

In Vitro Evaluation of Microleakage And Resin Tag Formation for Resin Cement of Composite Inlay

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Abstract

Aim: The aim of the study was to assess the microleakage level and subsequent resin tag formation of various luting agents used to lute inlays.

Methodology: Standardized cavity preparation with 4mm length, 3mm width and 1.5mm depth were prepared on buccal surface, 2mm above and 2mm below the cemento-enamel junction. Impression of the prepared cavity was made with poly vinyl siloxane and inlay was made in the laboratory. Then the inlay was cemented and the following groups were made: Group 1: total etch, bond, lute with Rely X ARC. Group 2: enamel etch, lute with Rely X U100, Group 3: total etch, bond, lute with Rely X U100, Group 4: enamel etch, lute with Rely X U 200, Group 5: total etch, bond, lute with Rely X U200 and Group 6: control group. The resin cements were used as per the manufacturer's instructions. Microleakage evaluation was done and resin tag formation was assessed using scanning electron microscopy and the results were tabulated.

Results: Total etch U200 shows the least microleakage level both in the enamel and cemental margins, whereas the enamel etch U100 shows the maximum microleakage in both the levels. Total etch U200 shows the maximum amount of resin tag formation in the coronal dentin level whereas enamel etch U 200 shows the maximum resin tag formation in root dentin level.

Conclusion: It can be concluded that total etch Rely X U200 produces the low microleakage when the cavity is pretreated by etching and bonding. Also the resin tag formation is maximum for total etch Rely X U200 which contributes to better bonding and low microleakage levels.

Keywords: Enamel etch, total etch, resin tag, microleakage

Date of Submission: 16 -10-2017

Date of acceptance: 16-11-2017

I. Introduction

The demand for esthetic restoration has continued to increase, as patients are attracted to a restoration that matches the colour of the natural teeth. Resin composite meets this demand and has become the most frequently used aesthetic restorative material in dentistry. Despite several problems, which are mainly associated with polymerization, shrinkage composite resin remains the most commonly used material. Resin composite shrinks on the order of 2% to 4%, often causing a gap to form at the least retentive marginal interface, which is usually the gingival margin. (1) Microleakage and bacterial ingress into the marginal gap may cause pulpal irritation and tooth sensitivity. (2)

Various modifications suggested in the restorative procedures to overcome the effect of polymerization shrinkage. The effect of polymerization shrinkage in direct composite resin can be avoided by restoring the cavity with a composite inlay. Composite resin inlays may be fabricated intra-orally (direct) or extra-

orally(indirect) and it can be bonded to the cavity. The advantage of inlay is that it is easier to achieve a good proximal contour, which is challenging to achieve in a direct restoration.(3) Studies have shown that composite inlays provided acceptable or excellent service in several years of clinical evaluation.(4,5) Though ceramic inlays are superior to composite resin inlay in certain aspects such as strength and esthetics, composite inlays are easier to fabricate and less expensive than ceramics.(6) Moreover, composite inlays are purported to exhibit similar properties to dentin, whereas those fabricated from ceramic cannot compensate for tooth deformation under occlusal loading.(7)

In clinical scenario the extension of class II cavity quite often goes beyond cemento enamel junction into the cementum. Such cavities become more technique sensitive to restore due to problems such as isolation, bonding and curing. Class II inlays overcome these problems and are best suited for a class II situation where the extension of proximal box beyond the cemento enamel junction.

Composite resin inlays are best luted with resin luting cements. Several types of resin cement are available to cement an indirect restoration. These differ in their pretreatment of the tooth surface prior to application of the resin cement and have been classified as etch-and-rinse adhesives, self-etching adhesives, and self-adhesive cements. Though etch and rinse adhesives are proved better, the introduction of self-adhesive cement reduced number of steps and in turn it reduces chance of contamination of oral fluid to prepared cavity. The seal or bond of the luting cement to the tooth surface is of the greatest significance in many restorative procedures, and is often the most important factor in achieving clinical success.(8) The bonding principle of dental adhesives is based on the formation of a hybrid layer,(9) as well as the penetration of adhesive into dentine tubules and formation of resin tags.(10) The aim of the study was to determine the level of microleakage and resin tag formation of various luting cements used to lute inlays.

II. Methodology

Thirty-six non-carious intact maxillary premolars collected and stored in saline after extraction until use.

