

## SEALANT BOND STRENGTHS AND ETCHING PATTERN ON ENAMEL DEFECTS

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إن المينا المعيبة يمكن أن تستفيد من المادة السادة اللاصقة. والهدف من هذه الدراسة هو تحديد قوة ارتباط المادة السادة اللاصقة بالمينا المعيبة ومقارنتها بالمينا السليمة وتقييم شكل التخريش على كلاهما. وقد استعمل في هذه الدراسة (36) رحي دائمة مقطوعة. عشرة أرحاء ذات سطوح مينائية طبيعية وعشرة أرحاء ذات سطوح مينائية معيبة لقياس قوة الارتباط باستخدام جهاز الانسترون. وكذلك استعمل عشرة أرحاء، نصف سطحها يحتوي على مينا سليمة والنصف الآخر يحتوي على مينا معيبة لدراسة شكل التخريش باستخدام المجهر الإلكتروني. وكذلك استعمل ستة أسنان منها ثلاثة ذات مينا معيبة وثلاثة ذات مينا سليمة لفحص مدى انطباق المادة السادة اللاصقة لسطح المينا الناعمة مستعملين المجهر. وقد وجد أن ارتباط المادة السادة اللاصقة بالمينا السليمة ( $16.90 \pm 8.08$  م ب أ) وهي أكبر بشكل واضح مما هو عليه بالمينا المعيبة ( $9.06 \pm 5.39$  م ب أ)، (ت = 2.55، P ≥ 0.02) وقد أظهر فحص المينا السليمة والمخرشة الشكل 2 للتخريش. في حين على العكس أظهر الفحص تخريش غير واضح للمينا المعيبة بالإضافة لذلك أظهر الفحص بالمجهر الإلكتروني تماس شديد للمادة السادة اللاصقة بسطح المينا المخرشة. نتائج هذه الدراسة تبين أن المينا المعيبة لا تتخرش بشكل جيد كما هو الحال في المينا السليمة وهذا ما يشرح سبب انخفاض درجة الارتباط مع المينا المعيبة.

Smooth surface enamel defects could benefit from sealants. The objectives of this study were to determine bond strength of a sealant on defective enamel compared to normal enamel and to evaluate the etch patterns on both. Thirty-six extracted permanent molars were used in this study. Ten molars with normal enamel surfaces and ten molars with defective enamel surfaces were used to measure bond strengths using an Instron Universal testing facility. Ten molars, half with normal and half with defective enamel were used to evaluate etching patterns using scanning electron microscopy (SEM). Six teeth, three with normal and three with defective enamel, were used to examine application and adaptation of sealant to smooth surface enamel using a dissection microscope. Bonding of sealant to normal enamel ( $16.90 \pm 8.08$  MPa) was significantly greater than that to defective enamel ( $9.06 \pm 5.39$  MPa), ( $t = 2.55$ ,  $P \geq 0.02$ ). SEM examination of etched normal enamel showed mostly type 2 etching patterns. In contrast, etched defective enamel showed vague resemblance to etched normal enamel. In addition, SEM examination showed close contact of sealant to etched enamel surface. The results of this study suggest that defective enamel does not etch as well as normal enamel which may explain the reduced bonding.

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### Introduction

Sealants are recognized by many researchers and clinicians as being one of a group of effective preventive measures. Sealants have been used in occlusal pits and fissures of primary and permanent teeth,<sup>1,2</sup> as well as occlusal sealant-composite restorations,<sup>3</sup> and occlusal amalgam-sealant restorations.<sup>4</sup> Some investigators used sealants over carious tooth structure and suggested a complete

cessation of the carious process.<sup>5,6</sup> Long-term clinical studies reported the effectiveness of fissure sealant.<sup>7,8</sup> It is believed that the bonding between sealant and enamel is principally mechanical.<sup>9</sup> While sealant application technique is rather simple, it should be followed precisely.<sup>10,11</sup>

Smooth surface enamel defects resulting from some kind of decalcification or hypoplasia would appear to be candidates for the use of sealant as a restorative material to prevent further loss of tooth structure. Sealants have generally not been used on smooth surfaces. However, there is no physical reason not to use them for certain smooth surface applications. Areas of severe abrasion, however, would not be indicated for this material and conventional restorations would be better suited. The objectives of this study were to determine tensile bond strength of a sealant on enamel defects compared to normal enamel and to evaluate the etch patterns of defective relative to normal enamel.

