J Dent Res 75(6): 1396-1403, June, 1996

Dentin Bonding: SEM Comparison of the Resin-Dentin Interface in Primary and Permanent Teeth

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Abstract. Previous studies have suggested minor differences between primary and permanent teeth in terms of dentin composition and morphology. Other reports indicated lower bond strengths of resin composites to dentin of primary teeth compared with dentin of permanent teeth; however, no information is available regarding differences in the micromorphology of the resin-dentin interface that may explain these lower bond strengths. Therefore, the purpose of the present study was to compare primary and permanent teeth in terms of the thickness of the hybrid layer developed with two bonding systems. Our hypothesis was that bonding differences previously reported between primary and permanent dentin would be reflected in hybrid layer differences observable in SEM analyses. Twenty human extracted and non-carious teeth were divided into 4 groups: 5 primary and 5 permanent teeth restored with All-Bond 2/Bisfil P system; and 5 primary and 5 permanent teeth restored with Scotchbond Multi-Purpose/Z100. The sample area available on each tooth was divided for the two dentin conditioning times (7 and 15 sec). Measurements of hybrid layer thickness were performed by means of SEM at x13,000. The results of this study indicated that the hybrid layer produced is significantly thicker in primary than in permanent teeth ($p = 0.0001$), suggesting that primary tooth dentin is more reactive to acid conditioning. No difference was observed in the hybrid layers produced by the two adhesive systems ($p = 0.7920$). The increased thickness of the hybrid layer in primary teeth (25 to 30%) and the subsequent lack of complete penetration of adhesive resin into previously demineralized dentin may contribute to the lower bond strengths to primary dentin reported in the literature. If a narrower hybrid layer more uniformly infused with resin is the goal of dentin bonding, it is concluded that a differentiated protocol for bonding to primary dentin (with shorter time for dentin conditioning) can be used as a means to reproduce the hybrid layer thickness seen in permanent teeth.

Key words: dentin bonding agents, dentin, adhesion, interfaces, primary teeth.

Received December 19, 1994; Accepted November 16, 1995

Introduction

Despite the fact that dentin adhesive systems have become a common tool in the armamentarium of contemporary dentists, the literature regarding bonding to dentin of primary teeth is very limited. The first study designed to compare the shear bond strengths of resin composite to the dentin in primary and permanent teeth was performed with Scotchbond, an adhesive system that promotes ionic bond to the hydroxyapatite present on smear layer (Fagan *et al.*, 1986). No significant differences were found between shear bond strengths in primary and permanent teeth. However, when the smear layer was removed and bonding was performed directly to the dentin surface, particular characteristics of primary teeth seemed to interfere with this bonding, decreasing its effectiveness. In a study performed with the Gluma system, Salama and Tao (1991) indicated that shear bond strength of resin composites to the dentin of primary teeth present significantly smaller values (8.3 ± 4.6 MPa), compared with the results obtained with permanent teeth (10.8 ± 3.1 MPa). Similar results were obtained when Tenure, Scotchbond 2, and Gluma were evaluated in primary and permanent teeth (Bordin-Aykroyd *et al.*, 1992). No single study has compared the bond strengths of newer bonding systems to primary and permanent tooth dentin. Two studies with very similar methodologies can be used to illustrate the differences in adhesion to both dentin types. In permanent teeth, Amalgambond presented bond strengths of 23.3 ± 5.7 MPa and All-Bond 19.3 ± 5.6 MPa (Triolo and Swift, 1992), while in primary teeth, Amalgambond had bond strengths of 12.6 ± 7.5 MPa and All-Bond 11.6 ± 6.6 MPa (Elkins and McCourt, 1993).

Little is known about the details of the composition and micromorphology of the dentin in primary teeth, but there are indications of some differences in relation to permanent teeth. A comparative analysis of the dentin hardness indicated that the central area of the coronal dentin is considerably harder in permanent teeth. It was concluded that permanent dentin is more highly mineralized, based on the fact that hardness is related to the degree of mineralization (Johnsen, 1988). In another study, energy-

