

# Influence of Immediate Dentin Sealing Techniques on Cuspal Deflection and Fracture Resistance of Teeth Restored with Composite Resin Inlays

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## Clinical Relevance

Immediate dentin sealing with Clearfil SE Bond can contribute to less cuspal deflection of teeth restored with composite resin inlays luted with Panavia F.

## SUMMARY

**This research evaluated the influence of immediate dentin sealing (IDS) techniques on cuspal deflection and fracture resistance of**

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teeth restored with composite resin inlays. Forty-eight maxillary premolars were divided into four groups: G1, sound teeth (control); G2, without IDS; G3, IDS with Clearfil SE Bond (CSE); and G4, IDS with CSE and Protect Liner F. The teeth from groups 2, 3, and 4 received mesio-distal-occlusal preparations. The impressions were made with vinyl polysiloxane, followed by provisional restoration and storage in water for seven days. The impressions were poured using type IV die stone, and inlays with Filtek Z250 composite resin were built over each cast. The inlays were luted with Panavia F. After storage in water for 72 hours, a 200-N load was applied on the occlusal surface using a metal sphere connected to a universal testing machine, and the cuspal deflection was measured with a micrometer. The specimens were then submitted to an axial load until failure. The following mean cuspal deflection ( $\mu\text{m}$ ) and mean fracture resistance (N) followed by the same lowercase letter represent no statistical difference by analysis

**of variance and Tukey ( $p < 0.05$ ): cuspal deflection: G1,  $3.1 \pm 1.5^a$ ; G2,  $10.3 \pm 4.6^b$ ; G3,  $5.5 \pm 1.8^{ac}$ ; and G4,  $7.7 \pm 5.1^{bc}$ ; fracture resistance: G1,  $1974 \pm 708^a$ ; G2,  $1162 \pm 474^b$ ; G3,  $700 \pm 280^b$ ; and G4,  $810 \pm 343^b$ . IDS with CSE allowed cuspal deflection comparable with that associated with sound teeth. The application of Protect Liner F did not contribute to a decrease in cuspal deflection. The IDS techniques did not influence the fracture resistance of teeth.**

## INTRODUCTION

Indirect composite restorations have been used to fabricate inlays, onlays, veneers, and crowns as a result of improved mechanical properties and controlled polymerization shrinkage stresses.<sup>1</sup> The traditional technique consists of making an impression of the tooth immediately after preparation and luting an acrylic resin restoration with provisional cements; the traditional approach may involve the use of provisional resin materials applied directly on the prepared tooth. Once the permanent restoration is ready, the provisional material is removed and an adhesive system is applied to the tooth, followed by a resin cement for the adhesive luting procedure.<sup>2</sup>

Studies<sup>3,4</sup> have shown that adhesive systems bond better to freshly cut dentin in comparison with dentin contaminated with temporary materials. This contamination may cause microleakage,<sup>5</sup> failure in hybridization, and sensitivity.<sup>6</sup> To avoid these problems, the immediate dentin sealing (IDS) technique was developed in the early 1990s<sup>7</sup>; this technique consists of the application of an adhesive system immediately after concluding the tooth preparation and prior to impression. Another technique consists of the application of an adhesive system and a low-viscosity composite resin to dentin immediately after concluding the preparation.<sup>8,9</sup> It is believed<sup>10</sup> that a layer of low-viscosity composite resin helps to protect the hybrid layer and, consequently, preserves the dentin seal.

With both techniques, further adhesion of the luting agent to the preexisting resin layer must be promoted by surface cleaning prior to luting,<sup>11</sup> with the purpose of removing remnants of provisional cements that may cause a significant decrease in the bond strength of the luting agent.<sup>6,12</sup>

These techniques have the clinical advantages of covering the prepared dentin with a resin agent immediately after cavity preparation, sealing and protecting the dentin-pulp complex, and preventing

and decreasing sensitivity and bacterial infiltration during the provisional stage.<sup>11</sup>

With the IDS technique, studies have shown that there is good bonding of the resin material with an adhesive system<sup>13</sup> and an increase in bond strength with an adhesive system and low-viscosity composite resin.<sup>8,9,14,15</sup> Jayasooriya and others<sup>16</sup> observed fewer gaps at the internal dentin-restoration interface in the specimens coated with an adhesive system and a low-viscosity microfilled resin compared with noncoated specimens. With regard to the marginal sealing capacity, the higher bond strength does not necessarily provide less microleakage when the IDS is used.<sup>17</sup> However, there is no information about the influence of IDS on cuspal deflection and fracture resistance of restored teeth.