### Materials and Methods

Thirty-six extracted caries-free permanent molars with normal and defective enamel preserved in 0.1 thymol solution were used in this study. The defective enamel used in this study included teeth with enamel hypoplasia exhibiting mild to moderate small pits that cover much of the buccal surfaces of the teeth [Fig. 1]. Teeth were divided into four groups. Groups I and II (10 teeth each) with normal and defective enamel surfaces were used to measure strength of bonding of sealants to enamel. Group III (10 teeth) half with normal and half with defective enamel were used to examine and compare etching patterns. Group IV (6 teeth) half with normal and half with defective enamel were used to examine application and adaptation of sealant to smooth surface enamel.

The buccal surface of each tooth was polished with non-fluoride prophylaxis paste for 20 seconds followed by thorough rinsing and drying. To measure tensile bond strengths (Groups I & II), teeth were embedded in an epoxy resin. A test procedure similar to the one developed by Kemper and Kilian<sup>12</sup> was used to determine tensile bond strength except that the buccal surfaces were not rendered flat to maintain hypoplasia. Sealant\* was applied according to the manufacturer's instructions. The enamel was etched for 60 seconds using

ESPE etching gel. The etching gel was then removed with an oil-free air/ water spray for 60 seconds and surface was dried thoroughly for 30 seconds. A layer of sealant was applied and cured for 10 seconds. Nylon cylinders were used as a matrix for composite resin\*\*. The cross sectional surface area of the nylon cylinders was the same in both normal and defective enamel and calculated as an area of circle. It should be noted that the buccal surface of molar teeth is not completely flat. However, the surface area calculated was small in relation to the whole buccal surface of molar teeth. It also, should be noted that defective enamel is irregular and could create more surface area and resistant shear stresses. Composite resin was applied according to the manufacturer's instructions. The teeth were stored in isotonic saline at 37°C for 24 hours prior to measurement of tensile bond strength. An Instron\*\*\* Universal testing machine equipped with 1000 lb load cell was used in a tensile mode with a crosshead speed 2.54 mm/ minute to cause failure of the bond strength. The failure mode was not the result of pure tensile stress due to curvature and irregularity of surfaces of teeth. The data were analyzed for differences using a one-way analysis of variance.

In group III, enamel surfaces were studied before and after etching to determine etching patterns using a scanning electron microscope (AMR Model 1000 A). On the same tooth surface, one area was



Figure 1. Stereoscopic photomicrograph of an example of buccal surface with enamel hypoplasia.

\* VISIO-Seal, ESPE - Premier Sales Corp, PA, USA.

\*\* VISIO-Dispers, ESPE - Fabrik Pharmazentischer Co., West Germany.

\*\*\* Instron, Inc., Canton, Mass., USA.

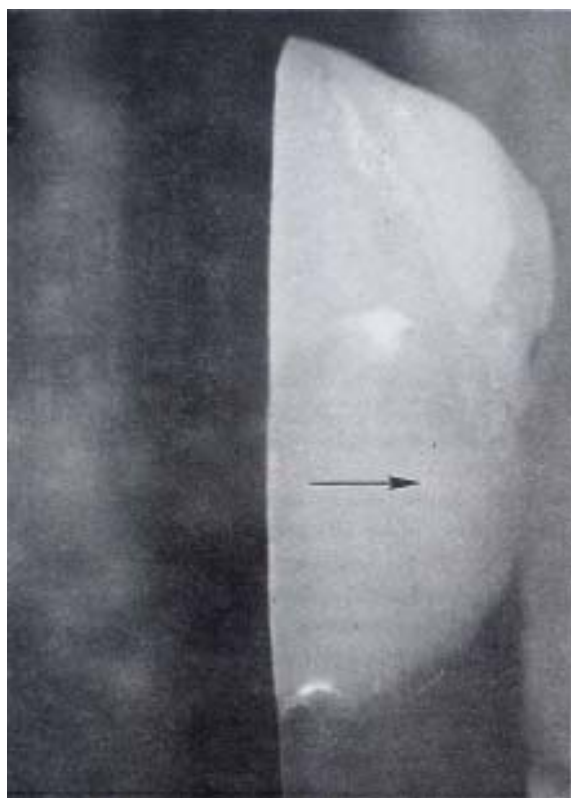


Figure 2. Stereoscopic photomicrograph of sealant (arrow) after application to the facial surface of a sectioned tooth.



Figure 3. Stereoscopic photomicrograph of a sectioned tooth showing sealant (arrow) on the enamel surface.