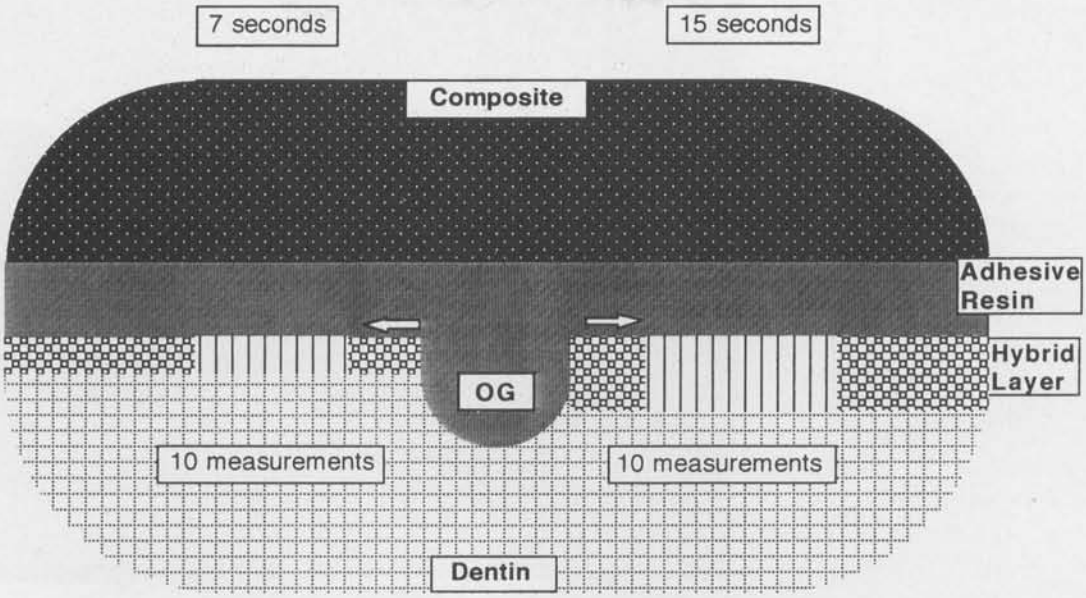

Figure 1. Schematic representation showing the methodology used for measuring the hybrid layer after 7 or 15 sec of dentin conditioning. The first measurement was performed 300 microns distal to the margin of the orientation groove (OG), and each following measurement was made at 100-micron intervals.

dispersive x-ray spectrometry (EDS) was used, and the results suggested that concentrations of calcium and phosphorus in both peritubular and intertubular dentin are lower in primary than in permanent teeth (Hirayama, 1990). Evaluation of the dentinal micromorphology also indicates potential differences between primary and permanent teeth (Koutsi *et al.*, 1994). Compared with permanent teeth, primary teeth presented a lower concentration and a smaller diameter of dentinal tubules at a distance of 0.4 to 0.5 mm from the pulpal surface.

The mechanism responsible for the adhesion of newer-generation dentin bonding systems is related to the creation of the hybrid layer (Nakabayashi, 1992), also called the resin-dentin interdiffusion zone (Van Meerbeek *et al.*, 1992, 1993). At the molecular level, this zone at the resin-dentin interface is a durable and acid-resistant intermixture of adhesive resin and dentin components (Nakabayashi, 1992). Based on current understanding, the characteristics of the dentin as a substrate for bonding of resin composites have an important influence on the morphology of the resin-dentin interface (Duke and Lindemuth, 1991; Nakajima *et al.*, 1991; Pashley *et al.*, 1992) and possibly in the ultimate performance of the system (Mixson *et al.*, 1993).

Regardless of eventual compositional and morphological peculiarities and differences in bond strengths, the same protocol is being recommended for bonding to primary and permanent teeth. This fact may lead to the establishment of a differentiated resin-dentin interface in the two dentitions, with potential deleterious consequences for the ultimate performance of the dentin bonding system. The purpose of this study, therefore, was to compare hybrid layer thicknesses in primary and permanent teeth, to verify the impact of tooth type on the micromorphology of the resin-dentin interface. We hypothesized that bonding differences between primary and permanent dentin would be reflected in hybrid layer differences observable by SEM analyses.

Materials and methods

Specimen preparation

Ten sound and erupted primary molars and 10 sound and erupted permanent molars were utilized for this evaluation. All teeth were stored in 0.2% sodium azide with distilled water solution for up to 6 months prior to the experiment. Since the exact ages of the donors were unknown, an attempt to match the stage in the biological cycle of the evaluated teeth (tooth age) was made in such a way that primary teeth in the final stage of rizolysis (old primary teeth) were paired with old permanent teeth (teeth with small pulp chambers, with significant wear and discoloration). Primary teeth that still presented complete root structure (younger primary teeth) were paired with recently erupted permanent teeth (teeth with large pulp chambers, without significant wear and discoloration). The dynamic nature of the dentin and its biological process of aging (dentin sclerosis) indicates an attempt for pairing the teeth selected for evaluation of the resin-dentin interface micromorphology. This procedure was intended to avoid eventual biases caused by the selection of, for example, only old primary teeth presenting sclerotic dentin, and their comparison with young permanent teeth that have large dentin tubules and still do not show significant sclerosis (Cox, 1988).

These teeth were divided into 4 groups: Five primary and 5 permanent teeth were restored with All-Bond 2/Bisfil P system, while 5 primary and 5 permanent teeth were restored with Scotchbond Multi-Purpose/Z100. All

extracted teeth were obtained under a protocol reviewed and approved by the Human Subjects Committee of the University of Michigan.

