COMPARATIVE ASSESSMENT OF RESINTAG AND SURFACE TENSION OF HYDROPHILIC PIT AND FISSURE SEALANTS REINFORCED WITH SILVER NANOPARTICLES WITH HYDROPHILIC AND CONVENTIONAL SEALANTS ON PERMANENT MOLARS – AN INVITRO STUDY

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Abstract:

Introduction: The failure of hydrophobic pit and fissure sealants are due to saliva contamination and poor mixture control. This disadvantage can be eliminated or reduced to a greater extent by hydrophilic materials. By incorporating silver nanoparticles by green synthesis to the hydrophilic sealants, it enhances its properties. This study aims to compare the resin tag length formed and surface tension of hydrophilic sealant, UltraSeal XT® hydro™ reinforced with silver nanoparticles with conventional hydrophobic sealant in vitro.

Materials and Methods: Green synthesis of silver nanoparticles was derived by using beetroot as a reducing agent. It was mixed with sealant in 1:10 ratio and applied to the teeth. Ultra seal and Clinpro sealants are also applied to the teeth. Resin tag length is assessed in Scanning electron Microscope and Surface tension is assessed using Goniometer.

Results: Results revealed that with regard to surface tension of the sealants, Reinforced Ultraseal had a statistically significant lower surface tension than Clinpro and UltraSeal. Post hoc tukey's revealed that reinforced UltraSeal had a statistically significant difference of 4.782 and 9.868 lesser surface tension than Clinpro and UltraSeal respectively.

With the resin tag formation, Reinforced Ultraseal had a statistically significant higher resin tag than Clinpro and UltraSeal.

Conclusion: Wettability of silver reinforced UltraSeal is better than the comparator and the resin tag length is more in silver reinforced UltraSeal, thus adding silver enhances the micromechanical retentive properties and wettability of the sealant.

Keywords: Hydrophilic sealants, Nanoparticles, Green synthesis, resintag, pit and fissure sealants.

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1. Introduction

Dental caries is one of the most chronic intraoral diseases, with major medical, social, and economic ramifications for both the individual patient and the general society, as it is depended on multiple factors such as presence of cariogenic microbial flora, amount of fermentable sugar present, host factors and also the associated environmental factors. [1]

The occlusal surfaces of posterior teeth are the most vulnerable to caries development due to pits and fissures with complex morphologies that provide the ideal environment for caries to thrive. [2] Pit and fissure sealants have consistently been suggested as a way to prevent pit and fissure caries in permanent molars. [3] [4] [5] [6]

Sealants mechanically seal off susceptible fissures and reduce plaque stagnation. The occlusal surfaces of molars can be protected from demineralization and caries formation by preventing the invasion of cariogenic bacteria and obtaining nutrients from fissures. [7] Pit and fissure sealants establish a micro mechanically bonded protective barrier in the pits and fissures of caries-prone teeth, preventing caries-producing bacteria from accessing their source of nutrients. [8] Despite the efficacy and caries-preventive effect of pit and fissure sealants have been thoroughly demonstrated in the literature, they are still regarded to be underutilised globally. [9] [10] [11] [12]

Sealants have been developed to treat active early fissure caries and even to arrest non cavitated fissure caries as the popularity of minimal intervention dentistry has grown. [13] Most of the commercially available resin-based pit and fissure sealants are hydrophobic material and majority of the failure of pit and fissure sealants are due to saliva contamination and poor mixture control. This disadvantage can be eliminated or reduced to a greater extent by hydrophilic materials.[9] The traditional sealants are hydrophobic, the unique moisture tolerant sealants are hydrophilic in nature. Hence, they are miscible with water and flow into moisture-containing etched enamel creating a strong bond for better retention[10] [11] [12] Hydrophilic sealants, which easily adhere to damp enamel surfaces, have just been introduced and offer a special advantage in paediatric dentistry, where patient compliance, isolation, and moisture management can be particularly difficult. [14]

However, numerous advancements have been made in restorative dental materials, the widely used dental resins including pit and fissure sealants remain bio inert with minimal interaction with biofilms in the oral cavity. This leads to the development of new materials which possess extra functional and therapeutic functions using nanotechnology. [15] The use of nanotechnology in dentistry has attracted much interest in recent years, with new ways for caries prevention and treatment, plaque-related biofilm control, and primary dental caries remineralization. [16] Silver nanoparticles have been shown to be effective antimicrobial components in prosthetic materials, adhesives, and implants, promoting capillary arrest, preventing biofilm formation, and inducing osteogenesis. [17] [18] [19] With all these advancement, silver nanoparticles extraction by green synthesis seems to be simple, rapid, non-toxic, dependable, and green approaches that can produce well-defined size and morphology under optimised conditions for translational research.

