

*“PFM crowns are radical restorations,  
requiring significant tooth reduction...”*

# Clinical Performance of Bonded Ceramic and Resin-Based Composite Inlays and Onlays Using a Self-Etch Bonding System: a 51-Month Report

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When a larger portion of the tooth is missing or decayed, an indirect restoration is usually indicated.<sup>1,2</sup> Many patients do not want metal in their mouths and refuse partial coverage gold restorations because they prefer something more esthetic and tooth-colored.<sup>3</sup> Porcelain-fused-to-metal (PFM) crowns are the most popular indirect restorations for posterior teeth. PFM crowns are radical restorations, requiring significant tooth reduction to achieve ideal mechanical retention and esthetics; up to 74% of the crown volume is removed during a traditional crown preparation, as reported by Edelhoff<sup>4</sup> (Figure 1 and Figure 2). Although metal-free inlays and onlays are good alternatives, unexpected failure of some of these restorations may have led to their limited use. More recent clinical studies have shown promising results.<sup>5-8</sup> The improved results may be due to a better understanding of the materials, and improvements in placement techniques (Figure 3 through Figure 5).

The purpose of this retrospective clinical report was to evaluate the clinical

service of ceramic and resin-based composite inlays and onlays at a mean clinical life of 51.46 months, as placed in a typical private practice under normal clinical circumstances, using a self-etch bonding system and resin cement. All the restorations in this study were performed in a dry field without the use of rubber dam. Most published studies have been accomplished at the university level, and have very controlled protocols, limited patient and tooth selection, as well as time-consuming and complicated techniques in many cases.<sup>9-12</sup> Highly controlled clinical studies are valuable for many reasons, but as stated by Manhart<sup>13</sup> they “do not reflect the situations in general dental practice.” For this reason clinical reports are of great value.

Eighty-seven patients who had previously received 341 restorations were asked to allow evaluators to examine their metal-free inlays and onlays; only 14 patients, seven men and seven women, were able to attend the evaluation at the given day and time. Fifty-four restorations were

evaluated: 50 fabricated with IPS Empress® (Ivoclar Vivadent, Amherst, NY) and four fabricated with belleGlass™ (Kerr Lab, Orange, CA). The restorations had a mean clinical life of 51.46 months, with a minimum clinical life of 48 months; 28 restorations were on molars and 26 were on premolars.

All patients were evaluated by two teams of dentist evaluators who were standardized by a pre-evaluation discussion. Each team consisted of two examiners. Both examiners observed the restoration and evaluated it individually on the parameters described below. Each restoration received a score from both teams. The two scores were then averaged. Representative restorations were photographed. A modified US Public Health Service Commissioned Corps clinical evaluation form 14 was used with seven clinical parameters: porcelain fracture (PF), marginal integrity and secondary caries (MI-SC), cavosurface margin discoloration (MD), anatomical form (AF), color match (CM), opposite tooth wear (OTW) and

parafunctional habits (PH). Table 1 shows the rating criteria for each parameter. Two additional questions were asked of the patients regarding any peculiar oral habits and their satisfaction level with the restoration.

## CLINICAL PROCEDURE

All restorations were performed on vital teeth in a practice by a single clinician (the primary author), using the following protocol:

- Teeth were prepared with 2 mm of occlusal reduction and 1.5 mm of axial reduction (when axial reduction was indicated). Sharp line angles were avoided, and no cavomargin bevels were placed (Figure 6).
- Areas in dentin considered to be close to the pulp, or very deep, were lined with resin-modified glass ionomer, Vitrebond™ (3M ESPE, St. Paul, MN).<sup>15</sup>
- Impressions were made with a polyvinyl siloxane impression material.



Figure 1 Virgin tooth; compare to Figure 2.

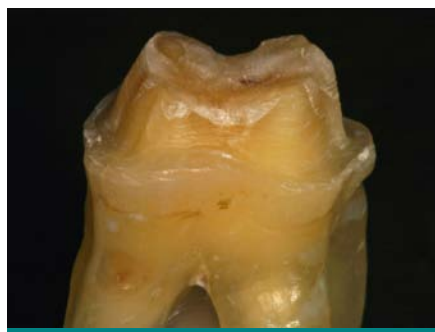


Figure 2 Edelhoff reported that approximately 68% to 74% of coronal tooth structure is removed during a typical crown preparation.<sup>4</sup>

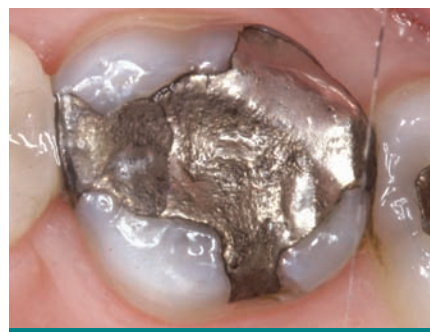


Figure 3 This tooth would have typically been treated with a full-crown preparation.

