Biomimetic Posterior Cast Dentistry:

Preserve and Replicate the Intact Tooth – Part 1

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by Dr. Randall G. Cohen
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Educational objectives:

Upon completion of this course, participants should be able to achieve the following:

1. Be able to describe biomimetic dentistry and to list the six main aspects of the clinical protocol
2. Understand how biomimetic cast restorations differ from full-coverage porcelain-to-metal crowns
3. Describe effective caries removal and disinfection
4. Explain the symptoms of dental crack syndrome and how dentin cracks will affect the clinical outcome
5. Describe how dental restorations fail, and to plan for that possibility
6. Describe how self-etch adhesives differ from total-etch products and how each creates the resin-dentin bond

Introduction

In restoring teeth biomimetically, the clinician's goal is to restore the tooth so that it will accommodate functional forces in a similar way as would an intact tooth. The objectives of biomimetic dentistry are enumerated as follows:

1. Eliminating infections and cracks in dentin
2. Immediately sealing dentin
3. Bonding the tooth side-to-side, front-to-back, and top-to bottom to prevent re-infection and new crack initiation
4. Lowering stress/strain in the tooth/restoration
5. Resisting loss of tooth structure from attrition, abrasion, erosion and abfaction
6. Marching the tooth's natural anatomy

The movement of dental restorative treatment toward conserving natural tooth structure represents an advance within dentistry because it often eliminates not only post-operative sensitivity but also the gradual catastrophic failure of aggressive dental treatments. Accordingly, the concept of biomimetic dentistry has emerged in response to the substantial loss of tooth structure and function of the 360-degree crown preparations that have long been the mainstay of clinical practice. Biomimetic restorations use dental materials that have physical properties similar to the intact tooth replacing what has been taken away. Such restorations are hard on the top (replicating enamel) and softer on the bottom (replicating dentin) with a "soft zone" (replicating the DEJ), creating a harmoniously functioning, durable restoration. "The Biomimetic principle, that is the idea that the intact tooth…is the guide to reconstruction,

The author would like to thank David S. Alleman, DDS (Director, Alleman-Deliperi Center for Biomimetic Dentistry) for his contribution.

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is in sharp contrast to the porcelain-fused-to-metal technique, in which the metal casting with its high elastic modulus makes the underlying dentin hypo-functional."[1] Full crown restorations that have been routine in most dental practices for decades have been noted as the least desirable treatment option.[2]

Advantages of Adhesive Dentistry

Improvements in materials science have developed adhesive systems, which eliminate the need to create preparations that rely on the frictional fit of a geometric prep design and can destroy the integrity of the tooth. Such adhesive systems that are effective on both enamel and dentin will predictably produce highly aesthetic, durable, and functional results when the correct protocol for use is followed. In addition, biomimetic dental treatment strengthens the tooth, protects the dental pulp and avoids periodontal disease secondary to subgingival crown restorations.

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The clinical aspect of adhesive dentistry is also simplified, making for an easier experience for both doctor and patient. Creating the biobase (buildup), preparing, impression making and cementing phases of treatment are easier by supragingival margins that eliminate the complications of tissue bleeding. Often, provisional castings are not needed, and teeth that might have required crown-lengthening surgery for full crowns can often be managed without invasive periodontics.

But creating dental restorations that are not only bonded but that will stay bonded requires a strong knowledge of current adhesive technology. Unfortunately, practicing dentists are confronted with a mass of raw information that is neither sorted nor put into a hierarchy, and is often contradictory. Accordingly, adhesive dentistry still requires sophisticated procedures which are highly operator dependent. The high quality results with adhesive techniques justify the special effort required.[3]

Clinical experience plays an important role in successful outcomes, but it is vital that procedural steps be based on valid scientific inquiry. Therefore, a scientifically based protocol for the use of adhesives and compatible restorative materials is imperative in order for the tooth to return to a functional state. The synthesis of the voluminous literature into a coherent protocol for restorative dentistry, titled "Six Lessons" has been developed at the Alleman-Deliperi Center in South Jordan, Utah, and forms the basis for the clinical procedures described in this article. This protocol also discusses the hierarchy of adhesive dentistry procedures, as well as teaches dentists how to avoid full crown restorations.

