Direct-Indirect Class V Restorations: A Novel Approach for Treating Noncarious Cervical Lesions

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ABSTRACT
Noncarious cervical lesions are highly prevalent and may have different etiologies. Regardless of their origin, be it acid erosion, abrasion, or abfraction, restoring these lesions can pose clinical challenges, including access to the lesion, field control, material placement and handling, marginal finishing, patient discomfort, and chair time. This paper describes a novel technique for minimizing these challenges and optimizing the restoration of noncarious cervical lesions using a technique the author describes as the class V direct-indirect restoration. With this technique, clinicians can create precise extraoral margin finishing and polishing, while maintaining periodontal health and controlling polymerization shrinkage stress.

CLINICAL SIGNIFICANCE
The clinical technique described in this article has the potential for being used routinely in treating noncarious cervical lesions, especially in cases without easy access and limited field control. Precise margin finishing and polishing is one of the greatest benefits of the class V direct-indirect approach, as the author has seen it work successfully in his practice over the past five years.

INTRODUCTION
Noncarious cervical lesions (NCCLs) have long been a topic of concern for patients and clinicians due to their high prevalence and associated undesirable clinical problems, including esthetic compromise and dentinal sensitivity. Etiologic factors described in the literature primarily include abrasion, acid erosion, and abfraction.

Abrasion is mechanical wear of hard tissues, and is most commonly associated with tooth brushing and abrasive dentifrices, but other factors might be involved in the process. Erosion is nonbacterial acidic dissolution of the crystalline substances hydroxyapatite and fluorapatite present in both enamel and dentin. Although the term “erosion” is extensively mentioned in the dental literature, a recent paper suggested that “biocorrosion” replace “erosion” because it more adequately explains tooth substance degradation caused by chemical, biochemical, and electrochemical degradation from exogenous and endogenous acids, proteolytic agents, and piezoelectric effects.

Abfraction NCCLs are described as resulting from biomechanical loading forces exerted on teeth and concentrating at the cementoenamel junction, eventually causing teeth to flex, undergo fatigue breakdown, and lose enamel and dentin, typically producing wedge-shaped lesions.

Evidence indicates that cyclic fatigue and biocorrosion contribute to the formation of NCCLs. Ultimately, NCCLs result from combined biocorrosive, stress, and
attrition mechanisms that interact at varying degrees to produce lesions of variable magnitude. The appearance of these lesions varies according to location and etiology, ranging from shallow saucer-like depressions to broad disk-shaped lesions, or to wedge-shaped lesions. The defect floor may be flat, indented, or sharply angled.\(^9\)

Although high by anecdotal observation, NCCL prevalence is not well documented. Different authors have reported widely diverse results due to varying methodologies.\(^{10-12}\) Despite the published disparity, the clinical presence of such lesions is real and affects all dental practices worldwide. In one significant study, 1,002 individuals and a total of 18,555 permanent teeth were examined to determine the prevalence and severity of NCCLs.\(^{13}\) The results indicated that the lesions were caused by a combination of erosion, abrasion, and abfraction mechanisms. One in six teeth presented NCCLs. One in three premolars had a NCCL, with the lower premolars exhibiting more severe lesions. Buccal lesions were most frequent. Prevalence and severity of the lesions increased with age.

Another study examined 391 individuals and reported a frequency of wedge-shaped defects of 19.1% in the younger and 47.2% in the older populations studied.\(^{10}\) The mean prevalence was three NCCLs per person. Hypersensitivity frequently accompanied the lesions.

The extensive numbers reported in both studies and the nature of the findings reinforce the importance of the clinician’s understanding of the etiology of these lesions and the necessity for being equipped with clinical measures to diagnose, prevent, and intervene when indicated.

