Microleakage of Self-Etching Sealants on Dry and Saliva Contaminated Enamel

by

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ABSTRACT

Purpose: To compare the microleakage of a self-etching sealant with a traditional phosphoric acid-etched sealant under non-contaminated and saliva-contaminated conditions. Methods: Seventy-eight sound extracted human molars were used (n=13). Teeth in groups 1 and 2 were cleaned with pumice, phosphoric acid etched, rinsed, drying agent applied, sealant placed (UltraSeal XT plus) and light cured. Teeth in groups 3 and 4 were sealed using the same steps as groups 1 and 2 with the addition of a bonding agent placed underneath the sealant. Teeth in groups 5 and 6 were cleaned with a proprietary flour pumice and rinsed prior to being sealed with a self-etching sealant (Enamel Loc®). Teeth in groups 2, 4 and 6 were contaminated with saliva and thoroughly air-dried prior to the sealant placement. All teeth were subjected to a thermocycling process, stained with silver nitrate, sectioned, and the images of sealant on the occlusal surface were recorded. Microleakage distance was measured and subjected to a two-way ANOVA analysis. Results: Significantly larger microleakage distances were found for the self-etching sealant compared to the traditional sealant group and those sealants that had a bonding agent placed underneath them. (P=0.0001). Saliva contamination did not significantly affect the microleakage distance (P=0.1674). Conclusions: Under the conditions used in this in-vitro study, the self-etching sealant, regardless of contamination condition, had extensive microleakage distances in comparison to little microleakage in the traditional phosphoric acid-etched sealant and/or those that had a bonding agent used underneath them.
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INTRODUCTION

The focus of this study was on a new sealant product called Enamel Loc®, made by the Premier Dental Products Company. The company has claimed by using Enamel Loc® the need for the phosphoric-acid etching step prior to sealant placement can be eliminated. It is an interesting claim since the time savings when using a self-etching sealant such as Enamel Loc® could have a profound impact on the technique used to place sealants in pediatric and general dental practices if proven to have satisfactory results. Enamel Loc® was approved for use by the Department of Health and Human Services October 4, 2006 and as of this writing is currently being used in dental practices across the United States.

Figure 1: Enamel Loc® self-etching sealant material.

Pediatric dentists and clinicians who work with children know that younger patients are able to tolerate procedures better that are brief in length and have few stimuli associated with them. For this reason, the pediatric dental profession is constantly searching for new dental materials that help make the overall dental experience more pleasant and efficient.

The purpose of placing pit and fissure sealants is to obturate the occlusal pits and fissures of caries-prone teeth [1, 2]. The placement of sealants cuts off needed nutrients
to caries causing-bacteria found within the pit and fissures of teeth and protects these areas from chemical insult. For a sealant to convey any benefit, it must be retained fully [3, 4, 5]. If any portion of a sealant is lost, the associated benefits of the sealant are lost with it. These benefits are also nullified when micro-leakage occurs around sealants. Therefore, it is important for sealant material to adhere to enamel and be retained once it is placed.

Figure 2: The occurrence of fissure caries in conjunction with failed sealant.

Traditionally, the adhesion of pit and fissure sealant to tooth structures is achieved through a total-etch technique. The total-etch technique requires that enamel be etched, rinsed, and dried before sealant is applied to pits and fissures. No bonding agent is required when using this most time tested technique. Buonocore reported in a 1955 publication on the retention benefits of resin to enamel by using a strong acid on teeth prior to the resin placement [6]. He found the porosities caused by etching a tooth with 85% phosphoric acid gave rise to a micro-mechanical bond between the resin and the enamel. This micro-mechanical bond between etched enamel and the resin allowed a
sufficient bond to occur so the resin could be retained and convey protective properties as intended.

The extent of preparing the enamel prior to using *Enamel Loc*® is to utilize a small rotary dental prophy-brush and use flour pumice to remove surface debris from the enamel and its associated pits and fissures. It then should be rinsed with copious amounts of water and dried to desiccation prior to placing the self-etchant sealant material. These self-etching products do not utilize phosphoric acid as an independent step. Instead, they use acidic functional monomers found within the sealant material that have higher pH’s than phosphoric acid gel. Therefore, this results in a lesser amount of enamel demineralization [7, 8]. Whereas the total-etch system removes the smear layer and the superficial hydroxyapatite, the self-etching products do not.

When using the total-etch system, the phosphoric acid is recommended to be placed on the surface of the enamel for a minimum of 15 seconds, then rinsed with copious amounts of water and dried until no moisture exists within the pits and fissures. These newer self-etching materials achieve a similar result by instead making the smear layer more permeable instead of rinsing it away. Both techniques aim to allow the cured resin sealant to be retained by retentive features of the pits and fissures as well as micromechanical retention to the etched enamel surface. What the self-etching products try to do is simplify this process therefore aiding clinicians and patients alike by reducing application time.

Self-etching dental materials attempt to use fewer steps and achieve similar results in the bonding process. In recent years, dental bonding systems have utilized a two-bottle system where the etchant and primer are combined into one bottle. This
allows practitioners to avoid phosphoric acid etching and rinsing with copious amounts of water. The water is needed during the rinsing process to remove the dissolved tooth structure and leaves behind a porous surface. During this rinsing stage, young children may become agitated and move or tongue-thrust if the water reaches the posterior tongue-pharynx area. A reflexive swallow may then contaminate the etched enamel surface with saliva. Even if dried off immediately, it has been shown that contact of saliva to etched enamel significantly lessens successful penetration of sealant into the enamel micro-porosities [9].

Therefore, one of the major causes of sealant failure is saliva contamination [10, 11]. Apart from patient factors which are not under an operator’s control, another factor most commonly from the operator side is poor isolation [11]. Poor isolation is often encountered because of improper equipment usage or lack of needed support personnel. Four-and-six handed dentistry can be advantageous when placing sealants. When an operator chooses to place sealants without assistance, the process is more difficult and the chance of salivary contamination is increased.

Feigal found in his study that the placement of bonding agent below the sealant layer was beneficial when used on saliva contaminated enamel [12]. Enamel Loc® is a product that does not require the use of phosphoric acid prior to sealant placement. Monomers are found within the Enamel Loc® allows the clinician to eliminate this separate etching step. We believed during our study design that the use of Enamel Loc® could have a similar effect on contaminated enamel as products that used a primer prior to sealant placement.
STATEMENT OF STUDY OBJECTIVES

Purpose of Study

The main purpose of this study is to compare the microleakage of self-etching sealants with that of sealants using traditional proven methods, namely, total-etching with and without a bonding agent. The secondary purpose is to evaluate the microleakage of both types of sealants when the tooth surface was contaminated with saliva.

