RESEARCH

Analysis of dental clinicians' ability to detect iatrogenic damage, and the possibility of using a low viscosity nano-filled resin to protect damaged surfaces

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Abstract

Objectives: The existing literature indicates that even with the utmost care, there is a high probability that iatrogenic damage will occur to adjacent teeth during routine Class II and crown preparations, making them three times more likely to be restored. This in vitro study investigated whether operator experience increases their ability to detect damage on approximal tooth surfaces. The possibility of treating iatrogenically damaged surfaces with a low-viscosity nano-filled adhesive resin was also examined. **Methods and Materials:** A total of 17 second year dental students and 10 experienced dentists examined 5 sets of typodont teeth in phantom heads. The first molars had Class II cavity preparations. Any iatrogenic damage of the adjacent teeth was recorded, and the detection and correct classification of damage were analyzed with regard to operator experience and tooth position. A total of 10 extracted natural teeth with varying types of iatrogenic damage were coated with a low-viscosity nano-filled resin (G Coat Plus) and the defects examined using SEM before and after treatment. **Results:** There was no difference between experienced dentists and second year students in their ability to detect the presence of damage ($P=0.710$). However, experienced dentists were significantly better at classifying the type of damage present ($P=0.008$). For upper molar preparations, tooth surface 25 distal was the easiest surface for both dentists and students to correctly classify in terms of defects ($P<0.0001$). SEM imaging revealed that the resin could uniformly coat shallow to moderate defects, and reduced surface roughness. **Clinical significance:** Both experienced dentists and students are able to detect the presence of iatrogenic damage in approximately 80% of instances. Experienced dentists are significantly better than students at correctly classifying the damage present. Once detected, the impact of iatrogenic damage could be reduced by applying a low viscosity resin.

Keywords: Detection, iatrogenic damage, prevention, Class II cavity preparation, coverage

Short title: detection and coverage of enamel surface damage

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Introduction

Iatrogenic damage occurs frequently in restorative dentistry, with a reported frequency of 64-100% for approximal surfaces adjacent to Class II cavity and full crown preparations. Iatrogenic damage can be scratches, grooves, indentations, or extensive damage, which is a combination of the three types. The consequences of iatrogenic damage to approximal enamel include a greater risk of caries initiation due to the changed topography, and the possibility of unnecessary restoration due to misinterpretation of defects as caries on bitewing radiographs.[1-4]

A further issue is that removal of the surface enamel layer leads to increased permeability of the enamel to acid,[5,6] a parameter which can be reduced by subsequent coating with an adhesive resin.[6] This raises the possibility of utilizing an adhesive resin or flowable composite resin to cover areas of iatrogenic damage to reduce the risk of caries development. The same concept could employ novel infiltrative resins, which can penetrate pores in the enamel and provide a physical barrier to acid diffusion.[7-10] Such infiltrants have been used for interproximal application.[11] Studies examining the effectiveness of infiltrant resins versus conventional adhesives (bonding resins) for protection against acid demineralization adjacent to orthodontic brackets have found that use of an adhesive in combination with the infiltrant, or adhesive alone were both more effective than infiltrant alone.[12, 13]

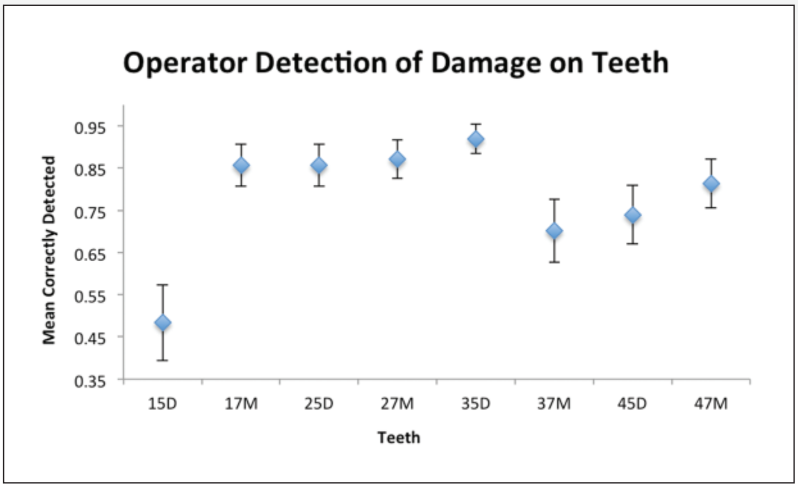

Figure 1: Detection of the presence/absence of damage on teeth for both Students and Experienced Dentists combined.