This study aims to compare the resin tag length formed and surface tension of hydrophilic sealant, UltraSeal XT® hydro™ reinforced with silver nanoparticles with conventional hydrophobic sealant in vitro.

2. Materials and Methods

An experimental in vitro study was carried out on a sample of 30 permanent molar teeth extracted for orthodontic or surgical reasons. The sample size was estimated based on the study done by Jayashri Prabakar et al [20] using G*Power 3.1.2 software with a power of 0.95 and $p \leq 0.05$ and sample size derived was 10 teeth per group and the total sample size will be 30.

Teeth with sound occlusal surfaces were included in the study, while teeth with developmental defects and caries were eliminated. Before the start of the study, ethical clearance was obtained from the institutional ethics committee, Saveetha University. All the molars were randomly allocated to three groups of 10 molars each using computer-generated randomization. Group I is a conventional Clinpro sealant, Group II will be hydrophilic Ultraseal XT hydro and Group III is Ultraseal XT hydro reinforced with silver nanoparticles.

Green synthesis of silver nanoparticles:

To remove any pollution, the beetroots were washed and cleaned with drinking water. The Beetroot was then chopped into little pieces and left to dry at room temperature. Using a grinder mixer, the dried beets were powdered. 20 grams of beetroot powder were mixed in 100 mL distilled water and left to boil for 5 minutes before being filtered.

0.0169gms 1 millimole of silver nitrate was added into a beaker. It was diluted with 50 ml of distilled water. The combination was then given 50 mL of filtered beetroot extract. Following that, the mixture was placed in an orbital shaker for 32 hours before being transferred to six centrifugation tubes. The tubes were placed in the centrifuge and centrifuged for 20 minutes at 10,000 rpm.

The supernatant liquid from each tube was discarded, and the leftover pellet solution that collected at the bottom of each tube was transferred to a single tube and stored in the refrigerator for later use. The pellet solution was spread out on a petri dish and dried for 8 hours at 100 degrees Celsius in a hot air oven. To obtain silver nanoparticles, the dried solution was scraped off the petri plate.

Incorporating silver nanoparticles into the sealant:

The silver nanoparticles were added to Ultraseal XT hydro sealant in a ratio of 1:10 by weight and mixed in an amalgamator for 10 minutes

Placement of sealant:

Acid etching of the selected teeth was carried out using 37% orthophosphoric acid for a duration of 30 seconds followed by rinsing with water and then dried using a three-way syringe to attain a white frosty appearance of enamel for Clinpro 3M ESPE sealant (group I). With UltraSeal XT Hydro (group II) and Ultraseal XT Hydro reinforced with silver nanoparticles (group III), the tooth should be dried gently and left moderately wet with a shiny semblance. The respective sealants were then applied to the teeth in each of the groups and cured for 30 seconds.

Resin Tag Length Assessment:

Procedure:

Thermocycling

Both the groups were then subjected to thermocycling at a temperature range of 5°C–55°C for 500 cycles, with a dwell time of 30s.

Tooth sectioning

All the molars were mounted on an acrylic block (Figure 1) and sectioned longitudinally in a mesiodistal direction through the centre of the sealant with a diamond wheel measuring 0.02 mm in thickness. (Figure 2) The Root portion of the teeth was then sectioned and removed.

Steps in Resintag length assessment by Scanning Electron Microscope (JSM IT - 300)

Polishing, decalcification, and drying of tooth specimens

The tooth sections were polished using a carbide stone. The polished sections were then decalcified using 37% phosphoric acid for 15 s to etch away any enamel mineral component not protected by sealants and then rinsed and stored in distilled water. The tooth sections were dried thoroughly under the heat lamp.

Mounting of tooth specimens

Tooth specimens were mounted on brass rings using a non-conductor tape made of carbon. This was then applied to the sections, in the areas that did not need scanning.

Gold sputtering

The mountings were then placed inside an ion‑sputtering device for 30 min using vacuum evaporation at 200–300Å.