The aim of this study was to evaluate the influence of the two IDS techniques on cuspal deflection and fracture resistance of teeth restored with composite resin inlays. This study was conducted under the null hypothesis that these techniques do not influence cuspal deflection and fracture resistance.

## MATERIALS AND METHODS

Forty-eight sound maxillary first premolars were obtained from the Tooth Bank of Pontifical Catholic University of Rio Grande do Sul after ethics committee approval was obtained. The teeth were cleaned and disinfected in 0.5% chloramine for 24 hours and then stored in distilled water at 4°C. The buccal-palatal and mesio-distal dimensions of each tooth were measured with a digital caliper (Mitutoyo, Suzano, SP, Brazil). A variation of 0.5 mm was allowed for each measurement to standardize the dimensions of the teeth.

The teeth were randomly divided into four groups ( $n=12$ ), as follows: group 1, sound teeth (control); group 2, inlay cavity; group 3, inlay cavity and IDS with adhesive system; and group 4, inlay cavity and IDS with adhesive system and low-viscosity composite resin. The materials used are listed in Table 1.

### Preparation of the Mesial, Distal, and Occlusal Surfaces

Each tooth was mounted vertically in a plastic ring with self-cured acrylic resin (Jet Classico, São Paulo, SP, Brazil) up to 2 mm below the cemento-enamel junction (CEJ) to mimic the alveolar bone support in a sound tooth. In groups 2, 3, and 4, a single operator performed cavity preparation on the mesial, distal, and occlusal surfaces with a 4159 diamond bur (KG Sorensen, Barueri, SP, Brazil) at high speed under

Table 1: *Materials Used in the Study*

Materials	Composition	Manufacturer
Clearfil SE Bond	Self-etch primer: 10-MDP, HEMA, hydrophilic dimethacrylate, photoinitiator, water Adhesive: 10-MDP, bis-GMA, HEMA, hydrophilic dimethacrylate, microfiller	Kuraray Medical Inc, Tokyo, Japan
Protect Liner F	TEG-DMA, Bis-GMA, methacryloyl fluoride-methyl, methacrylate copolymer	Kuraray Medical Inc, Tokyo, Japan
Panavia F	ED primer A: HEMA, 10-MDP, 5-NMSA, water, accelerator ED primer B: accelerator, water, sodium benzene sulfinate A-Paste: methacrylate, 10-MDP, quartz-glass, microfiller, photoinitiator B-Paste: methacrylate, barium glass, sodium fluoride, chemical initiator	Kuraray Medical Inc, Tokyo, Japan
Filtek Z250	Bis-EMA, UDMA, Bis-GMA, TEGDMA, silane-treated ceramic	3M ESPE, St Paul, MN, USA

*Abbreviations: Bis-EMA, ethoxylated bisphenol A dimethacrylate; Bis-GMA, bisphenol-glycidyl methacrylate; 5-NMSA, N-methacryloyl-5-aminosalicylic acid; HEMA, hydroxyethylmethacrylate; TEGDMA, triethylene glycol dimethacrylate; 10-MDP, 10-methacryloyloxydecyl dihydrogen phosphate; UDMA, urethane dimethacrylate.*

constant water and air cooling. The width between the buccal and lingual cavosurface angle was two-thirds of the distance between the buccal and lingual cusp tips, and the occlusal isthmus was 3 mm deep. The widths of the proximal boxes corresponded to one-third of the distance between the buccal and lingual surfaces of the teeth at the level of the gingival wall and measured 1.5 mm deep. The proximal boxes were located 1 mm coronal to the CEJ. The internal line angles were rounded, the cavosurface angles were approximately 90°, and the angle of divergence of the walls of the preparations was approximately 6°. The dimensions of the cavity were standardized using a digital paquimeter with precision of 0.01 mm.

