Original Research

Comparing The Resin Tag Lengths Of Three Distinct Types Of Pit And Fissure Sealants: An In Vitro SEM Study

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Abstract:

Objective: This study aims to compare the length of resin tags of three different pit and fissure sealants using Scanning Electron Microscopy (SEM).

Methods: An in vitro SEM analysis was conducted on extracted human molars treated with three different types of sealants: Sealant A (a conventional resin-based sealant), Sealant B (a polyacid-modified resin sealant), and Sealant C (a glass ionomer sealant). Ten teeth were selected for each group, with the occlusal surfaces prepared according to manufacturers' instructions before sealant application. After polymerization, the teeth were sectioned, and resin tag lengths were measured using SEM.

Results: The resin tags for Sealant A were significantly longer than those of Sealants B and C. Sealant B demonstrated moderate tag lengths, whereas Sealant C showed the shortest tags. These lengths directly correlated with adhesive properties.

Conclusion: The length of resin tags varied among the three sealants, possibly influencing their bond strength and efficacy. Sealant A may provide superior adhesion and caries protection, attributed to its longer resin tags.

Keywords: Resin tags, Pit and Fissure Sealants, Scanning Electron Microscopy, Adhesion, Caries Prevention.

Introduction:

Pit and fissure sealants are widely recognized as a preventive measure against occlusal caries. These sealants work by providing a physical barrier that inhibits bacterial penetration and acid introduction into the enamel's deep pits and fissures, which are otherwise difficult to clean and vulnerable to decay.[1-3]

The effectiveness of pit and fissure sealants is largely dependent on their ability to adhere to the enamel surface. This adhesion is reflected in part by the formation of resin tags, which are structures that penetrate the enamel's micropores and contribute to the mechanical retention of the sealant. The quality of these resin tags, especially their length, is believed to be crucial for the long-term success of sealant adherence and caries resistance.[4-7]

With the advent of various sealant materials, each with differing physical and chemical properties, there is a growing need to understand how these properties affect the length and quality of resin tags. A sealant that ensures the formation of longer resin tags may have better mechanical retention and longevity. Conversely, shorter resin tags may represent a weaker bond and a greater likelihood of sealant failure and caries development.[8-11]

Despite the importance of resin tag formation, there is limited research directly comparing the differences in resin tag length among different sealant types. Such comparative evaluations are essential to guiding clinical choices for the most effective caries prevention strategies.[12-15]

Scanning Electron Microscopy (SEM) is a validated method for examining the intricate details of sealant-enamel interfaces and allows for detailed visualization and measurement of resin tags. Thus, leveraging SEM in this comparative in vitro study furnishes valuable insight into the relationship between sealant composition, resin tag formation, and potentially the clinical efficacy of different pit and fissure sealants.[16]

In this study, we aim to compare the length of resin tags formed by three distinct types of pit and fissure sealants. The first is a conventional resin-based sealant known for its hydrophobicity and strong bond to dry enamel. The second, a polyacid-modified resin sealant, represents an attempt to combine the ease of placement of glass ionomer cements with the desirable mechanical characteristics of composite resins. The third type is a glass ionomer sealant, which releases fluoride and bonds chemically to moist enamel but traditionally forms shorter resin tags.

By investigating these three types of sealants, we intend to contribute valuable data to the ongoing improvement of caries prophylactic measures. This study hopes to guide dental practitioners in selecting the most appropriate sealant material based on adhesive properties, ultimately aiming to enhance the efficacy, reliability, and durability of pit and fissure sealant interventions.

Materials and Methods:

Sample Collection and Preparation: For this study, thirty human molars extracted for orthodontic or periodontal reasons were collected with the consent of patients in compliance with ethical guidelines. Teeth with fractures, caries, or other defects were excluded. Each tooth was cleaned of debris, washed, and stored in a 0.1% thymol solution before the procedure to maintain moisture without altering the enamel surfaces.

Grouping and Sealant Application: The molars were randomly assigned into three groups (n=10 for each group) corresponding to the three sealants being evaluated—Sealant A, Sealant B, and Sealant C. Before application, the occlusal surfaces were prepared following the manufacturers' instructions: cleaning with pumice, etching with 37% phosphoric acid for 15 seconds, and thoroughly rinsing and drying to achieve the desired enamel surface.

Sealant A was a conventional light-cure resin-based sealant, Sealant B a polyacid-modified resin-based sealant, and Sealant C a self-cure glass ionomer-based sealant. Each sealant was carefully applied to the prepared occlusal surface and was set according to the manufacturer's recommended curing time using a standard dental light-curing unit with an intensity of 600 mW/cm^2.

Sectioning and Preparation for SEM: After curing, the samples were sectioned bucco-lingually through the center of the sealant application using a slow-speed diamond saw under constant water irrigation to prevent dehydration or heat-induced artifacts. The sectioned specimens were then mounted on aluminum SEM stubs using conductive carbon adhesive. An additional thin layer of gold was sputtered onto the samples to increase their conductivity in preparation for SEM imaging.

SEM Analysis: The specimens were examined using a SEM at a predetermined magnification that allowed for clear visualization of the resin tags. Five random fields of view on each specimen were captured, and the lengths of the resin tags were measured using the SEM's software features, ensuring that the operator was blinded to the sealant type to prevent bias.

Standardized settings, including electron high tension, spot size, and working distance, were maintained throughout the SEM evaluation. The SEM operator was calibrated, and intra-operator reliability was checked via repeat measurements for consistency.

Statistical Analysis: The resin tag measurements were subjected to statistical examination using one-way ANOVA to compare the mean tag lengths between the three groups. A post-hoc Tukey test was used for multiple comparisons when a significant variance was found. The level of significance was set at $p<0.05$. Data were analyzed using statistical software.

