Minimally Invasive Dentistry: Paradigm Shifts in Preparation Design

Brian P. LeSage, DDS*

While the concept of minimally invasive dentistry has long been considered a rational, viable approach to restorative care, preparation design, material science, and long-term evidentiary support have only recently begun to provide the foundation necessary to support such treatment in the everyday practice. This article reviews the fundamental paradigm shift evidenced in contemporary prosthodontics as required to facilitate the emerging interest in delivering conservative restorative alternatives.

Learning Objectives:

This article discusses the importance of tooth preservation as compared to traditional approaches that typically resulted in excess removal of tooth structure. Upon completing this article, the reader should:

- Recognize the role of contemporary material science in the delivery of conservative restorative options.
- Be aware of the preparation design and material selection considerations associated with rehabilitation of compromised aesthetics.

Key Words: minimally invasive, tooth preparation, porcelain, aesthetics, anterior

**Private practice, Beverly Hills, California.*

Brian P. LeSage, DDS, 436 N Roxbury Drive, Ste. 100, Beverly Hills, CA 90210
Tel: 310-276-2468 • E-mail: brian@cosmetic-dentistry.com

The recent paradigm shift in fixed prosthodontics has been significantly influenced by current advancements in adhesive sciences and implant dentistry.[1,2] These changes have dramatically altered the way practitioners diagnose, treatment plan, and perform clinical dentistry. By forcing clinicians to think in terms of conserving tooth structure, vital tissues, and aesthetics, traditional restorative concepts that advocated removal of critical tooth structures have been modified to promote preservation of those same tooth structures.

Preparation Design

Conventional porcelain restorations required significant tooth reduction to facilitate material physical properties, retention, and resistance form, combined with aesthetics. Contemporary restorative materials have, however, evolved to enable the use of novel materials (eg, thinner ceramics, powder/liquid porcelains, and dentin bonding agents) that deliver optimal aesthetics and durability, without the need to remove excess underlying tooth structures. Concerns with maintaining GV Black's principles of retention and resistance form are no longer conflicting concepts,[3] and can be easily maintained using contemporary veneer preparations and adhesive systems.

Once the caries has been removed, before proceeding to create the final cavity form, it is imperative that the clinician first determine if any functional and parafunctional complications exist prior to initiating tooth preparation procedures.[4] By allowing the clinical situation to guide material choice, selection of a conservative technique that will ensure maintenance of an optimal amount of natural tooth structures will be ensured. Proper material selection should, therefore, ensure placement of a restoration that can biomimetically replicate the biomechanics and structural integrity of the original tooth form, while retaining an optimal amount of natural tooth structures whenever possible.[5,6] By focusing on restoring the biomechanical, structural, and aesthetic integrity of dentition via adhesive protocols, clinicians can now eliminate detrimental and aggressive preparation designs

Figure 1. Preoperative view. Tooth #9(21) was previously deemed hopeless and an orthodontic extrusion technique was employed.

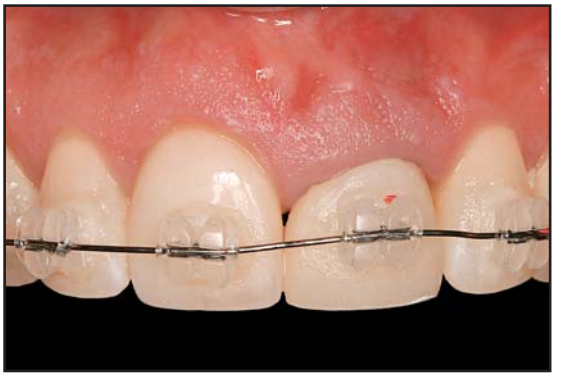

Figure 2. Once sufficient hard and soft tissue contours were evidenced, the tooth was prepared for removal and subsequent implant placement.

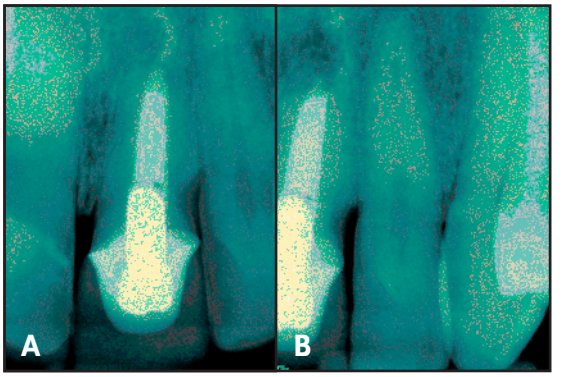

Figure 3A. Preoperative radiograph demonstrates evidence of periapical pathosis. 3B. Root resorption was also evident on the distal aspect of tooth #9.