Clinical Focus of Study

The focus of this study was to help clinicians understand whether or not the latest advancement in sealant technology being promoted by the Premier Dental Company would result in similar microleakage when compared to traditional sealant materials and methods. As one of the first university based studies on self-adhering sealants, our aim is to aid clinicians in determining whether or not self-etching sealant materials will be a useful sensible alternative to existing sealant material.

Specific Aim

The aims of this study were to evaluate and compare the microleakage of three sealant procedures under saliva-contaminated and non-contaminated conditions utilizing the following:

1. Total-etch sealing method.
2. Total-etch sealing method with prior use of a bonding agent.
Null-Hypothesis

(1) The microleakage occurring in association with self-etching sealant does not differ from those of total-etch sealant or total-etch sealant with prior use of a bonding agent.

(2) When enamel is contaminated with saliva, the microleakage occurring in association with self-etching sealant does not differ from those of total-etch sealant or total-etch sealant with prior use of a bonding agent.

(3) The microleakage of sealants in each study group does not differ when comparing saliva-contaminated teeth to non-contaminated teeth.
LITERATURE REVIEW

History of Pit & Fissure Sealants

In 1955, Dr. Michael Buonocore, from Eastman Dental Center, was the first to discover and report on the preparation of enamel using a weak acid [6]. This was the first time that the body of scientific literature recommended the use of acrylic (sealant) materials as a possible method of caries prevention [6].

Dr. Buonocore’s story of discovery starts with knowledge of the industry of his day and his own personal experience working with paint and cement [6]. He knew from his past experience that paint adhered better to concrete when muriatic acid was used on the surface of the concrete prior to the application of the paint. Using this concept and knowing that the acid actually increased the surface area and porosity of the cement, he demonstrated retention of dental materials to enamel could similarly be enhanced [13]. This was the beginning of what the dental profession now commonly refers to as the “acid-etch-technique”.

It wasn’t until 1967 that Dr. Buonocore and co-worker, Dr. Cueto, published a paper acknowledging their first successful application of resin to the pits and fissures of teeth. In his original paper, Dr. Buonocore advocated the use of “obturating” the pits and fissures as a possible caries prevention technique [1]. It was Dr. Buonocore and the scientists at Eastman Dental Center who helped set the stage for the beginning of the era of dental sealants and what we now know today as adhesive dentistry.
Etching of Enamel

Initially, 85% phosphoric acid was used as the original enamel-conditioning solution by Dr. Buonocore [6]. This concentration of acid was used because it was readily available to dentists as a silicate-cement liquid. What Dr. Buonocore found was that the “conditioning” of the enamel with this concentration of acid allowed for increased bond strengths between enamel and the resin [6].

To this day, conditioning surface enamel with a weak acid (phosphoric acid 35-37%) is still the standard method for preparing enamel pits and fissures prior to sealant placement [14]. The retention of sealants occurs because the low-viscosity sealant material can flow into the etched enamel, forming hardened resin tags after the polymerization process is complete [6]. Application of 37% phosphoric-acid etchant from 15 to 60 seconds results in the formation of microscopic retentive areas in the surface of the enamel averaging approximately 27 microns in depth [15].

The benefit of conventional phosphoric acid-etching cannot be understated even to this day according to a recent study by Perry and Reuggeberg [16], where the use of an acid resin primer in lieu of conventional acid etching demonstrated greater incidence of microleakage. Their final recommendation did not advocate self-etching primers over traditional etching procedures [16].

Many dental materials now have an etchant component incorporated within their chemistry, allowing for resin bonding to tooth structure without prior phosphoric-acid etching. Using the conventional total etch technique results in a lower incidence of marginal microleakage than when using an acid-primer with sealants [16]. Others have found that self-etching primers can provide an effective alternative to conventional
phosphoric acid etchants in conditioning the enamel for successful placement of sealants [17, 18]. The Enamel Loc® product tested in the present study attempts to circumvent the total etch technique and instead use chemicals impregnated into its resin-based component to shorten the bonding technique by eliminating the use of phosphoric-acid.

Pits & Fissures: the Niches for Bacteria

Utilizing an etchant increases the surfaces of the enamel found in pits and fissures, but what are pits and fissures exactly? The pits and fissures are enamel faults, narrow shafts that primarily are found on the occlusal surfaces of teeth. The occlusal surface, the top portion of the crown of the tooth, is made of enamel and is the most highly calcified tissue in the human body. Enamel consists primarily of inorganic material (96%), water (3%) and organic material (1%) [19]. Pits and fissures have their beginnings on the surfaces of the teeth and wind their way down towards the dentino-enamel junction [20]. In many instances, fermentable food particles find these unique hideaways within the pits and fissures which allows for a conducive caries forming environment. These pits and fissures are a major contributing reason why over 80% of all carious lesions found in young permanent teeth involve pits and fissures [21].

Figure 3: Pits and fissures of studied tooth
Microbiological Observations

The structure provided by the pits and fissures are conducive for bacterial growth. Dental caries is an infectious disease caused primarily by *Mutans Streptococcus* and then *Lactobacillus* bacteria [22]. These bacteria form a biofilm, also known as dental plaque, and adhere to tooth structure via a sticky glucan polymer. When “at risk” pit and fissures are exposed and potentially provide an ecologic niche for *Mutans streptococcus* colonization, sealant placement should be considered to inhibit this bacterial growth [23]. This occurs by the filling in of the pits and fissures with a resin based sealant material.

Isolated bacteria colonies, both *Mutans Streptococcus* and *Lactobacillus*, have a difficult time surviving below sealants if an adequate seal is made at the sealant-enamel interface [24]. An intimate adaptation between the sealant and enamel keeps fermentable carbohydrates and bacteria separated from each other. This starving of the *Mutans streptococcus* bacteria dramatically reduces the likelihood of caries progression in high-risk individuals [24].

In 1976, scientists found that bacterial counts of pits and fissures of sealed teeth had less than .01% of the bacterial counts found in the pits and fissures of teeth left unsealed [25]. In 1978, a longer term study by Going et al confirmed the Handelman study results [26]. These early studies confirmed if a clinically visible sealant was lost, there was no lasting benefit to the tooth even though it had been sealed at some time in the past [27]. For sealants to be effective and keep bacterial levels in the pits and fissures to a minimum, they must be completely retained.
Efficacy of Sealants

For a sealant to perform as intended, it must seal off oral fluids from migrating into the depths of the pits and fissures. Cueto and Buonocore wrote that the caries incidence in pits and fissures of permanent molars could be reduced by as much as 86.3% by sealing them with an adhesive at 6 month intervals [1]. This was over 30 years ago when caries rates were much higher. But even today, 88% caries in children is still found in the pit and fissure systems of the enamel [21]. When sealing teeth at high-risk for caries, the benefits of a well placed sealant still decreases the risk of pit and fissure caries dramatically [28]. The suggestion of sealing teeth every six months [1] is similar to current clinical procedures. Although most sealants need no upkeep, a regular check of placed sealants is necessary to maintain any sealant that has been fractured, lost or has developed an open margin.

