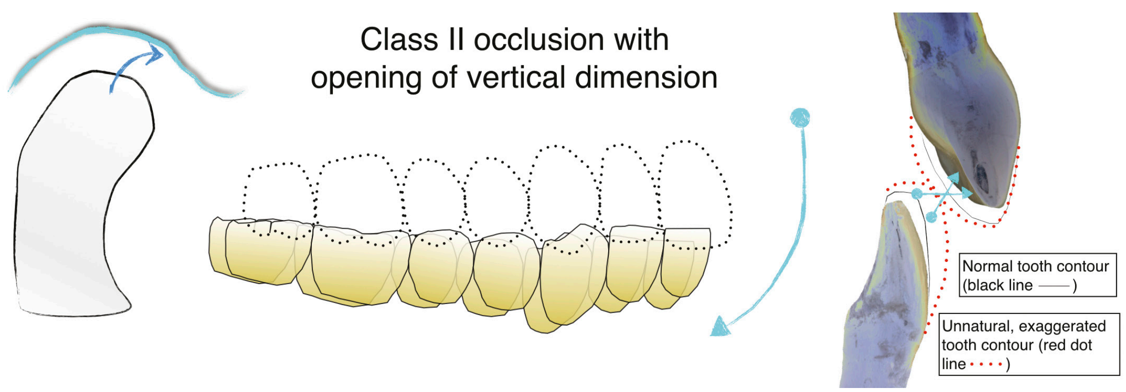

Figure 13: Opening of VDO in skeletal Class II patients.

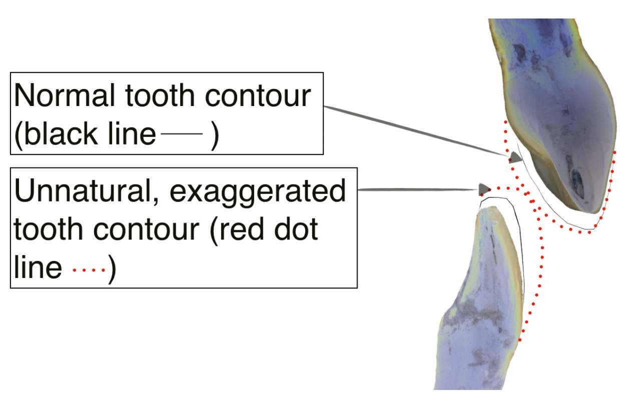

Figure 14: Nonrestorable changes in overjet/overbite jaw relationships in skeletal Class II patients with increased VDO.

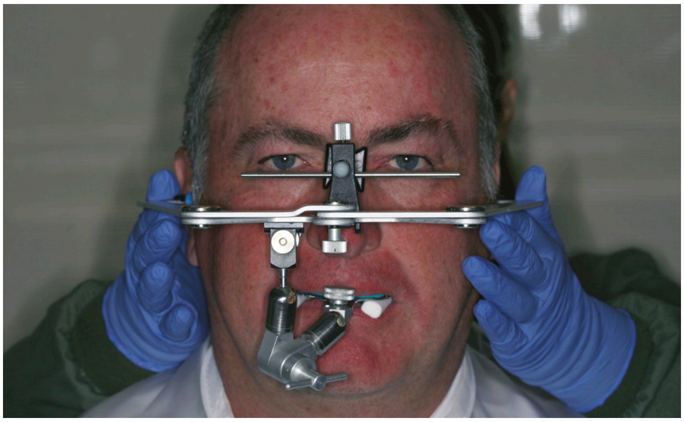

Figure 15: Facebow utilized to register correct maxilla orientation for articulator transfer.

Figure 16: Preoperative image showing canted smile, discolored anterior teeth, inconsistent color development in restorative treatment, and poor occlusal form of lower dentition.

Figure 17: Wax-up of maxillary dentition for patient communication and fabrication of silicone putty matrix guide.

