Biologic Restoration: The Effects of Composite Inlays on Patient Treatment Plans

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A technique for restoration of decayed and fractured teeth with composite inlays or onlays is presented. This approach conserves the tooth structure, requires less preprosthetic periodontal surgical intervention, and provides excellent functional results, while minimizing the incidence of post-therapeutic endodontic involvement. Two thousand seven teeth were restored using this technique over a period of 120 months, with a mean time of 59.6 months in function. The technique is described, and the advantages of this treatment modality are discussed. (Int J Periodontics Restorative Dent 2011;31:115–123.)

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The need to comprehensively manage the restorative margin-periodontium interface to maximize patient prognosis is well established. Prerestorative periodontal crown lengthening surgery is often required to uncover deep subgingival caries and restorations or to establish the appropriate biologic width between the planned restorative margin and alveolar crest to afford the necessary dimension for development of a healthy attachment apparatus. Such a treatment approach provides the most stable and predictable attachment apparatus possible in anticipation of the added demands placed on the periodontium by restorative dentistry and controls the soft tissue contours around the restoration. Failure to provide the necessary access for placement of supragingival or intrasulcular restorations both increases the difficulty of execution of the planned restorative therapy and leaves the patient with a milieu in which it is more difficult to perform appropriate plaque control measures. If adequate biologic width is not established between the restorative margin and the alveolar crest,
the resultant inflammation contributes to the initiation of periodontal disease in that area. Finally, pre-restorative periodontal therapy, which does not adequately anticipate and participate in the final soft tissue morphology, results in a non-keratinized, concave interproximal col form, which is more vulnerable to bacterial penetration following increased plaque accumulation. It is for these reasons that prerestorative periodontal therapy has become a mainstay of comprehensive care.

The advent of adhesive dentistry has significantly altered the approach to excavation, preparation, and restoration of carious or fractured teeth. Use of more conservative preparations helps to preserve a greater amount of the tooth structure. Theoretically, such an approach would offer the advantages of a lesser incidence of endodontic therapy and minimization of invasion of the periodontium, thus decreasing both the need for pre-restorative periodontal surgery and the extent of such surgery when necessary.

The development of a restorative technique that would preserve greater amounts of the tooth structure, decrease the extent of preprosthetic periodontal surgical intervention, and provide stable long-term results would potentially offer significant advantages over more conventional approaches in day-to-day clinical practice.

**Clinical technique**

Well-established protocols were followed regarding patient examination, diagnosis, and formulation of a comprehensive treatment plan. Appropriate radiographs were taken, and mounted study casts were obtained when necessary. Periodontal inflammatory lesions and endodontic periapical lesions were eliminated, and an appropriate occlusal scheme was developed. The patient's home care efforts were maximized. If periodontal regenerative therapy was required around the tooth to be restored, it was carried out prior to tooth restoration. The mucoperiosteal flaps were designed and sutured in such a manner so as to provide maximum soft tissue coverage of the interproximal bone through development of long soft tissue papillae.

At the time of tooth preparation, periodontal resective surgery was carried out. Partial-thickness buccal and lingual/palatal mucoperiosteal flaps were reflected appropriately with the necessary releasing incisions. Partial-thickness flaps are always used to ensure a uniform flap thickness and to afford the opportunity to position the buccal mucoperiosteal flaps apically using a periosteal suturing technique. Periodontal resective surgery was carried out to eliminate periodontal defects, according to accepted protocols. Osteoplasty is employed to reduce alveolar ledging and to establish positive osseous architecture to help anticipate and participate in final soft tissue healing.

The extent of osseous resection to establish biologic width apical to the planned restoration was less than suggested in anticipation of other restorative protocols. Only 2.5 mm of biologic width was created between the most apical extent of the planned restorative margin and the alveolar crest. Upon healing, the 2.5 mm between the alveolar crest and restorative margin will include approximately 1.0 mm of connective tissue attachment crestal to the alveolar crest, followed by 1.0 mm of junctional epithelial adhesion and a 0.5-mm gingival sulcus. This is in marked contrast to suggestions in the literature of establishing a dimension of 3.5 to 5.0 mm between the planned restorative margin and the alveolar crest to afford adequate dimension for development of the necessary attachment apparatus and gingival sulcus.

Following appropriate periodontal surgical intervention, all margins of the preparation, and therefore the restoration, will be supragingival. Such a relationship between the soft tissues and restorative margins maximizes restorative margin visibility and control of the final preparation form. Impression taking, cementation, and margin finishing were optimized through establishment of such a restorative margin–soft tissue margin relationship. Finally, the restorative clinician was also better able to control the final restorative emergence profile, which helps dictate the dimensions of the interproximal space and the subsequent ability of the patient to perform appropriate home care measures.
On the same day that periodontal surgical therapy was accomplished, tooth excavation/preparation and restoration began.