Dennison et al. at the University of Michigan reported in 1980 that sealant failure rates decrease over time [29]. In other words, sealants are more likely to fail sooner than later. In the Dennison study, 17.3% of sealants needed to be resealed due to some portion of the sealant failing after 6 months. This proportion declined to 7.8% after 18 months [29].

Feigal found the failure rate of sealants to be between 5-10% each year [30]. Appropriate follow-up recall visits are necessary to check for any sealant failures; these are more likely to occur during the immediate six month period following initial placement [29, 30]. This is important for the dentist placing the sealant to know because the caries incidence of teeth that have been sealed is directly dependent on the ability of the tooth to retain the sealant [5, 28].
In the most recent studies, Ahovuo-Saloranta et al. found that sealing molars at high caries risk has significant benefit after analyzing split-mouth studies using sealed teeth on one side of the mouth and a control side using unsealed teeth [31]. The ADA Council of Scientific Affairs as of 2008 has also recommended that sealants can be used effectively to prevent the initiation and progression of dental caries [32].

Retention of Sealants

Prior studies have attempted to identify the primary cause of sealant failure [33, 34, 9, 18]. The variables that have been addressed include the causes of microleakage and the penetration depth of sealant into the etched tooth surface and have looked into techniques such as agitating the phosphoric-acid during the etching phase [34]. From these studies, simple changes in the application technique of fissure sealants, such as ultrasonic stimulation during the etching procedure and drying etched enamel with acetone prior to placing sealant material have shown to improve the quality of sealant retention [35].

It has also been documented in the literature, as mentioned previously, that retained sealants are advantageous in reducing the likelihood of observing carious lesions within the pits and fissures of sealed teeth [36]. Houpt et al found in a six year study that the overall effectiveness of reducing caries by sealing teeth was 56% [37]. They found that occlusal surfaces with partial or complete loss of a sealant resulted in a similar caries levels as unsealed teeth [37]. When sealants fully occlude the orifices of pits and fissures, caries will not be initiated [29]. Therefore, the intimate relationship between sealant effectiveness and its ability to be retained cannot be overlooked. Recently, Griffin et al. found that teeth with fully or partially lost sealants were not at a higher risk
of developing caries than were teeth that had never been sealed [38]. This could be attributed to the placement of bonding agent on the occlusal surface prior to sealant placement. Though the actual sealant is lost, the bonding resin still remains in the pit and fissure.

Prior to the 1990’s, the best likelihood of a sealant being retained came strictly from a direct interface between the enamel of teeth and the sealant material. This “bond” was purely done via mechanical retention. What occurs is what Dr. Buonocore had discovered three decades earlier. The etching of the enamel increased the surface area by causing the enamel to become very porous. The low-viscosity sealant material was then able to flow into the porosities of the newly etched enamel and once cured, the formed resin tags kept the sealant in place [1]. In was in the 1990’s the idea of using bonding agents prior to sealant placement began to get more attention due to their added advantages [10, 39].

Salivary Contamination

One area where there is an added advantage of utilizing a bonding agent prior to placing a sealant is on saliva contaminated teeth. The most common cause of sealant failure clinically is due to salivary contamination of the enamel [10]. When working with children, this contaminating process can happen very quickly and easily. Once the surface is contaminated, no matter the length of time, loss of porosity of the enamel surface occurs which lessens the effect of the etching and subsequent bond [40].

When enamel is contacted by saliva after being etched, it reduces the surface energy, wettability, and renders a less favorable bonding surface [41]. A build-up of salivary products (e.g. glycol-proteins) blocks the micro-etched enamel surface,
preventing resin penetration of the surface [40]. If the enamel is exposed to saliva for anything more than about a second or more the end result is blocked porosities that lessen the opportunity for a good bond.

Moisture contamination, other than saliva contamination, can occur for reasons including when an opercula of the gingival tissue extends over the distal marginal ridge of a partially erupted tooth. When this occurs, the occlusal surface tends to be contaminated with gingival crevicular fluid at the time of sealant application [33]. Because of the chance of fluid contamination on teeth with operculums, finding a hydrophilic bonding system is necessary to seal teeth with this condition. The reason for getting a sealant on a tooth prior to it being 100% erupted is that a well placed sealant on a tooth increases its chances of staying caries free. But due to the hydrophobicity of our current sealant materials, clinicians wait to place sealants until a tooth has erupted further. Timing in the placement of sealants on newly erupted teeth is critical in the success of sealants placed on teeth in this category [42].

Though gingival crevicular fluid plays a role in contaminating etched enamel surfaces the greater risk comes from a child moving his/her tongue causing salivary fluid to be moved onto the etched enamel. The working time a dentist has when placing sealants is really dependent upon a child’s temperament and coping skills. The longer it takes to place the sealant, the greater the risk of contamination. For those children who are able to sit still and follow instruction, drying agents can increase the surface energy of enamel resulting in a better bond and increase the wettability of enamel [35].
Use of a bonding agent under sealant material

Feigal et al. and Peutzfeldt et al. studies support the use of a bonding agent prior to placing sealants. When this step is added, these studies produced results showing significant improvement in sealant survival [18, 43]. Hitt et al. also found that when there is moisture contamination, the use of a bonding agent under sealants can render similar bond strengths when compared to sealants placed on dry, uncontaminated enamel [39].

The placement of bonding agent under sealants allows for better penetration than sealant alone into the pits and fissures. This maximizes the wettability of the enamel and enhances bonding potential which can be of great importance when the goal is to have the enamel retain the sealant material [39, 44]. This wetting phenomenon supports the idea that if a tooth has any form of moisture on it the properties of the bonding agent are better able to wet the surface of the tooth than when sealant is used alone. Therefore, when enamel is contaminated by moisture, placing a layer of bonding agent can increase sealant retention [45]. It is the wetting capability of the bonding agent that allows it to convey its benefit when placed underneath sealant material.

Self-etching Sealants

When a tooth is etched with 37% phosphoric acid for 15 seconds, changes occur in the enamel. On the surface, a shallow layer of enamel about 10 microns deep, containing plaque, surface and subsurface pellicle along with some enamel prisms, is removed. This is followed by a selective decalcification, or up to 120 microns deep, which produces spaces within the enamel [46].

Overall, the acid etching procedure enhances bonding to enamel by, (1) removal of surface debris, (2) raising the free surface energy of the enamel to exceed the surface
tension of the bonding material, (3) producing spaces (etching patterns) into which the resin may penetrate to form tag-like extensions and interlock mechanically when set; and (4) increasing the surface area of enamel available to the bonding material [47].