### IDS Techniques

Immediately after cavity preparation, one of the IDS techniques was applied to the teeth in groups 3 and 4. In group 3, the Clearfil SE Bond adhesive system was applied as follows: the self-etching primer was applied to dentin using a brush tip and was left in place for 30 seconds. Excess solvent was removed by air-drying for five seconds. The bond was applied to the surface cavity with a brush tip, and gentle air-drying was applied for three seconds, followed by light-curing for 20 seconds with a light-curing unit (Optilux Plus, Gnatus, Ribeirão Preto, SP, Brazil). The irradiance was monitored by a radiometer (Model 100 Demetron, Kerr, Danbury, CT, USA) set between 450 and 500 mW/cm<sup>2</sup>. Polymerization of the adhesive was followed by the application of an air-blocking barrier (glycerin jelly) and 10 seconds of additional light-curing to polymerize the oxygen inhibition layer.<sup>13</sup> In group 4, Clearfil SE Bond was applied as described in group 3 without the air-blocking barrier. After application of the adhesive, Protect Liner F was placed on the adhesive surface using a brush-on technique and light-cured for 20

seconds. The surface of the cured flowable composite resin was wiped with a cotton pellet soaked in alcohol for 10 seconds to remove the unpolymerized layer on the surface.<sup>18</sup>

### Restorative Procedures

Impressions of the preparations were taken with polyvinyl siloxane (3M ESPE, St Paul, MN, USA), with individual trays made from self-cured acrylic resin using the putty/wash one-step technique. The impression material was allowed to set for 10 minutes before it was removed from the preparation. Temporary self-cured acrylic resin crowns were then luted onto the preparations with non-eugenol cement (Temp Bond NE, Kerr). Tooth specimens were stored in water at 37°C water for seven days. The impressions were poured after one hour using Durone Type IV stone (Dentsply, York, PA, USA).

The casts were lined with die spacer, except in the marginal areas. Four horizontal layers of composite resin (Filtek Z250, 3M ESPE) were inserted in the casts with a Thompson spatula (nos. 2 and 12), which resulted in a 90° inclination between the internal slopes and cusps. Each resin layer was light-cured for 40 seconds, followed by finishing with polishing discs and silicone tips (Soft-Lex, 3M ESPE).

### Luting Procedures

Following storage, the provisional restorations were removed, and the remaining temporary cement on the inlay preparation was scraped off with a dental instrument. Subsequently, the dentin (group 2) and the sealed dentin (groups 3 and 4) were cleaned with a mixture of water and pumice using a rotary brush for 10 seconds. The fitting surface of the restoration was cleaned with alcohol and sandblasted with 50 µm aluminum oxide for five seconds, rinsed, and dried. A layer of silane (Ceramic Primer, 3M ESPE) was applied, followed by gentle air-drying for five

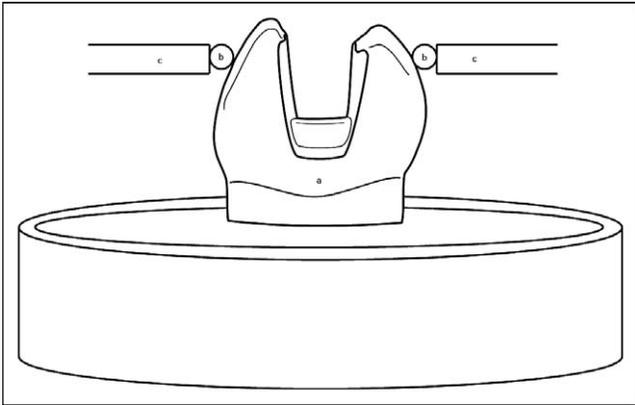


Figure 1. Schematic figure of the cuspal deflection test: (a) tooth; (b) resin spheres; (c) micrometer.

seconds. The coated surfaces of the preparation (except in group 2) were then acid-etched with 37% phosphoric acid for 10 seconds and rinsed and dried to remove debris. A mixture of ED Primer A and B was applied for 30 seconds and gently air-dried for five seconds. The base and catalyst of Panavia F resin cement were mixed according to the manufacturer's instructions. The crowns were seated using a 1-kg standard load for two minutes. Excess cement was removed with a microbrush and each surface (buccal, lingual, mesial, distal, and occlusal) was light-cured for 40 seconds. The margins were finished with polishing discs (Sof-Lex). The specimens were stored in distilled water at 37°C for 72 hours and were then submitted to the cuspal deflection and fracture resistance tests.