**RESTORING NCCLs**

Deciding whether or not to restore or perform grafting procedures as treatment for NCCLs remains subjective and controversial among clinicians, with lesion depth, lesion sensitivity, and professionals’ desire to restore them the main criteria.\(^{14}\) However, based on biomechanical principles, there are strong indications that NCCLs should be restored to counteract the degradation resulting from stress corrosion.\(^{15}\) An indication for surgical root coverage arises when recession generates esthetic compromise, results in root sensitivity, or complicates home care procedures.\(^{16,17}\)

Several effective techniques are currently available for providing root coverage and keratinized tissue gain for single or multiple cervical lesions with excellent prognosis.\(^{18-20}\) The surgical approach should be the primary treatment alternative when gingival recession is associated with minor or no tooth cavitation and unaesthetic anatomical compromise (Figure 1A–D).

Cervical lesions that are 2 mm deep or shallower have a better prognosis. The clinical situations can be divided into the following: (1) root exposure with no cavitation, (2) root exposure with cavitation, and (3) no root exposure with cavitation. When cavitation...
involves the clinical crown with minor to no root exposure, adhesive restorative techniques are recommended.

CHOICE OF RESTORATIVE MATERIALS FOR NCCLs

Although silver amalgam and gold have been used for restoring cervical lesions for many decades and each demonstrates particular advantages and disadvantages, neither material is normally an appropriate option due to the more invasive nature of the cavity preparations, requiring retention form that is unnecessary with adhesive restorations. Furthermore, many patients no longer accept metal-based materials and expect tooth-colored restorations to be offered as treatment options in contemporary dental practices.

Because of their biocompatibility, adhesion, and fluoride release, resin-modified glass ionomers (RMGI) are suggested as viable alternatives for restoring NCCLs, especially in caries-susceptible patients. Their clinical behavior, however, falls short compared with their composite resin counterparts regarding color stability, anatomical form, surface texture, marginal integrity, and marginal discoloration. Related tooth-colored restoratives, such as polyacid-modified resin composites (“compomers”), are also available, but their clinical performance remains questionable compared with composite resins. Sandwich techniques with either conventional or RMGI have also been advocated in attempts to combine the benefits of glass ionomer liners with veneering composite resin layers. Although the technique may have some benefits (e.g., improved marginal seal), its advantages over composite resins alone are questionable.

COMPOSITE RESINS: CHALLENGES AND DIFFICULTIES WHEN RESTORING NCCLs

In addition to their excellent physical and optical properties, composites can easily be manipulated, inserted, sculpted, and light-activated, making them the material of choice for restoring class V defects. The direct approach has been the primary method for restoring both carious and NCCLs. However, as simple as the direct approach may be, there are challenges and difficulties associated with this conventional restorative technique.

Among these is access to difficult-to-reach areas, as in NCCLs on first or second maxillary molars (Figure 2). The ramus and cheeks frequently defy careful and precise instrumentation of the lesions and make material placement and contouring quite difficult. The second issue involves field control, which can be conventionally achieved using a rubber dam and clamps to retract the gingival margins. Clamp placement frequently aggravates the soft tissue, especially in lesions with deep subgingival margins that require the use of anesthetic to avert sensitivity and discomfort. However, the mere sting of a needle itself aggravates most patients. An alternative field control method is the modified isolation technique, which requires packing retraction cords to block intra-crevicular fluid and provide access to cavity

**FIGURE 2.** Difficult-to-reach areas, such as NCCLs on first and second maxillary molars, present an operative challenge because the ramus and cheeks make instrumentation of the lesions, material placement, and contouring difficult. Red arrows indicate the most difficult access areas.
margins. Although this alternative procedure can often be accomplished without anesthesia, the issue of contamination remains, especially in the mandibular arch. Furthermore, the use of rotary instruments present additional subgingival marginal finishing and polishing challenges, such as invariably scarring soft tissue, leading to potential discomfort and gingival recession. Finally, if addressed with the conventional direct method, restoring multiple lesions in a quadrant during a single appointment requires a long appointment time, which can generate some patient distress. Treating several teeth at once requires each lesion to be restored individually, following the protocol steps one by one to avoid contaminating the adhesive interface and optimize material placement and finishing.