A Look at Restorative Failures

The potential for failure of any dental procedure occurs at one of three levels. The first is biologic failure and is evidenced by a leaking restoration leading to bacterial invasion, pulpal degeneration, cold sensitivity, pain on biting, crack initiation and propagation and reactivated residual decay. Often neither the patient nor the doctor is aware of the problem and consequently the disease process continues unseen and unaddressed and can lead to a catastrophic failure.

If a clinical failure occurs, the patient becomes aware of the problem because of obvious symptoms such as a fractured restoration. Failures of this type can either be repaired or the restoration easily replaced. If a tooth fracture has occurred at this point, it is still restorable, preferably with a direct composite. Another example of clinical failure is minimal supragingival recurrent caries around a biomimetic onlay.

The last kind of restorative failure is called "catastrophic failure" because the disease process from long standing microleakage has caused deterioration to the point where the required treatment is either endodontics, replacement of the entire cast restoration (often involving periodontal surgery) or tooth extraction. How a restoration fails is vitally important since this will determine the ultimate longevity

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Fig. 1

of the tooth. Clinical failures without recurrent disease are preferable because they are readily accessible and simple to repair in contrast to biologic failures, where the disease process is present but the clinical symptoms are not apparent. The bacteria that grows unseen under leaking restorations, often leads to a catastrophic failure. Dentists frequently claim "successful" restorations simply because they have not yet fallen out, yet these cases have still failed biologically as evidenced by recurrent caries, periodontitis and pulpal necrosis, requiring extensive retreatment and sometimes extraction.

So, the question arises as to which treatment materials and methods would be best, not only for replicating nature, but also in creating a system with some degree of "tooth banking" so that if it fails, it is totally reparable without tooth loss or irreversible damage to an existing restoration.

Biomimetic Dentistry: An Overview

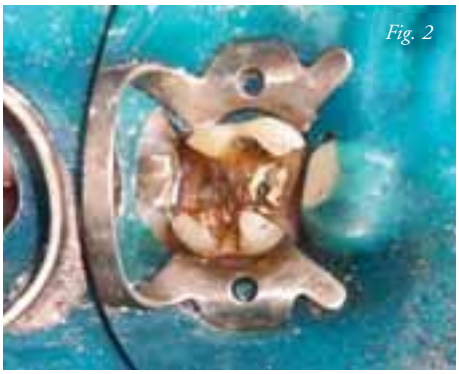
Fig. 2

The goal of the restorative dentist toward replicating nature involves a series of research-based treatments that restore the natural tooth approximating its predisease state expressed as "Six Lessons" as follows:[4]

1. Caries debridement and disinfecting dentin
2. Removal of structural compromises (cracks) in dentin
3. Dentin bonding
4. C-factor control
5. Enamel preparation and onlay design
6. Occlusal adjustment

The order of importance is in numerical order from one through six, however the order of treatment is: 2, 1, 5, 3, 4, 6, and this will be the sequence of treatment in the clinical example shown.

Clinical Case


Fig. 3

Following a routine examination, tooth #14 was found to show signs of failure of the large existing amalgam, specifically recurrent caries and cracks into dentin (Fig. 1). In addition, the adjacent tooth showed similar signs of breakdown of the existing amalgam. Accordingly a biomimetic onlay with a securely bonded Biobase was treatment planned for #14, and a direct composite restoration planned for #15.

Lessons #2 and #1: Eliminating cracks and infections in dentin


Fig. 4

Structural compromises in dentin are what cause failure, and removal of the crack (Lesson #2) as completely as possible without going into the pulp is a critical first step to prevent propagation and tooth fracture. All materials, biologic and manufactured that possess the capability to split and break, all behave the same way, and in dentistry, the symptoms of crack propagation often follow a history of intermittent pain to cold. The cold sensitivity abates when the pulpal side of the crack remineralizes, and returns when the cracks propagate under occlusal loading. The longer the crack, the longer the patient experiences the cycle of sensitivity.[5]

After removing the old amalgam with a #330 bur (Tri Hawk) (Fig. 2) the dentin was stained with Caries Detector Solution (Kuraray) in order to reveal recurrent caries (Fig. 3). A shoulder former diamond (F-62 Pollard Dental) was used to establish a stain-free periphery (Fig. 4) and to remove undercut enamel. Cracks were removed as completely as possible without causing a pulp exposure using a #4 round bur (SS White) or diamond on the high-speed handpiece under a minimum of 4.5X magnification, after which the following measurements were made in order to determine the appropriate restorative strategy: (refer to top next page)

