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Clinical Measurement of Palatal Tooth Wear Following Coating by a Resin Sealing System

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Clinical Relevance

This randomized clinical study presents the results of applying a resin-based dentin bonding agent to the palatal surfaces of worn and eroded anterior teeth. The application of the barrier protected the teeth for up to three months.

SUMMARY

This study investigated the hypothesis that coating eroded teeth with a resin-based dentin bonding agent gave protection from tooth wear. Nineteen adults with palatal tooth wear exposing dentin were recruited, following referral by their general dental practitioner. Alternate teeth were coated with the resin adhesive, while the uncoated teeth acted as controls. Accurate impressions of the eroded teeth, onto which were cemented machined stainless steel discs to act as reference areas, were scanned with a non-contacting laser profilometer at 3, 6, 12 and 24 months. The mean thickness of resin at baseline application was 0.15 mm and, from 0 to 6 months, the rate of wear of the control teeth was higher than those covered with Seal & Protect. There was a statistically significant difference in "wear" measured between resin covered and control teeth at three months. The Inter Class Correlations (repeated measurements) for the step heights obtained for the original and repeat impressions was excellent at 0.99. This study shows that coating eroded teeth with a resin-based adhesive has the potential to prevent further tooth wear.

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INTRODUCTION

Severe wear of teeth can lead to early tooth loss. Unlike dental caries, where the disease is generally

restricted to a few teeth, tooth wear normally involves multiple teeth. Restorations used to replace lost tissue are themselves damaging and, in most situations, have a limited longevity. Therefore, techniques that limit or prevent further damage may extend the longevity of the tooth without the need for expensive or problematic restorations.

The hypothesis that, coating exposed dentin with bonding agents to protect against tooth wear, has been previously investigated in laboratory studies and studies *in situ*.[1-2] The authors compared Seal & Protect (Dentsply Ltd, Weybridge, UK) with OptiBond Solo (Kerr UK, Peterborough, UK), both applied to sections of dentin that were then subjected to an erosion and abrasion laboratory model. This study showed that both materials significantly protected the dentin compared to control surfaces.[2] The hypothesis was further investigated in an *in situ* study comparing the same materials.[1] The results of this study indicated that Seal & Protect provided more protection than OptiBond Solo. The next stage in the development was to undertake a controlled clinical investigation of the hypothesis.

Previous techniques to measure tooth wear have included contacting and non-contacting profilometers.[3-7] Metal discs have been used as reference points to measure erosive tooth wear in previous studies and have the advantage of being resistant to acids. The current study investigated the hypothesis that coating eroded teeth with Seal & Protect protected them from tooth wear. An additional aim was to measure the rate of wear on the unprotected tooth surfaces using stainless steel discs as reference point.

METHODS AND MATERIALS

Adult subjects with upper anterior palatal tooth wear exposing dentin were recruited, following a referral by their general dental practitioners. The study was approved by Guy's Hospital Ethical Committee (LREC Study Number: 01/02/10). All subjects completed a questionnaire about their dietary habits. The Smith and Knight tooth wear index (TWI) was used to record the severity of the tooth wear using previously published guidelines.[8] This index grades tooth wear at four levels: no wear (0), enamel wear (1), minor dentin exposure (2), dentin exposed for more than 2/3 of the surface (3) and pulpal exposure (4). Calculation of the sample size was estimated based on the results of previous work both in the laboratory and in patient-based studies.[1-2,4]

Machined stainless steel discs (Exactoscale Ltd, Surrey, UK) 2 mm in diameter and 0.2 mm thick were cemented onto dentin on the palatal surfaces of all upper anterior teeth using previously described methods.[1] In brief, rubber dam isolation was used to cement the discs to the tooth surface, and the discs were covered with masking tape to prevent flow of dentin bond onto adjacent surfaces. An impression of the disc and tooth was then taken with specially constructed impression trays using a light bodied silicone material (President, Coltene, Switzerland). After the first impression, alternate teeth were randomly selected for coating with Seal & Protect (Dentsply), following the manufacturer's guidelines. Then, another silicone impression was taken with a new special tray. Patients were recalled at 3, 6, 9, 12 and 24 months and impressions taken using the same technique.