Figure 18: Putty matrix guide in place demonstrating additional length for esthetic development.

rizon.[13,14] Inaccurate recording of the patient's maxilla can lead to canting or midline shifting in the planned restorations. The lower cast was mounted to the upper cast with a CR bite registration. Photographs of the patient with a full smile and with lips in repose were taken for esthetic analysis **(Fig 16)**. A wax-up was created on a duplicate mounted set of casts that properly depicted the desired cosmetic outcome **(Fig 17)**. A polyvinyl siloxane (PVS) guide was fabricated from the model wax-up to use as an intraoral guide when placing the direct resin. Alternatively, a cosmetic "wax-up" can be created digitally and printed; a PVS guide then can be produced from this printed model.

Etching, composite layering, and finishing: The PVS guide was tried in to ensure passive and accurate fit **(Fig 18)**. A line was scribed in the intaglio of the guide detailing the lingual wall of the incisal edges of the teeth to be bonded. The teeth were isolated and micro etched with 50-micron aluminum oxide to remove the pellicle, plaque, and superficial extrinsic staining. In the hope of creating reversible prototype restorations, minimal to no tooth structure was removed. The teeth were etched for 15 seconds with phosphoric acid (if the enamel is unprepared, it should be etched for a full 30 seconds) **(Fig 19)**. A fifth-generation dentinal adhesive was placed per manufacturer's recommendations **(Fig 20)** and polymerized. If the extent of the wear is so excessive that there is minimal enamel remaining, a self-etch or selective etch protocol would be appropriate for the adhesive phase of treatment.

Prior to positioning the PVS guide, a nanohybrid composite was placed into the guide, being sure to bring the material to the scribed line and filling the incisal lingual portion of the guide completely **(Figs 21 & 22)**. The composite was lightly condensed into the matrix to ensure that there were no voids or underfilled areas. It is critical that separation between the teeth be maintained when placing composite in the PVS

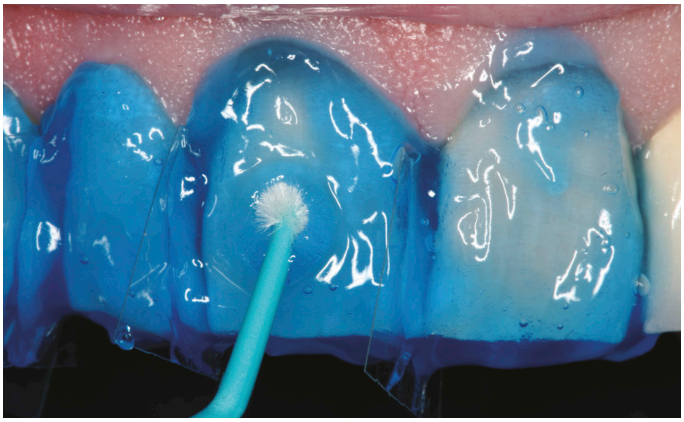

Figure 19: Application of 37% phosphoric acid for 30 seconds to unprepared tooth structure.

Figure 20: Bonding adhesive placed on etched, but unprepared, natural dentition.

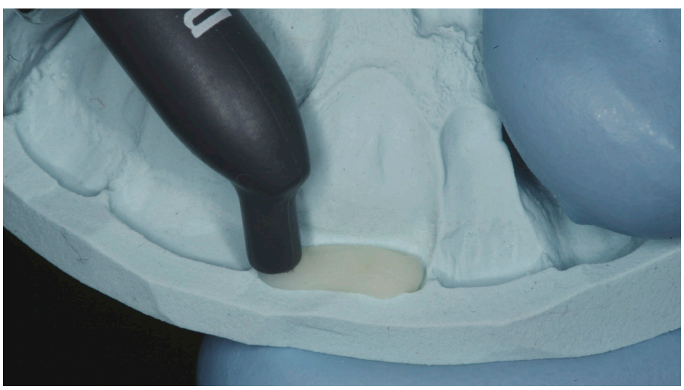

Figure 21: Nanofilled composite placed into putty matrix.