2.1 Preparation of tooth samples:

Standardized cavity preparation with dimension of 4mm length, 3mm width and 1.5mm depth were prepared on buccal surface parallel to the cemento-enamel-junction, 2mm above and 2mm below the cemento enamel junction with high speed airtorhandpiece using tungsten carbide bur (FG-271 SS White)

2.2 Impression making:

For impression of the prepared cavity, equal amounts of the base and the catalyst of low viscosity poly vinyl siloxane(PVS) impression material(Aquasil-LV Ultra, Dentsply, Germany) were syringed into the prepared cavity and on the surrounding tooth surface. Simultaneously a plastic container (30mm x 25mm) filled with high viscosity poly vinyl siloxane (PVS) (Aquasil soft putty-regular, Dentsply, Germany). Then the tooth sample was half embedded into the high viscosity PVS, taking care that the entire prepared cavity along with the low viscosity material and the surrounding tooth surface are completely inside the high viscosity poly vinyl siloxane. The tooth was removed from the impression after five minutes. The cavity was restored temporarily with non eugenol cement (Rely X Temp NE). The impression cast in die stone and inlays fabricated in the lab.

2.3 Lab procedure:

The cast was applied with two coats of model separator on to the cavity, and then the cavity was filled with indirect composite resin (Adoro SR) and cured. The tissue surface was sand blasted with aluminium oxide(40 μ) and the buccal surface was polished.

2.4 Cementation of inlays:

The temporary cement removed from the cavity and cleaned with pumice slurry. The fabricated inlay placed in cavity to examine the marginal fit in naked eye. Inlays with gross marginal defect discarded and fresh inlays fabricated.

The prepared teeth were randomly divided into six teeth in each groups (n=6)

Group 1: total etch, bond, lute with Rely X ARC

Group 2: enamel etch, lute with Rely X U100

Group 3: total etch, bond, lute with Rely X U100

Group 4: enamel etch, lute with Rely X U 200

Group 5: total etch, bond, lute with Rely X U200

Group 6: control

2.5 Procedure:

Silanating(Rely X Ceramic Primer 3M ESPE) of fitting surface of inlay was done for all the groups

Group 1: (Rely X ARC as per manufacturers instructions) The cavity was etched with 37% orthophosphoric acid (multi purpose etchant, 3M ESPE) for 15 seconds, rinsed with water for 10 seconds. Excess water was blot

dried followed by application of 2 consecutive coats of bonding agent (Adper Single Bond 2, 3M ESPE, USA) on the cavity for 15 seconds and light cured for 10 seconds. Then Rely X ARC base paste and catalyst paste was dispensed in a mixing pad and mixed into a homogenous paste within 20 seconds using a spatula. The mixed cement was evenly applied to the entire cavity and the inlay was seated into the cavity and cured for 2 seconds initially and excess cement was removed with scaler followed by 40 seconds curing.

Group 2: (Rely X U100 as per manufacturers instructions) The enamel surface of the cavity was etched with 37% orthophosphoric acid (multi purpose etchant, 3M ESPE) for 15 seconds, rinsed with water for 10 seconds. Excess water was blot dried followed by dispensing of Rely X U100 base paste and catalyst paste in a mixing pad and mixed into a homogenous paste within 20 seconds using a spatula. The mixed cement was evenly applied to the entire cavity and the inlay was seated into the cavity and cured for 2 seconds initially and excess cement was removed with scaler followed by 40 seconds curing.

Group 3: Protocol of group 1 was followed using Rely X U100

Group 4: Protocol of group 2 was followed using Rely X U200

Group 5: Protocol of group 1 was followed using Rely X U200

All the bonded specimens were stored in 37°C distilled water for 24 hours. The specimens were then subjected to thermocycling for 500 cycles between 5°C & 55°C with a dwell time of 30 seconds and transfer time of 5 seconds.

2.6 Microleakage Evaluation:

The teeth were sealed with two layers of nail varnish up to 1.0 mm from the restoration margins after the root apices were sealed with sticky wax. They were then immersed in 1% methylene blue solution for 24 hours and stored at room temperature. After storage, the teeth were thoroughly cleaned with brush and dried. The teeth were sectioned longitudinally in a bucco-palatal direction. One half of every tooth section was utilized for microleakage testing and the other half for evaluating the resin tag penetration. The sections for microleakage were cleaned and examined under stereomicroscope for the dye penetration and were scored by 2 independent examiners as follows

Scoring system as per Piemjai (11)

0 = No leakage

1 = dye penetrated to one half of axial wall

2 = dye penetrated through axial wall, but not up pulpal wall

3 = dye penetrated up pulpal wall.