Measurement of resin tag length

The gold‑sputtered sections were then placed inside the SEM of 20 kV capacity and photographs of the sections were obtained. The resin tag lengths were then measured. (Figure 3)The average of each photograph was calculated.

Figure 1: Tooth Sample Mounted

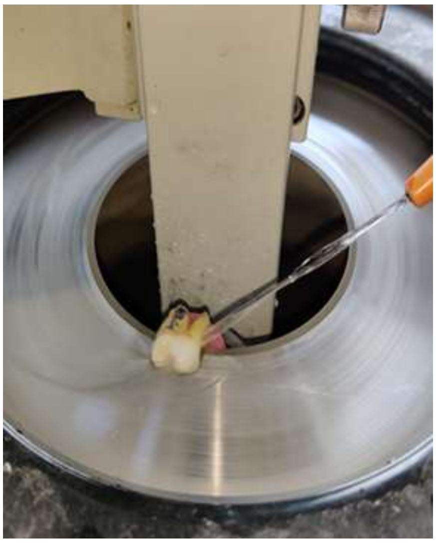

Figure 2: Buccolingual sectioning of tooth specimen

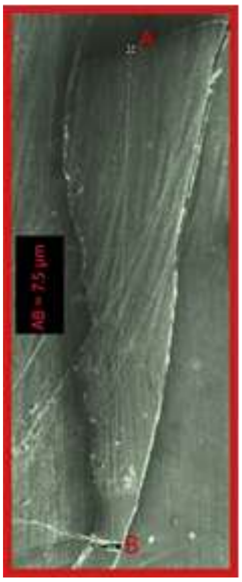

Figure 3: Resin Tag length of Reinforced Ultra seal XT

Figure 4: Contact Angle of Clinpro, Ultraseal XT and Reinforced Ultraseal XT

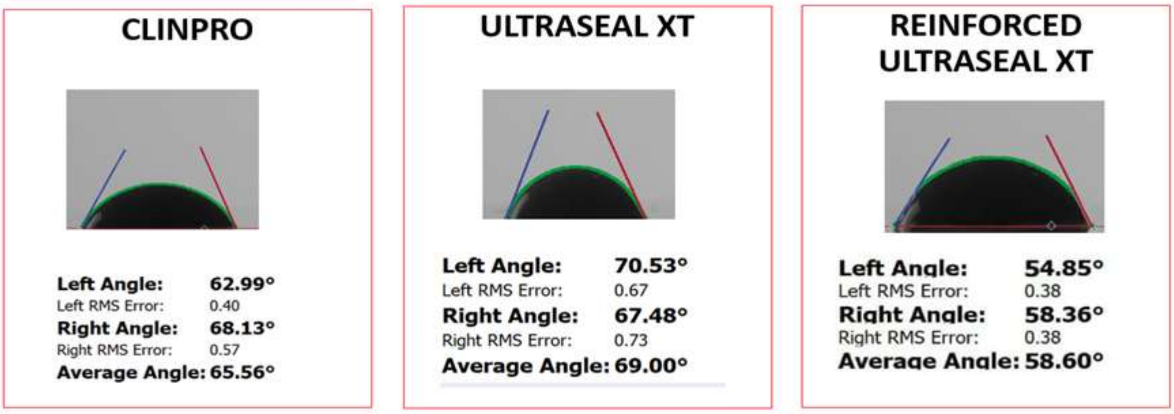

Figure 5: Ossila Goniometer

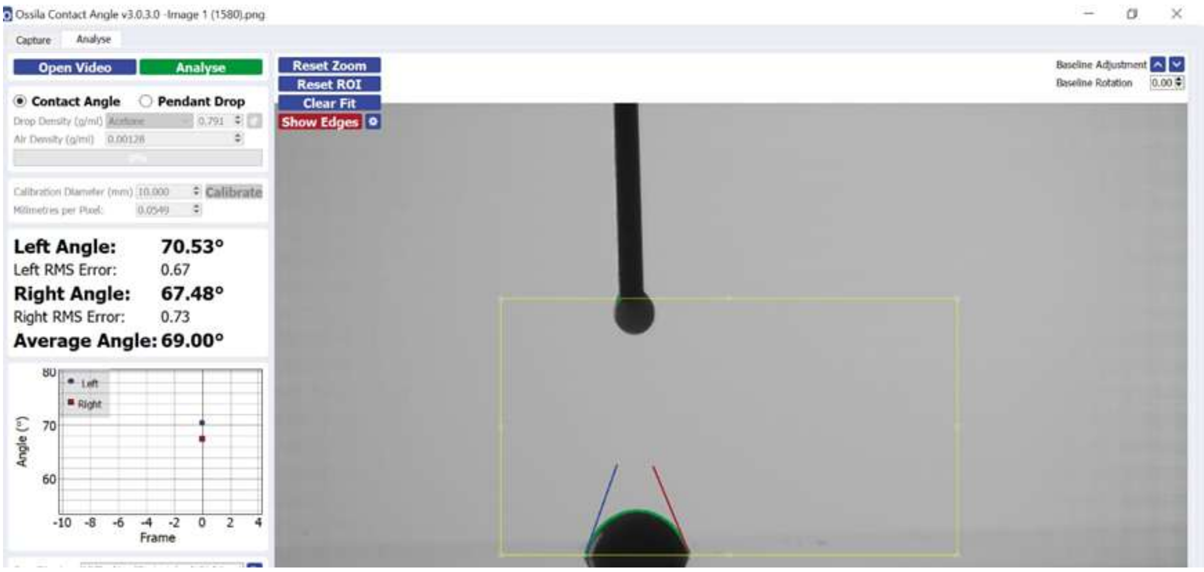

Figure 6: Contact Angle assessment in Goniometer

Measurement of Contact Angle:

Goniometer / Tensiometer is used to calculate the contact angle of the sealants to the surface, the lesser the contact angle - lesser the surface tension, which leads to more wettability of sealant.

Sealant tube is placed on the holder present in the goniometer, one drop of sealant material is made to fall on the glass slide, Goniometer captures and calculates the contact angle which is formed. Same procedure is repeated for all the three types sealants. (Figure 4,5,& 6)

Statistical Analysis:

For statistical analysis, SPSS software version 23.0 was used. One way ANOVA was used to compare the surface tension and resin tag between the three groups and for post hoc comparisons Tukey's test was used.

3. Results

Results revealed that with regard to surface tension of the sealants, Reinforced Ultraseal had a statistically significant lower surface tension than Clinpro and UltraSeal (table 1). Post hoc tukey's revealed that reinforced UltraSeal had a statistically significant difference of 4.782 and 9.868 lesser surface tension than Clinpro and UltraSeal respectively (table 2).