Prior to cavity preparation, a thorough biomechanical structural analysis of the tooth must be performed. The presence or absence of marginal ridges; the coronal, apical, mesial, and distal extension of the caries lesion(s); the buccolingual intercusp width; and the dental enamel thickness at the bases of each cusp must all be assessed. The presence or absence of a intact pulp chamber roof must be ascertained, and the condition of the pulp and presence or absence of cracks in the remaining tooth structure must all be addressed. Such observations guide the creation of the cavity preparation in helping to determine whether to preserve the walls of the cavity and whether to cover the cusps with the restoration. This guidance aids the clinician in choosing the correct preparation form, whether it be inlay, onlay, or overlay.

The ideal morphology of the preparation is one that allows removal of the least amount of healthy tooth structure to access and eliminate the caries lesion, while also considering the shape and extension of the eventual restoration. It is imperative that at least a 3-mm-thick layer of restorative material be present on the occlusal aspect of the tooth and that at least a 2-mm-thick layer of restorative material be present in the marginal ridge areas if the marginal ridge of the tooth was compromised by caries or upon final tooth preparation.

The use of rubber dam is a prerequisite with this technique. Once rubber dam has been placed, treatment can proceed.

The old restoration or caries was removed, with care taken not to remove any healthy tooth structure. A cavity preparation was made that conserved the remaining tooth structure as much as possible. The cavity preparation was nonretentive, and its geometry was as simple as possible. All internal corners of the preparation must be rounded, and the preparation walls must diverge by 10 to 12 degrees. The width of any retained tooth structure must be at least 2.0 mm; the minimal width of retained tooth structure at the base of each cusp must be at least 2.0 mm for vital teeth and 3.0 mm for endodontically treated teeth. When preparing the area for reception of an onlay restoration, the working cusps must be reduced 2.0 to 2.5 mm, and the non-working cusps must be reduced 1.5 to 2.0 mm. Naturally, the preparation must have well-defined margins.

An adhesive technique was employed, which included the following steps:

- The preparation was etched using Ultra-Etch (Ultradent), and chlorhexidine was applied as a protease inhibitor.²
- Priming was carried out with Optibond FL Prime (Kerr) for 60 seconds.
- Bonding was achieved with Optibond FL adhesive (Kerr) for 60 seconds.³
- Light curing was carried out for 60 to 80 seconds.
- The tooth was built up with Adonis (Sweden & Martina).⁴
- An impression was taken using Imprint II Garant Quick Step Aquasil Ultra (3M ESPE).
- Temporization was carried out with Fermit-N (Ivoclar Vivadent).

All materials were used in accordance with the manufacturers’ recommendations.

If one to two teeth were treated in a given quadrant, the restorations were completed and inserted on the same day that tooth preparation and crown lengthening surgery were performed. If more than two teeth were treated in a given quadrant, the restorations were inserted within 24 to 48 hours of periodontal surgical therapy and cavity preparation.

Endodontic therapy was performed in conjunction with periodontal and restorative treatment if pulpal necrosis was evident radiographically prior to therapeutic intervention or if pulpal exposure was encountered during cavity preparation. In addition, if the dentin protecting the pulp was so thin as to be able to visualize the pulp clearly through the remaining dentin, endodontic therapy was carried out prior to tooth restoration, even in the absence of an overt pulpal exposure.

The definitive restoration was inserted according to the following protocols:

- Rubber dam was reapplied, and the provisional restoration was removed.
• The cavity preparation was cleaned with Ice brushes (Sweden & Martina), the enamel margins were cleaned with fine diamond burs, and the cavity preparation was sand-blasted.
• Etching was carried out with Ultra Etch for 30 seconds.
• Bonding was accomplished with Optibond FL adhesive; Adonis composite cement was applied.
• The definitive inlay, onlay, or overlay restoration was cemented using the same Adonis composite cement.
• Excess cement was removed.
• The restorative margins were refined. Since the margins were supragingival, the clinician had excellent visualization of the marginal areas of the restoration.
• Rubber dam was removed.
• Occlusion was checked and adjusted as necessary.
• The restoration was polished with Super Polish (Kerr) and Brownie Mini Points (Shofu).

### Results

In 10 years of using this technique, 2,007 teeth have been treated through the described diagnostic, surgical, endodontic, and restorative protocols. Treated teeth include maxillary and mandibular canines, premolars, and molars (Table 1). Of these 2,007 treated teeth, 225 either received endodontic therapy prior to restoration or required endodontic therapy during restoration (11%); 62 teeth required endodontic intervention at some time following restoration (3%) (Table 1).