The impressions were stored dry and scanned within three days using a non-contacting laser profilometer (Keyence LC-2400 Series Laser displacement meter) following previously published protocols.[1-2,9] Data acquisition and analysis were performed with the UBSoft for Windows software package (UBM Messtechnik GmbH). All the teeth were scanned using the same operating conditions of the scanner. Three areas on the scanned image, which presented as a digitized three-dimensional grid of the impression surface of the tooth, were selected, and the vertical step height between the disc and the tooth surface was measured.[1] The same areas were selected for each successive impression of the same tooth sample.

Repeat impressions were taken from 10 patients at their first visit and measured using the profilometer to assess their reproducibility. The step heights from the disc to regions A, B and C were measured on the initial impression and compared to repeat impressions on a total of 21 sites. Reproducibility of the method was analyzed using intra-class correlation (ICC) for repeated measurements of continuous quantitative variables.

The data obtained from the study of the test (Seal & Protect) and control teeth (no covering) were described and analyzed using two outcome variables—the step height (mm) at each time interval and the change in step height from baseline at each time interval (mm), which was termed "wear." Both variables approximated a normal distribution, and nested analysis of variance (ANOVA) was used to assess differences in the data. The analysis replicated the design of the study: areas nested within teeth nested within subjects. Intermediate time intervals were not analyzed for differences due to missing data. Since the time of the final visit varied among subjects, this potentially confounding factor was included in the ANOVA model. "Step height" was analyzed, including the baseline step height as a further covariate in the model. The "wear" data were analyzed without the latter covariate. Further analysis was performed on "paired" data. This set only included step height and wear data related to the test and control where they were applied to similar teeth in the same subject measured at the same final time point. Analysis was also carried out on total data at three months.

Table 1: *The Number of Discs at Each Review Period*

		Review Period (months)					
		0 Months	**3 Months**	**6 Months**	**9 Months**	**12 Months**	**20 Months**
Unprotected Teeth	Teeth at Review	56	28	35	33	40	27
	# of teeth with lost discs	0	7	7	16	27	24
	% of teeth with discs lost	0%	25%	20%	48.5%	68%	88%
Protected Teeth	Teeth at Review	51	28	30	28	37	31
	# of teeth with lost discs	0	6	7	14	26	28
	% of teeth with discs lost	0%	21.4%	23.3%	50%	70.3%	90.3%

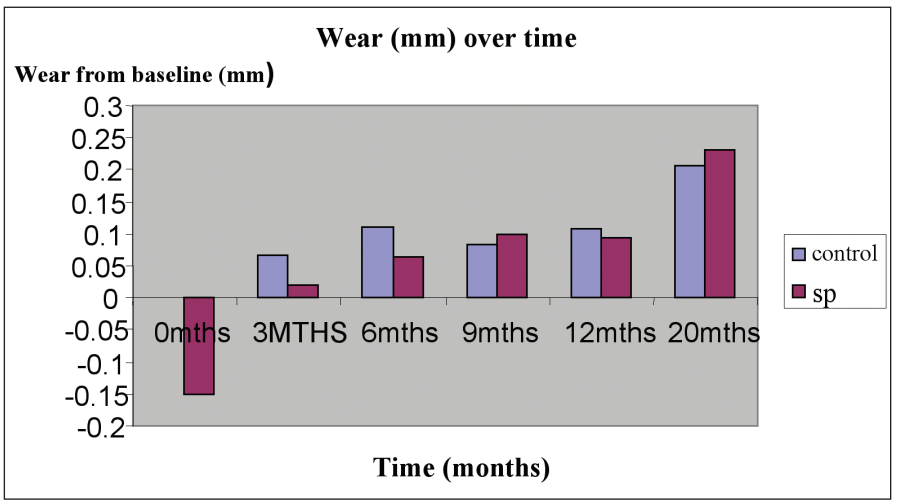

Figure 1. *Shows the mean step heights for Seal & Protect (SP) and control teeth at 0, 3, 6, 9, 12 and 20 months.*

RESULTS

A total of 19 patients, 11 male and 8 female, were recruited and had a median age of 33 (range 27 to 48 years of age). Three patients withdrew, one moved from the area, a second became unhappy with his or her appearance and requested restorations, while the third was referred for further treatment. Although the patients were booked at 3, 6, 9, 12 and 20 months, not all managed to achieve these review appointments at the required time. Nineteen patients began the study, 10 presented for review at 3 months, 12 at 6 months, 9 at 9 and 12 months and 5 at 20 months.