Crowns were divided from the roots by means of a high-speed diamond bur just apical to the cementum-enamel junction, and the pulp tissue was removed by means of a stainless steel hand instrument. A second cut was then made at the occlusal surface, perpendicular to the long axis of the tooth, with a conical carbide bur (#7664) at high speed with copious water spray, to expose an area of dentin within 1.0 mm of the dentin-enamel junction (DEJ), at the central groove area. The area of exposed dentin was divided into two halves (mesial and distal) by means of a fine diamond conical bur, so that a distinct area for each dentin conditioning time protocol would be obtained.

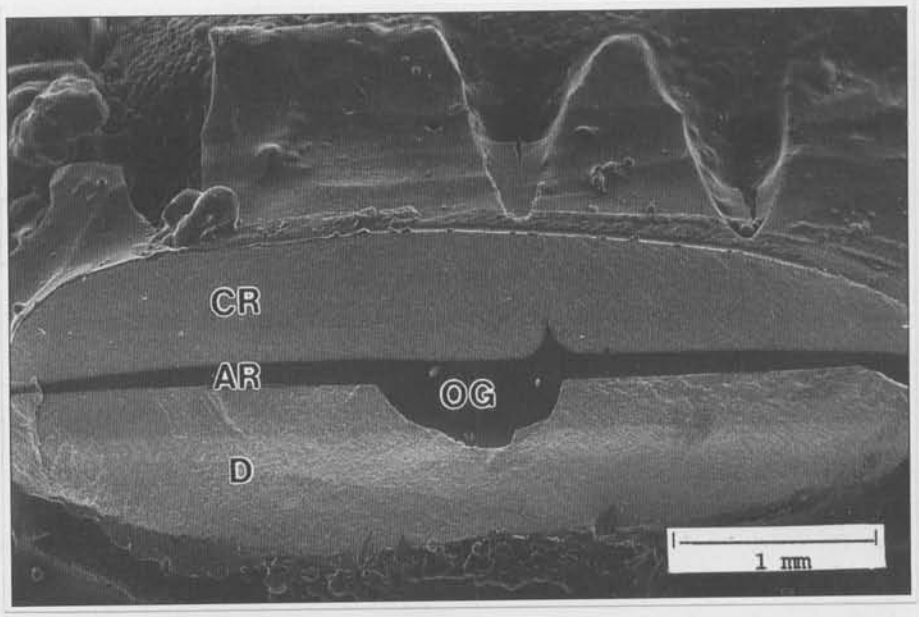

Figure 2. Photomicrograph illustrating a primary tooth prepared for evaluation of the resin-dentin interface (25x). CR = Resin Composite; AR = Adhesive Resin; D = Dentin; OG = Orientation Groove.

Bonding procedures

For better reproduction of *in vivo* conditions, bonding procedures were performed in teeth that had supporting pulp chambers full of fluid. Each crown was fixed to an acrylic platform that was penetrated in its center by a tube connecting the pulp chamber to a pressure apparatus. We reproduced physiological intrapulpal pressure in this *in vitro* study by filling the pulp chamber with distilled water and connecting the mounted tooth to a 1-cm-diameter plastic tube also containing distilled water. The column height was adjusted to 34 cm (Mitchem *et al.*, 1988) to provide approximately 25 mm Hg of pressure, which is the average tissue pressure in healthy pulp (Van Hassel, 1971).

To ensure that the pulpal chamber of each tooth was filled with water (and not an air bubble), we prepared a channel with a diameter of approximately 1 mm in the lingual surface of the crown. This channel was sealed with "sticky wax" only after the corresponding valve was completely opened and water was flowing continuously without signs of the presence of air. All teeth were kept under positive hydrostatic intrapulpal pressure during 12 hrs prior to the dentin conditioning and bonding procedures, to establish an equilibrium between external (surface) and internal (pulp chamber) pressures and also to achieve a homogeneous baseline pressure for all samples. Intrapulpal pressure was then reduced to 0, simulating decreased pulpal pressure in the presence of local anesthesia with vasoconstrictor, as found in most clinical bonding situations. Dentin was conditioned with either 10% phosphoric acid gel (All-Bond 2, Bisco, Itasca, IL) or 10% maleic acid gel (Scotchbond Multi-Purpose, 3M Dental Products Division, St. Paul, MN) in two different times: 7 sec (half of the manufacturer's recommended conditioning time), and 15 sec (recommended time).

The acidic conditioning of the two experimental areas, although randomly allocated, was done in a standardized sequence. The first area to be etched was the one that received the longest etching time (15 sec). When the first area had 8 sec of etching, acid was applied to the second area (the one that received 7 sec of acid etch). All samples were then rinsed with 180 cc of distilled water for 30 sec by means of a hypodermic syringe. By this sequence, all etching procedures were done at once, and consequently, all areas received the same amount of water irrigation. After irrigation, all teeth were dried with a stream of uncontaminated compressed air for 1 to 2 sec, allowing for a moist dentin technique to be used (Kanca, 1992; Gwinnett, 1992; Perdigao et al., 1993), and then primer was applied as recommended by the manufacturers. Equal amounts of primers A and B were mixed and 5 consecutive coats applied to the dentin for the All-Bond 2 group, as specified by the manufacturer; 1 coat of primer was applied to the dentin for the Scotchbond Multi-Purpose group, as specified. After being primed, the dentin was dried with a gentle air stream for 5 sec in both groups.