Self-etch adhesives do not require the use of a separate acid etch step. Instead, they prime the enamel and generate a layer that incorporates minerals into the hybrid zone [48]. The newer all-in-one self etching adhesive systems are not as acidic as the phosphoric acid when using the traditional total etch technique [49]. Multiple investigators have reported low resin-enamel bond strength of all-in-one self-etch materials [50, 51, 52, 53]. It has been found that one way to make the substrate (enamel) more receptive to bonding with all-in-one adhesive systems is to cut it prior to placing the adhesive [53].

Use of acidic resin primer technology, like that found in 3M product Prompt-L-Pop and similar in concept to Enamel Loc® have revealed differing results when looking at microleakage. Duangthip and Lussi found the use of acidic-resin-primers demonstrate a higher level of microleakage when used in lieu of traditional etching measures [33].

An abstract was found during the literature search for this study that supported the idea of self-etching sealants. It was presented at the Baltimore Convention Center at the 83rd IADR meeting in 2005. In this abstract, Matsunga et al. revealed similar microleakage results when comparing traditional sealants to the new self-etching sealants [54]. In this laboratory study, bovine teeth were used. The results revealed the adhesion interface between enamel and the experimental sealant had excellent sealing ability. This was thought to be due to surface modification by the chemical action of the phosphate monomers found within the self-etching sealant material. If studies like this
one could be repeated and proved, self-etching sealants would be helpful when clinicians attempt to place sealants on young permanent molars.

The self-etching sealant in this Matsungu study was described as being placed on the tooth for 40 seconds prior to being light cured. The chemical constituents included triethylene glycol dimethacrylate, BIS-GMA, phosphate methacrylate monomers and camphorquinone initiation system. The results revealed similar microleakage amounts when compared to traditional sealants [54]. This was the only study that looked at self-etching sealants that could be found during the literature review.

Perdigao and Sezinando had an abstract that was presented at the IADR in Toronto in 2008. They found that enamel etched with 35% phosphoric acid prior to placement of the self-etching sealant significantly improved the sealing ability of Enamel Loc [55]. We may conclude from their research that its self-etching monomer technology needs to be improved before it clinicians can confidently place this product using only the companies recommended placement technique.

Other Factors Affecting Sealant Retention (Drying Agents, Physical Properties of Sealants, and Light Curing)

*Drying Agents.* The resin based sealants used in dentistry are hydrophobic. Therefore, moisture left in pits and fissures can restrict the wetting of the enamel surface with sealant. Drying agents can displace aqueous deposits found in the residual organic debris prior to sealant placement. Drying agents, such as *PrimaDry®* (Ultradent Corporation, South Jordon, UT), displace moisture from the pits and fissures of teeth prior to placing resin sealants. The product of *PrimaDry®* is 99% ethyl alcohol [56].
After etching with phosphoric acid and rinsing, organic matter can remain in the occlusal convoluted anatomy within the depths of pits and fissures. This is due to the inability of the pumice and bristles of a prophy brush to access these areas. These areas also can entrap water that air drying cannot evaporate. *PrimaDry®* volatizes the moisture found in such moist fissures, allowing for a more easily wettable surface. Though it has been reported the use of post-etching drying agents enhances sealant retention, it has not been statistically supported in some studies [57, 58]. The application of a product that volatizes moisture from the occlusal surface of a tooth prior to sealant placement improves sealant penetration depth into pits and fissures [35]. Drying the etched fissure system with acetone has improved the quality of sealing fissures [35].

What works laboratory is not necessarily adaptive to the needs of the clinician. Though we know the total etch system on enamel works, saliva contamination still persists as a problem. This is where newer technology in sealant materials, currently known as self-etching sealants, is being explored.

*Physical Properties of Sealants.* When evaluating the filler content of sealant material, one study found that unfilled sealants exhibited less microleakage than filled sealants [59]. Many classical sealants have little to no filler material in them. The extra strength that is conferred to the sealant from the filler particles has also been found to have no effect on sealant micro-leakage [14]. Interestingly, some companies add filler to the resin and still label the product as sealant. There could be up to as much as 60% filler embedded in the resin of some sealant brands. This study used *Ultraseal XT plus®* which is marketed as having 58% filler material in it.
UltraSeal XT plus®, is a 58% filled sealant material and advertised as being a pit and fissure sealant along with being a flowable composite [60]. Its active ingredient is BIS-GMA and the approximate concentration of the BIS-GMA is unknown as this is proprietary information. Gillet showed that using flowable composites as sealant materials gave almost full penetration to the depth of the fissure and may have greater long term effectiveness if done under ideal conditions than traditional sealants [61].

Duangthip and Lussi also found that the modulus of elasticity of a resin based material, including a non-viscous sealant, could play a role in sealant microleakage [34]. Because shrinkage stress can be related to the viscosity of the sealant and its modulus of elasticity, this could play an important role when addressing microleakage.

They also revealed that Y-type fissures (a martini glass shape), showed they had larger unfilled areas when compared to U-type and V-type shaped fissures [34]. It has been shown that overfilling of sealant or resin in the fissure can result in more shrinkage and thus greater microleakage. If different amounts of sealant are placed in the fissures of teeth in a study, keeping all other variables the same, this alone affect the results due to the amount of sealant or bonding agent used [62].

Light-Curing of Sealant and Bonding Agent Together. The air-inhibited phenomenon allows for composite resin to adhere to itself if left undisturbed between layers. This is why resin-based dental materials bind to the layer of bonding agents when used prior to sealant placement. Torres et al. tested whether or not there was a significant difference when light-curing sealants individually or together when used with a bonding agent. They found that there is no effect on bond strength when cured individually or as a single unit [63].
Evaluating Sealant Retention

The best way to evaluate sealant retention is through in-vivo studies. Due to the fast pace of material advancement, in-vitro product evaluation is indispensable. In-vitro methods of measuring sealant retention on enamel include bond-strength tests, SEM (scanning electron micrograph) evaluations, and microleakage distance measuring. For this study, the use of microleakage was the methodology utilized to evaluate sealant retention.

Microlkeage

The microleakage term we use in this study is a quantifiable distance that clinicians and researchers use to measure the possible performance of a restorative material in the oral environment [64]. Microlkeage is defined as the clinically undetectable passage of bacteria, fluid, molecules or ions between the enamel surface and the restorative material applied to it [65]. A dye or some sort of marker is needed to represent the effusion of bacteria filled saliva underneath sealants. The silver nitrate method we used in this study is a common method of measuring microlkeage at the tooth-restoration interface. Microlkeage was used as measurable criteria in this study as a way to evaluate the longevity of sealant retention.