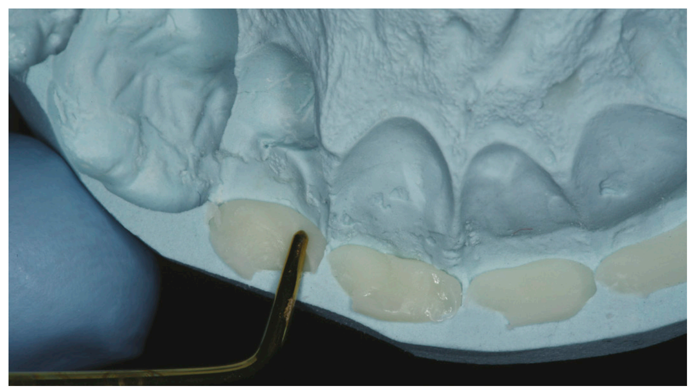

Figure 22: Manipulation of nanofilled composite in putty matrix, creating separation between individual teeth.

guide. The guide was set aside and protected from light while the same shade of composite was placed and blended on the teeth to be restored. The composite was placed on each tooth and left uncured, being sure to maintain separation between each tooth **(Fig 23)**. The PVS guide was placed into position, with great care taken not to apply too much pressure so as not to distort the putty guide or force excess composite into the lingual or palatal potion of the matrix **(Fig 24)**.

A thin composite instrument was used to create separation between the composite on each of the teeth prior to curing. The composite was cured from the facial surface of each tooth for 10 seconds **(Fig 25)**. The putty matrix was gently removed, revealing the lingual wall and the incisal facial line angle created from the matrix **(Fig 26)**. Working one tooth at a time, additional layers of nanohybrid composite were placed to create the optimal facial contours **(Fig 27)**. The composite should be slightly overbuilt to allow for final contouring and polishing. Following the buildup and polymerization of each prototype tooth, the proximal walls were polished to a high finish. Polishing of the proximal composite walls allows for direct composite placement without the fear of bonding each tooth to the adjacent teeth.

Once all the teeth in the arch were bonded, contouring and polishing was completed utilizing carbide composite trimming burs, discs and rubber polishing wheels, cups and points **(Fig 28)**. The occlusion was evaluated and adjusted for appropriate tooth contacts in CR and disclusion in anterior and lateral protrusive jaw movements. The prototype bonding was evaluated for smile esthetics, phonetics and "feel" **(Fig 29)**.

Managing occlusal forces: To manage a patient's occlusal forces in both centric contacts and functional excursions, it also may be necessary to utilize prototype bonding on the opposing arch. To flatten this patient's "stepped" occlusal plane, direct resin was bonded to the facial aspects of the mandibular

Figure 23: Addition of nanofilled composite to incisal edges of teeth to be restored for prototype bonding.

Figure 24: Seating of putty matrix guide, combining the composite from the guide to the composite placed on the incisal edges of the teeth.

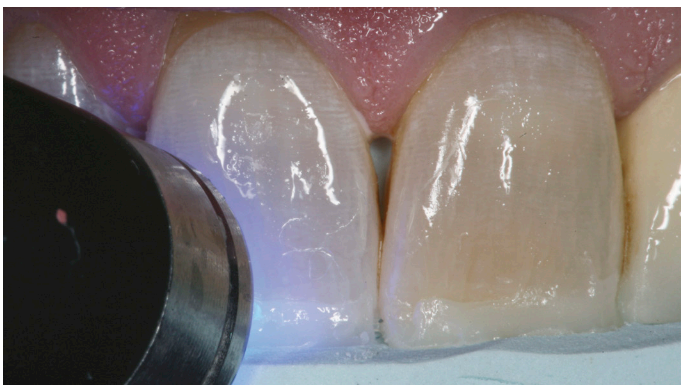

Figure 25: Polymerization of the nanofilled composite with putty matrix in place.