THE DIRECT-INDIRECT TECHNIQUE

A direct-indirect technique is one in which the composite resin is directly applied and sculpted onto the tooth surface prior to acid-etching and adhesive application. It is then light-activated, removed, and finished extraorally prior to indirect adhesive cementation. Also called semi-direct, this technique has anterior and posterior applications, and its advantages have been considerably discussed in the literature.\textsuperscript{30–33} When initially introduced, the technique’s greatest benefits emphasized the ability to subject the chairside-fabricated veneers (Figure 4A–D) or inlays to additional light-curing and heat-tempering processing, which enhanced the physical properties and clinical behavior of the finished composite restorations due to increased monomer conversion.\textsuperscript{34–37} Benefits beyond improved physical properties, however, render the direct-indirect technique an optimal restorative choice and paramount in providing enhanced clinical results because it facilitates greater operator control over the final anatomical and color outcome. Especially in the case of direct-indirect composite resin veneers, the advantages far surpass those of the direct veneer (Table 1).\textsuperscript{32}

THE DIRECT-INDIRECT CLASS V RESTORATION

The direct-indirect class V restoration naturally evolved from its direct-indirect veneer counterpart, as it is actually a semi-veneer covering the cervical and possibly the middle third of the clinical crown, depending on the size of the lesion. Like the veneer technique, the composite resin is applied and sculpted onto the cervical lesion, light-activated, removed, finished, polished, and bonded. Because some NCCLs are deep and V-shaped, and considering that these restorations are cemented, direct-indirect class Vs might alternatively be termed class V composite inlays.
When compared with the direct technique, the direct-indirect class V restoration provides several advantages (Table 2).

### Access to Difficult-to-Reach Areas

Canines and premolars are usually easy to reach operatively and present no major challenge to the direct approach. Molars, in contrast, introduce greater difficulty to even a skilled operator because of inaccessibility due to tooth position in relation to soft and hard tissues. Direct instrumentation in those areas (e.g., cavity preparation, material placement, contouring) is cumbersome and elusive at times. The direct-indirect approach effectively circumvents these problems because the composite is applied in larger increments and pressed over the lesion and beyond the gingival margin without much need for precise contouring. The operator initially uses a finger and contouring instruments to achieve a gross anatomical shape, which will subsequently be precisely refined extraorally after light-activation and restoration removal from the cavity.

### Field Control

The orthodox direct approach for restoring class Vs mandates absolute field control (i.e., rubber dam). The benefits of this technique are obvious, as it provides the operator prolonged working time without worrying about contamination, especially in the lower arch and situations of poor periodontal health. Alternatively, modified rubber dam techniques and retraction cords can be indicated for periodontally healthy patients and where margins are not too subgingival.

With the direct-indirect class V technique, alternative field control measures are indicated, precluding the use of conventional rubber damming and clamps. The class V inlays are adhesively cemented, therefore, allowing reduced exposure of the bonding agent to oral cavity moisture and further contamination. The level of field

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**FIGURE 4.** Direct-indirect veneers offer the added benefits of chairside fabrication and cementation associated with improved physical properties as well as optimal color and form integration.

**TABLE 1.** Comparison between direct and direct-indirect composite resin veneers

<table>
<thead>
<tr>
<th>Capabilities</th>
<th>Direct</th>
<th>Direct-indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accomplished in one appointment</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Chance for corrections</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>Shade try-in</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>Enhanced physical properties</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>Marginal polish</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>Marginal adaptation</td>
<td>—</td>
<td>✓</td>
</tr>
<tr>
<td>Periodontal health maintenance</td>
<td>—</td>
<td>✓</td>
</tr>
</tbody>
</table>
control varies by case and influences whether multiple inlays can be luted one-by-one or all at once.

**Composite Handling**

Composite resin handling can vary from very easy to extremely difficult, depending on lesion location and effectiveness of the selected field control technique. In easily accessible areas, the operator has prolonged working time, and the composite application, modeling, curing, finishing, and polishing becomes stress-free. When hard-to-reach areas are restored, the direct-indirect technique presents one of its greatest benefits, which is relieving the operator concern about precise intraoral contouring and enabling completion of almost all finishing and polishing extraorally. However, handling a composite inlay of minute dimension during finishing and polishing may be a major challenge until the operator reaches his or her comfort zone.