The restored teeth have been in function for a mean period of 59.6 months. During this time, no fractures of the tooth structure or restorative material have been observed. All teeth are functioning asymptotically.

<table>
<thead>
<tr>
<th>Tooth treated</th>
<th>No. of teeth treated</th>
<th>Endodontic therapy after restoration</th>
<th>Endodontic therapy before restoration</th>
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<td>Maxillary canine</td>
<td>6</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Mandibular canine</td>
<td>2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Maxillary premolar</td>
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<td>11</td>
<td>41</td>
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<tr>
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</tr>
<tr>
<td>Total</td>
<td>2,007</td>
<td>62</td>
<td>225</td>
</tr>
</tbody>
</table>
Patient 1

The patient presented with numerous maxillary subgingival restorations demonstrating fractures and recurrent caries (Fig 1a). Following removal of the older restorations and excavation of all present caries, subgingival extension of the loss of tooth structure was evident on the right molars and second premolar (Fig 1b). Tooth preparation was idealized as best as possible after placement of rubber dam (Fig 1c), and provisional restorations were placed. Crown lengthening osseous surgery was performed to afford 2.5 mm from the alveolar crest to the most apical extent of the tooth preparation (Fig 1d). Tooth preparation was completed, and the provisional restorations were replaced after impressions were taken. Definitive restorations were delivered within 48 hours (Fig 1e). A radiograph taken 6 years postinsertion demonstrates intact margins and no loss of attachment apparatus around the teeth (Fig 1f).
Patient 2

Extensive caries, which had invaded the pulpal chambers, were evident on the right mandibular first and second molars (Fig 2a). If crown lengthening osseous surgery were to be performed to such an extent so as to provide the usually acceptable 4 mm of dimension between the caries lesions and the supporting alveolar bone in all directions, the furcations of the first molar would be invaded. Following endodontic therapy, caries excavation, and temporization, lack of adequate tooth structure for restoration and subgingival extension of the compromised tooth structure were evident (Fig 2b). Crown lengthening osseous surgery was performed to provide 2.5 mm of dimension from the restorative margins to the crest of the alveolar bone in all directions (Fig 2c). Following rubber dam application, final tooth preparation was carried out. Impressions were taken, and provisional restorations were placed. The definitive restorations were delivered the same day as crown lengthening osseous surgery and impression taking (Fig 2d). The emergence profiles of the restorations were contoured to help prevent soft tissue pile-up and to aid in patient plaque control efforts (Fig 2e). A radiograph taken 4 years after insertion of the restorations demonstrates intact margins and a stable alveolar bone crest (Fig 2f).
Patient 3

The patient presented with radiographic evidence of extensive recurrent caries in all four posterior segments (Fig 3a). Clinical views demonstrated the compromised nature of the amalgam and composite restorations in the maxillary and mandibular posterior teeth. Following removal of defective restorations and excavation of all decay, subgingival extension of the compromised tooth structure was evident in the maxillary left quadrant (Fig 3b). Crown lengthening osseous surgery was carried out as described previously, impressions were taken, and definitive restorations were delivered within 48 hours of surgical intervention in the maxillary left quadrant. Note that the maxillary right quadrant had been treated previously in a similar manner. Radiographs taken 6 years after the maxillary and mandibular posterior teeth were restored demonstrate intact restorative margins and stable alveolar crests (Fig 3c). Clinical views underscore the stability of these restorations and the superior esthetic results attained (Figs 3d and 3e).

Fig 3  Patient 3.

Fig 3a  Numerous defective restorations and recurrent caries were evident radiographically in the maxillary left posterior segment. The maxillary right posterior segment presented with similar problems.

Fig 3b  Following removal of the restorations and excavation of all decay in the maxillary left posterior region, subgingival extension of the compromised tooth structure and the inflamed nature of the interproximal soft tissues were evident.

Fig 3c  Radiographs taken 6 years after insertion demonstrate intact restorative margins and stable alveolar crests.

Figs 3d and 3e  Clinical views of the (left) maxilla and (right) mandible underscore the esthetic nature of the restorations placed.
Discussion

The described technique offers considerable potential advantages over conventional therapeutic approaches. The technique is easy to execute and may be performed in a short period of time. Restorative margin visualization is enhanced significantly when compared to more conventional approaches. This fact increases the ease of therapy and delivers greater control to the clinician.