Figure 26: Putty matrix lifted following light-curing of composite, demonstrating additional tooth length.

Figure 27: Nanofilled composite added to facial of individual teeth to block out discoloration of natural teeth and to create proper shape and contour for final esthetics.

Figure 28: Contouring of composite bonding with esthetic trimming bur.

Figure 29: Prototype bonding complete, resurfacing natural tooth structure and existing dentistry to create a pleasing smile and appropriate function and occlusion.

incisors and the buccal cusps of all mandibular posterior teeth. This facial addition of material to the mandibular incisors created additional posterior occlusal space to allow for direct resin additive dentistry to support the increased VDO **(Figs 30-32)**. Occlusal and esthetic adjustments were made as needed and the patient was monitored for several months, evaluating for prototype success.

Adjustments: Mobility of teeth, chipping or failure of the bonded restorations, or heightened tooth sensitivity should alert both patient and dentist to functional disharmonies, parafunctional habits such as bruxism, or destructive patient behaviors. Adjustments and modifications of tooth shape and length, plus occlusal modifications, should be made until occlusal stability is attained and the patient is satisfied with tooth length, shape, and contour.

Options after prototype phase: Following the evaluation period, the patient can choose from three options **(Fig 33)**. First, he or she can choose to maintain the prototype bonding indefinitely. The challenge with maintaining the prototype bonding, as described earlier, is that there are drawbacks to its esthetic qualities, including shine-through of the unprepared tooth structure, lack of natural incisal translucency, monochromacity of the restorative material, and limitation of the final polish of the composite **(Fig 29)**. The advantages of maintaining the prototypes are an obvious decrease in treatment costs and no irreversible tooth structure loss due to preparation.

There are two restorative options following the prototype phase. The first of these is to resurface the prototype bonding with a layered composite veneer approach utilizing opaquers, tints, and microfills for ultimate esthetics and polish. In this option, the facial aspects of the teeth are prepared ideally, leaving the nanofill lingual wall that was created for the prototype phase. The advantage of '"resurfacing" is that the functional contours of the lingual wall and incisal edge position established during the prototype phase are maintained and only the esthetic issues related to color, opacity, and translucency are recreated with more highly esthetic materials.

The second restorative option for the prototype restorations (the option chosen by the patient in this case) is to eventually transition to porcelain, either as veneers, veneer onlays, or full-coverage crowns. It is critical that the functional components (i.e., lingual contours, incisal edge position, and facial contours) be reproduced with the provisionals and, ultimately, the definitive porcelain restorations. Typically, the prototype bonding will serve as a buildup restoration, allowing ideal preparation design for the porcelain restorations. Because the prototype bonding depicts the desired facial contour and incisal edge length, depth cuts can be made through it to help ensure adequate, but not excessive, tooth preparation **(Figs 34-36)**. In the present case, the prototype bonding on the lower arch served to create more ideal occlusal form and the ability to create a bite relationship where centric relation is in harmony with the patient's maximum intercuspation (MIP). This CR/MIP harmony allowed for more predictable bite registrations at the impression appointment, as the author was able to guide the patient into his natural and stable occlusal interdigitation **(Fig 37)**.

The laboratory technician was able to utilize the casts of the prototype bonding as guides for creation of the appropriate length and contour in the desired final restorations. There should be a seamless transition from the proven prototypes to the definitive restorations, provided the dentist supplies the technician with a cast or digitized impression of the prototypes and the technician methodically follows the shape and contour thus dictated **(Figs 38 & 39)**. As occurred in this case, the author has often experienced patients choosing to maintain the prototype bonding on less esthetic areas of the mouth in order to minimize costs **(Figs 40 & 41)**. This patient elected to maintain the prototype bonding on the lower dentition and will transition to definitive porcelain restorations when the prototypes demonstrate signs of breakdown. The prototype bonding has maintained well over the four years since treatment was completed without composite chipping or breakage, with minimal wear observed **(Fig 42)**.