A thin layer of adhesive resin was then applied in both groups with disposable brush tips provided by the manufacturers. No air thinning was used at this point, to avoid contamination and inclusion of air bubbles into the adhesive layer. The adhesive coating was then light-cured for 20 sec with an Elipar II visible-light-curing unit (Espe, Seefeld, Germany). The resin composite was applied to the dentin in small layers (increments) about 1 to 2 mm thick and cured for 40 sec. Bisfil P (Bisco, Itasca, IL) was used to restore samples treated with All-Bond 2, and Z100 (3M Dental Products Division, St. Paul, MN) was used to restore the samples in the Scotchbond Multi-Purpose group. All restorations were flat and parallel to the occlusal surface, presenting a homogeneous thickness of about 2 to 3 mm (Fig. 2). After each restoration was completed, 60 sec of light curing was used in addition to prior procedures to ensure complete polymerization of the resin composite. The

Table. Mean thickness (± SD) of the hybrid layer in primary (n = 5) and permanent teeth (n = 5) with the utilization of All-Bond 2/Bisfil P and Scotchbond Multi-Purpose/Z100, after application of dentin conditioner for 7 and 15 sec

	All-Bond 2 (10% phosphoric acid)		Scotchbond Multi-Purpose (10% maleic acid)	
	Primary	Permanent	Primary	Permanent
7 sec	1.98 (± 0.19)[a,b]	1.49 (± 0.15)	1.91 (± 0.07)	1.62 (± 0.23)
15 sec	2.88 (± 0.03)	2.12 (± 0.26)	2.89 (± 0.16)	2.43 (± 0.22)

[a] Data are described in microns.
[b] All values reflect the result of 10 measurements for each sample.

intrapulpal pressure was then resumed, and all teeth were kept under a positive pressure of about 34 cm H_2O for 24 hrs.

Microscopic evaluation

After 24 hrs under intrapulpal pressure, all teeth were removed from the acrylic platform and prepared for fracturing. To direct the fracture line, we prepared a groove in both sides of the sample (resin composite and dentin), at the center of the crown, in a mesio-distal orientation. Each sample was then embedded in orthodontic acrylic resin (L.D. Caulk Co., Milford, DE) to avoid separation of the resin composite from the dentin caused by mechanical stresses generated during fracturing procedures. Care was taken to keep the previously prepared groove exposed. Fracture was performed with a single-edged blade oriented away from the dentin side toward the resin composite. After irrigation, all teeth were air-dried for 15 sec and then stored in a desiccation cabinet (Structure Probe, USA) for 24 hrs.

All samples were mounted in stubs and coated with gold in a Sputter Coater, Model S 150B (Edwards, USA), as a routine preparation for scanning electron microscopy (SEM). Each sample was then analyzed in a Scanning Electron Microscope (Model 1000B, Amray, USA), with an accelerating voltage of 20.0 kV. For each etching-time area (7 or 15 sec) on each tooth, 10 measurements of hybrid layer thickness were performed with the particle measurement system (PMS) under x13,000 (Figs. 1 and 5). The first measurement was made at about 300 microns from the center of the crown (orientation groove). The other 9 measurements were made in intervals of approximately 100 microns from the initial measurement. To control significant changes in the measurements, we analyzed all samples in a standard angulation of 15 to 18 degrees (base of the stubs in relation to horizontal).

Statistical analyses

Repeated-measures ANOVA was used for the analysis of time and its relation to tooth type (primary or permanent teeth) and dentin adhesive system (All-Bond 2 or Scotchbond Multi-Purpose). The need for this statistical analysis was determined by the use of a multivariate analysis of variance that demonstrated a significant effect of time for dentin conditioning on the thickness of the hybrid layer. Once the significance of time had been established, repeated-measures ANOVA was performed to test the hypothesis of main-group effects (tooth type, adhesive system, and the tooth type/adhesive interaction system) on hybrid layer thickness.