Figure 4: No microlkeage visible under stereo microscopy at tooth sealant interface.
MATERIALS AND METHODS

Ethical Approval

On January 18, 2008 the Institution Review Board (IRB) Human Subjects Committee at the University of Minnesota determined that this study was exempt from review under federal guidelines 45 CFR Part 46.101(b) category #4. The protocol was approved by the IRB (Study Number 0801E24515).

Pilot Study

The sample size for this study was determined by an initial pilot study. In total, 12 teeth were used in the pilot study to evaluate the expected micro-leakage distances we could expect to find. Our research team believed if we ran some of the testing steps prior to the actual experiment, we could lessen the likelihood of a critical error by learning how to utilize each machine involved in the process prior to using the actual teeth in the study.

Our pilot study revealed that 13 teeth in each individual group would provide us sufficient data to identify significant changes between sealant material and different sealant methodologies.

Preparation of Teeth

Seventy-eight non-carious molars were collected from the University of Minnesota’s department of Oral Surgery and the Hennepin County Medical Center. All teeth were stored in .2% sodium azide solution after extraction and kept in this solution during the time prior to the study. Once the teeth were gathered, each tooth was identified with a number that was cut with a high-speed hand-piece and a 330 bur into the side of the root surface. The tooth was then randomly assigned to one of six groups.
through use of a Microsoft randomization program. The following table reveals how the six individual groups of teeth were categorized.

<table>
<thead>
<tr>
<th>Product</th>
<th>Non-Contaminated</th>
<th>Saliva Contaminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etchant and Sealant</td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>Etchant, Bonding Agent, Sealant</td>
<td>Group 3</td>
<td>Group 4</td>
</tr>
<tr>
<td>Self-Etching Sealant (Enamel Loc)</td>
<td>Group 5</td>
<td>Group 6</td>
</tr>
</tbody>
</table>

Table 1: Study Categories

Within this study, two different experimental conditions were compared. These groups included the following:

(1) Teeth contaminated with saliva prior to sealant placement

(2) Non-contaminated teeth prior to sealant placement.

The dental materials to be tested in this study were comprised of the following:

(1) A self-etching sealant, *Enamel Loc®*, made by *Premiere Dental USA*.

(2) Traditional sealant (*Ultraseal®*), placed without prior placement of an adhesive.

(3) Use of a bonding agent (*3M ESPE*), *Adper Single Bond Plus®* used prior to placement of *Ultraseal®* sealant material.
Prior to the application of sealant material, the occlusal tables of teeth in groups 1 through 4 were polished with a clean dry prophy angle brush using a low speed Midwest hand-piece. Teeth in groups 5 and 6 were cleaned using proprietary flour pumice. This pumice had been included in the Enamel Loc® sealant kit.

Groups 1 through 4 were then acid-etched for 15 seconds while the acid was agitated with a sheppard’s hook dental explorer from Hu-Friedy. Teeth were then rinsed with copious amounts of water for 15 seconds and air dried until the surface of the enamel was chalky white. The air-source utilized was the same compressor system used by the University of Minnesota pediatric dental clinic.

For all saliva contaminated groups the saliva was obtained from the same volunteer at the time of the experiment by collecting whole saliva from the floor of the mouth with a pipette. The volunteer was the same for each saliva sample. The subject had been NPO for 6 hours prior to the saliva collection and tooth brushing had not occurred for that same period of time. Since Hebling and Feigal [12] had used a subject to gain saliva for their contamination experiments we chose the same for this study. Teeth were handled with nitrile gloves and cotton forceps during trials to avoid finger-oil contamination.

**Table 2: Materials Used in Study**

<table>
<thead>
<tr>
<th>Materials in Study</th>
<th>Manufacturer</th>
<th>City, State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultradent Etch Gel</td>
<td>UltraDent</td>
<td>South Jordan, Utah</td>
</tr>
<tr>
<td>Ultraseal Sealant #725</td>
<td>UltraDent</td>
<td>South Jordan, Utah</td>
</tr>
<tr>
<td>PrimaDry Agent</td>
<td>UltraDent</td>
<td>South Jordan, Utah</td>
</tr>
<tr>
<td>Enamel Loc Sealant</td>
<td>Premiere Dental</td>
<td>Buffalo, NY</td>
</tr>
<tr>
<td>Enamel Loc Flour Pumice</td>
<td>Premiere Dental</td>
<td>Buffalo, NY</td>
</tr>
<tr>
<td>Adper Single Bond Plus</td>
<td>3M ESPE</td>
<td>St. Paul, MN</td>
</tr>
</tbody>
</table>
According to which group a tooth was in, the following steps were performed:

**Group 1** → Occlusal surfaces were cleaned with a dry disposable prophy brush (Acclean disposable, *Henry Schein*, Melville, NY). Sealants were placed using the traditional method of etching with 34% phosphoric acid (*Ultradent Corporation*, South Jordan, UT) for 15 seconds, rinsed with copious amounts of water for 15 seconds, dried until a chalky surface of the enamel was observed. *Primadry®* was then placed within the pits and fissures and again dried. The *Ultraseal®* sealant material was then placed. The sealant material was light-cured (Spectrum Curing Light, *Dentsply Caulk*, Milford, DE) for a period of 40 seconds. The light was rested on the cusp tip of each molar to standardize the light-curing process.

**Group 2** → Occlusal surfaces were cleaned with a dry disposable prophy brush (Acclean disposable, *Henry Schein*, Melville, NY). Sealants were placed using the traditional method of etching with 34% phosphoric acid (*Ultradent Corporation*, South Jordan, UT) for 15 seconds, rinsed with copious amounts of water for 15 seconds, dried until a chalky surface of the enamel was observed. *Primadry®* was then placed within the pits and fissures and again dried. Whole saliva pipetted from the floor of our subject’s mouth was placed on the surface of the tooth with a micro-brush and then air dried. An attempt was made to dry the enamel to regain a dry, chalky surface after contamination occurred. Once completely dry, the *Ultraseal®* sealant material was worked into the fissures of the tooth with the brush tip that comes with the *Ultraseal®* product and then light cured (Spectrum Curing Light, *Dentsply Caulk*, Milford,
DE) for 40 seconds. The light was rested on the cusp tip of each molar to standardize the light-curing process.

**Group 3** Occlusal surfaces were cleaned with a dry disposable prophy brush (Acclean disposable, *Henry Schein*, Melville, NY). Sealants were placed using the traditional method of etching with 34% phosphoric acid (*Ultradent Corporation*, South Jordan, UT) for 15 seconds, rinsed with copious amounts of water for 15 seconds, dried until a chalky surface of the enamel was observed. *Primadry®* was then placed within the pits and fissures and again dried. Single-bond plus was then placed on the surface with the included applicator brush in the single unit dispenser and air thinned. It was then light cured (Spectrum Curing Light, *Dentsply Caulk*, Milford, DE) *Ultraseal®* sealant was then brushed into the fissure with the attached applicator tip that comes with the product and again light cured (Spectrum Curing Light, *Dentsply Caulk*, Milford, DE). The light was rested on the cusp tip of each molar to standardize the light-curing process.