> "Knowing that the treatment is reversible can help patients feel more comfortable about proceeding."

Figure 30: Prototype bonding on facial aspect of lower anteriors to open vertical dimension, allowing addition to mandibular posteriors to flatten “stepped” occlusal table.

Figure 31: Prototype bonding on buccal cusps of mandibular posterior dentition to flatten “stepped” occlusal plane.

Figure 32: Prototype bonding complete on lower arch.

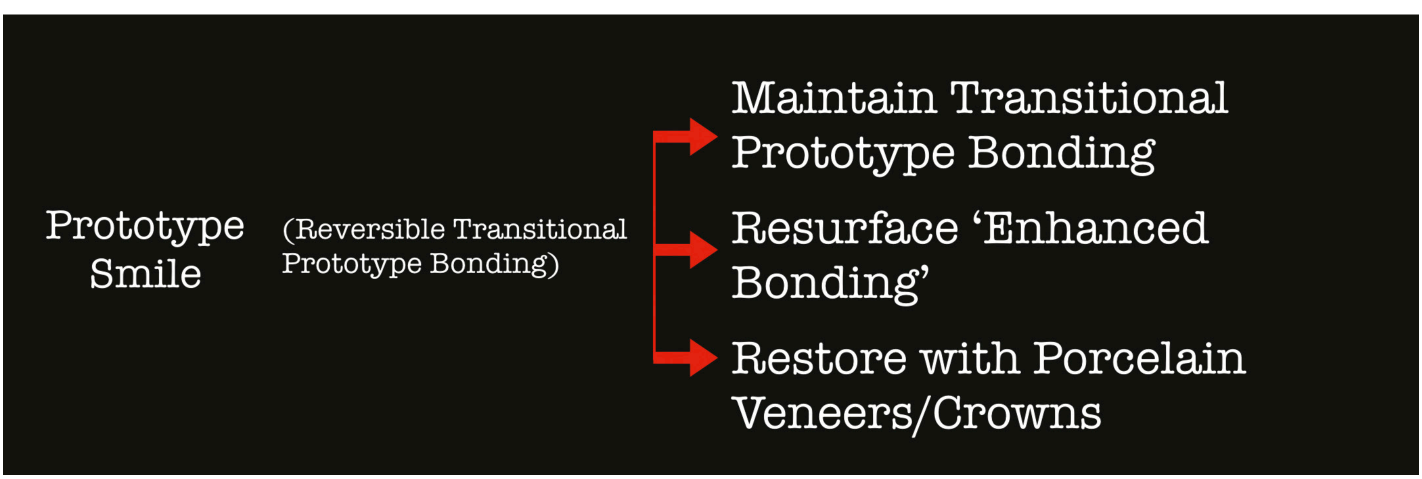

Figure 33: Algorithm to determine treatment options following successful prototype trial period.

Figure 34: Depth cuts in prototype bonding for idealized preparation of porcelain veneers.

Figure 35 Finalized porcelain veneer preparations based on facial and incisal form of the prototype bonding.

Figure 36: Final maxillary preparations based on the prototype bonding.

Figure 37: Bite registration for mounting case for definitive restorations. With the patient's CR bite coincident with MIP, bite registration becomes more predictable.

Figure 38: Final porcelain restorations bonded in place, following shape and form of tested prototype bonding.

Figure 39: Occlusal view of final porcelain restorations bonded in place, following shape and form of tested prototype bonding.

"...some patients may determine that the prototype restorations themselves satisfy all of their esthetic and functional needs and decide to maintain these restorations indefinitely."

Figure 40: Retracted frontal view of final porcelain restorations demonstrating prototype bonding in place on lower arch supporting restored maxillary dentition.

Figure 41: Retracted left lateral view of final porcelain restorations demonstrating prototype bonding in place on lower arch supporting restored maxillary dentition.

