

# Hybrid Layer Width after Conventional Diamond, Carbide and Ultra-Sound CVD Burs

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**Objectives:** The aim of the present study was to evaluate hybrid layer thickness of primary molars sectioned with diamond, carbide and ultrasonic CVD burs. **Study Design:** The occlusal enamel surfaces of ten molars were removed and superficial dentin was exposed. Three standardized cavities were prepared at mesial, central and distal exposed dentin with diamond, carbide and ultrasonic CVD burs, respectively. A self-etching adhesive system (Adhese, Ivoclar/Vivadent) was applied to prepared cavities and composite resin Z100 (3M/ESPE) was inserted according to manufacturers' instructions to hybridized dentin. Samples were light-cured and the crown was sectioned mesio-distally dividing the restored cavities in two halves which were observed under scanning electron microscopy (SEM), in order to quantitatively evaluate hybrid layer thickness ( $\mu\text{m}$ ). Three repeated measures were performed at mesial, central and distal sites and mean values obtained were submitted to one-way analysis of variance (ANOVA). **Results:** Data (mean  $\pm$  sd) obtained were ( $\mu\text{m}$ ): 2.69 (0.44), 3.38 (1.23) and 2.72 (1.18) for diamond, carbide and CVD burs, respectively. No differences were observed among groups ( $p > 0.05$ ). The adhesive systems promoted mechanical retention, uniform and continuous hybrid layer and resin tags formation at all dentin sites for all instruments tested. **Conclusion:** The results suggest that the minimally invasive cavities prepared with diamond, carbide and CVD for ultrasound, promoted hybrid layer formation with a similar thickness regardless the bur used. **Keywords:** primary teeth, adhesive system, hybrid layer, CVD diamond burs.

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## INTRODUCTION

The development of new restorative materials and dentin bonding agents has changed the design of dental cavities allowing ultra-conservative preparations and the development of aesthetics concepts. The diamond-coated, ultrasonically driven tip (CVD - Chemical Vapor Deposition) has been used as an alternative method to perform cavity preparations.<sup>3</sup> The main goal of the CVD burs is to remove only caries lesions, preserving as much healthy tissue as possible.<sup>13</sup> In addition, these burs provide greater comfort for the patient since the noise intensity, vibration and heat production is minimized.<sup>3,8,14</sup> Lima and co-authors

examined the cutting characteristic of diamond burs obtained by CVD technology and observed that these burs produced more accurate and conservative preparations.<sup>15</sup> Additionally, according to Borges and co-authors CVD burs demonstrate improved cutting ability and longevity of the tips.<sup>4</sup> On the other hand, it has been observed that the time required to prepare minimally invasive cavities with CVD burs may take almost eight times longer than conventional diamond tips coupled to a high-speed rotary device.<sup>26</sup>

Dentin adhesive systems have become indispensable for the contemporary dental practice and several studies have evaluated the *in vitro* behavior of the self-etching adhesives in primary teeth.<sup>1,17,24</sup> The self-etching adhesives supposedly provide an advantage over conventional etch-and-rinse adhesives since the etching and priming stages are combined, simplifying the bonding technique and decreasing the risk of over drying dentin.<sup>6,20</sup> Besides, it has been observed that self-etching systems can achieve acceptable bond strengths values both in enamel and dentin of primary teeth.<sup>17</sup> Shimada *et al* observed that self-etching and total-etching adhesives etched the primary enamel deeper than the permanent enamel and that bonding of the adhesive systems (self-etching or conventional) to primary enamel was almost identical to permanent enamel.<sup>24</sup>

Although current adhesive systems present satisfactory bonding outcomes it is uncertain whether cavity preparation

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with different burs would modify enamel/dentin characteristics and interfere with adhesion. In a previous microleakage study, Vieira *et al* observed that all cavities prepared with conventional high-speed diamond burs exhibited total absence of dye penetration whereas cavities prepared with ultrasonic device with CVC diamond tip presented 46% of dye penetration.<sup>26</sup>