This laboratory study examined the ability of operators to detect and classify iatrogenic damage in typodent teeth. The possibility of coating iatrogenically damaged surfaces with a low-viscosity, nano-filled adhesive resin was also examined using scanning electron microscopic imaging of defects in natural teeth.

Methods and Materials

To assess detection of defects, 17 second year dental students and 10 experienced dentists examined 5 sets of typodont teeth in phantom heads, where the first molars had previously undergone Class II cavity preparation by experienced dentists. The second year dental students were aged from 18 to their mid-twenties, while the age of the experienced dentists was not recorded.

The 27 operators examined typodont teeth adjacent to the pre-prepared first molars for iatrogenic damage, employing a modified version of the classification used by Medeiros et al. in 2000.[14] Operators were requested to identify by visual or tactile examination whether iatrogenic damage was present on the premolar and second molar teeth, and as well as to classify any damage detected. The classification of defects included scratches, indentations, grooves, and extensive damage. As a gold standard, teeth were initially examined using 3X magnification and the type of damage characterized, then the teeth scanned utilizing a non-contact 3D scanner (ATOS Gesellschaft für Optische Messtechnik GR, GOM mbH, Braunschweig, Germany). The depths of damage were recorded for each tooth.

The classification used for damage was explained to all operators both visually and in print form, and sample images of different types of damage were provided to each operator. To ensure that the second-year dental students had sufficient understanding of iatrogenic damage, a lecture on

Table 1: Initial analysis of operator ability to correctly detect the presence/absence of damage and to classify the type of damage at varying depths

Depth of damage	Experienced Dentists (ED) % Damage Detected	% ED Correctly Classified	Student (S) % Damage Detected	% S Correctly Classified
0 to 119	68.8%	60.0%	68.8%	51.1%
120 to 210	90.0%	47.5%	86.8%	32.4%
211 to 310	90.0%	52.5%	94.1%	36.8%
311 to 540	100.0%	55.0%	100.0%	41.2%

Table 2: Operator detection of the presence/absence of damage

Operator	Mean	Std. Error	95% Confidence Interval	
			Lower	Upper
Student	0.798	0.019	0.758	0.833
Experienced Dentists	0.809	0.024	0.758	0.851

that topic was included as part of the overall training. Once all operators had completed their assessments, the teeth were removed from the models and inspected again using 3X magnification for any additional damage caused by operators during their tactile examination.

To explore the viability of protecting damaged surfaces by coating with a low-viscosity nano-filled resin, 20 natural teeth were mounted vertically in groups of two. During cavity preparation in the first tooth, the bur was allowed to 'slip' on occasion to damage the adjacent tooth, simulating a most common cause of iatrogenic damage from clinical practice. The damage on the adjacent teeth ranged from shallow scratches to deeper grooves and indentations.

The teeth were coated with a low-viscosity nano-filled resin (G Coat Plus™, GC Corporation, Tokyo, Japan) that was light cured according to the manufacturer's instructions. Teeth were sputter coated with gold to a thickness of 2-5 nm and viewed on an FEI Quanta 200 SEM under high vacuum conditions at 10 kV with an Everhart-Thornley detector, at a working distance of approximately 14 mm.

Statistical analysis

Operator ability to detect damage, and operator ability to correctly classify the type of damage were analyzed using SPSS version 21, applying a generalized linear mixed model with a dichotomous outcome variable. The most appropriate covariance was selected using the Corrected Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC).

Results

The examination of teeth at the end of the study did now reveal additional damage to the teeth from the explorers used to detect damage.

Detection of damage

In terms of operator ability to detect the presence or absence of damage, all operators could detect damage deeper than 310 µm, and >86% of operators detected damage >120 µm in depth (Table 1).