### Cuspal Deflection Testing

Resin spheres (approximately 1.5 mm in diameter) were fixed with adhesive to both cusps. Following the methodology of González-López and others,<sup>19</sup> the spheres were positioned on the cuspal vertices and served as reference points for measuring the inter-cuspal distance, using a precision micrometer (Mitutoyo), with a measurement sensitivity of 1  $\mu\text{m}$  (Figure 1). A fixation device was used to fix the micrometer in the same position. Each specimen was attached to the lower platen of a universal testing machine (Emic DL-2000, EMIC, São José dos Campos, PR, Brazil), and a steel sphere with an 8-mm diameter was used to apply a 200-N occlusal load at a cross-head speed of 0.5 mm/min. The load was applied perpendicular to the long axis of the tooth, simultaneously contacting the buccal and palatal cuspal inclines. When the 200-N load was achieved, the machine was locked and three consecutive measurements of the cuspal deflection were

made. The mean distance of the composite resin spheres prior to loading was subtracted from the mean distance of the spheres after application of the load. Thus, the cuspal deflection was obtained. The specimens were then submitted to a compression test until fracture occurred.

### Fracture Resistance Testing

The specimens were submitted to compression in a universal testing machine (EMIC-DL2000). A steel sphere with an 8-mm diameter was used to apply an occlusal load perpendicular to the long axis of the tooth at a cross-head speed of 0.5 mm/min, simultaneously contacting the buccal and palatal cuspal inclines. The load was applied until fracture occurred. The maximum load was recorded in Newtons.

### Fracture Mode Analysis

After visual examination, the fractures were classified as follows: type I, cusp fracture at the CEJ; type II, cusp fracture below the CEJ; type III, restoration fracture and cusp fracture at the CEJ; type IV, restoration fracture and cusp fracture below the CEJ; and type V, longitudinal fracture dividing the tooth along the axis.

### Statistical Analysis

After data collection, the Kolmogorov-Smirnov normality test was applied to the cuspal deflection and fracture resistance data. The analysis of variance (ANOVA) and Tukey ( $p < 0.05$ ) parametric statistical tests were applied to compare the study groups. All statistical analyses were performed using SPSS version 10.0 (SPSS Inc, Chicago, IL, USA).

## RESULTS

According to the ANOVA and Tukey tests, the lowest mean cuspal deflection was obtained in group 1 (3.1  $\mu\text{m}$ ), differing statistically from group 4 (7.7  $\mu\text{m}$ ) and from group 2 (10.3  $\mu\text{m}$ ) ( $p < 0.05$ ) but not differing statistically from group 3 (5.5  $\mu\text{m}$ ) ( $p > 0.05$ ). Group 3 did not differ statistically from group 4. The highest mean cuspal deflection was obtained for group 2, which did not differ statistically from group 4 (Table 2).

The highest mean fracture resistance was obtained for group 1 (1974 N), differing statistically from the other groups ( $p < 0.05$ ). The fracture resistances of group 2 (1162 N), group 3 (700 N), and group 4 (810 N) were not statistically different from each other ( $p > 0.05$ ) (Table 3).

Table 2: Mean Cuspal Deflection ( $\mu\text{m}$ ) of the Groups

Groups	n	Mean, $\mu\text{m}$	$\pm$ SD
Group 1 (sound teeth)	12	3.1 A	1.5
Group 2 (without IDS)	12	10.3 B	4.6
Group 3 (IDS with CSE)	12	5.5 AC	1.8
Group 4 (IDS with CSE + Protect Liner F)	12	7.7 BC	5.1

Abbreviations: CSE, Clearfil SE Bond; IDS, immediate dentin sealing; SD, standard deviation.  
<sup>a</sup> Means followed by the same letter did not differ statistically according to Tukey test at a significance level of 5%.