Another *in vitro* evaluation compared the topography and smear layer formation in primary and permanent molars cavities and observed that high speed rotary instruments produced regular layers on enamel/dentin whereas ultrasonic abrasion generated more irregular and uneven surface. Both instruments promoted a consistent smear layer formation, partially or completely obliterating the dentinal tubules both in primary or permanent teeth.<sup>19</sup>

In view of the fact that different burs may change topographic characteristics of primary dentin and interfere with hybrid layer formation promoted by self-etching adhesives, this study aimed to evaluate hybrid layer formation promoted by self-etching adhesives to primary dentin after the use of diamond, carbide and CVD burs.

## MATERIALS AND METHOD

This study was analyzed and approved by the Ethical Research Committee of the University of Taubaté, Brazil (CEP/UNITAU n° 382/04).

### Specimen preparation

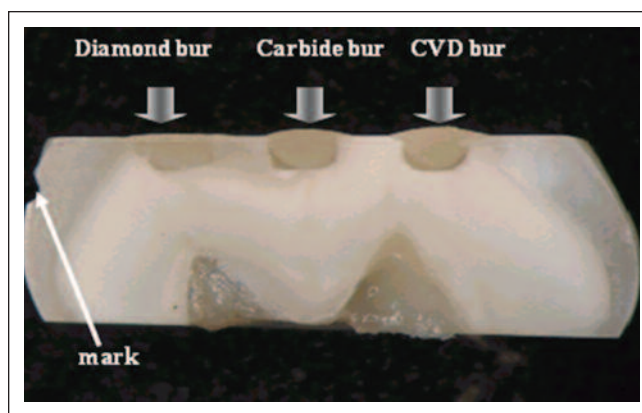
Ten sound, extracted human second primary molars were obtained with the informed consent of patients and after extraction teeth were stored in deionized water with thymol granules at 5°C for no longer than 2 weeks. Teeth were cleaned and placed in deionized water for 24 h before the beginning the experiment. The occlusal enamel was removed with a diamond disc in a cutting machine (Isomet, Struers, Accutom 5) in order to obtain a flat dentin surface.

Standardized class I restorations (1 mm deep checked by a periodontal millimeter probe and width equivalent to the tip used) were prepared at three sites: a) mesial: diamond bur (#1343, KG Sorensen), b) central: carbide bur (#56, Jet) and c) distal: CVD tip (8.2137, CVDentUS®, Clorovale Diamantes, São Paulo, Brasil) ultrasonically driven (Profi II US AS – Dabi Atlante, Ribeirão Preto, SP). The diamond and carbide burs were replaced after every fifth preparation whereas CVD tip was not replaced.<sup>26</sup>

The cavities were hybridized with the self-etching adhesive Adhese (Ivoclar/Vivadent) and restored with the hybrid composite Z100 (3M/ESPE), according to the manufacturers' instructions. Twenty-four hours later the crown was sectioned mesio-distally dividing the restored cavities in two halves which were flattened with wet 1,200-grit aluminium oxide abrasive papers and polished with 6, 3, 1 and ¼ µm-grit diamond pastes in a polishing machine (Struers, DP-10, Panambra, Figure 1).

### Scanning electron microscopy (SEM)

The section obtained was demineralized with 37%



**Figure 1.** Mesio-distal transversal cut of the primary molar. The cavities prepared with the three types burs (diamond, carbide and ultrasonic CVD) are observed and a mark was created at the mesial position to acknowledge the sequence of the cavities and burs.

phosphoric acid for 1 min and deproteinized with 3% sodium hypochlorite for 3 min. Samples were dehydrated in ascendant concentrations of ethanol to 100% and critical point dried (CPD 030, Balzers, Liechtenstein). The samples were sputter coated with gold (MED 010, Balzer, Liechtenstein) and examined under SEM (VP 435, Leo, Cambridge, England) at 20 kV.<sup>21</sup>

### Hybrid layer evaluation

SEM images at 3000x were taken of the adhesive interface. Hybrid layer thickness was analyzed at the mesial, central and distal sites of each cavity by three repeated measures provided by the SEM image. The layer thickness was determined as the distance between the top of the hybrid layer and the base of the hybrid layer. The three repeated measurements of width at each site were made at approximately equally spaced points across the image.