Three patients initially presented with gastric reflux and nine reported high consumption of carbonated drinks (a minimum of four cans per day). One patient drank more than two liters of orange juice per day, another drank four glasses of wine per day and had a habit of holding the drink in the palatal vault. One patient admitted to being bulimic. Two were bruxers (of which one also reported chewing Vitamin C tablets daily and consuming herbal teas). The likely cause of the tooth wear from two patients could not be determined.

From the 51 teeth covered with Seal & Protect, 13 had a TWI score of two (minimal dentin exposure), 32 had a TWI score of three (moderate dentin exposure) and six teeth had a TWI score of four (severe dentin exposure and near pulpal involvement). For the 56 control teeth, 22 teeth had a TWI of two, 31 had a TWI of three and three teeth had TWI of four. The total number of discs cemented onto the upper anterior teeth at the initial appointment was 107. The mean number of discs cemented to each subject was 5.6 (SD 1.8).

Table 1 shows the number of patients who were reviewed at each time period and the times of debonding, if relevant, are also shown. The data shown in Table 2 represents the percentage of teeth available for review, with those lost discs at the monthly intervals. Because some patients failed to keep their set review appointment, the number of discs reviewed altered at each period. The total number of impressions taken was 424, of which 14 impressions were unacceptable, 12 were from teeth coated with Seal & Protect and two were from the control teeth. The remaining impressions were scanned with the non-contacting profilometer, using the previously described technique.[1]

Figure 1 shows the mean difference in wear between those teeth protected with Seal & Protect and the control teeth over time. The mean thickness of Seal & Protect at baseline application was 0.15 mm and is represented by the negative value. From 0 to 6 months, the rate of wear of the control teeth was slightly higher than those covered with Seal & Protect. The mean values of wear from the final visit show slightly lower wear for the Seal & Protect coated teeth compared to the control teeth, but ANOVA showed there were no statistically significant differences between them for "step height" or "wear" measure-

Table 2: *Retention of Seal & Protect*

		Review Period (months)					
		0 Months	**3 Months**	**6 Months**	**9 Months**	**12 Months**	**20 Months**
Protected Teeth	# of teeth at review	51	28	30	28	37	31
	# of teeth that could not be scanned	7	6	9	16	26	29
	# of teeth showing any retention of S&P	44 (100%)	21 (95%)	14 (66.6%)	10 (83.3%)	5 (45%)	0 0
	# of teeth showing overall retention of S&P	44 (100%)	9 (40.1%)	6 (28.6%)	1 (8.3%)	0	0

ments. Results of further ANOVA analysis for differences in "step height" (with baseline value included as a covariate) between baseline and three months for the control and test teeth showed that there was no significant difference between step heights. However, there was a statistically significant difference in "wear" (baseline value not included) measured between Seal & Protect-covered and the control teeth at three months. The ICC for the step heights obtained for the original and repeat impressions was 0.99.

DISCUSSION

The overall statistical analysis shows that there was no statistical difference between "wear" or "step height" of the control and Seal & Protect-covered teeth at the final patient visit. There was also no significant difference in step height between baseline and three months for Seal & Protect and the control teeth, suggesting that the layer of resin (applied after baseline) had been removed. However, there was a significant difference in wear (change in step height without including the baseline value in the calculation), indicating that some protection had been provided by Seal & Protect, albeit for only up to three months.