**Stress Caused by Polymerization Shrinkage on Tooth**

The composite resin quantity, cavity geometry, and C-factor are reported to influence the shrinkage stress exerted on the tooth in class V restorations.38,39 Layering techniques have been advocated to minimize the undesired consequences of composite shrinkage (i.e., post-operative sensitivity, microleakage),40–42 but there are divergent findings regarding the efficacy of incremental layering versus bulk filling.43–45 The benefits of bulk filling class V defects, however, make it more attractive to operators, because they frequently include use of a single shade, thus minimizing the number of steps and reducing operative time. Depending on cavity/lesion size and depth, incremental layering or bulk filling may be indicated for both the direct and direct-indirect class V approaches, primarily for esthetic reasons, as composites of varying chroma and opacity may be utilized. Because the direct-indirect technique advocates supplemental secondary light-activation of the class V inlay extraorally, the bulk fill technique should be used whenever possible. The additional extraoral light cure counteracts problems associated with insufficient curing at the bottom of thicker inlays.

**Gingival Margin Finishing**

Marginal finishing for the direct-indirect class V restorations resembles the process for finishing relined provisional margins. Once the composite is pressed over the cervical margin of the lesion and extended over the free gingival margin, it is light-cured and removed from the mouth. The margins are outlined with a pencil for precise visualization, and finishing is completed with discs. Magnification (e.g., loupes or microscope), in combination with the sequential use of

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**TABLE 2. Comparison between direct and direct-indirect class V restorations**

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Direct</th>
<th>Direct-indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to difficult-to-reach areas</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Field control</td>
<td>Rubber dam or modified isolation</td>
<td>Modified isolation</td>
</tr>
<tr>
<td>Composite handling</td>
<td>Totally intraoral</td>
<td>Intra- and extraoral</td>
</tr>
<tr>
<td>Stress caused by polymerization shrinkage on tooth</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Gingival margin finishing</td>
<td>Totally intraoral</td>
<td>Totally extraoral</td>
</tr>
<tr>
<td></td>
<td>Accomplished with burs, discs, and rubber rotaries</td>
<td>Completed with discs</td>
</tr>
<tr>
<td>Restoration marginal adaptation</td>
<td>Difficult to achieve</td>
<td>Excellent</td>
</tr>
<tr>
<td>Periodontal health maintenance</td>
<td>Dependent upon quality of gingival margins</td>
<td>Excellent</td>
</tr>
<tr>
<td>Patient comfort</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
discs of varying grits, permits finishing the margins to the utmost contour and polish. Unlike the direct-indirect method, finishing direct class V cervical margins intraorally can be difficult and demonstrate less than ideal outcomes, especially in subgingival margins in hard-to-reach areas. Potential problems arising from direct finishing include, but are not limited to, flash and overhangs, rough gingival margins, and nicking the cementum as a result of poor access to and instrumentation of the margins.

Restoration Marginal Adaptation

Adaptation of the composite to the cervical margin of a NCCL using the conventional technique involves contouring instruments and brushes. Marginal sealing and tightness of the tooth-composite interface depends upon proper material placement and implementation of proper adhesive protocols. In straightforward clinical scenarios, achieving a tight marginal seal can be fairly predictable with satisfactory results. Once again, it is in difficult cases that adaptation problems are likely to arise. In an in vitro study, Haller and colleagues investigated the marginal seal of cervical composite inlays in comparison to conventional class V restorations. The results showed better performance of the inlays regarding microleakage. In the study, the inlays were further subjected to additional light-curing and heat tempering, which made the bonded inlays more resistant to thermal stress, probably by relaxing material stress and enhancing bond stability. The direct-indirect class V restoration achieves the same benefits of stress reduction through the material application and polymerization mechanisms employed, providing a much better marginal adaptation.