All sound teeth (group 1) presented type I fractures (100%). There was a predominance of type I and type II fractures in the experimental groups. Type III fractures occurred in groups 3 and 4, and type IV fractures occurred in groups 2, 3, and 4. Type V fractures were less common and occurred in one specimen in groups 3 and 4 (Table 4).

## DISCUSSION

The null hypothesis of the present study was partially rejected. IDS caused a decrease in cuspal deflection, but neither sealing technique had an influence on fracture resistance.

Cuspal deflection is a nondestructive methodology that verifies the deformation of the cuspids when a load is applied in the occlusal region. In this study, an occlusal load of 200 N was applied to perform this nondestructive test; a load of up to 300 N can be applied without the risk of tooth fracture.<sup>20</sup>

The lowest mean cuspal deflection was obtained for the sound teeth (3.1  $\mu\text{m}$ ), corroborating the results of the study of Jantararat and others.<sup>20</sup> This small cuspal deflection is due to the biomechanical behavior of the dentin-enamel junction, which allows a strong bond between these two substrates.<sup>21</sup> Intact teeth with a complete enamel covering are very stiff, and an occlusal load causes only a small deformation. The deformation depends on the intensity of the force applied.<sup>19,20</sup> Sound teeth distribute load-generated stress more homogeneously because enamel is not appreciably deformed, and the deformation is transferred to the more resilient dentin.<sup>22</sup> When the continuity of the enamel is lost as a result of

preparation, the properties of the dentin play a major role in cusp behavior.<sup>23</sup> The loss of dental structure, such as enamel and dentin, causes a decrease in tooth stiffness, and consequently there is an increase in cuspal deflection under occlusal loads.<sup>19,20,24</sup> Therefore, it is necessary to try to recover this stiffness when restoring the tooth.

In the case of inlay restoration, the stiffness of the tooth tends to be restored when the material used for luting bonds strongly with the tooth tissues and restorative material, with the formation of a monobloc restoration. Therefore, two bond interfaces are formed, corresponding to the tooth/luting material and restoration/luting material. Among the three experimental groups in the present study, variation occurred only at the tooth interface; the same treatment was used at the restoration interface.

Group 3, in which IDS with the adhesive system only was performed, presented cuspal deflection (5.5  $\mu\text{m}$ ) that did not differ statistically from that of the sound teeth and that was statistically lower than that of group 2 (10.3  $\mu\text{m}$ ), in which no IDS technique was performed. A possible explanation for this finding could be that the Clearfil SE Bond adhesive system was applied directly on the cut dentin. Studies<sup>3,4</sup> have shown that adhesive systems bond better to freshly cut dentin immediately after preparation, in comparison with dentin contaminated with temporary materials, thereby providing greater bond strength to the dentin substrate and, consequently, less cuspal deflection. Another factor to consider is that in group 2, ED Primer was applied on dentin, whereas in group 3, Clearfil SE Bond was

Table 3: Mean Fracture Resistance (N) of the Experimental Groups

Groups	n	Mean	$\pm$ SD
Group 1 (sound teeth)	12	1974 A	708
Group 2 (without IDS)	12	1162 B	474
Group 3 (IDS with CSE)	12	700 B	280
Group 4 (IDS with CSE + Protect Liner F)	12	810 B	342

Abbreviations: CSE, Clearfil SE Bond; IDS, immediate dentin sealing; SD, standard deviation.  
<sup>a</sup> Means followed by the same letter did not differ statistically according to Tukey test at a significance level of 5%.

Table 4: Fracture Mode in the Experimental Groups

Groups	Type I	Type II	Type III	Type IV	Type V
Group 1 (sound teeth)	12	—	—	—	—
Group 2 (without IDS)	5	3	—	4	—
Group 3 (IDS with CSE)	4	3	2	2	1
Group 4 (IDS with CSE + Protect Liner F)	4	4	2	1	1

Abbreviations: CSE, Clearfil SE Bond; IDS, immediate dentin sealing.

applied. Both resin materials have some similarities and some differences in their composition, which may influence the results.