The mean values and standard deviation obtained (µm) were statistically analyzed by one-way ANOVA with the software SPSS for Windows Release 5.0 ( $p > 0.05$ ).

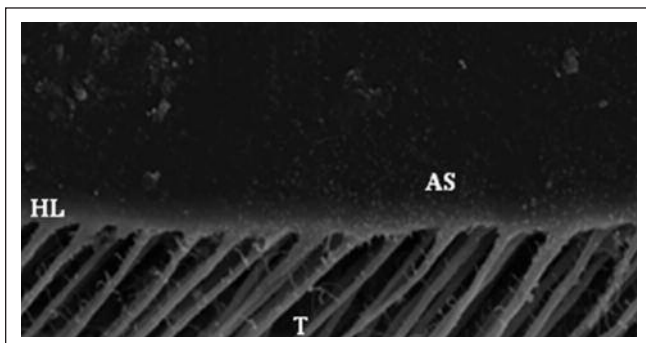
## RESULTS

The mean thickness of the hybrid layer (µm) according to the bur used is exhibited in Table 1. No differences were observed among the groups ( $p > 0.05$ , Table 1). The microscopic images (Figures 2 to 4) revealed the hybrid layer formed between the adhesive system and dentin and the occurrence of tags within hybridized dentin. For all the groups (Figures 2, 3 and 4) a hybrid like layer could be clearly observed. The bonded interface did not present signs of granular zones or regions with pores and cracks nor separation between composite and adhesive layer as a result of shrinkage during specimen preparation for SEM. The resin tags for the three instruments tested were funnel-shaped due to the dissolution of the top peritubular dentin. There were lateral extensions of resin tags into the lateral branches of the tubules of Figure 2 and 4, however, more apparent in Figure 3. These resin tags were long and uniform for all three instruments used.

**Table 1.** Mean (standard deviation) hybrid layer thickness ( $\mu\text{m}$ ), according to the type of rotatory cutting instrument used (diamond burs, carbide tips and ultrasonic CVD diamond burs).

Specimen	Diamond bur	Carbide bur	Ultrasonic CVD diamond bur
1	2.148	2.067	2.306
2	2.038	4.504	0.792
3	2.644	1.986	1.219
4	3.410	4.010	4.193
5	2.336	5.641	2.876
6	3.088	3.534	2.533
7	2.800	2.929	2.794
8	2.628	2.397	3.053
9	2.698	2.406	2.749
10	3.126	4.348	4.721
Mean (sd)	2.692 (0.438)	3.382 (1.226)	2.724 (1.178)

No significant differences were observed among groups, according to one-way ANOVA.



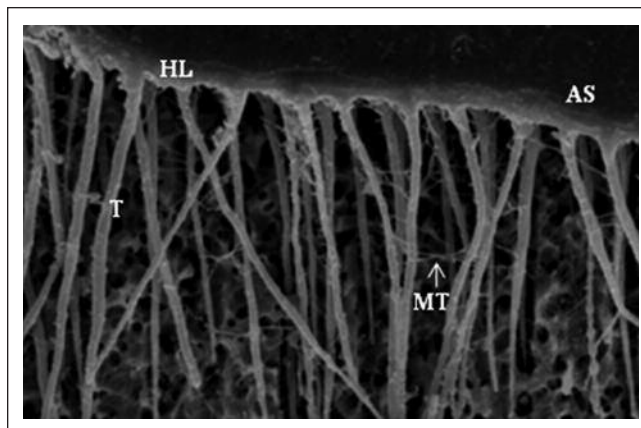
**Figure 2.** Hybrid layer (HL) formed between adhesive systems (AS) and dentin, presenting tags (T), when high-speed diamond bur was used (3.000X of magnification).