Results

A hybrid layer was found at the interface between the adhesive resin and dentin substrate in all primary teeth that

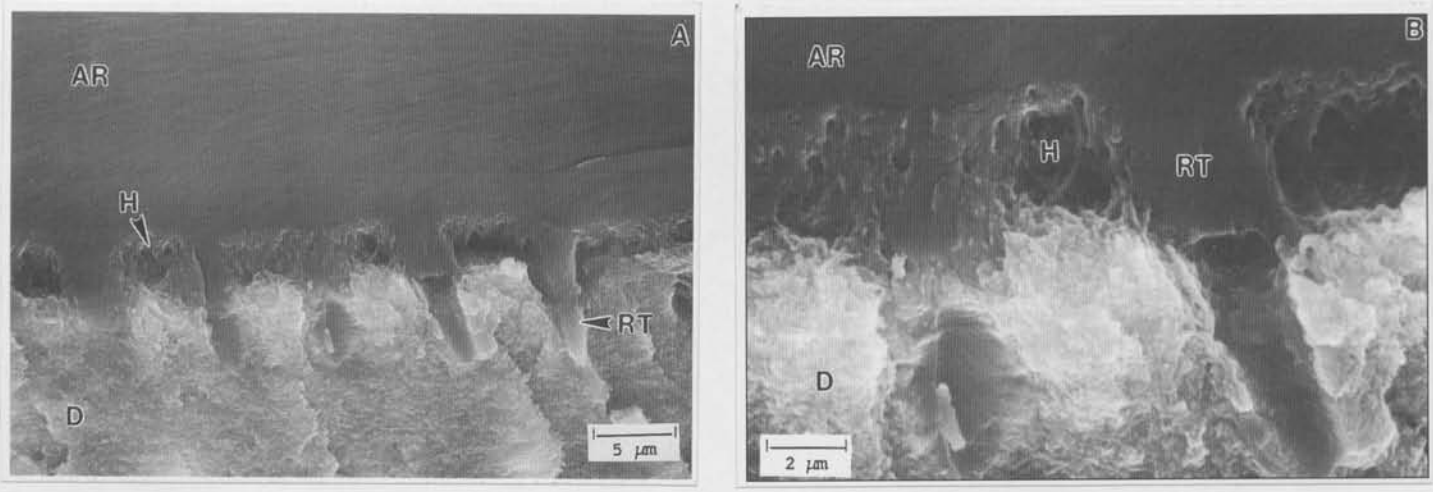

Figure 3. Photomicrographs showing an illustrative area of the (a) resin-dentin interface of Scotchbond Multi-Purpose in a primary molar conditioned for 15 sec (3000x) and in (b) a higher magnification (8000x). AR = Adhesive Resin; H = Hybrid Layer; RT = Resin Tag; D = Dentin.

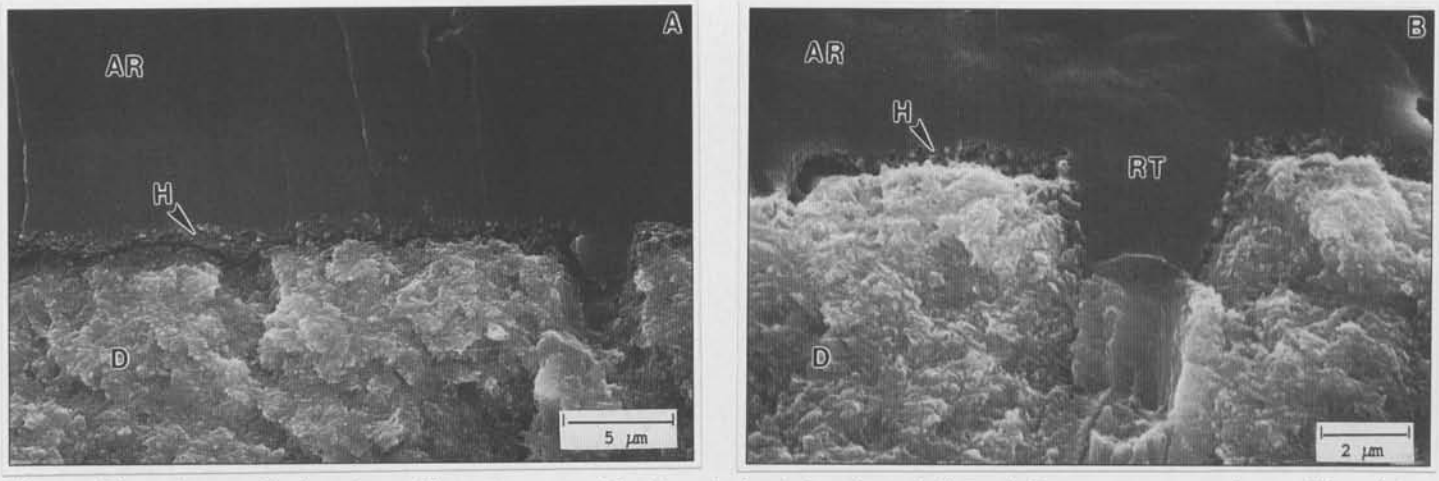

Figure 4. Photomicrographs showing an illustrative area of the (a) resin-dentin interface of All-Bond 2 in a permanent molar conditioned for 15 sec (x 4000) and an area of the (b) resin-dentin interface with a characteristic resin tag (funnel shape) in a permanent molar (8000x). Abbreviations as in Fig. 3.

were evaluated. This zone of resin infiltration at the dentin surface presented similar micromorphological features in both primary (Fig. 3) and permanent teeth (Fig. 4), except for its thickness (Fig. 5).