2.7 Procedure for scanning electron microscopy and resin tag measurement:

The other half of the tooth section was prepared for evaluation under scanning electron microscopy. The tooth sections were polished using silicon carbide paper 400 and 800 grit. The polished sections then decalcified using 37% phosphoric acid to remove any debris that accumulated during sectioning and polishing. Then the sections rinsed and stored in distilled water. The tooth sections dried thoroughly under the heat lamp. Gold sputtering done by mounting the samples on a copper stub, which was vacuum dried and coated with gold (Auto fine coater JOEL JFC-1600). The gold sputtered samples were then examined under SEM at 20 kv. The photomicrographs of the representative areas were obtained at 1500 x magnification. The resin tag lengths then measured and the average length of the resin tag was calculated.

III. Discussion

The development of internal stresses during polymerization of the direct restoration causes cuspal flexure or debonding. Indirect restoration is preferred to overcome the major disadvantage of polymerization shrinkage that occurs during direct composite restoration. Extraoral polymerization also improves both the physical and mechanical properties of the composite restoration and are critically linked to marginal fit and integrity. (11,12) There are numerous factors that either directly or indirectly contribute to the possible causes of disturbance in marginal integrity that referred to as microleakage. Microleakage at the tooth-cement interface is more critical than at the restoration-cement interface because the former may lead to secondary caries, postoperative hypersensitivity and pulpal inflammation. (13–15)

Maxillary premolars indicated for orthodontic extraction of similar age group were used for this study. Selecting such teeth was to standardize the quality of substrate on which the inlay was cemented.

The cavity design used in this study was decided based on the following advantages.

1. The restoration margins are located in enamel as well as in cementum.
2. Such cavity design largely replicates the margins involved in class II design.
3. It has unfavourable configuration factor resulting in high contraction scores within an adhesively fixed resin material.

4. Preparation and restoration of such cavities are minimal and relatively easy, thereby reducing the variability and it is easier to standardize such preparation than class II cavities.

All restorations had previously undergone thermal cycling in order to subject the restorations to thermal expansion and contraction challenges. This was done so that the different thermal expansion coefficients of tooth tissue from the restorative materials may lead to gap formation as such. To assess the in-vitro performance of resin materials, thermal cycling is the common method used to which the resin restorations are exposed. Different techniques described for studies of margin quality. The most widely accepted method is the dye penetration test.(16) In our study 1% methylene blue solution was used for dye penetration test. The samples evaluated at 30X magnification under a stereomicroscope. The dye penetration recorded by the use of graded criteria. Regarding microleakage in the enamel margin, if the cements were manipulated according to the manufacturer's instructions, the conventional resin cement Rely X ARC produced the best result. This level of low microleakage could also be achieved in Rely X U200 by modifying the manufacturer's instructions i.e. pretreating the cavity by etching and bonding. When enamel and dentin surfaces are etched to remove the smear layer and some of the mineral phase of tooth surfaces, microspaces are produced in the demineralised substrates. This allows infiltration of the bonding agent to form resin tag resulting in positive effect on the marginal seal.(17) Adhesive monomers are able to penetrate and replace these spaces thus forming a hybrid layer after their polymerization on mineral substrates.(18) The formation of resin tag was observed in our SEM evaluation only in group 1 and groups were additional treatment was done with self adhesive cements. This hybridized dentin has been explained to be impermeable like enamel, but more acid resistant than enamel and it could have inhibited microleakage.(18) Though there was a difference in the mean leakage values, there was no statistical difference between the groups.

The results obtained in this study the enamel margin shows that Rely X ARC is the best luting cement if all the margins of the cavity lie in enamel. The clinician could choose Rely X U200 only if there is a need for decrease in steps involved in luting such as hypersalivation where isolation could be challenging, poor mouth opening, poor accessibility etc. Regarding the leakage on cemental margin, it was found that Rely X U200 was as equally effective as Rely X ARC in terms of mean leakage scores Rely X U100 showed the maximal leakage on the cemental margin. The performance of Rely X U200 was better than Rely X ARC on cemental margin. This could be because of the less mineralized tissue encountered at the cemental margin where the self adhesive mechanism of Rely X 200 was probably more effective. There was no statistically significant difference between groups. According to Piwowarczyk A et al(2005) in self adhesive cement(Rely X U100& U200), the specific multifunctional phosphoric-acid methacrylates of this cement react with the tooth surface in multiple ways, resulting in an effective seal. Besides the formation of complex compounds with calcium ions, different kinds of physical interactions such as hydrogen bonding or dipole-to-dipole interactions were supposed to favourably affect the adhesion of this self-adhesive cement.(19)