ED Primer is a one-step self-etching primer that has a moderate capacity for dentin demineralization. As a result of the presence of the hydrophilic monomer 2-hydroxyethyl methacrylate (HEMA), ED Primer presents some permeability, allowing changes at the dentin-adhesive interface and, consequently, hydrolytic degradation of this interface.<sup>25</sup> Clearfil SE Bond is a two-step adhesive system that has a self-etching primer and an adhesive, with a pH close to 2, and it also has moderate capacity to demineralize dentin.<sup>26</sup> As the primer in this adhesive system also has the hydrophilic monomer HEMA, it has some permeability. However, the application of the adhesive on the primer, which contains a larger quantity of hydrophobic monomers, tends to reduce the permeability of this adhesive system.<sup>27</sup> Although the specimens were stored in water for the period of only 72 hours in this study, researchers<sup>28,29</sup> have shown that hydrolytic degradation begins in the first moments after the application of adhesive. It is likely that a lower permeability of Clearfil SE Bond may have favored the maintenance of the bond to the substrate and less cuspal deflection. In addition, the better bond between Clearfil SE Bond and the substrate may have favored greater absorption of polymerization stresses generated by shrinkage of the resin cement, contributing to the greater polymerization stress relief at the bond interface.<sup>30,31</sup> Studies<sup>31,32</sup> have shown that polymerization shrinkage, which is generated as a result of the lack of nonadhered surfaces, may rupture the bond between the resin material and cavity walls, resulting in gaps or failures at the interfaces.

In group 4 (IDS with the adhesive system and low-viscosity composite resin), the mean cuspal deflection was intermediate, at 7.7  $\mu\text{m}$ , which differed statistically only from the control group. Although some studies<sup>8,9,14,15</sup> have shown higher bond strength to dentin with this technique, this bond capacity was not reflected in the cuspal deflection

methodology. Nevertheless, the difference of only 2.2  $\mu\text{m}$  between group 3 and group 4 may have occurred by chance, considering that no statistically significant difference was found. In the literature, there is no study evaluating the cuspal deflection of teeth restored with the IDS technique. Therefore, the present study provides new information and demonstrates that the application of a low-viscosity composite resin does not significantly contribute to a decrease in cuspal deflection.

The clinical importance of cuspal deflection is that the greater the magnitude of this deflection, the greater the deformation and, consequently, the greater the possibility of fatigue failure. This type of failure, characterized by fracture in the presence of stress far below the maximum strength of the restored tooth, occurs in most dental fractures.<sup>33</sup> Therefore, the results obtained for cuspal deflection indicate that the teeth restored with composite resin inlays using the IDS technique would take a longer time to suffer failure due to mechanical fatigue.

In both IDS techniques, the bond of the luting agent to the preexisting resin layer must be promoted by cleaning the surface prior to luting<sup>11</sup> to remove remnants of temporary cements, which may cause a significant decrease in the bond strength of the luting agent.<sup>6,12</sup> Therefore, after removing the provisional restoration, the preparations in all of the groups received prophylaxis with pumice stone and water. ED Primer was then applied on the Clearfil SE Bond adhesive (group 3) and on the low-viscosity composite resin (group 4). ED Primer contains water, as well as the hydrophilic monomer HEMA; it would be more appropriate to apply a hydrophobic adhesive that did not contain water. Nevertheless, according to the study of Okuda and others,<sup>34</sup> ED Primer did not negatively influence the bond strength when it was applied on Protect Liner F for luting with Panavia F, and higher bond strength was obtained in the study of Udo and others.<sup>18</sup> The reason for this finding is not clear, but it may be related to the polymerization of Panavia F in the presence of ED Primer.<sup>18</sup> ED Primer contains aromatic sulfinate salts, and it is believed that this

accelerates interfacial polymerization between the dentin sealing surface and resin cement.<sup>34</sup>

The fracture resistance and mode of fracture were also evaluated in this study. Many variables may be found in the literature with respect to the fracture resistance test, such as location of the forces applied, speed of the tests, and shape of the compression devices.<sup>35</sup> In the present study, an 8-mm sphere coupled to a universal testing machine was used as a result of the extensive cavity preparation performed in the teeth. In destructive tests, it is fundamental for the compression sphere to be in contact with the internal slopes of the buccal and lingual cusps. Under these conditions, a compressive force is applied to the tooth, and the buccal and lingual cusps are externally displaced, with a resultant stress on the tooth-restoration interface. If the compression sphere is located exclusively on the restoration, stress absorption by the restorative material will occur, with a vertical force crushing the restoration.<sup>35</sup> In the present study, the contacts were verified and the sphere was in contact with the buccal and palatal cuspal inclines.