Periodontal Health

The effects of subgingival restorations on periodontal health have been widely investigated. Problems associated with restorative material type and poorly finished restorations include a change in the subgingival microflora leading to plaque accumulation, gingivitis, and recurrent caries. Because achieving excellent margins through utmost surface and marginal polish becomes imperative, so does selecting proper finishing and polishing techniques. Several papers confirm that the smoothest composite resin surface can be achieved by using aluminum oxide finishing discs. It is impossible to intraorally gain access to subgingival margins with discs unless some means of gingival retraction is utilized. This leaves the only option of using burs and rubber polishers for smoothing margins, and a perfect result is seldom achieved. However, extraoral finishing and polishing of class V inlays provide unmatched surface smoothness, which, in turn, promotes less plaque retention and, consequently, a healthier periodontal environment.

Patient Comfort

The direct-indirect class V technique provides a more comfortable experience for the patient versus the direct technique. There is minimal intraoral working time, which reduces the length of time patients keep their mouths open, allowing them to rest between restorative steps. Anesthesia is seldom needed, even when packing retraction cords is required. Perhaps the greatest comfort provided by the inlay technique results from the absence of subgingival finishing. Other than removing minor flash of luting resin at the gel stage with a sickle scaler or similar instrument and buffing the restoration surface with rubber cups, there is no aggressive contact with the soft tissue. As stated previously, scarring of gingival tissue and nicking the cementum/root surface during operative procedures is a nuisance and cause of great uneasiness to patients. This benefit becomes evident immediately after completing treatment, when no damage to either tooth or periodontium ensues, and sound integration between soft tissue and restoration is perceived (Figure 5A–D).

THE TECHNIQUE

Step 1. Composite Selection

Physical Properties

In terms of physical properties, the criteria for selecting restorative composite resins include modulus of elasticity, handling, resistance to wear, and
polishability. Controversy exists regarding the extent to which compressive versus tensile stresses plays a role in retentive failure in vivo of stress-induced NCCLs, and the choice of a lower over a higher modulus of elasticity composite to enable better stress distribution remains debatable.\(^{53–55}\) Predicting failure risk of the tooth-restoration adhesive interface based on stress dissipation properties alone is difficult both in vitro and in vivo due to the essentially deformable nature of composites and the interrelationship between the actual composite resin, tooth substrate, and periodontal ligament.\(^{56}\) While the use of microfills has been recommended for stress-generated NCCLs based on their higher resiliency and lower modulus of elasticity, controversy surrounds this recommendation.\(^{57}\)

Although most state-of-the-art composites could be indicated for restoring NCCLs, the author prefers to use microfill or nanofill restoratives because of the excellent inherent properties related to their filler size and distribution. Their handling and polishability enable proper manipulation and sculptability, and promote excellent surface smoothness and gloss.\(^{58–60}\) Surface smoothness of composite resins has been shown to directly correlate with gloss.\(^{61}\) Change in gloss is primarily influenced by composite resin material characteristics (i.e., filler type, distribution, resin matrix chemistry).\(^{62}\)

Of equal clinical relevance, wear is another important characteristic when selecting the composite resin for a NCCL class V restoration that will be subjected to intraoral abrasion from whichever source. Despite its importance, however, reported wear rates should not dictate restorative composite resin selection for a NCCL, since clinical assessment of wear is not as easily accomplished as in a laboratory setting, given the many variables involved in producing wear. While conventional and reinforced microfills (e.g., Renamel Microfill, Cosmedent, Chicago, IL; Micronew, Bisco, Inc., Schaumburg, IL) provide excellent polish and gloss, wear rates vary according to product brand and composition. This fact per se should not preclude the clinical use of microfills, as they have demonstrated superior clinical performance. Submicron-filled composites have been reported to exhibit both high gloss and have low wear rates,\(^{62}\) which provides a strong indication for their clinical implementation in NCCLs. A few commercial products include Estelite Omega and Estelite Asteria (Tokuyama Dental, Taitou-kuTokyo, Japan), and Filtek Supreme Ultra (3M ESPE, St. Paul, MN, USA).