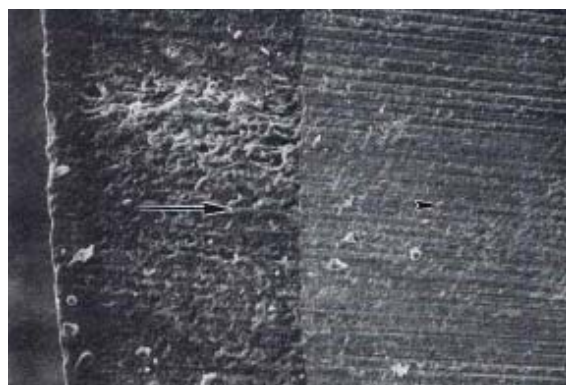


Figure 4. SEM photomicrograph of enamel (arrow) - sealant (arrowhead) interface. (x120)

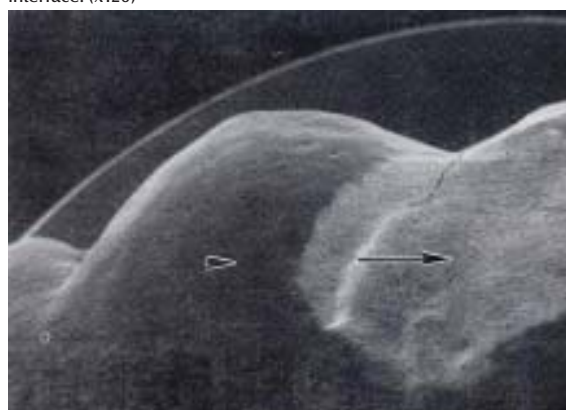


Figure 5. SEM photomicrograph of normal enamel with (arrow) and without (arrowhead) etching. Note the perikymata patterns (asterisk). (x 19)

etched and compared to an adjacent unetched area [Fig. 5]. In group IV, normal and defective enamel surfaces were examined following sealant application and were photographed using a dissection microscope.

### Results

Stereoscopic examination (Group IV) of sealant applied to normal smooth surface enamel is shown in Figs. 1 and 2. Sealant formed a semi-circular layer on the smooth buccal surface of both normal and defective enamel. It was evident that this layer is thick in the center and becomes thin as it approaches the periphery. Scanning electron microscopic examination showed close contact of sealant to etched enamel surface with no evidence of damage or separation [Fig. 3].

Normal smooth surface enamel (Group III) with and without etching is shown in Figure 5. Scanning

electron microscopic examination of etched normal smooth surface enamel showed the usual etching patterns reported by Silverstone et al.<sup>13</sup> However, type 2 etching pattern in which the periphery of prisms were preferentially etched was more common [Fig. 6]. Scanning electron microscopic examination of etched smooth surface enamel defects, depicted in Fig. 7, showed peculiar surface structure with vague resemblance to the usual etching patterns of normal healthy enamel. In few areas, the etching pattern of these defects tends to appear more like etched dentin surface with some surface debris.

Bond strengths (Groups I & II) data and statistical analysis are reported in Table 1. The normal bond strength to healthy etched enamel-sealant averaged  $16.90 \pm 8.08$  ( $x \pm SD$ ) MPa which is significantly greater than the bond strength of sealant to etched defective enamel  $9.06 \pm 5.39$  MPa, ( $t = 2.55$ ,  $P < 0.02$ ).

The coefficient of variation of normal healthy enamel was 47% while that for defective enamel was 59%.

Table 1. Bond strengths of sealant to normal and defective enamel (Tensile, MPa).

Group	Range	Mean	St. Dev.	St. Error	N
I normal enamel	7.65–28.33	16.90	8.08	2.55	10
II defective enamel	4.25–21.25	9.06	5.39	1.70	10

$t = 2.55$   $P < 0.02$

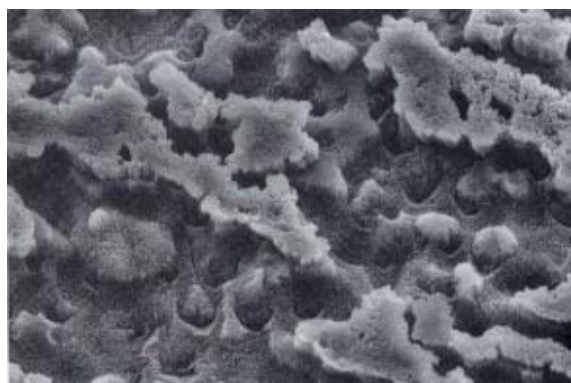


Figure 6. SEM photomicrograph of normal enamel that has been etched for 60 seconds. Note the periphery of prisms (arrow) etched preferentially (type 2). (x3900)



Figure 7. SEM photomicrograph of defective enamel that has been etched for 60 seconds. Note the variations of etching pattern. (x 600)

## Discussion

In this study 18 teeth with enamel hypoplasia were used. Boyde<sup>13</sup> found 6 premolars with enamel hypoplasia among approximately 1500 extracted human teeth.