## DISCUSSION

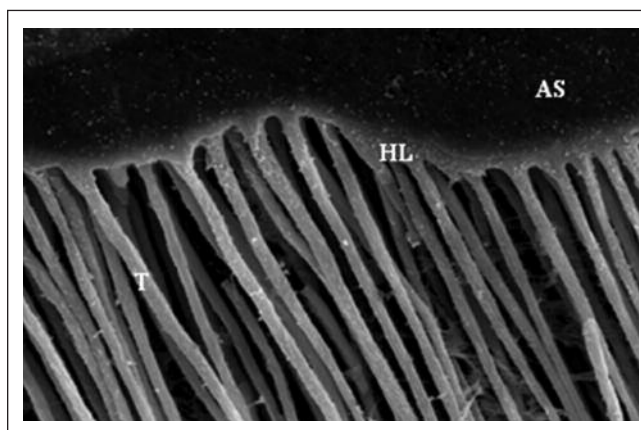
The application of rotary instruments to caries lesions has often resulted in excessive removal of tooth structure. In addition, conventional caries removal and cavity preparation using a turbine and a handpiece with a bur presents disadvantages to pediatric patients, whose perception during operatory procedures is unpleasant.<sup>3</sup>

CVD diamond tips can be considered an alternative method for minimally invasive restorations due to its durability, easier cleaning, sterilization and greater efficiency during cutting.<sup>4,9,14,15</sup> The association to an ultrasound device provides extra benefits to pediatric patients such as lower noise and painless characteristics during caries lesion removal and cavity preparation.<sup>3,8</sup> As the CVD tips are coupled to an ultrasound apparatus the active end does not revolve around itself, it vibrates allowing a more accurate access to certain areas of the tooth. The access to difficult areas decreases the possibility of removal of unnecessary sound dental structures.<sup>4,8,14,15</sup>

A possible drawback of the CVD tips may be the manipulation of the ultrasonic instrument compared to the conventional rotary system. Vieira *et al* reported that although handling is not difficult, it demands practice.<sup>26</sup> Yet, the



**Figure 3.** Hybrid layer (HL) formed between adhesive system (AS) and dentin, presenting tags (T) and microtags (MT), when high-speed carbide bur was used (3.000X of magnification).



**Figure 4.** Hybrid layer (HL) formed between the adhesive system (AS) and dentin, presenting tags (T), when CVD diamond bur was used (3.000X of magnification).

authors observed that cavity preparation is time-consuming and microleakage at the adhesive interface is higher for cavities prepared with CVD burs compared to conventional rotating instruments<sup>26</sup> although others have observed that cavities prepared with conventional diamond burs and CVD tips presented similar microleakage at the adhesive interface.<sup>10</sup>

The study design of the current investigation comprised the evaluation of hybrid layer thickness promoted by conventional diamond burs, carbide drills and the new ultrasonic CVD burs. Repeated measurements identified hybrid layer thickness in specific sites of each cavity prepared and the results showed no statistically significant difference of the hybrid layer width formed after application of the self-etching adhesive. The use of a single adhesive system allowed observation of a singular factor and the results obtained were directly related to the performance each instrument tested.

Previous studies which evaluated the type of burs used (CVD, diamond and carbide) reported that the thickness of the smear layer varied according to the cavity configuration, kind of instrument employed and the presence or absence of refrigeration.<sup>5,22</sup> The characteristics of the smear layer have



been evaluated in permanent teeth after cutting with CVD and diamond burs and it was observed that the first tip produced thinner smear layer and porosities along the cavity wall which could facilitate dentin etching and consequently, hybridization.<sup>27</sup> Others reported that high speed rotary instruments produced a regular smear layer on enamel and dentin of primary and permanent teeth whereas ultrasonic abrasion promoted more irregular surfaces with a granular and wavy aspect but both instruments were able to promote partial or complete obliteration of the dentinal tubules.<sup>19</sup> The topography and smear layer formation may influence hybrid layer particularly when self-etching adhesives are used. However, the SEM images of this study exhibited a uniform and continuous hybrid layer for all instrument tested which implicates that smear layer was probably homogeneous among groups.