The statistical analyses indicated that primary teeth presented thicker hybrid layers compared with permanent teeth (Table), and this difference was statistically significant ($p = 0.0001$). It also demonstrated that 15-second dentin conditioning produces significantly thicker hybrid layers compared with 7 sec ($p = 0.0001$). The differences in composition of the two dentin adhesive systems studied did not significantly influence ($p = 0.7920$) hybrid layer thickness. The effect of tooth type on hybrid layer thickness was not dependent on the adhesive system used ($p = 0.1189$).

For describing the overall results, we analyzed the influence of tooth type and time of dentin conditioning on hybrid layer thickness. The analysis used the data derived from All-Bond 2 and Scotchbond Multi-Purpose together, which was justified because no significant difference in hybrid layer thickness was observed between the two dentin adhesive systems. In primary teeth, the mean thickness was 1.95 microns for 7 sec of dentin conditioning and 2.88 microns for 15 sec. In permanent teeth, 7 sec of dentin conditioning produced mean hybrid layer thickness of 1.56 microns, while 15 sec produced a mean of 2.28 microns. The results demonstrate that the hybrid layer was thicker in primary teeth compared with permanent teeth for both etching times (7 and 15 sec).

Discussion

This study represents the first investigation of primary tooth dentin and its response to the most contemporary dentin bonding systems. Significant differences between primary and permanent teeth were found in hybrid layer thickness, suggesting higher reactivity for primary dentin to acidic dentin conditioners.

Several steps were performed in our attempt to reproduce the *in vivo* situation as much as possible. Intrapulpal pressure is an important consideration when shear bond strength tests are performed (Pashley, 1991). This observation served as the basis for the application of a standard fluid pressure to all teeth to simulate the *in vivo* physiology of the dentin-pulp complex. Based on the system originally suggested by Prati *et al.* in 1991, a modified apparatus was developed for the application of positive intrapulpal pressure. During dentin conditioning and bonding procedures, the pulpal pressure was reduced to zero to reproduce the effects of local anesthetics with vasoconstrictors commonly used for restorative procedures. Fifteen minutes after the restorative procedures were performed, the intrapulpal pressure was resumed, and the teeth were left under positive pressure for 24 hrs. The effects of the acids used for dentin conditioning may be influenced by the presence of liquids inside the dentin tubules. The dilution of the dentin conditioner caused by these fluids may decrease its potential for demineralization of the intertubular and peritubular dentin, and eventually affect hybrid layer thickness.

Only sound teeth were used for this research. Dentin is considered a living structure with the ability to react when exposed to different stimuli (*e.g.*, caries) by forming reparative dentin (Pashley, 1989). Consequently, decayed teeth are not ideal models for initial comparisons of the micromorphology of resin-dentin interfaces in primary and permanent dentition, because these structures could have been influenced by different stages of disease progression. Tooth age was also taken into consideration. It is known that dentin undergoes a process of aging by increasing its level of mineralization (deposition of peritubular dentin) and consequently reducing the diameter of the tubules (Ten Cate, 1989). To avoid the influence of this factor on overall results, we attempted to match tooth ages as described in "Materials and methods".

It is known that different instruments used for cavity preparation produce different smear layers (Gwinnett, 1984). Consequently, the use of sandpaper or diamond saws for cutting dentin in preparation for bonding procedures creates a surface that does not resemble the surface obtained clinically and may produce unrealistic amounts of smear