With the resin tag formation, Reinforced Ultraseal had a statistically significant higher resin tag than clinpro and ultraseal (table 3). Post hoc tukey's revealed that reinforced ultraseal had a statistically significant difference of 0.82 and 0.14 more resin tag formation than clinpro and ultraseal respectively (table 4).

Table1: Surface Tension - One-Way Anova Test

	N	Mean ± Std. Deviation	95% Confidence Interval for Mean		F value	P value
			Lower Bound	Upper Bound		
Clinpro	**10**	**64.17±2.20**	**61.44**	**66.91**	**21.604**	**0.000**
Ultraseal	**10**	**69.26±1.63**	**67.23**	**71.30**		
Reinforced UltraSeal	**10**	**59.39±1.71**	**57.27**	**61.52**		
Total	**30**	**64.27±4.51**	**61.78**	**66.78**		

Table 2: Multiple Comparisons – Tukey's Post Hoc

Groups (I)	Mean Difference (I-J)	Sig.	95% Confidence Interval		Groups (I)
			Lower Bound	Upper Bound	
Clinpro	**Ultraseal**	**-5.086***	**.003**	**-8.24**	**-1.93**

	Reinforced UltraSeal	**4.782***	**.004**	**1.63**	**7.93**
Ultraseal	**Clinpro**	**5.086***	**.003**	**1.93**	**8.24**
	Reinforced UltraSeal	**9.868***	**.000**	**6.72**	**13.02**
Reinforced UltraSeal	**Clinpro**	**-4.782***	**.004**	**-7.93**	**-1.63**
	Ultraseal	**-9.868***	**.000**	**-13.02**	**-6.72**

Table 3: Resin Tag - One-Way Anova Test

		Mean ± Std. Deviation	**95% Confidence Interval for Mean**		**F Value**	**P Value**
			Lower Bound	**Upper Bound**		
Clinpro	**10**	**5.86±0.46**	**4.81**	**6.89**	**2.957**	**0.086**
Ultraseal	**10**	**6.54±1.1**	**5.75**	**7.31**		

Reinforced UltraSeal	**10**	**6.68±0.4**	**5.86**	**7.50**		
Total	**30**	**6.36 ± 0.65**	**5.47**	**7.20**		