Figure 42: Retracted frontal view, four years postoperative.

HELPFUL HINTS

Perfecting Esthetic Prototype Techniques

Significant to a dentist's ability to create esthetic prototypes is refining their skills in first developing tooth shape and contour, then tooth color and intrinsic characteristics to create natural-looking restorations.

Splint Therapy During Prototype Phase

It is important for patients to understand the implications of their clenching/grinding issues. Therefore, unless patients are already committed to wearing an appliance, the author typically does not have patients wear any nighttime protective guard during this treatment phase.

Bonding to Existing Porcelain Restorations

Additional adhesive protocol is required when bonding to existing porcelain restorations. Similar to natural dentition, the restorations in this case were micro-etched, after which a 9.5% hydrofluoric acid was applied for 3 minutes. Silane and bonding adhesive were then applied prior to loading the composite resin.

Recognize the Value of Prototype Bonding

Many patients decide to maintain their prototype bonding and not proceed with more refined dental treatment. To motivate patients to continue with a more esthetic and/or durable restoration, the author applies a portion of the fee paid for the prototype bonding toward the cost of the definitive treatment.

Summary

There are several issues—including esthetic, occlusal, functional, phonetic, and airway—that must be addressed when treating the patient with worn dentition. The traditional strategy of utilizing a preoperative wax-up without testing the planned occlusal and esthetic changes is subject to many challenges, the obvious being that once the teeth have been prepared for a specific type of treatment, the dentist and patient are committed to following through with that particular treatment. Also, because testing is completed during the definitive treatment phase, there is little opportunity for any needed changes to the planned treatment. With the "CPR" method—concept to prototype to restoration—utilizing direct resin as a prototype material in a no-preparation technique, composite can be bonded to the unprepared tooth structure to define the desired incisal edge positions and the occlusal, lingual, and facial contours. The patient therefore is able to function with this prototype bonding for months to be certain they are satisfied with their speech and esthetics; and the dentist can monitor the bonded teeth for composite chipping or tooth mobility that would signify that the functional contours are inappropriate. When both patient and dentist are satisfied with the esthetic, phonetic, and functional characteristics of the prototype bonding it can be maintained indefinitely, resurfaced with a more esthetic composite layering technique, or eventually transitioned to porcelain restorations.

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"The restorative dentist's challenge when treating the wear patient is to create the space necessary for the teeth to be restored."

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1. Using the author's concepts, direct bonded restorations allow the dentist to work out

a. occlusal, functional, phonetic, and retentive issues.
b. functional, phonetic, retentive, and esthetic issues.
c. phonetic, retentive, and esthetic issues.
d. esthetic, occlusal, functional, and phonetic issues.

2. The benefit of the restorative philosophy of concept to prototype to definitive restoration is that

a. it allows for a prototype to be developed which, once refined, is irreversible.
b. it provides a safe but irreversible opportunity for treatment of occlusal wear.
c. it utilizes direct resin bonding in a gross preparation with irreversible technique.
d. it allows for a safe, reversible, and precise restorative opportunity.

3. Treatment of patients with excessive occlusal wear with prototypes requires

a. co-management of occlusal, esthetic, and retentive issues.
b. utilization of strategies to optimize restorative predictability.
c. exclusive co-management of occlusal and phonetic issues.
d. management of individual retentive issues while utilizing multiple strategies for clinical success.

4. Prototype restorations

a. should be tested for success and evaluated for possible limitations.
b. can provide verification that the preparations made are both retentive and provide adequate reduction.
c. should be checked for accuracy of phonetic and occlusal issues once reduced adequately for the final restorations.
d. in most cases are functionally inadequate when used for more than three or four weeks.

5. The author's main objective during the prototype phase of treatment is to

a. get an accurate final cosmetic evaluation.
b. maintain an accurate transfer of the wax-up.
c. retain the reversibility of care.
d. retain the prototype restorations.

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