When faced with a tooth demonstrating extensive caries breakdown, a significantly greater amount of tooth structure may be preserved than with more conventional techniques. Edelhoff and Sorensen have demonstrated that 67.5% to 77.7% of dental tooth structure must be removed during tooth preparation for a full-coverage restoration. When preparing teeth to receive conventional inlays, onlays, or partial crowns, only 16%, 34%, or 38% of the dental tooth structure must be removed, respectively. In addition, the location of the removed tooth structure is in many cases critical to the long-term success. The more conservative tooth preparation technique presented affords the opportunity to maintain the marginal ridge of the tooth, rather than replace it with restorative material. It has been shown by Sakaguchi et al. and Linn and Messer that cusp deformation occurs to a significantly greater degree under occlusal loading when the marginal ridge is lost or absent. These investigators demonstrated that the presence of an intact marginal ridge significantly reduces cuspal deformation, approaching a minimal value. As such, the long-term prognosis of the tooth is enhanced.

The ability to perform a more conservative tooth preparation, and thus remove less tooth structure, also decreases the need for endodontic therapy in teeth that do not exhibit preexisting radiographic evidence of periapical pathology. It is interesting to note the low incidence of endodontic therapy (3%) subsequent to tooth restoration over a period of 10 years with a mean time in function of 59.6 months for teeth that initially exhibited extensive caries breakdown.

The potential for post-therapeutic tooth and restorative material fracture is significantly lessened through use of the same material for tooth build-up, tooth restoration, and cementation of the restoration. If such a tooth was restored through the more conventional means of post and core build-up and a full coverage approach, the buildup, restoration, and cement would be three different materials with inherent differences in elasticity, tensile strength, and compressive strength. As a result, the potential to experience various stresses within the tooth resulting from differences in these properties would be greatly increased.

When using the described technique, if repair of the restoration is necessary as a result of either postrestorative endodontic intervention or restoration fracture, such repair is easily accomplished without removing the restoration.

Clinical experience also strongly suggests that the use of this restorative approach offers significant advantages in patients suffering from “cracked tooth syndrome.” The elasticity of the restorative material used (for the buildup, restoration, and cement) is close to the elasticity of dentin. Patients suffering from the aforementioned syndrome who have been restored using this technique have uniformly demonstrated an amelioration and eventual elimination of symptoms. This stability and comfort has been maintained.

The need for prerestorative periodontal crown lengthening surgical intervention is also lessened through use of this restorative approach. The more conservative nature of the tooth preparation results in a lesser invasion of the biologic width and, hence, the attachment apparatus necessary to help maximize periodontal health over time. Noteworthy is the fact that the statistics presented demonstrate that periodontal health may be attained and maintained in a variety of patients when only 2.5 mm of space is present between the restorative margin and the alveolar bone crest. No recurrent periodontal problems have been noted around any of the restored teeth in question during the 10-year observation period of this study (mean time of observation, 59.6 months). All patients have remained on 3-month periodontal maintenance schedules and have demonstrated similar periodontal health between their restored and nonrestored teeth.
Another significant periodontal advantage to this therapeutic approach is the decreased risk of furcation invasion during periodontal crown lengthening surgery. The ability to avoid the development of surgically induced furcation involvement is once again a result of the more conservative nature of the tooth preparation and the need to establish only 2.5 mm of biologic width dimension for development of a stable attachment apparatus apical to the restorative margin, thus lessening the need to compromise the furcal entrance of the tooth.

Finally, treatment time and patient discomfort are significantly reduced. Crown lengthening periodontal surgery, tooth preparation, impression taking, and temporization are performed on the same day if one to two teeth are to be restored in a given quadrant. Should a greater number of teeth require restoration, the restorations are delivered within 24 to 48 hours of surgical intervention and tooth preparation, with or without endodontic therapy, as indicated. Thus, the number of treatment appointments and the duration of therapy are reduced significantly.

One of the most difficult challenges facing conscientious clinicians in today’s treatment environment is the formulation of acceptable and justifiable algorithms of care. The introduction of predictable implant therapy continues to impact such treatment algorithms. When faced with the options of crown lengthening surgery, endodontic therapy, post and core build-up, and full-coverage restoration of a single rooted tooth versus tooth extraction and placement of a single implant, abutment, and crown, the clinician must carefully weigh the biologic, physical, psychologic, and financial advantages and disadvantages of each treatment approach. Use of the described technique has the potential to significantly impact the decision-making process through the minimization and, in many cases, elimination of the need for endodontic and periodontal surgical intervention to effect the appropriate restoration of the tooth in question.

In addition to the biologic advantages of this treatment approach, which must be considered of paramount importance, the patient is also provided with a highly esthetic restoration that has proven extremely stable over time.

References