**Group 4** Occlusal surfaces were cleaned with a dry disposable prophy brush (Acclean disposable, *Henry Schein*, Melville, NY). Sealants were placed using the traditional method of etching with 34% phosphoric acid (*Ultradent Corporation*, South Jordan, UT) for 15 seconds, rinsed with copious amounts of water for 15 seconds, dried until a chalky surface of the enamel was observed. Whole saliva pipetted from the floor of our subject’s mouth was placed on the surface of the tooth with a micro-brush and then air dried. An attempt was made to dry the enamel to regain a dry, chalky surface. Once completely dry, *Single Bond Plus* was worked into the fissures of the teeth with
the application brush that comes with the bonding agent and lightly air dried and light cured (Spectrum Curing Light, *Dentsply Caulk*, Milford, DE). *Ultraseal®* was then placed on the bonding agent layer using the brush tip that connects to syringe and again light cured for 40 seconds. The light was rested on the cusp tip of each molar to standardize the light-curing process.

**Group 5**  This group included non-contaminated teeth (no saliva contamination). Teeth were cleaned with a disposable prophy-brush (Acclean disposable, *Henry Schein*, Melville, NY) and proprietary flour pumice that was included with the *Enamel Loc®* sealant kit. The flour pumice was then rinsed with copious amounts of water for 15 seconds. The self-etching sealant material (*Enamel Loc®*) was then applied to the teeth, allowed to sit on the enamel uncured for 20 seconds and then light cured (Spectrum Curing Light, *Dentsply Caulk*, Milford, DE) for 40 seconds. The light was rested on the cusp tip of each molar to standardize the light-curing process.

**Group 6**  This group of teeth were contaminated with the same subjects saliva that had been used in groups #2 and #4 and had the same steps applied to them as those teeth in Group #5. The proprietary flour pumice sent with the *Enamel Loc®* product was used. Saliva was then placed onto the occlusal surface of the tooth to contaminate it. The occlusal surface was air dried for a period long enough to allow a dry surface to reappear on the enamel. *Enamel Loc®* was then placed on the surface of tooth, allowed to sit uncured on the surface for 20 seconds and then light cured for 40 seconds (Spectrum Curing Light, *Dentsply Caulk*, Milford, DE). The light was rested on the cusp tip of each molar to standardize the light-curing process.
Microleakage Testing

Once the sealants had been light cured, they were then subjected to a thermocycling process. All sealed teeth were subjected to 500 thermocycles alternating between hot water (55°C) and cold water (5°C) with a 30-second immersion time in each of the different temperature baths (Thermo Immersion Bath, NESLAB, Newington, NH). This process took approximately nine hours. After being subjected to thermocycling, the teeth were immediately immersed in 50% AgNO₃ solution (Sigma-Aldrich Co., St. Louis, Missouri) for 2 hours. After all teeth were soaked in AgNO₃ for two hours, excess AgNO₃ solution was rinsed off with tap water. The teeth were then placed in a developing solution under fluorescent light for 8 hours.

After the staining process, each tooth was sectioned buccolingually using water coolant and a low speed diamond wheel sectioning machine (model no. 650, South Bay Technology, Inc., San Clemente, Calif). After sectioning, each half tooth sample had two
measurements performed on it. These two areas included the buccal and lingual cusp inclines from where the sealant interfaced with the enamel to the point where no silver nitrate could be detected. Using this method, four surfaces per tooth were measured. These four readings were averaged and microleakage for any studied tooth was given as a single number by averaging them together.

Figure 6: Low speed diamond sectioning machine used to separate teeth into halves.

Microleakage was measured by two different operators who were each blinded to which group a tooth was in. The image of the enamel-sealant interface at the cavity margin was captured at approximately 90x magnification under a stereomicroscope and stored in digital format (Image-Pro Plus software version 4.5 for Windows, Media Cybernatics, Inc., Silver Spring, MD). From these pictures, the operators were able to review on numerous occasions the microleakage distance measurements. If the microleakage readings differed on any sample more than 10%, the sample was reviewed with both operators present to determine the true distance. The microleakage was evidenced as a dark line at the enamel-sealant interface and was measured in millimeters using the Image-Pro software.
The 78 teeth provided a total of 312 microleakage measurements (78 teeth x 2 measurements per sectioned tooth x 2 halves per tooth). Each half tooth then had the distances of microleakage averaged so any tooth’s average microleakage was made up of 4 different measurements.

Figure 7: Microsoft *Image Pro®* measurement of microleakage using stereomicroscopy.
RESULTS

Data Summary and Statistical Analysis

We used 13 measurements of microleakage within each cell for the factorial design between 3 types of self-adhering sealants (sealant, sealant with bond, and self etching sealant) under two conditions (non-contaminated and contaminated). We listed the means (Mean), standard deviation (Std), minimum (Min), and maximum (Max) for the microleakage level within each group.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealant not contaminated (Group 1)</td>
<td>13</td>
<td>0.07</td>
<td>0.07</td>
<td>0</td>
<td>0.26</td>
</tr>
<tr>
<td>Sealant contaminated (Group 2)</td>
<td>13</td>
<td>0.18</td>
<td>0.12</td>
<td>0.02</td>
<td>0.40</td>
</tr>
<tr>
<td>Sealant with bond not contaminated (Group 3)</td>
<td>13</td>
<td>0.21</td>
<td>0.13</td>
<td>0.03</td>
<td>0.47</td>
</tr>
<tr>
<td>Sealant with bond contaminated (Group 4)</td>
<td>13</td>
<td>0.34</td>
<td>0.23</td>
<td>0.03</td>
<td>0.79</td>
</tr>
<tr>
<td>Self etching sealant no contamination (Group 5)</td>
<td>13</td>
<td>1.25</td>
<td>0.18</td>
<td>0.98</td>
<td>1.65</td>
</tr>
<tr>
<td>Self etching sealant contaminated (Group 6)</td>
<td>13</td>
<td>1.29</td>
<td>0.28</td>
<td>0.59</td>
<td>1.61</td>
</tr>
</tbody>
</table>

Table 3: Individual cell sample size, mean, standard deviation, min/max values in mm’s.
Figure 7: Microleakage distance of each tested group.