There were no significant differences between experienced

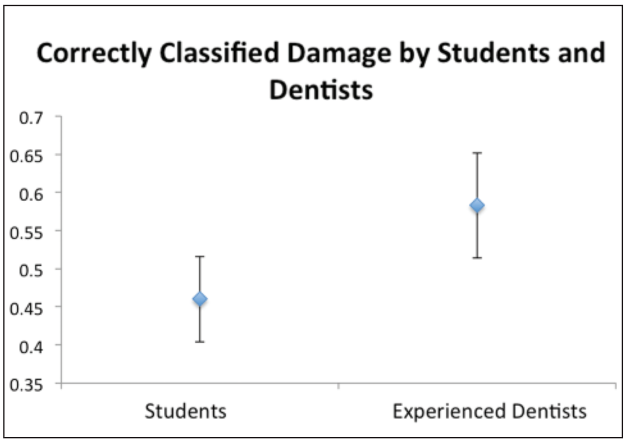

Figure 2: Classification of correct type of damage by Students and Experienced Dentists

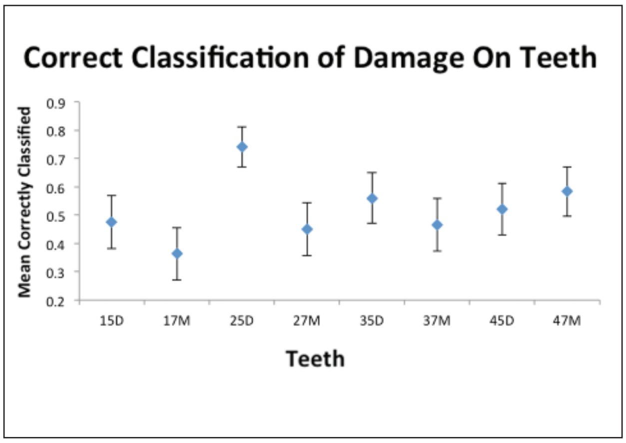

Figure 3: Estimated marginal means of classification of type of damage for Students and Experienced Dentists combined

Table 3: Classification of type of damage on different teeth

Tooth	Mean	Std. Error	95% Confidence Interval	
			Lower	Upper
15D	0.475	0.047	0.384	0.568
17M	0.363	0.045	0.279	0.456
25D	0.741	0.040	0.656	0.812
27M	0.450	0.047	0.360	0.543
35D	0.560	0.047	0.467	0.649
37M	0.466	0.047	0.375	0.559
45D	0.521	0.047	0.428	0.612
47M	0.583	0.046	0.490	0.670

dentists and students in their ability to detect the presence of damage (P=0.719). Both students and dentists detected around 80% of the areas of damage (estimated marginal means 0.798 (confidence interval 0.758-0.833), and 0.809 (CI 0.745-0.851, respectively), as summarized in Table 2.

There was a statistically significant difference between performance according to the site of the damage (P<0.0001), with the 15 distal surface being the most difficult tooth for all operators to score correctly, as shown in Figure 1. There was also a significant difference in operator detection of damage between the various models containing the teeth (P<0.0001), with model 1 being more difficult than models 2, 3 and 4 for operators to detect damage on. The interaction between operator and model (P<0.0001) was also significant, indicating different proportions of experienced dentists and students detected damage on different models with changing levels of accuracy.

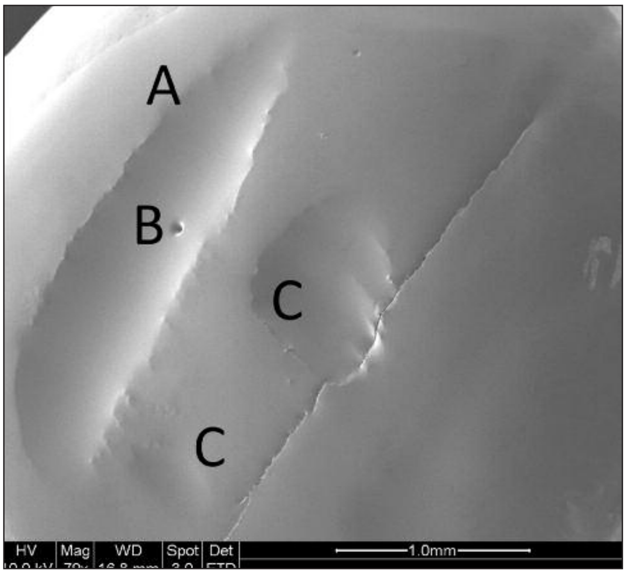

Figure 4: SEM images of damage of moderate depth following nano-filled adhesive resin coverage, where A and C represent a groove and indentations respectively, and B shows a porosity present within the resin.