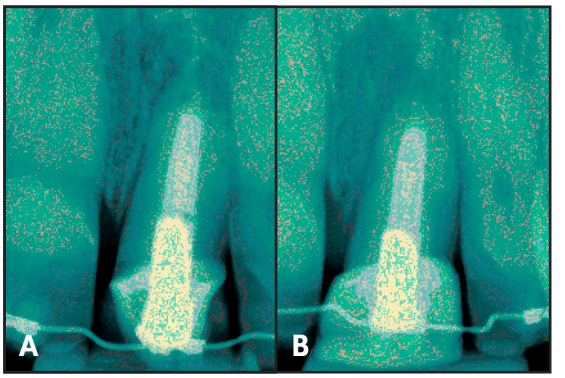

Figure 4A. Further extrusion with visible bone extension on the mesial aspect of tooth #9. 4B. The full extent of extrusion demonstrated approximately 2 mm to 3mm of bone "growth" on the mesial aspect.

Figure 5. Occlusal appearance demonstrates complete grinding through the metal on the lingual aspect of the original crown and partial post and core as the tooth was extruded.

Figure 6. Using the the "lolli-pop" prototype technique to prosthetically develop papillae on tooth #9 over multiple months and a bis-acrylic mock-up of teeth #6 through #11 following 3 weeks of function.

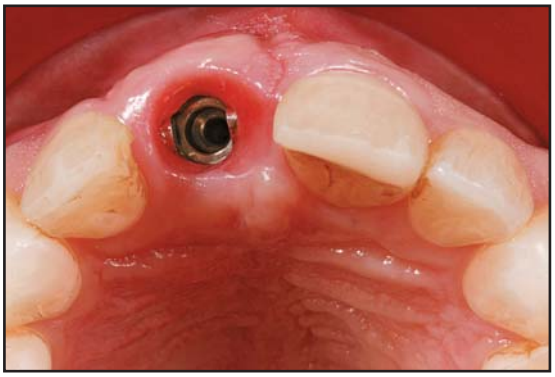

Figure 7. Note the full horizontal contour of gingival tissue and reproduction of the cross-section of the central incisor within the gingival scallop.

and keep tooth reduction within enamel structures, with optimal aesthetic results. Material sciences have also allowed use of restoratives with increased stiffness and ideal surface characteristics, which allows bonded restorations to support incisal or masticatory function.[6]

Material Selection and Application

Ideal material selection can then be performed with a complete understanding of the physical, mechanical, and biological factors that will influence the tooth-restoration complex. While the aesthetics of the restorative material will also be a primary concern to the patient, contemporary material sciences have enabled the use of biocompatible materials with optimal strength and aesthetics.[6-9]

Porcelain Restoratives

All-ceramic materials have been traditionally used in indirect restorations when aesthetics were a consideration. Porcelain is described simply as crystalline structures in a glassy matrix that is, in itself, a very aesthetic, but brittle material.[9] In its early application on porcelain-fused-to-metal (PFM) restorations, 1 mm of porcelain thickness was generally required circumferentially. The delivery of restorations with an even thickness was advocated for decades, with little to no evidence to support this widely accepted rationale.[8,10] Particularly when restoring patients with adjacent porcelain veneers and crowns, clinicians were taught to provide uniform tooth reduction to enable sufficient ceramic buildup for the crown and to allow the technician to match the crown's thickness within the veneer. Novel restorative materials have, however, enabled the use of a thinner veneer material that can match an adjacent tooth or crown, with very little tooth removal required for its retention or aesthetics.[11]

Three-Step Bonding

The advent of the total etch technique has revolutionized modern adhesive dentistry and the manner in which restorative treatment is diagnosed, treatment planned, and

Figure 8. A guided preparation technique was used to allow placement of 0.5 mm depth cuts into the patient's approved prototype. The prototype for implant crown #9 was not prepared and the access hole was positioned slightly more facial than ideal.