The groups were assigned as listed in Table 2:

<table>
<thead>
<tr>
<th>Description</th>
<th>Non-Contaminated</th>
<th>Saliva Contaminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>UltraSeal Sealant</td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>UltralSeal Sealant + Bond</td>
<td>Group 3</td>
<td>Group 4</td>
</tr>
<tr>
<td>Enamel Loc SE Sealant</td>
<td>Group 5</td>
<td>Group 6</td>
</tr>
</tbody>
</table>

Table 4: Tested study groups.
Figure 8: Box-plot of millimeters of microleakage distance found within the three major study groups.

**Figure 8 legend:**
The plus sign (+) represents the sample mean.  
The line drawn through the center of elongated boxes is the sample median.  
The top edge of the elongated box represents the upper extent of the 3rd quartile (75th percentile) of samples and the lower edge of the elongated box represents the lower extent of the 1st quartile (25th percentile).  
Extending from the box are the "whiskers". If no outliers, the bottom whisker extends to the minimum data value and the top whisker extends to the maximum.  The SAS software determines which values are "outliers" and use small boxes to indicate these "outliers".
Our box-plot graph reveals the range of microleakage distance was least for the sealants placed without bonding agent when compared to the other two groups. The group of sealants having had bonding agent placed below showed a greater distance of microleakage when compared to the sealants without prior bonding agent placement, but less than what was found with the self-etching product. The distance of microleakage was significant (p<0.05) when comparing each of the three different groups.
Figure 9: Box plot of the microleakage versus contamination conditions.
Figure 4 reveals visually that there was little difference in microleakage distances when teeth were grouped either as “contaminated” or “uncontaminated”. No significant difference in microleakage was found within study groups between saliva contaminated and uncontaminated teeth.

![Graph showing microleakage distances](image)

**Figure 10:** Cell means for the factorial design.
Figure 5 reveals a visual increase in the microleakage distance when comparing the three study groups. Teeth contaminated with saliva had greater microleakage when compared to the non-contaminated teeth within each group. Results revealed that there was significant difference when comparing microleakage of the three main groups. But, no significant difference was found when measuring the microleakage distance between contaminated and non-contaminated samples *within* each group. The following paragraphs reveal this quantitative finding.

Two-way ANOVA analysis

The primary analysis used two-way ANOVA to compare the micro-leakage level between 3 types of self-adhering sealants under two conditions.

The F-test for the interaction term between sealant and contamination found no statistical significance (p=0.65). The F-test for the main effects suggested statistical significance for the sealant types (p<0.0001) and contamination condition (p=0.032).

We performed post-hoc Tukey HSD tests to compare the pair-wise difference between sealants. The tests indicated that the microleakage levels were statistically significantly different between any pair of sealants at level of 0.05.

The mean microleakage level difference between sealant and sealant with bond was -0.15mm with 95% CI (confidence interval) of (-0.27, -0.02). The mean microleakage level difference between sealant and self etching sealant was -1.14mm with 95% CI of (-1.27, -1.02). The mean microleakage level difference between sealant with bond and self etching sealant is -0.99mm with 95% CI of (-1.12, -0.88).
The mean microleakage level difference between no contamination and contamination was found to be -0.091mm with 95% CI of (-0.17, -0.0081).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Sum of squares</th>
<th>Degree of freedom</th>
<th>Mean Square</th>
<th>F Value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealant</td>
<td>20.18</td>
<td>2</td>
<td>10.09</td>
<td>294.51</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Contamination</td>
<td>0.16</td>
<td>1</td>
<td>0.16</td>
<td>4.71</td>
<td>0.032</td>
</tr>
<tr>
<td>Interaction term</td>
<td>0.03</td>
<td>2</td>
<td>0.02</td>
<td>0.44</td>
<td>0.65</td>
</tr>
<tr>
<td>Error</td>
<td>2.47</td>
<td>72</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (Corrected)</td>
<td>22.83</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Two-way ANOVA summary table.
DISCUSSION

If newer sealant materials can achieve similar or better results than traditional sealants while using fewer steps in the placement process, it would make sense for dentists to consider these types of products. *Enamel Loc®,* made by the *Primere* dental company, is a self-etching sealant material utilizing self-incorporated chemicals eliminating the need to etch teeth prior to placement. Therefore, use of *Enamel Loc®* could save clinicians time and allow for less opportunity for salivary contamination prior to sealant placement. Clinicians who place sealants everyday know that just a few seconds can make a big difference in whether or not an enamel surface becomes contaminated prior to being sealed on a behaviorally challenged child.

Rationale for developing this study

The purpose of studying contamination in each group was chosen for a reason. Contamination of molars is difficult for dentists and hygienists to avoid in a child’s moist oral cavity. Many states also allow assistants to place sealants under direct supervision. Some clinical dental assistants may have no more than a few hours of experience prior to getting to work on a patient. Because of this and not realizing the level of importance of salivary contamination on desiccated enamel, this study wanted to reveal if the affects of re-drying a tooth could still convey the benefits of sealant placement.

Obstacles in the Placement of Sealants

Experienced clinicians will tell you that by having to use the total-etch technique can present problems. Spraying a child’s tooth with water to remove etchant can cause them to gag or choke. This can cause child patients to close their mouths or to swallow
and move their tongues, therefore, contaminating the etched surface. Once saliva contaminated, the chance of sealant successfully bonding to the enamel is reduced. Saliva as we now know contains proteins and mucins known to lessen the success rate [66, 33]. Even when cotton role isolation has been meticulously placed, the tongue movement and act of swallowing can still lead to contamination [33]. Therefore, lessening the time it takes to place a sealant with fewer stimuli increases the chance for successful sealant placement.

Since sealant effectiveness can be directly related to being retained, the application procedures used in their placement are paramount for long-term success [36]. Salivary contamination of an etched enamel surface could have deleterious effects on the quality of the bond. One objective of this study was to look at how salivary contamination affected the level of microleakage. This was done by comparing etched, dried and sealed teeth to those that were contaminated after the etching process. Contaminated teeth were dried until no moisture could be detected on the tooth. This method was chosen since clinicians may at times feel they can still seal a tooth if it is dried off after being contaminated. Previous work has shown that saliva contamination of etched enamel, even for a single second, resulted in a tenacious coating which blocked the porosities of etched enamel [9].

The microleakage term we use in this study is a quantifiable distance that clinicians and researchers use to measure the possible performance of a restorative material in the oral environment [64]. A dye or some sort of marker is needed to represent the effusion of bacteria filled saliva underneath sealants. Silver nitrate was the
marker we chose to use in this study. Soaking teeth in silver nitrate is a common method used to measure microleakage at the tooth-restoration interface.

This in-vitro study was also intended to evaluate the latest type of sealant, Enamel Loc® that claimed to bond to tooth structure without the need to etch teeth prior to being placed. The standard which we felt it to be tested against included techniques and materials currently used in the mainstream practice of dentistry. As the science of adhesive dentistry has progressed, so has the ability of dentists to perform similar dental procedures using fewer steps.