Dentin hybridization is the fundamental request for the adhesion mechanism.<sup>9,12,18</sup> Conventional adhesive systems partially demineralize dentin, promote calcium ions removal and the exposure of the collagen fibrils, which undergo a partial fibril collapse. Primer is able to diffuse and adheres to the partially collapsed collagen enabling the permeation of the adhesive per se.<sup>6,23</sup> The self-etching primer used is able to permeate dentin, modify smear layer and partially demineralize the tissue. The hybrid layer formed is thinner than the one observed for conventional adhesives, however, studies have attested its bonding efficiency due to the homogeneity of the layer produced.<sup>2,23</sup> A previous report observed that the two-step self-etching adhesives and the etch-and-rinse conventional technique produce a continuous and uniform hybrid layer in dentin.<sup>2</sup>

In the current study, the self-etching adhesive produced a uniform hybrid layer and resin tags within partially demineralized dentin regardless the rotary cutting instrument employed (Figs 2 to 4). The mean hybrid layer thickness obtained of the three burs (2.934  $\mu\text{m}$ ) was superior to that reported for permanent dentin in a previous *in vitro* investigation (0.5 to 1.5  $\mu\text{m}$ ).<sup>7</sup> Another observation has reported the formation of a continuous and uniform hybrid layer under SEM for both deciduous and permanent teeth after the application of a two-step self-etching adhesive and a conventional one-bottle etch-rinse system (Clearfil SE Bond and Single Bond).<sup>25</sup> In this particular case, the morphology of the permanent and primary teeth did not interfere with the hybrid layer formation. In another investigation, the two-step self etching adhesive and a conventional single-bottle etch-and-rinse (Clearfil SE Bond and Single Bond) etched the primary enamel deeper than the permanent enamel and the authors suggested that the effects of the acid etch seemed more intense on primary than on permanent enamel.<sup>24</sup> This could be explained by the mineralization pattern of the primary teeth which is approximately four times lower than in permanent teeth.<sup>13,16,28</sup>

These morphological characteristics possibly explain the formation of a thicker hybrid layer in primary teeth compared to the previous findings since the acidic primer of the self-etching system would be able to dissolve and permeate

primary dentin to a greater extent compared to permanent dentin. The presence of numerous and prolonged resin tags with lateral branches support the formation of a consistent hybrid layer since resin tags assist micromechanical interlocking which increases bond strengths.<sup>2,12,23</sup>

The results of this *in vitro* study demonstrate that carbide burs, diamond burs and ultrasonic CVD diamond burs can be used for cavity preparation in primary teeth when quality and thickness of the hybrid layer formed is considered. Clinically, the results support the advantages of the use of CVD burs for minimally invasive cavities preparations along with the described advantages of this instrument concerning longevity and operator trauma reduction. Clinicians should rethink cavity preparations and caries lesion removal methods based in the inheriting characteristics of each instrument and extrapolate its application according to the profile of each patient under care.

*In vitro* studies are necessary to overcome initial uncertainties of new materials and methods. However, due to the limitations of an *in vitro* evaluation new experiments contemplating primary dentin bond strength and longevity of the bonded interface should be performed in order to safely suggest ultrasonic CVD diamond burs as an interesting option for cavity preparation.

## CONCLUSION

The self-etching adhesive promoted mechanical interlocking and a homogeneous hybrid layer formation regardless the rotary instrument used. Conventional high-speed diamond, carbide and ultrasonic CVD diamond burs exhibited similar hybrid layer thickness formation which enhances the indication of ultrasonic CVD tips as an attractive restorative option.

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