The traditional method for restoring an erosion or decalcified areas is to prepare cavity and insert a restoration, e.g., foil, resins, amalgam.<sup>14</sup> The conservative approach can be used without the need for a cavity preparation by using glass ionomer and restorative resin materials.<sup>14</sup> Unfortunately, these techniques require either cavity preparation or time consuming procedures during placement. In this study, the efficacy of a shortened method to restore hypoplastic areas by using sealants was investigated. We propose using sealants to restore the whole defective areas on buccal surfaces in case of mild to moderate enamel hypoplasia. The physical limitations of sealant use on occlusal surfaces are not applicable for buccal surfaces.<sup>15,16</sup> Sealant will restore contour of the tooth in mild cases of enamel hypoplasia [Figs. 2 and 3], This method would be particularly beneficial for children and disabled patients. Advantages of sealant application is the simplicity of use and short treatment time required, which may improve the cost effectiveness of the treatment.

In this study, etching patterns of normal healthy enamel were similar to that reported by Silverstone et al.<sup>17</sup> However, they reported type 1 etching pattern as the most common while in our study type 2 was the most common. Etching pattern of defective enamel was vague and has no resemblance to that

of normal enamel. This could be due to difference in structure and composition of defective enamel. Poole et al<sup>18</sup> suggested that variation of etching patterns could be due to differences in orientation of crystallites relative to the direction of attack together with differences in chemical composition between central and peripheral parts of enamel prisms. This explanation may highlight the variation in enamel structure that can occur not only between normal and defective enamel but also from tooth to tooth, or site to site, on a single tooth surface. Also, variation of etching patterns for defective enamel could be a result of different etiology of the enamel defects in different teeth which is unknown.

Stereoscopic and SEM examinations depicted close contact between the resin and etched enamel. Such close contact may reduce microleakage and decrease the incidence of caries recurrence or further decalcification of enamel defects.

Although bond strength tests are usually performed on flat surfaces produced by grinding sound teeth on a disc, this was not possible in this study because it was important to simulate the clinical situation of mechanical bonding to normal and defective enamel surface. Grinding of tooth surface to create a flat surface will result in alteration of surface topography. It is known that the deep areas as well as surface parts of hypoplastic pits have peculiar surface morphology depending on the etiology of these defects.<sup>13</sup> Within these limitations, the results of bond strengths should be interpreted. The reported data should not be construed as pure tensile bond strengths since shear stresses participate in the failure mode. Neither should the surface areas tested be considered equal since they are larger in defective enamel. This situation of not grinding tooth surface to measure bond strength has been documented in another study on chemomechanical system of caries removal.<sup>19</sup> In that study, the authors did not grind surface after caries removal to avoid altering the dentin substrate.

The mean bond strength of sealant to normal healthy enamel in the present study was 16.90 MPa which is significantly greater than bond strength to defective enamel (9.06 MPa). The bond strength to normal enamel reported in our study is similar to or less than other reports.<sup>15,20,21</sup> The lower values obtained could be due to differences in specimens'

preparation, or due to variation in enamel structure of smooth surfaces in our study vs. occlusal enamel used by the other investigators.

Variation of bond strengths between normal and defective enamel could be due to difference in etching patterns. In some cases, it could be due to bonding to exposed dentin rather than bonding to full enamel layer. In addition, the variation of bond strength between normal and defective enamel could be due to the difference in the enamel surface area under the same cross section nylon cylinders, i.e. smooth normal enamel and irregular defective enamel. The coefficient of variation of bond strength data were very high - 47% and 59%. A contributing factor to this large variation is the inherently poor reproducibility of the test method, particularly surface preparation. Tests of adherence in ideal conditions usually have high variation since failure is often due to specimen imperfections of which the investigator is unaware. The high coefficient of variation suggests that the clinical classification of normal enamel does not predict in any specific manner that the sealant will adhere better than when the enamel is classed as defective.

The success of a pit and fissure sealant is related mainly to the ability of the dentist to apply the sealant under optimal conditions rather than to physical properties of the sealant itself.<sup>10,20</sup> In clinical situations some failures could occur due to loss of sealant. Thylstrup et al<sup>16</sup> have suggested that as most sealant failures occur within 6 months of their placement, checks for sealant retention should be made relatively soon afterwards. This regular check-up will help correction of failure cases.

## Conclusion

Sealant provides good bonding to normal enamel. The bond strength of sealant to normal enamel was significantly higher than that to defective enamel. The results suggest that sealant treatment of smooth surface enamel defects may be of benefit to prevent further enamel destruction. However, a certain percentage of cases would be expected to fail.

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