performed.[7,11-13] Using a three-step system, the clinician knows the enamel substrate is properly etched and, if done properly, limiting the dentin etch to 15 seconds will maximize collagen demineralization to a resealable distance. By ensuring creation of a solid bond within the enamel, retention is ensured and potential failure is avoided by eliminating adhesion in the dentin. The primer is then positioned and agitated for 30 seconds to ensure complete infiltration to the intertubular and peritubular dentin. In an indirect technique, it is best to cure this layer.[14] Then the adhesive is applied in a thin coat and the restoration seated with cement being placed onto the tooth and inside the restoration. Light curing can then be performed with a spot bond first followed by final, complete polymerization. Using the aforementioned technique, the biomimetic behavior of porcelain veneers bonded to teeth has demonstrated clinically predictable results as both the mechanical behavior and microstructure of the intact tooth aesthetics are generally restored.[5]

Case Presentation

A 35-year-old male patient presented with a preexisting, unaesthetic, and failing PFM crown on tooth #9(21). The restoration was removed, and the patient elected to have tooth #8(11) treated with an all-ceramic veneer following delivery of an aesthetic crown restoration for tooth #9. A "classic" veneer preparation was used on tooth #8 and a traditional crown preparation was applied to tooth #9 using conventional guidelines.[13] The traditional veneer preparation design was, therefore, slightly more aggressive than the design currently used for contemporary materials, in order to provide sufficient space for porcelain buildup that would match the adjacent crown. A stacked feldspathic veneer and PFM crown were fabricated, tried in over several appointments, and finally delivered in the customary fashion.

Approximately 14 years later, a routine full-mouth radiographic series was performed, and external root resorption on the distal aspect of tooth #9 was noted (Figure 1). Consultation appointments with an endodontist and two periodontists confirmed the poor long-term prognosis of this tooth. After deliberation of the risk, benefits, and treatment options, the patient requested implant restoration of tooth #9 and veneers for teeth #7, #8, and #10.

Orthodontic extrusion was performed to maximize the necessary hard and soft tissues over a six-month period, minmizing the need for surgical intervention (Figures 2 through 5). The periodontist atraumatically extracted tooth #9 and an implant (ie, Nobel Perfect, Nobel Biocare, Yorba Linda, CA) was placed in the overdeveloped extraction site (Figures 6 and 7). Routine tissue healing and follow-up occurred, and in 4 months a prototype was fabricated and delivered using the lolli-pop technique.[15] Once ideal tissue scalloping was achieved and mock-ups were fabricated, the patient elected to commence restoration of the anterior canines with porcelain laminate veneers as well.

Figure 9. Note the minimally invasive preparation design following removal of the the bis-acrylic. Tooth reduction was limited to the areas with pencil line markings.

Figure 10. The traditional, more aggressive, preparation design on tooth #8 as compared to the more minimally invasive preparation design on the adjacent teeth.

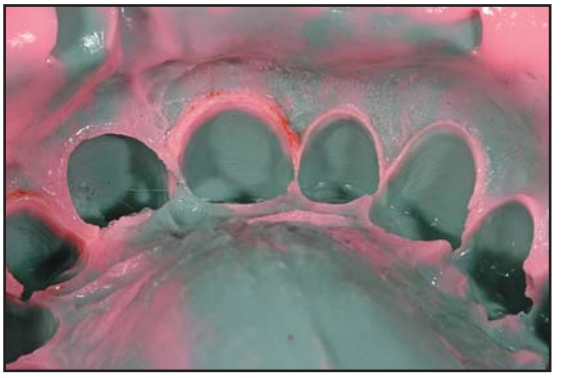

Figure 11. A reversible hydrocolloid impression was made of the minimally invasive preparations keeping the prototype crown #9 in place to establish the midline location and direction and the central incisor length and width.

Figure 12. Try-in of porcelain veneer #8 to confirm the midline location and direction and the central incisor length have been replicated from the prototype guide.

Figure 13. Postoperative appearance. Note the harmonious integration and aesthetic soft tissue contouring surrounding each restoration.

The porcelain veneer on tooth #8 was cut off with little to no additional removal of tooth structure (Figure 8). Using a prototype-guided preparation technique,[16,17] little to no enamel was removed and no dentin was exposed on newly prepared teeth #6, #7, #10, and #11. (Figures 10 and 11). By allowing the clinical situation to determine the material selection and using a mock-up of the final case made from the diagnostic wax-up to determine appropriate reduction, a minimally invasive preparation design was maintained. A CAD/CAM-fabricated zirconia crown (Lava, 3M ESPE, St. Paul, MN) was subsequently fabricated and delivered for the implant-supported restoration. The definitive result blended in with the veneers on teeth #6 through #11 (Figures 12 and 13).