**Shade and Optical Properties**

In cases of no root exposure with cavitation and minor root exposure with cavitation, tooth-colored composites are indicated. The cervical one-third of the natural dentition presents higher opacity and accentuated chroma because the dentin is at its thickest and the enamel is at its thinnest, making the inner dentin color show through the thin outer enamel. Optically, this demands the use of composite resins that replicate natural dentin and enamel to achieve a seamless restoration.

This can be achieved either by (1) using artificial dentin and enamel composites as separate layers, or (2) utilizing a single layer of a composite shade of an
intermediate opacity between the two. The first technique calls for selecting a higher chroma dentin shade than that intended. The veneering enamel composite can be selected according to either an (1) polychromatic or (2) natural layering approach. The polychromatic method uses a VITA-based veneering enamel composite of the intended hue and chroma, and a dentin of the same hue but with a higher chroma. The natural layering method employs a VITA or non-VITA dentin composite of the desired hue with a higher than intended final chroma, and non-VITA enamel shade that modulates the dentin color to the desired chroma and value, while maintaining the same hue of the underlying dentin composite. Both techniques are equally effective, and the decision to utilize one over the other depends upon the operator’s preference and mastery of the selected technique. The author favors the use of VITA enamel shades over non-VITA shades because they provide more predictability in attaining the final hue, chroma, and value of the cervical tooth color. Cavities deeper than 2.5 mm may be restored with the dual layer (i.e., dentin and enamel) approach. However, in most cases, a higher opacity VITA enamel suffices to provide the proper opacity/value while
imparting a natural depth and blending effect with the surrounding tooth structure and adjacent dentition (Figure 6A and B).

In cases where there is root exposure with no cavitation and grafting procedures are dismissed as a primary option, gingival-colored composites (e.g., Gingafill, Cosmedent, Chicago, IL; Amaris Gingiva, Voco, Indian Land, SC) may be utilized alone (Figure 6C) or in combination with tooth-colored composites (Figure 6D). This approach minimizes the long-clinical-crown appearance that ensues if only tooth-colored composites are used, which invariably creates an unaesthetic result, especially when the restorations are displayed during the smile (Figures 7A–D and 8A–D).

**Step 2. Cavity Preparation**

Cavity preparation varies from none, in cases of erosion/abrasion lesions, to beveling of the enamel where wedge-shaped lesions with sharp enamel occlusal cavosurface margins present. In the former case, class V restorations may appear more like a thin contact lens veneer that may extend onto the middle and occlusal thirds, and in the latter, it assumes the actual shape of a class V inlay.

**Step 3. Composite Application**

If the cervical margin is equigingival or slightly subgingival, packing retraction cords is unnecessary. Packing a non-impregnated cord of adequate thickness may reveal margins that are deeper subgingivally and, thus, assist in imprinting the margins on the composite. For the more common scenario of lesions shallower than 2.5 mm, the selected single composite shade is made into a small ball that is rolled between the fingers and pressed onto the cervical lesion, covering not only the cavity, but also extending beyond its boundaries over the beveled enamel, interproximally and, most importantly, over the gingival margin (Figure 9A–C). Gentle finger pressure assures an accurate imprint of the gingival margin into the squashed composite increment. Although instruments may be used for further contour refinement, this is often not necessary, since all gross excess will be removed through extraoral finishing and polishing.

**Step 4. Light-Activation and Restoration Removal**

The restoration is thoroughly light-cured by providing proper light intensity and cure time, according to the type of curing unit employed (e.g., halogen, LED, plasma ARC). Using a curette, the restoration is flicked off and...
further light-cured extraorally from its outer and inner aspects to ensure adequate polymerization.

A thick direct class V restored using the bulk fill technique would normally require an extended light exposure for maximum polymerization, and this prolonged curing time may have deleterious effects on the pulp.66,67 Performing the final light-cure extraorally for the direct-indirect class V restoration allows for prolonged light exposure as needed without concern for potential pulp damage arising from increased temperature.