Table 4: Multiple Comparisons – Tukey's Post Hoc

(I) Groups		**Mean Difference (I-J)**	**Sig.**	**95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Clinpro	**Ultraseal**	**-0.68**	**0.08**	**-0.94**	**-0.42**
	Reinforced Ultraseal	**-0.82**	**0.1**	**-0.95**	**-0.69**
Ultraseal	**Clinpro**	**0.68**	**0.08**	**0.42**	**0.94**
	Reinforced Ultraseal	**-0.14**	**0.07**	**-0.2**	**-0.08**

Reinforced Ultraseal	**Clinpro**	**0.82**	**0.1**	**0.69**	**0.95**
	Ultraseal	**0.14**	**0.07**	**0.08**	**0.2**

4. Discussion:

For many years, the occlusal surface, particularly the pits and fissures of posterior teeth, has been known for its high caries susceptibility. [(21)] Because of the unique morphology of the pits and fissures, it is unquestionably more fragile. [(22)] Occlusal pits and fissures come in a variety of shapes, but they're usually narrow and tortuous, and they're thought to be a good place to keep bacterial and food remains. This is due to the fact that the morphology makes mechanical debridement impossible.[(23)]

The physical occlusion of pits and fissures is thought to be responsible for sealants' cariostatic characteristics.This stops new bacteria from colonising the pits and fissures, as well as the supply of fermentable carbohydrates to any bacteria that remain in the pits and fissures. [(24)(25)(26)(27)] A viscosity that allows penetration into deep and narrow cracks, enough working time, rapid cure, good and prolonged adhesion to enamel, low sorption and solubility, wear resistance, minimal tissue irritation, and cariostatic action are all requirements for an effective sealant. For a better viscosity, the sealant should possess low surface tension and low contact angle to the tooth structure. [(28)]

The viscosity measurement and resin tag formation are crucial aspects that must be addressed for a sealant to be effective and held for a longer period of time. [(29)]

This study evaluated the resin tag length and contact angle of three pit and fissure sealants, Ultraseal XT, Clinpro, Ultraseal Xt reinforced with silver nanoparticles. Scanning Electron Microscopy analysis allowed the assessment and measurement of resin tag length, its penetration depth. No comparative studies have been done comparing the resin tag formation and surface tension. Molars extracted for therapeutic purpose, which were free of caries, developmental defects, fractures and discolouration were included in the study.

The tooth specimens were treated to a thermocycling technique to simulate the temperature encountered intraorally.Thermocycling is a common method in dental research, especially for testing adhesive materials' performance. Its goal is to thermally stress the adhesive bond at the tooth–restoration interface by exposing restored teeth to severe temperatures similar to those found intraorally. [(30)]

Alterations in the caries morphology might influence the caries progression. Previous studies have proved that the resin tag length of Ultraseal XT Hydro is better than the Clinpro 3M ESPE sealant. In this study, the resin tag length of Silver nanoparticle reinforced Ultraseal XT Hydro showed better results compared to the other two groups, but it was not statistically significant.

The estimation of surface tension has been done for the first time in this study; it also demonstrated that the surface tension of reinforced Ultraseal Xt Hydro is lower compared to the Clinpro and plain Ultraseal XT Hydro group. This implies that lower the contact angle, lower the surface tension and higher the wettability. Lower the surface tension, lower will be the viscosity and many studies are present in the literature with evidence. Viscosity is the resistance exhibited by the liquid/sealant to flow. [(31)] Internal frictional forces within the liquid controls the resistance of the liquid. Higher the viscosity of the liquid, slower the liquid flows. Factors influencing the penetration of the sealant are viscosity, resin tag length, surface tension, etc., [(32)]

The longer the resintag formed, the more the retention of the sealant, this has been proved in many studies. In the present study, the mean length of resin tags obtained ranged from 5.86 to 6.68 μm for all groups. Similar in vitro studies conducted by Prabhakar et al. [(33)] showed mean resin tag length in the range of 5–10 μm. Surface tension ranged from 57.27 to 71.30 degree.

5. Conclusion:

Based on the findings of the present study, it can be concluded that the wettability of silver reinforced UltraSeal is better than the comparator Clinpro and plain UltraSeal and also the resin tag length is more in silver reinforced UltraSeal, thus adding silver enhances the micromechanical retentive properties and wettability of the sealant.

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