Classification of damage

In terms of correct classification of type of damage, the performance of experienced dentists was significantly better than that of students (mean 0.460 (CI 0.406-0.526) versus 0.583 (0.511-0.652), respectively) (P=0.008), as shown in Figure 2.

There were significant differences in classification of damage according to site for both groups of operators (P<0.0001), as shown in Table 3 and Figure 3. Tooth surface 25 distal was the easiest surface for all operators to classify correctly (mean 0.741, CI 0.656-0.812), with 74% of operators correctly classifying damage on this surface. It was more difficult for operators to classify damage on the 17 mesial than on 25 distal or 47 mesial.

There was a difference between the models used (P<0.0001), as shown in Table 4, with model 4 being easier for operators to classify damage on than models 1 and 5.

Table 4: Classification of damage on different models

Sets of Models	Mean	Std. Error	95% Confidence Interval	
			Lower	Upper
1	0.437	0.039	0.362	0.516
2	0.578	0.040	0.498	0.653
3	0.564	0.040	0.484	0.640
4	0.631	0.038	0.553	0.702
5	0.399	0.039	0.326	0.477

Attempted repair iatrogenic damage by a low viscosity resin

SEM examination showed that application of resin gave adequate coverage of scratches to the enamel. The nano-filled resin covered deeper grooves and indentations, but these remained as undulations in the surface. The resin could not adequately cover areas of deep damage. A small number of porosities were noted within the resin that were attributed to incorporation of air during application rather than defects present on the tooth surface.

Discussion

The results of this study show that once properly trained, dental students can perform equally well as experienced dentists at detecting when damage has occurred to approximal surfaces adjacent to cavity preparations. There was however an important difference between operators, with experienced dentists significantly better than students in correctly classifying the type of damage. This latter difference is expected because of the clinical experience of the dentists with the use of explorers, while the second year students have yet to begin clinical practice.

Tooth surface 15 distal was the most difficult tooth for all operators to detect the presence or absence of damage on. In 4 of the 5 models used, the surface had no damage, while on the remaining model the damage was a scratch. This may indicate the challenge in exploring this surface for a right handed operator. Conversely, tooth surface 25 distal was the easiest tooth to classify. This surface is easier to see and to explore with an instrument for a right handed operator.

Applying the nano-filled resin could uniformly coat and repair minimal defects such as scratches, but a higher viscosity material such as a flowable composite resin would be needed for moderate defects such as grooves and indentations. When using a resin, care must be taken to prevent trapping air bubbles as it is applied into the defect. The authors also considered the possibility of the porosities also being caused by the high vacuum required for SEM imaging, since this was undertaken within 30 minutes of applying the resin onto the teeth. Evaporation of volatile constituents remaining within the resin could lead to bubble formation, most commonly by heterogeneous nucleation at a solid-liquid interface.[15] For clinical purposes, the resin used is sufficiently set within 20 seconds of light curing following application.[16] Ensaff et al. reported that the majority of polymerization shrinkage within dental composite resins occurs within 300 seconds.[17] Thus, it was not considered likely that the high vacuum conditions of the SEM caused the defects in the resin.

In conclusion, the study found that both experienced dentists and students are able to detect the presence of iatrogenic damage in around 80% of cases. This means that assessing the adjacent teeth for damage should be a step during the preparation of Class II cavities and full crown preparations. When damage is found, a suitable adhesive material can be applied to the damaged surface, with a nano-filled low viscosity resin for shallow damage such as scratches, and flowable composite resin for more extensive damage. This can be done before the tooth from the original operative procedure is restored, when access to adjacent surfaces is excellent.

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