The sound teeth group presented the highest mean fracture resistance (1902 N), differing statistically from the other groups, and these data concur with those of previously published studies.<sup>36-38</sup> The enamel is supported by the total dentin volume, making it less prone to fracture, which explains the higher mean obtained for the fracture resistance.<sup>39</sup> The fracture resistances in groups 2, 3, and 4 did not differ statistically. Group 2 recovered 58% of the resistance of a sound tooth, group 3 35%, and group 4 41%. These findings are in agreement with those of other studies<sup>36,37,40</sup> that verified that the different restorative techniques did not restore the resistance of a sound tooth. Nevertheless, the use of adhesive restorations has been recommended for reinforcing remaining dental structures,<sup>38,41</sup> even if full strength is not recovered.<sup>36,42</sup>

The results of the present study show that the IDS techniques did not contribute to an increase in fracture resistance of teeth. However, the mean fracture resistances in groups 3 and 4 were very close to or even higher than the values for habitual occlusal forces. Occlusal forces may clinically attain 800 N in bruxers, a value similar to the mean obtained for the test specimens in group 4. There is no consensus in the literature, but the physiological values are even lower, considering that clinically, the forces are distributed over more than one dental element, decreasing the load on an individual tooth even further.<sup>35</sup>

It is also important to analyze the mode of fracture. Not only does the result of the fracture resistance test guarantee that a material is ideal for restoring a weakened tooth but it also shows the mode of failure when a fracture does occur, that is, whether or not the prognosis will be favorable.<sup>21,43</sup> The classification of fractures used in the present study was created in accordance with the fractures observed in the specimens. In the sound teeth group, all fractures were at the CEJ (type I). The predominance of this fracture type might be due to the maximum strength inherent in sound teeth. When a sound tooth is submitted to a compressive load, it presents a higher stress concentration in enamel and dentin around the cervical area, which explains the fractures in this region.<sup>39</sup> Fractures also occurred below the CEJ (types II and IV) in the experimental groups. This may be explained by the loss of tooth volume, both in terms of depth and thickness, leading to an increase in stress in the region below the CEJ.<sup>39,44</sup> In general, there was a predominance of type I and type II fractures for the experimental groups. These fractures occurred between the tooth substance and the inlay, indicating that this interface represents the weakest part of the restored tooth. However, type III and type IV fractures were also observed in the experimental groups. These fractures occurred in the composite resin inlay first, preserving the tooth/inlay interface and leaving part of the restoration attached to the cusp, showing the bond capacity of the resin materials to the tooth structure. Nevertheless, most of the fractures that occurred in the experimental groups still allowed the salvage of the tooth. Dalpino and others<sup>45</sup> and Silva and others<sup>46</sup> also verified a prevalence of recoverable fractures when the teeth were restored with resin materials.

Transfer of the results of laboratory studies to the clinic must be done with caution because *in vitro* studies cannot reproduce the real situation in the oral cavity. According to the results obtained, IDS techniques with Clearfil SE Bond produced less cuspal deflection in composite resin inlay restorations when the adhesive luting technique with Panavia F was used. It would be interesting to analyze, *in vitro*, the cuspal deflection behavior after aging by means of mechanical fatigue and/or thermal cycling.

## CONCLUSIONS

Despite the limitations of this *in vitro* study, the following conclusions can be drawn:

- The IDS technique with the Clearfil SE Bond

adhesive system allowed cuspal deflection comparable to that of a sound tooth.

- Application of the low-viscosity composite resin Protect Liner F on the Clearfil SE Bond adhesive system did not contribute to a decrease in cuspal deflection.
- The IDS techniques did not influence the fracture resistance of teeth.
- Most of the fractures that occurred in the experimental groups allowed recovery of the dental structure.

#### Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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