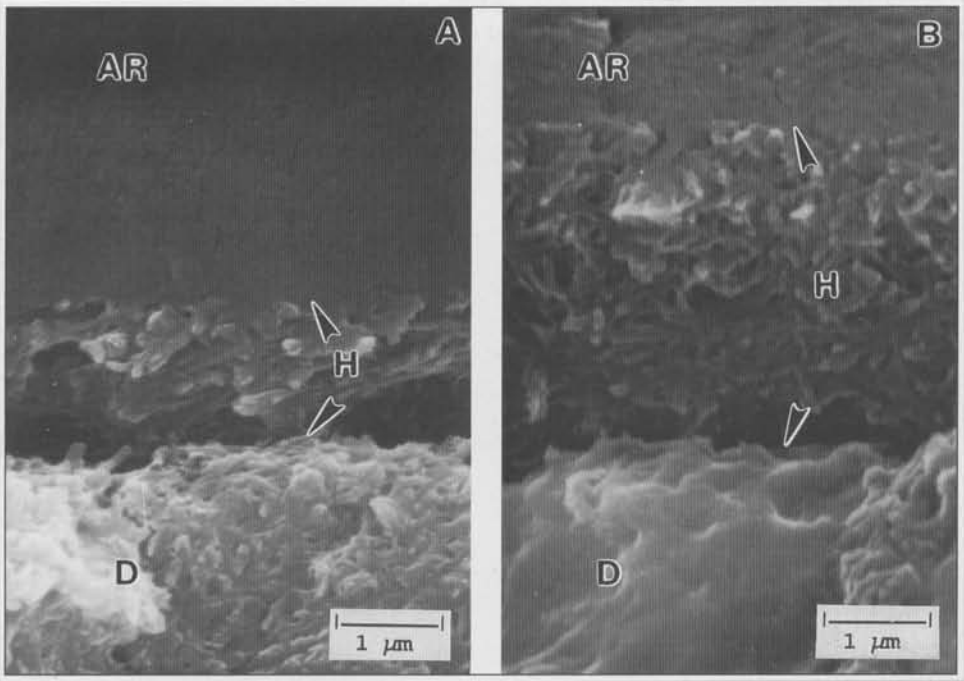

Figure 5. Photomicrographs showing the hybrid layer thickness in (a) permanent tooth (13,000x) and in (b) primary tooth (13,000x). The dentin was conditioned for 15 sec with 10% phosphoric acid, and the All-Bond 2/Bisfil P system was used in both teeth. Abbreviations as in Fig. 3.

layer. This altered substrate for *in vitro* bonding tests may affect the data, ultimately producing results not comparable with the clinical situation. To avoid this bias and better simulate *in vivo* conditions, we used carbide burs with copious water irrigation for preparing the dentin surface for bonding procedures.

The depth of tooth preparation was controlled (Mitchem and Gronas, 1986; Suzuki and Finger, 1988; Pashley *et al.*, 1993), and peripheral dentin was used for all procedures in this study. A difficulty associated with this design is the fact that primary teeth have relatively more coronal pulp (Johnsen, 1988) due to their smaller external dimensions and proportionally larger pulp chambers. Consequently, a depth of 1 mm beyond the DEJ in a primary tooth may not be equivalent to 1 mm beyond the DEJ in a permanent tooth. Actually, this relationship is still not well-understood, and no clear information is available regarding what is considered superficial or deep dentin in primary teeth, and how they can be compared with permanent teeth. Nevertheless, comparing clinically relevant depths of primary and permanent dentin is valuable.

The preparations were performed on occlusal surfaces, in both primary and permanent teeth, following the methodology described by Van Meerbeck *et al.* (1992) and Perdigao *et al.* (1994). An important characteristic associated with occlusal surfaces used as substrate for bonding is that a flat cut exposes dentin in different depths in relation to the pulp chambers, *i.e.*, the dentin related to the area of pulp horns is proportionally deeper (presenting larger and more concentrated tubules, with less intertubular dentin) compared with the dentin adjacent to the areas between the pulp horns. However, hybrid layer thickness did not seem to be affected by the differences in dentin depth at the occlusal surface, since the measurements were very similar (Table) when different positions at the crown were compared (Fig. 1).

Several studies have been performed dealing with the establishment of the correct protocol for adhesive systems (Tao and Pashley, 1988; Pashley, 1991a; Wang and Nakabayashi, 1991; Pashley *et al.*, 1992). When acid is applied to dentin, mineral components of this structure are partially removed, exposing the collagen mesh-work (Van Meerbeek *et al.*, 1992). If strong acids are used for long periods of time, the smear layer and smear plugs are removed completely, and excessive demineralization of the peritubular and intertubular dentin is seen (Erickson, 1992). This excessive demineralization may cause severe collapse of the dentinal collagen mesh-work (Tam and Pilliar, 1994). In this case, the action of hydrophilic primers may not be enough to reconstitute this mesh-work of collagen fibrils to the original level, and consequently the bonding ability is compromised. Based on these facts, it can be concluded that the dentin conditioning step is fundamental for effective bonding, and times for application, concentration, and composition of the acidic solution should be carefully controlled. The results of this study showed that time for dentin conditioning can directly influence hybrid layer thickness.

The ideal hybrid layer should be large enough to allow for a stable interlocking of the adhesive resin around the exposed collagen fibers. On the other hand, the demineralized zone should not be excessively deep, because the primer and adhesive resin may not flow among all the exposed fibers and completely embed them. In this case, an area in the bottom of the hybrid layer may become weaker, and consequently more susceptible to failure (Tam and Pilliar, 1994). In other words, a significant removal of inorganic components, without substitution by adhesive resin, leaves collagen fibrils without the support of either the dentinal inorganic matrix or the primer and adhesive resin infiltration. Another negative aspect regarding this zone of non-embedded demineralized dentin was described in a cryo-SEM evaluation of the characteristics of silver ion penetration at the resin-dentin interface (Sano *et al.*, 1994). When the bottom area of the hybrid layer is not completely filled by the adhesive, it may become a "pathway" where microleakage can occur in the absence of other gaps. A representative sample of primary tooth hybrid layer from this study (Fig. 6) suggests more complete resin impregnation of the demineralized region closer to the resin side and less complete impregnation near the dentin. This finding was frequently observed in primary teeth that were exposed to 15 seconds' dentin conditioning, and may