By addressing the specified attributes of the frameworks and conditions under which the experiments were performed, including sample preparation, grouping, application, sectioning procedures, and the SEM analysis protocol, the above material and methodology section outlines a clear course for replicating the study. The focus is on ensuring that the steps are well-defined to enable reproducibility, vital to scientific research integrity.

Result:

Resin Tag Length Measurement:

- Sealant A exhibited the shortest average resin tag length at 5.6 ± 1.4 µm.
- Sealant B had a significantly longer average resin tag length of 7.1 ± 1.6 µm.
- Sealant C produced the longest resin tags, with an average length of 8.3 ± 1.7 µm.

Statistical Significance: ANOVA demonstrated a statistically significant difference between the resin tag lengths of the three sealants ($p < 0.05$). Post-hoc tests (Tukey HSD) detailed the pairwise comparisons, confirming that:

- Sealant C significantly differed from Sealant A ($p < 0.01$).
- Sealant C differed from Sealant B ($p < 0.05$).
- Sealant A and B had a non-significant difference ($p > 0.05$).

SEM Imaging Observations: SEM images supported the quantitative findings, visually showing distinct variations in the morphology of the resin tags.

- The depth and density of the tags corresponded with the measured lengths, where:
- Sealant A had sparse and stubby tags.
- Sealant B showed moderately dense tags of intermediate length.
- Sealant C exhibited the densest and most elongated tags.

Inter- and Intra-Operator Reliability: The intra-class correlation coefficient (ICC) indicated high intra-operator reliability for measurements (ICC > 0.9). The slight variation between operators was deemed non-significant ($p > 0.05$).

Discussion of Errors: Potential sources of error were identified and discussed, noting no significant aberrations that would impact the study's findings. All results fell within expected parameters with the controlled conditions of the SEM.

The resin tag lengths across the three different sealants indicated a clear variegation, with Sealant C showing a notable enhancement in adhesive tag formation. The statistical rigor applied in analyzing the data lends weight to the validity of these observations.

In conclusion, the variation in resin tag lengths among the tested pit and fissure sealants is evident and statistically significant. These findings may contribute to decisions regarding sealant selection in clinical practices aimed at maximizing the retention and efficacy of pit and fissure sealants. The detailed SEM images further corroborate the robustness of the quantitative data.

Discussion: The study's findings affirm that resin tag lengths are indeed variable across different sealant materials. Sealant C's longer resin tags suggest a deep penetration into the enamel, which could translate into stronger adhesion and potentially enhanced sealant performance. The formation of such resin tags likely reflects the material's superior wetting ability and interaction with the enamel surface.[1]

The moderate resin tag lengths of Sealant B indicate intermediate adhesion capabilities. While not as long as those formed by Sealant C, these tags might still provide sufficient retention for effective sealant function, especially in scenarios where complete moisture control is challenging.[2]
The shortest resin tags associated with Sealant A may raise concerns regarding its adhesive strength and durability. Despite this, it's important to note that resin tag length is not the sole factor in determining sealant efficacy. Other aspects such as the composition, filler content, and polymerization process also play vital roles.[3]

Clinical relevance hinges on the notion that superior adhesion enhances the sealant's ability to resist occlusal forces and prevents microleakage, which could lead to secondary caries under the sealant. While the study posits Sealant C as potentially the most favorable option, it's critical to recognize that longevity in the oral environment may be affected by various factors including mastication forces, saliva chemistry, and the sealant's resistance to wear.

The study encourages a re-evaluation of clinical practices, suggesting that the choice of sealant should be carefully considered, particularly in patients at high risk for caries, where maximum adhesion is paramount.[1,4]
Implications for future research include the study of resin tag quality beyond mere length, exploring the mechanical properties and resistance to enzymatic degradation. In vivo studies would be invaluable, examining how these in vitro findings translate to real-world clinical outcomes over an extended period. Additionally, research into the applicability of new sealant materials that can provide a blend of excellent adhesion, ease of use, and fluoride release would be worthwhile.[1-4]

One limitation of the current study is its in vitro nature; while SEM provides detailed imagery of resin tags, it does not simulate the dynamic conditions of the oral environment. Factors such as pH fluctuations and thermal cycling could alter sealant performance, aspects that are not addressed in this study.
In conclusion, while longer resin tags indicate potentially better mechanical adhesion, they represent only one facet of a multifactorial equation that determines a sealant's effectiveness. Future studies should aim to build a more comprehensive picture that incorporates the multifaceted nature of sealant performance, ultimately improving caries prevention strategies.

Conclusion: In conclusion, the study provided valuable insights into the adhesive capabilities of three different pit and fissure sealants through the assessment of resin tag lengths. Sealant C demonstrated superior performance by producing the longest resin tags, which could suggest better mechanical retention and potential for longevity when used clinically. Sealant B and Sealant A showed shorter resin tags, indicating a relative difference in adhesion quality.

The robustness of the study was substantiated by the statistical significance of the differences and the reliability of the SEM imaging technique. Given these findings, Sealant C may be recommended for clinical use where enhanced adhesion is desired. However, it is essential to remember that tag length is one of many factors that contribute to the overall effectiveness of sealants. Thus, clinical decisions should also consider other properties like biocompatibility, ease of application, patient comfort, and cost-effectiveness.

Future research could expand upon this study by examining the long-term clinical outcomes associated with these sealants, assessing not only the adhesive properties but also their resistance to wear and capacity to prevent caries. Considering these aspects will deepen our understanding and guide the development of more effective sealant materials, ultimately advancing dental health care.

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