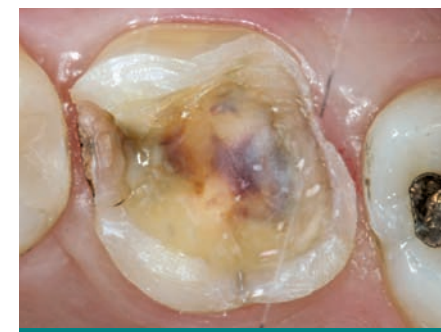


Figure 4 Note the large band of enamel and dentin preserved by the use of a non-metal bonded onlay.



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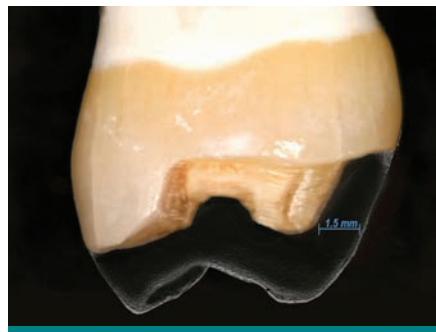
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**Figure 5** Observe the excellent esthetic final result.



**Figure 6** Preparation for a non-metal onlay, with 2 mm of occlusal reduction and 1.5 mm of axial reductions when needed.

- Cord retraction was usually unnecessary, as most cavomargins were supragingival.
- Provisional restorations were fabricated using a bis-Acryl provisional material and cemented with provisional resin cement.
- At the final cementation appointment, the provisional restorations were removed.
- The teeth were thoroughly cleansed with pumice on a rubber cup.
- A dry field was achieved for cementation by careful isolation using cotton rolls. On some occasions, cord retraction was necessary. A rubber dam was not used.
- Clearfil® Liner Bond 2V (Kuraray America, New York, NY), one of the only dual-cure bonding agents available at

the time, was used as the bonding agent for all restorations.

- Nexus® 2 (Kerr Dental), Variolink® (Ivoclar Vivadent) or Lute-It® (Pentron Clinical Technologies, LLC, Wallingford, CT) were used as the luting agents. Each cement was used for approximately one third of the restorations. Fifty restorations were fabricated with Empress and four with belleGlass.

At the 51-month evaluation, 100% of the restorations were serving, and all patients reported that they were satisfied with their restorations. All teeth were free of pain and none had required endodontic therapy. Tissue health was excellent when compared to PFM crowns on adjacent teeth (Figure 7).

**Table 1 Rating Criteria and Evaluation Form\***

CLINICAL PARAMETER	RATING CRITERIA
<b>Porcelain Fracture</b> (visual)	Alpha (1) None Bravo (2) Up to 0.5 mm (no action) Charlie (3) > 0.5 mm (repair) Delta (4) To dentin (replacement needed)
<b>Marginal Integrity &amp; Secondary Caries</b> (checked with explorer)	Alpha (1) Undistinguishable margin Bravo (2) Margin ditching, no crevice Charlie (3) Crevice, possible caries (repair needed) Delta (4) Crevice with obvious caries (replacement needed)
<b>Cavosurface Margin Discoloration</b> (visual)	Alpha (1) None Bravo (2) Slightly less than 1/2 margin inv Charlie (3) Moderate, more than 1/2 margin Delta (4) Unsightly (repair needed)
<b>Anatomical Form</b>	Alpha (1) No evidence of wear Bravo (2) Minor wear < 0.5 mm Charlie (3) Moderate > 0.5 mm Delta (4) Dentin exposed (replace)
<b>Color Match</b>	Alpha (1) Perfect match Bravo (2) Slight mismatch Charlie (3) Severe mismatch
<b>Parafunctional Habits</b>	Yes No
<b>Opposite Tooth Wear</b>	Alpha (1) No evidence of wear Bravo (2) Minor wear < 0.5 mm Charlie (3) Moderate > 0.5 mm Delta (4) Dentin exposed

\* A modified USPHS clinical evaluation form was designed and used.

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**Figure 7** When the restoration margins are left supragingival, tissue health is better. Compare a PFM crown on the second premolar with subgingival margins vs a distal-occlusal onlay on the first premolar.



**Figure 8** This onlay on tooth No. 14 shows the excellent tooth-preserving results obtained with non-metal onlays.



**Figure 9** This restoration part of the study showed marginal stain; 70.4% of the restorations showed similar staining.



**Figure 10** Observe how these three restorations in this study performed well even under heavy occlusal load and parafunction.