**Step 5. Extraoral Finishing and Polishing**

The imprinted cervical margin is clearly evident on the cured composite, and a pencil is used to outline its fine edges, facilitating visualization during the finishing stage. Aluminum oxide discs of varying grits are used sequentially to remove the gross excess, and to finish and polish the margins to ideal contour, smoothness, and gloss (Figure 10).

**Step 6. Surface Pre-Cementation Treatment of Restoration**

The restoration inner surface is airborne particle-abraded using 27–50 μm aluminum oxide particles, or alternatively with a 30 μm silicate ceramic (e.g., CoJet, 3M ESPE, St. Paul, MN) (Figure 11). Although composite resins vary considerably and may require different protocols for adhesive cementation, mechanical roughening is reported to produce effective bond strengths on microfills, hybrids, and nanofills.68,69 After air abrasion, the intaglio of the restoration is cleaned with 35–40% phosphoric acid for 10 seconds, rinsed, and dried. Silanation has been shown to enhance bond strengths of laboratory processed composites70 and may be incorporated as an additional step for the direct-indirect class V technique. Despite the proven benefits of silane application, this step is optional, as its advantages in class V inlays have not yet been reported. Next, a hydrophobic adhesive resin (e.g., All Bond 3, Bisco, Inc., Schaumburg, IL; OptiBond FL, Kerr Corporation, Orange, CA, USA; Scotchbond MP, 3M ESPE, St. Paul, MN, USA) is applied and air-thinned. The inlay is set aside under a light-protective shield until cementation. If more than one inlay is being completed, the clinician should be organized in the sequence according to which they will be cemented.

**Step 7. Surface Pre-Cementation Treatment of NCCLs**

Following the packing of the retraction cord to reveal the dentinal margin, the dentin and enamel surfaces of the cavity are airborne particle-abraded with 27–50 μm aluminum oxide (Figure 12A and B). This step enhances bond strengths by roughening the dentin and removing
the aprismatic layer of uninstrumented enamel beyond the bevel line, thus enhancing bonding in that area.\textsuperscript{71,72} Air abrasion of enamel and dentin promotes similar bond strengths for both etch-and-rinse and self-etch adhesives, although the tag formation seems to be more evident for self-etch adhesives.\textsuperscript{72} A recently published literature review concerning the effectiveness of self-etch versus etch-and-rinse adhesives with multiple steps for treating NCCLs determined that there is insufficient evidence to support one adhesive or bonding protocol over another.\textsuperscript{73} Clinical judgment at the time of the procedure should determine adhesive selection. For example, if gingival inflammation is present, using a three-step total-etch adhesive that requires acid-etching may be contraindicated, because the acid will likely promote bleeding. This is not the case with self-etch adhesives that tend to be gentler on the soft tissue and do not provoke bleeding upon contact with the gingiva, even if moderately inflamed. Three-step total-etch adhesives are considered the gold standard and, therefore, may be considered a primary choice over other adhesives.\textsuperscript{74}

The dentin and enamel are etched with 35–40\% phosphoric acid for 15 seconds and rinsed. Surface
moisture control is completed by aspirating excess water (Figure 13). Filled three-step total-etch adhesives are preferable for this technique based on the benefits they present. A primer is applied (e.g., All Bond 3 A&B, Bisco, Inc., Schaumburg, IL; OptiBond FL, Kerr Corporation, Orange, CA) and agitated onto the dentin surface for at least 20 seconds. Excess primer is aspirated, and the remnant solvent is further volatilized by gentle air spray. A thin coat of hydrophobic adhesive is applied, excess is aspirated, and the adhesive light-activated (Figure 14A and B). The filler content of the adhesive creates a slightly thicker layer that enhances bond strength and minimizes microleakage, promoting longer life expectancy in the class V restoration. Although the adhesive is cured prior to cementation, the composite inlay will fit properly, since sandblasting provides room to accommodate adhesive thickness.