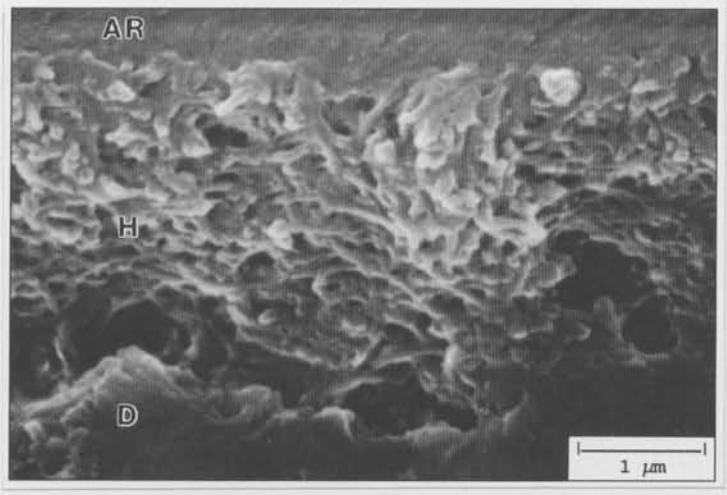

Figure 6. Photomicrograph showing an illustrative area of the resin-dentin interface of All-Bond 2 in a primary molar conditioned for 15 sec, suggesting incomplete primer and adhesive resin penetration at the bottom of the hybrid layer (20,000x). Abbreviations as in Fig. 3.

explain the differences found in previous investigations regarding bond strengths in primary and permanent teeth (Salama and Tao, 1991; Bordin-Aykroyd *et al.*, 1992; Triolo and Swift, 1992; Elkins and McCourt, 1993).

Significant differences were observed between primary and permanent teeth regarding hybrid layer thickness. The action of the dentin conditioners seemed to be more intense in primary than in permanent teeth, causing deeper decalcification of the intertubular dentin. As a consequence, the hybrid layer was significantly thicker in primary teeth, as can be seen in Fig. 5. The reasons for this phenomenon are not understood, but differences in chemical composition, micromorphology, or chemical reactivity of the dentin may contribute. To decrease the possibility of having a weaker area or a pathway for microleakage at the bottom of the hybrid layer in primary teeth, due to excessive depth of demineralization during conditioning of the dentin, it seems advisable for dentin conditioners to be applied for a shorter time when the primary dentition is being treated. The corrected time for dentin conditioning can be calculated by taking the resulting hybrid layer thickness obtained for permanent teeth as the "gold standard". The ideal time for conditioning permanent teeth with either 10% phosphoric or 10% maleic acid is 15 sec, and the mean hybrid layer thickness obtained in this study was 2.3 microns. The results of this research suggest that a shorter application time (approximately 50%) for the dentin conditioner solutions in primary teeth seems sufficient to create a hybrid layer thickness similar to that seen in permanent teeth. By reducing the time for dentin conditioning, not only hybrid layer thickness but also smear layer removal can be adjusted to the parameters established for permanent teeth. In a SEM study of the dentin surface after acidic conditioning, it was demonstrated that the smear layer is removed significantly faster from the dentin of primary teeth compared with permanent teeth (Nör *et al.*, unpublished observations). Based on this finding, a shorter time for dentin conditioning was indicated for primary teeth, to create a dentinal substrate for bonding that is similar to what is found in the permanent dentition.

The use of a differentiated protocol for bonding to primary teeth with a shorter time for dentin conditioner application (approximately 50% for the two systems evaluated in this study) may have beneficial effects on the performance of composite restorations in pediatric patients. This hypothesis still needs to be confirmed through well-conducted randomized clinical trials and reliable shear bond strength tests based on the criteria suggested by Pashley (1991b) for *in vitro* simulation of *in vivo* conditions.

Acknowledgments

The authors acknowledge Dr. Mark Fitzgerald, Department of Cariology and Operative Dentistry, Dr. Lloyd H. Straffon, Department of Orthodontics and Pediatric Dentistry, and Dr. James K. Avery, Department of Oral Biology, The University of Michigan, for valuable advice and fruitful discussions. The authors would like to extend special thanks to Dr. Paul J. Loos for assistance in the preparation of the manuscript, and Dr. Michael A. Shork and Dr. Walter Bretz for helping with the statistical analysis. This work was supported, in part, by NIH-NIDR Grant # 10170, and by CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) process #2889/92-3. This paper is based on a thesis submitted to the graduate faculty, University of Michigan, in partial fulfillment of the requirements for the Master of Science degree in Pediatric Dentistry.

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