**Table 2 Results by Number (%) of Restorations (N = 54)\***

RATING	PF	MI-SC	MD	AF	CM	OTW
ALPHA (1)	30 (55.6%)	47 (87.1%)	15 (27.8%)	39 (72.2%)	2 (3.7%)	43 (79.6%)
BRAVO (2)	23 (42.6%)	6 (11.1%)	38 (70.4%)	15 (27.8%)	52 (96.3%)	7 (13.0%)
CHARLIE (3)	1 (1.8%)	1 (1.8%)	1 (1.8%)	0	0	0
DELTA (4)	0	0	0	0	0	0
Not Possible						4 (7.4%)

\* The results showed that 87% of the restorations had undistinguishable margins with the explorer evaluation, but 70.4% had visual marginal stain.

The overall performance was good (Figure 8): 23 restorations (42.6%) had minor chipping (PF), and one restoration had a ceramic cohesive fracture (PF), which was deemed to need repair, not replacement. The patient had been unaware of the

fracture. Six restorations (11.1%) had a marginal crevice without dentin exposure; one restoration had a deep crevice with possible decay (MI-SC) and was deemed to need repair but not replacement. Minor marginal stain was present in 70.4% of

the restorations (Figure 9). One restoration had extensive marginal stain (MS) and was deemed to need repair; 96.3% of the restorations showed slight CM; and 7.4% had severe CM. Eight patients showed signs of parafunctional habits (Figure 10), and seven patients reported either smoking or drinking tea or coffee routinely. A summary of these results is shown in Table 2.

The primary goal of this study was to evaluate the clinical success of non-metal inlays and onlays using a self-etch bonding system and resin cement in a typical private practice setting. The results of the study yielded very encouraging data. First, this study underscores the observation that non-metal indirect inlay and onlay restorations are an acceptable restorative option. Second, satisfactory clinical success can be achieved using a self-etch bonding system. Self-etch bonding systems are more clinically forgiving in regards to humidity, as shown by Werner and Tani.<sup>16</sup> Postoperative sensitivity is a common problem observed when using a total-etch bonding system. In his study, Barghi reported three out of 21 restorations had postoperative pain at the 6-month recall and one tooth required endodontic treatment at 2 years.<sup>10</sup> Kramer reported a 13% incidence of postoperative pain and two endodontic treatments.<sup>8</sup> For this reason, the use of a resin-modified glass ionomer liner and a more user-friendly adhesive system, such as a self-etch bonding system, should be considered.

Although marginal stain was evident, it did not appear to have clinical relevance or to compromise patient satisfaction. Marginal staining may be due to the low acidity of the adhesive system used, which may be unable to etch uncut enamel as well as a total-etch system can. This modified

technique, using total-etch on margins and self-etch on dentin, may be useful to decrease marginal staining; Etch the enamel for 20 seconds, wash and dry, and follow by normal application of the self-etch primer and resin over both dentin and enamel. Conflicting results have been reported with the use of this technique;<sup>17,18</sup> further clinical evaluation would be desirable.

Although the use of a rubber dam provides the most predictable means of isolation, it was not compulsory for clinical success in this study. Other studies have demonstrated similar results.<sup>19-21</sup> The authors are not stating that isolation is unimportant in adhesive dentistry; isolation is a must. However, careful selection of adhesive systems, coupled with excellent cotton roll or other isolation, appear to be sufficient to achieve clinical success.

Non-metal partial inlays and onlays have many advantages. Their primary clinical advantage is that they are less traumatic and more conservative to the tooth structure and surrounding tissues. Historically, the most conservative and ideal results have been obtained using partial-coverage gold alloy restorations. At this time, ceramic or resin-based composite inlays and onlays may not be able to match the longevity of gold alloy<sup>22-24</sup> but further improvements in materials and improved techniques will eventually overcome this problem. Partial-coverage non-metal inlays and onlays surpass gold in an improved ability to show secondary caries. This ability, coupled with its ease of repair, may be of benefit to the long-term longevity of the tooth (Figure 8). Finally, because of the improved gingival health achieved with supragingival margins and the overall benefits of non-metal inlays and onlays, they are clearly an excellent alternative choice to PFM crowns. In many cases, these restorations should be considered before the more invasive PFM procedure.

## CONCLUSION

As shown by the results of this retrospective clinical report, ceramic and resin-based composite inlays and onlays are an acceptable restorative alternative when used in a busy general private practice. Although partial-coverage gold alloy restorations are considered to be the most conservative and most reliable restorations,



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many patients continue to refuse metal and ask for more esthetic restorations. Patients receiving PFM crowns should be informed of their limitations and educated on more tooth-preserving alternatives. The less invasive and esthetic tooth-colored inlays and onlays need to be considered as alternatives for PFM crowns.

## DISCLOSURE

The authors do not have any financial interest in the companies whose materials are included in this article.

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