When doing our literature review for this study, no other studies were identified on Pub-Med that had tested a self-etching sealant material in the past. Of course, when searching the key words “dental and sealant”, hundreds of studies, position papers and conference papers were found. Included in this large body of research and information is a revealing a story of improvements in sealant technology that extols the benefits of sealants when used on teeth at high-risk for caries.

Interpretation of Results

Our study found that there was a significant difference when comparing all of the teeth in contaminated groups and non-contaminated groups. What our data revealed was that there was no significant difference when focusing on each individual study group. The significant difference between contaminated teeth and non-contaminated teeth only was found when we collapsed the data. This was due to the high variability found within each of the groups. This raised the power and because of this we could not detect a significant difference. After collapsing the data, we increased the ability to detect a difference when comparing a larger sample size and addressing the collapsed groups.
A reason that the p-values in this study were so close to the significance level could have been attributed to the technique we utilized for this experiment. The saliva we used could have had a lesser concentration of proteins and mucins than that used in other studies. The enamel was then re-desiccated to the point where a dry chalky surface was attempted to be regained. No sign of salivary moisture was visibly left on the surface of the enamel or in the pits and fissures on studied contaminated teeth. Other studies, when contaminating enamel with saliva, will leave a small amount of moisture in the pits and fissures prior to placing bonding agent or just plain sealant. Because of the hydrophobic character of composite based products, this in itself could produce differing results.

Other findings that could have led to p-values that were close to the .05 level include a small sample size and a difficult time in measuring the actual microleakage distance on teeth that had a bonding agent used on them. Microleakage distance was difficult to measure due to the lack of a definite starting point on the occlusal surface. On some samples, a thin layer of sealant or bonding agent was found to have spread over the cuspal inclines. This was most noticeable in the groups having bonding agent placed on them. When the bonding agent had been “thinned out” by a stream of air from the triple syringe, it pushed the bonding agent into the pits and fissures while also spreading the bonding agent material to all surfaces of the tooth. This caused ambiguous measurements for some of our samples. Two individual data collectors were blinded to the study groups and were independent of one another. If more than a 10% discrepancy occurred, the microleakage distance was re-measured with both parties present and attempted to
discover the cause of the discrepancy. The tooth in question then had its microleakage distance remeasured after both parties concurred on an accepted measurement.

The *Enamel Loc®* product did not perform well in this study. Group 5 (uncontaminated *Enamel Loc®* teeth) and Group 6 (contaminated *Enamel Loc®* teeth) were found to have significantly greater microleakage than any of the other groups. Because so many of the *Enamel Loc®* sealants in both groups had been lost during the thermal cycling or cutting process, the distance of microleakage used was estimated by an assumption on what length of enamel the lost *Enamel Loc®* sealant would have covered.

**Improvements in Future Studies**

Future studies using similar microleakage measuring techniques should add a step in the preparation of the tooth prior to soaking it in silver nitrate. After subject teeth have gone through the thermocycling process, an explorer and a hard bristled tooth brush should be used to remove any “flash” present prior to immersing all samples into the 50% silver nitrate solution. This is because a layer of silver nitrate below the intermediary bonding layer does not necessarily indicate sealant failure. Instead, some bonding agent could have broken away from the enamel on the smooth enamel cuspal inclines away from the pits and fissures. By removing flash, future studies would be more representative of what actually occurs intraorally.

**Comparison with Other Studies**

Park and Lee’s study evaluated salivary contamination and found that using self-etching primers recovered bond strengths comparable to the total etch technique after
dentin had been contaminated with saliva. [67]. Our findings when comparing groups (3) and (4) would support their study. Yazici et al. found that contamination of enamel before and after adhesive placement did not worsen the micro-leakage of the total etch and rinse technique when used with Single Bond or the one-step self-etching adhesive [68]. This again is supported by our study in that no statistical difference was found when comparing contaminated to uncontaminated sub-groups.

Silverstone et al. found that when exposed to saliva for a second or more, etched enamel becomes coated with a tenacious surface coating that cannot be removed by simple washing [9]. Though this may occur, this study disagrees with the finding that all forms of salivary contamination significantly lessen bonding ability.

Under conditions where there is obvious visible salivary contamination on a tooth, Gomes-Silva et al. found there to be a benefit when using an intermediate bonding agent layer below the sealant [69]. Our method of air drying in an attempt to regain a desiccated tooth surface may have contributed to our study’s findings being contrary to their study.

The Role of Viscosity

Bonding agents are less viscous and therefore can have an easier time flowing into the pits and fissures when placed on the occlusal surfaces of teeth when compared to the sealant material that is placed afterwards. The bonding agent, a non-viscous resin, flows into the depths of pits and fissures left behind on an etched tooth. When a non-viscous resin is cured, it allows resin-tags to mechanically lock into the enamel. The surface area contact combined with the cured resin tags in the enamel allows for the greatest retention of the dental material to the tooth structure. Therefore, a stronger bond
may occur when a bonding agent is used prior to sealant placement if the sealant is highly viscous. Our research indirectly may support this since the viscosity of the Enamel Loc® was greater than that of Ultraseal®.

Clinical Relevance

In situations where a child’s patience is just about to disappear and a tooth has already been etched but contaminated with saliva, this study reveals some benefit. Redesiccating a tooth with blasts of air after contamination is beneficial and should be done prior to sealant placement. Because of the difficulty of re-etching a tooth in a child who has already been upset due to visual stimuli or sour flavors, the simple attempt to regain a dry enamel surface may allow for a tooth to extol benefit from a sealant when placed under these conditions.

Newer products are necessary for the advancement of dental material science. Conceptually, the use of a self-etching sealant is one with obvious benefit. Our study revealed that improvement is needed for Enamel Loc® to compare favorably with traditional sealant methods. There was a significantly greater level of failure of the Enamel Loc® self-etching sealant material when compared to all other groups in this study.
CONCLUSIONS

Within the limitations of this study, we conclude that:

1. The self-etching sealant, *Enamel Loc®*, did not effectively seal the enamel and allowed for significant microleakage that would cause ultimate failure.

2. When using the total etch technique of the enamel and *Ultraseal®* provided a significantly better seal (less microleakage) than the *Enamel Loc®* sealant.

3. Using an intermediary bonding agent and *Ultraseal®* sealant provided a significantly better seal (less microleakage) than the *Enamel Loc®* sealant.
LITERATURE CITED


55. IADR Abstract to be listed

56. MSDS PrimaDry, Drying and Priming Agents, Ultradent Products, Inc.


60. Ultradent Products, Inc. description of product and procedure instructions via homepage of Ultradent Corporation.