Step 8. Cementation of the Class V Inlay

A light-cured resin luting cement or flowable restorative composite resin can be used for cementing the class V inlay. Translucent resin of any shade usually provides good color blending and elicits natural looking results. A thin coat of hydrophobic adhesive is applied to the intaglio of the inlay, which is subsequently covered with the selected luting resin, and carried onto the pre-hybridized lesion with tweezers or a sticky handle (Figure 15A–C). Once positioned, the inlay is pressed to ooze the excess luting resin. A small-tipped light guide (e.g., VALO, Ultradent Products, Inc., South Jordan, UT; Optilux Demetron, Kerr Corporation, 

**FIGURE 13.** Dentin and enamel are etched with 35–40% phosphoric acid for 15 seconds to comply with a three-step etch-and-rinse adhesive application protocol.

**FIGURE 14.** Following primer application, a thin coat of hydrophobic adhesive is applied, and light-cured.

**FIGURE 15.** The inlay is covered with a thin coat of hydrophobic adhesive, followed by luting resin, and it is carried onto the pre-hybridized lesion.
Orange, CA) is used to push the inlay into position away from the cervical margin, and it is spot-cured for 1–3 seconds, depending on the intensity of the curing unit (Figure16). The luting resin, which has reached a gel stage, is removed with a sickle, and the interproximal areas are checked with dental floss to ensure complete removal of luting resin (Figure17). An air-inhibiting gel is applied over the spot-cured inlay, and final light-curing is realized for the length of time necessary according to the curing unit used (Figure18). The adhesive tooth-inlay interface depicts an enhanced micromechanical as well as physical-chemical link to ensure optimal bond of the restoration (Figure19).

Step 9. Final Finishing and Polishing
The occlusal margin of the inlay will frequently demonstrate a thicker rim requiring additional intraoral refining. Finishing discs of varying grits are used sequentially to finesse any roughness and execute minor contour changes. As the gingival margins of the inlay have been previously finished and polished, touching these areas with rotary instruments should be avoided to prevent unnecessary scratching of the smooth and glossy surface. Next, rubber polishing points and cups are used, followed by felt discs and polishing pastes, to bring the class V inlay to its final surface polish and gloss (Figure20A). Meticulous attention to material selection, cavity preparation, adhesive protocol, and light-curing, in addition to precise finishing and polishing techniques, assures a potentially long-lasting result for direct-indirect class V inlays (Figure20B).

DISCUSSION
The direct-indirect class V composite inlay technique may seem cumbersome and difficult to implement clinically at first glance, since it advocates a completely different paradigm compared with conventional direct
class V restorations. Certainly, the direct approach is unquestionably a viable option and could still be considered the primary indication for carious or NCCLs with easy access and where field control does not pose a challenge. The change in mentality beginning to consider executing the direct-indirect technique requires a learning curve of working with tiny inlays intra- and extraorally. For that reason, using high magnification loupes or microscopes is essential if precise margin finishing and polishing is to be achieved, which is one of the greatest benefits of this novel approach. Frequently, the operator will require a change in gloves because of cuts or tears from the discs during finishing, due to the difficulty in handling such small restorations. Because of their minute size, preventing the inlays from flying from one’s hands across the operatory room while handling them during finishing and polishing is also an expected challenge. Loss of some restorations is to be anticipated, and remakes are sometimes necessary.

The author has a 4.5-year follow-up involving 62 direct-indirect class V composite inlays, a few made from microfills and the vast majority from nanofills, all of which demonstrate immaculate polish and excellent marginal integrity. The adhesive protocols employed varied from case to case and included one-step and two-step self-etch adhesives with selective enamel etching and etch-and-rinse three-step adhesives. Of the 62 restorations, only one inlay debonded within four years and required remake. Future in vitro research should be conducted to ascertain the most appropriate bonding protocol for this technique, as well as to evaluate the quality of the marginal seal and integrity of the adhesive interface in comparison the conventional direct restorative approach.

CONCLUSION

The novel technique presented in this article optimizes the treatment of NCCLs through the creation of direct-indirect class V restorations. The greatest benefits of this technique are precise extra-oral margin finishing and polishing, and overcoming challenges associated with field control, composite handling, maintaining periodontal health, and controlling polymerization shrinkage stress.

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