The method used in this study utilized the UBM Profilometer to measure tooth wear, and it depended on retention of the metal discs for reproducible reference points. One of the biggest problems was disc retention failure, as, once the disc was lost, the tooth could no longer be used to compare wear with any successive impression. For this reason, nested analysis was undertaken to compare similar teeth in the same individual. At three months, there was slightly less disc loss in the Seal & Protect group, and it is possible that the presence of resin around the disc may have helped to retain the disc. During disc cementation, every effort was made to ensure that there was no contact between it and the opposing tooth. Another possibility might have been that the relatively small surface area of the disc was insufficient to maintain a long-term bond. Disc loss rose from about 50% loss at nine months to 90% by 20 months. Any future work involving the use of discs may opt to use shorter time intervals, as disc retention is better in the early stages.

The average thickness of the Seal & Protect layer at the start was a mean 0.15 mm. Previous work using Seal & Protect to seal cervical cavities showed a comparable sealant thickness of 169.2 µm after five applications.[10] Only two applications were applied in this study, and the thicker application may have been due to operator differences. A thicker application layer may provide improved protection from tooth wear. By three months, the step height data were no longer negative, showing that the coating had been worn away. This was supported by the statistical analysis showing no significant difference between the baseline step height and that at three months for the test teeth. A clinical study on 24 patients showed that Seal & Protect placed on cervical dentin remained intact after 19 months.[10] The early loss of Seal & Protect in this study was probably the result of a combination of attrition, erosion and abrasion. Also, Seal & Protect is not a true dentin adhesive, having been formulated to treat dentinal sensitivity. Previous laboratory and *in situ* work by Azzopardi and others[1-2] showed that Seal & Protect could protect teeth against erosion and abrasion. Further work on a greater range of bonding resins may be useful to see if these are more resilient.

Previous work by Bartlett, Blunt and Smith[4] showed that patients with unexplained dental erosion had a median of 39.5 µm of wear over six months (6.58 µm/month) and that control groups (patients not exhibiting erosion) had a much lower rate of 3.7 µm at six months. Work by Mitchell and others[7] on a mapping technique to measure erosion on children's teeth showed comparable results of erosion of 50 µm at nine months (5.56 µm/month) on 25% of the teeth analyzed. The patients in this study showed a higher average wear rate at six months of 110 µm (18.3 µm/month) and, even with the protected teeth, the wear at six months was 65 µm (10.8 µm/month). Closer examination of the results obtained by Bartlett and others[4] shows that the range of wear at six months was between 17.6 µm and 108 µm in the erosion patients; therefore, the data from this study may be more comparable. The slight differences in wear may reflect a differing experimental design from the 1997 study that used a contacting laser profilometer. It is more likely

that the different wear rates in these studies are due to patient variation.

Most subjects had extensive dentin exposure on the palatal surfaces of their upper anterior teeth. The wear was sufficient to allow enough space to cement the metal discs and prevent them from immediately falling off from contact with the opposing incisors. The cause of tooth wear was difficult to assess. In nine subjects, a high intake of dietary acids was recorded, which may suggest that the major cause was extrinsic erosion. However, another three subjects reported gastric reflux, which probably resulted in intrinsic erosion. The impact of bruxism and abrasion was also recorded. Typically, tooth wear was multifactorial and had led to palatal dentin exposure.[11-12]

On the whole, impression-taking was accurate, with only 3% of the total (14 impressions) unreadable. This was primarily due to the use of special trays made for each patient, allowing the impressions to be taken accurately, and with good reproducibility. The additional cured silicone impression material, President, was used, and previous work using this material has favorably reported its dimensional accuracy.[13-15] The impression technique and scanning were accurate, which was reflected in a reproducibility that showed good agreement between original and repeat impressions (0.99). The setup for measuring the impressions was, however, time-consuming. For each tooth, a specially-made device was fitted to accurately relocate the impression to the profilometer stage.

CONCLUSIONS

This study observed that a resin-based coating may offer some protection from tooth wear when applied to the palatal surfaces of upper anterior teeth albeit only for three months. There is a potential therefore for this non-invasive technique to delay restorations and possibly prolong the longevity of teeth.

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