Conclusion

Although increased focus has been placed on the delivery of minimally invasive dentistry in the recent literature, the concept of maintaining the patient's natural tooth structures to provide optimal bonding, strength, and retention is not a novel one. Contemporary material advancements have, however, begun to facilitate the clinician's obligation to provide optimal care with minimal removal of healthy dentition. Combined with predictable adhesive technologies and methodologies, clinicians are now equipped to deliver aesthetic restorations while preserving a larger percentage of underlying tooth structures during multidisciplinary treatment, thus maintaining the patient's health and longevity of his or her natural dentition.

Acknowledgment

The author mentions his gratitude to Dr. Sasha Jovanovic, Los Angeles, CA, for the periodontal procedures depicted and to Sam Lee, CDT, Gardena, CA, for laboratory fabrication of the restorations herein. The author declares no financial interest in any of the products mentioned herein.

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Continuing Education (CE) Exercise No. 4

To submit your CE Exercise answers, please use the answer sheet found within the CE Editorial Section of this issue and complete as follows: 1) Identify the article; 2) Place an X in the appropriate box for each question of each exercise; 3) Clip answer sheet from the page and mail it to the CE Department at Montage Media Corporation. For further instructions, please refer to the CE Editorial Section.

The 10 multiple-choice questions for this Continuing Education (CE) exercise are based on the article "Minimally Invasive Dentistry: Paradigm Shifts in Preparation Design" by Brian P. LeSage, DDS. This article is on Pages 97-101.

1. Prior to completing the preparation design, the clinician must:
a. Remove any existing caries.
b. Determine if any functional complications exist.
c. Determine if any parafunctional complications exist.
d. All of the above.

2. Restorative material selection shoulds:
a. Allow use of a material that will mimic the biomechanics of the original tooth form.
b. Ensure placement of a restoration that delivers optimal structural integrity.
c. Both a and b are correct.
d. Neither a nor b are correct.

3. Traditional preparation designs required:
a. Equal tooth reduction for veneers and crowns when placing these restorations adjacent to one another.
b. Minimal tooth reduction for the veneered restoration and additional reduction for the crown.
c. Aggressive tooth preparation designs for all six anterior dentition, regardless of the type of restoration being delivered.
d. All of the above.

4. How do biomimetic protocols enable the use of minimally invasive dental procedures?
a. By providing equidistant preparation parameters for both porcelain veneers and crown restorations.
b. By enabling the use of adhesive restorations that provide both strength and aesthetics.
c. Both a and b are correct.
d. Neither a nor b are correct.

5. Porcelain is described as:
a. Crystalline structures in a glassy matrix.
b. An aesthetic, brittle restorative material.
c. Both a and b are correct.
d. Neither a nor b are correct.

6. Material sciences have enabled the use of:
a. Porcelain materials with optimal stiffness for reliable function.
b. Ceramics with ideal surface characteristics for optimum performance.
c. Both a and b are correct.
d. Neither a nor b are correct.

7. Because dentin structures can break down over time, it is imperative to:
a. Maintain a solid bond in the enamel structures.
b. Provide a thorough dentin bond.
c. First use an acid etchant to enable optimal bond in the dentin.
d. Sand blast the interior aspect of the porcelain restoration to enable proper bonding.

8. Approximately 1 mm of porcelain material is generally required for contemporary restorations. Preparation designs for both crowns and veneers must provide an even thickness to ensure restorative success.
a. Both statements are true.
b. Both statements are false.
c. The first statement is true, the second statement is false.
d. The first statement is false, the second statement is true.

9. Adhesion of minimally invasive restorations must be limited to:
a. Placement within the dentin structures.
b. Retention within the enamel structures.
c. Placement primarily within the dentin and some enamel.
d. The restorative material of choice.

10. Collagen demineralization is:
a. Imperative for restorative success.
b. Avoided using a three-step etching system.
c. Maintained during initiation of the total etch procedure.
d. Maximized to a resealable distance when the dentin etch is limited to 15 seconds.