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Six Lessons

1. Caries debridement and disinfecting dentin
2. Removal of structural compromises (cracks) in dentin
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6. Occlusal adjustment


Fig. 5


Fig. 6


Fig. 7

- Isthmus width
- Cusp width
- Box depth
- Tooth length

Structural compromise can be horizontal (HSC), vertical (VSC), or both. Cracks into dentin represent both forms of structural compromise while HSC can be noted as a too-wide isthmus (>3mm) or a too-thin cusp (<3mm). VSCs are proximal boxes that are too deep (>4mm). Each of these clinical circumstances requires either an indirect or stress-reduced direct restoration to reduce stresses from polymerization and occlusal loading.[6]

Caries Debridement

Removing decay and rendering the dentin free from active bacteria (Lesson #1) are foundational to a successful long-term clinical result.

Brannstrom recognized the significance of bacteria on the prepared dentin as being one cause for post operative pain.[7] Subsequent researchers documented that antibacterial restorative materials resulted in the least amount of post operative sensitivity when compared to other materials.[8] Accordingly, control of bacteria is important within the context of biomimetic restorative dentistry.

As caries progresses deeper, the bond between composite resin materials and the dentin substrate drops off sharply.[9] As a result, the contraction force of the setting composite may overwhelm the bond and create a gap between the resin and the dentin substrate.[10] Gaps between dentin and composite create bacterial niches that cause pulpal irritation with the increased potential for subsequent endodontic intervention.[11] The over-cutting of dentin presents a worse problem since accidental exposures of the pulp will occur with more aggressive caries removal. Caries removal protocol must rely on objective data that is predictably replicated by clinicians.

Historically, the tactile indicator of an explorer tip has been used to test prepared dentin for residual decay. This test was a subjective since each explorer that was used more than once had a different degree of sharpness, and every clinician exerts a variable level of pressure onto the instrument. Further, the precise quantifying of a "tackiness" level is impossible, as is revealing the full lateral extent of affected dentin. Accordingly, revealing the denatured collagen in the dentin using a dye test (Caries Detector Solution Kuraray) has become the gold standard in establishing a replicable, visual verification of appropriate removal of affected dentin without creating pulp exposures (Fig. 3).[12]

The visual test for caries activity requires the use of a dye that once applied and rinsed, will selectively stain infected and affected dentin. Following removal of a failed restoration, the first step is to establish a periphery with no red or pink staining (using the Caries Detector Solution) within 2mm of the DEJ using a shoulder former diamond (F62, Pollard). Once this is accomplished, the clinician removes infected and affected dentin using a #4 round bur or diamond (under irrigation to dissipate frictional heat) until the caries detector solution is either completely removed, or in deep dentin shows as a "pink haze." Further attempts to remove stained dentin are not advised since a pulp exposure becomes increasingly probable. In the clinical example shown, final caries removal was accomplished in the above manner (Fig. 5).

Lesson #5 Adhesive prep design: direct and indirect bonding to enamel

The onlay prep needs to be flat, with rounded internal angles. The geometric designs of the G.V. Black preparations are counterproductive because they create

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Fig. 8

high C-factors, interfere with seating, and still cause some internal stress, irrespective as to how passively they might fit.

Accordingly, the preparation is remarkably simple. The handpiece was turned to the side, and the flat-ended diamond was used to remove the four thin cusps (Fig. 6). The final preparation of the case takes place following the building of the Biobase.

Lesson #3: Creating a secure bond with dentin sealing and resin coating

Once the cracks and decay are removed, the dentin needs to be as free from bacteria as possible and then securely bonded. Dentin bonding is accomplished with two possible strategies: total-etch and self-etch. Total-etch bonding relies on the dimineralizing effects of phosphoric acid to strip off the smear layer and open the dentinal tubules in preparation for the creating of the hybrid zone between tooth structure and resin.[13] While this bonding strategy has been in use in the profession for many years, it is a considered technique-sensitive since the phosphoric acid leaves the protein portion of the dentin unsupported, thus requiring a precise amount of moisture to remain on the tooth following the rinsing of the phosphoric acid. Drying the substrate too much results in the collapse of the collagen, forming an impermeable organic layer and preventing the formation of a stable dentin bond. Accordingly, the loss of bond strength results in gap formation, leading to post-operative sensitivity and ultimately the failure of the restoration. Leaving the substrate too wet causes water blister and resin globule formation, with a similar lowered bond strength and post-operative pain.[14]

A newer bonding strategy that maintains the dentin in a fully mineralized state is called "self-etch" because it etches and primes the dentin simultaneously. Since there is no separate etch step, then there is no unsupported collagen, and therefore no need to maintain a narrow window of dentin moisture content for a successful bond. Self-etching adhesives penetrate rather than dissolve away the smear layer, incorporating it into the hybrid zone. These adhesives are simple and predictable to use with no resultant post-operative pain.[15]

Treating the cut dentin with a disinfectant is desirable to lower the bacterial count and protect the pulp. While the use of multiple scrubs of four percent chlorhexidine, EDTA and sodium hypochlorite has been advocated for many years by Strupp,[16] there is one bonding agent, Clearfil SE Protect (Kuraray) that possesses an antibacterial adhesive monomer (MDPB) that is more effective in killing bacteria.[17]

In the clinical example, the primer (bottle #1) for an antibacterial, self-etch adhesive (Clearfil SE Protect, Kuraray) was selected as the dentin bonding agent and was applied to the dentin substrate and left undisturbed for 20 seconds (Fig. 7). Then the preparations were dried thoroughly with a specially designated air-only syringe (Clean and Dry Syringe, Best Buy Dental). Next, the microfilled resin (bottle #2) was applied to the preparations, lightly aired, then light cured (Fig. 8). ■

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This CE activity is supported by an unrestricted grant from Kuraray America

Author's Bio

Dr. Randall G. Cohen is in private practice of general, cosmetic and restorative dentistry in Bucks County, Pennsylvania since his graduation from Temple University School of Dentistry in 1982. He has published papers in several journals and has lectured nationally on adhesive dentistry.

Disclosure: Dr. Cohen declares having received an honorarium from Kuraray America for this lecture.

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Post-test

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1. A biologic failure
   a. is often unnoticed by doctor and patient
   b. occurs from a leaking restoration
   c. can lead to a catastrophic failure
   d. all of the above

2. Following removal of a failed restoration, the first step is
   a. occlusal adjustment
   b. removal of thin cusps and placement of the enamel bevel
   c. staining with caries detector solution and creating a stain-free periphery
   d. removal of caries from the floor of the preparation

3. Which of the following is descriptive of crack propagation in dentin?
   a. the longer the crack, the shorter the sensitivity cycle
   b. can result in intermittent pain to cold
   c. cold sensitivity abates under occlusal loading
   d. none of the above

4. In deep dentin,
   a. the bond is easier to achieve than in shallow dentin
   b. a decreased potential for gap formation exists during the setting of composite
   c. caries removal should proceed until the caries detector solution shows up as a "pink haze"
   d. the tactile indicator of the explorer tip indicates the proper end point for caries removal

5. An example of a biomimetic restoration
   a. is one where dental materials are used that have physical properties similar to the intact tooth
   b. is a 360-degree porcelain to metal crown
   c. is a MODB amalgam
   d. is a classic G.V. Black casting preparation

6. Collagen denaturation of the dentin is best diagnosed by
   a. tactile indication of the explorer tip
   b. dehydration of the preparation
   c. caries detector solution
   d. none of the above

7. An example of a clinically failed restoration is
   a. recurrent caries around a PFM crown
   b. a fractured ML cusp without recurrent decay
   c. minimal supragingival recurrent caries around a biomimetic onlay
   d. both b and c

8. Which of the following is the an example of a horizontal structural compromise?
   a. cracks into dentin
   b. isthmus width greater than 3mm
   c. cusp thickness less than 3mm
   d. all of the above

9. Full crown restorations
   a. function in complete harmony with the underlying dentin
   b. are the best way to preserve the integrity of the tooth
   c. are the least desirable treatment option for cuspal protection
   d. eliminate the need for endodontics

10. The program entitled "Six Lessons"
    a. teaches dentists a scientifically based clinical protocol for adhesive restorative dentistry
    b. establishes a hierarchy of adhesive dentistry procedures
    c. teaches dentists how to avoid full crown restorations
    d. all of the above

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