Based on the results obtained in this study, the selection of resin cements, if the class II cavity extends beyond the cemento-enamel junction, Rely X U200 could be the material of choice. If the gingival tissue extends up to the gingival seat margin or more occlusally, it would be challenging to prevent contamination of the gingival seat by crevicular fluid. In such a situation, it would be prudent to lute the inlay with Rely X U200 following manufacturer's instructions as this would reduce the multiple steps involved in luting. If the gingival tissue is positioned well below the gingival seat margin, there is less danger of infiltration of the crevicular fluid into the gingival seat of the cavity. In such situation, Rely X U200 will be used with an additional pretreatment as described in the study. Various steps have been taken to reduce the microleakage by incremental curing, controlling polymerisation shrinkage, etc.(20) The dye penetration was more in cementum compared to enamel for Rely X ARC and Rely X 100. This could be due to difference in chemical composition of enamel and cementum. The bonding mechanism of resin cement is based on the concept that, when the dentin surface is etched, the dentin demineralises and exposes the collagen fibres. The monomer present in the resin cement diffuses completely into the demineralised dentin and encapsulates the collagen fibres, leaving no demineralised dentin within the spaces around the collagen fibres.(21) If the monomer doesn't infiltrate the demineralised dentin/cementum completely, microleakage occurs. Bonding of these resin cements to enamel is found to be better because the organic phase of enamel is keratinous and non collageneous. So there are no spaces around the collagen fibres that can initiate microleakage. In addition, Rely X U200 is claimed by the manufacturers to have better flow properties and less viscosity than Rely X U100. According to Piemjai et al (2002), higher viscosity of cements limits their infiltration into the spaces around the collagen fibres, thus leading to microleakage in this layer. Adhesive monomers are able to infiltrate these spaces and form complete hybridization of demineralised dentin and therefore minimal microleakage occurs.(11) Hence, the better performance of Rely X U200 could be attributed to the fact that low viscosity promoted better infiltration of the resin into the spaces around the collagen fibres leading to lesser microleakage.

Resin tags were observed in group 1,3 and 5, where etching and bonding was done. Considering the resin tag values at the coronal margin, Rely X U200 total etch had best resin tag infiltration, which again reflected the least microleakage values at the enamel and cementum margins. The resin tag infiltration at the root margin was greatest with Rely X U200 total etch which reflected the least microleakage values. In this study, a resin tag formation was observed only in groups where bonding agent was used. This is because of lower viscosity and surface tension of the bonding agent, where as the resin cement as such was not able to produce resin tags because of higher viscosity. In this study Resin tag depth was higher in groups where microleakage were lesser, reinforcing the results observed under the stereomicroscope. Thus it can be postulated that, the longer the resin tags formed, lesser will be the microleakage and lower the viscosity of luting cement, lesser will be the microleakage.

IV. Conclusion

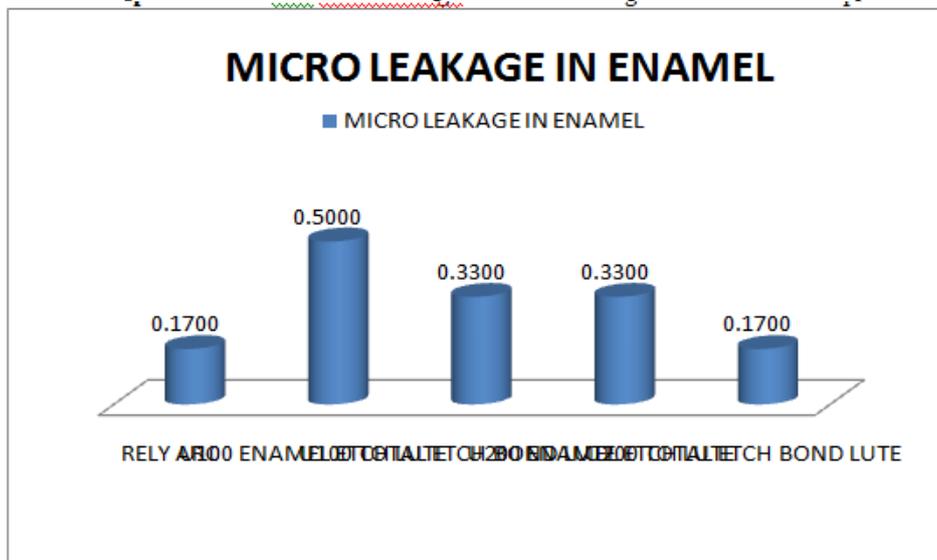
Within the limitations of this study, it can be concluded that total etch Rely X U200 produces the low microleakage when the cavity is pretreated by etching and bonding. Also the resin tag formation is maximum for total etch Rely X U200 which contributes to better bonding and low microleakage levels.

References

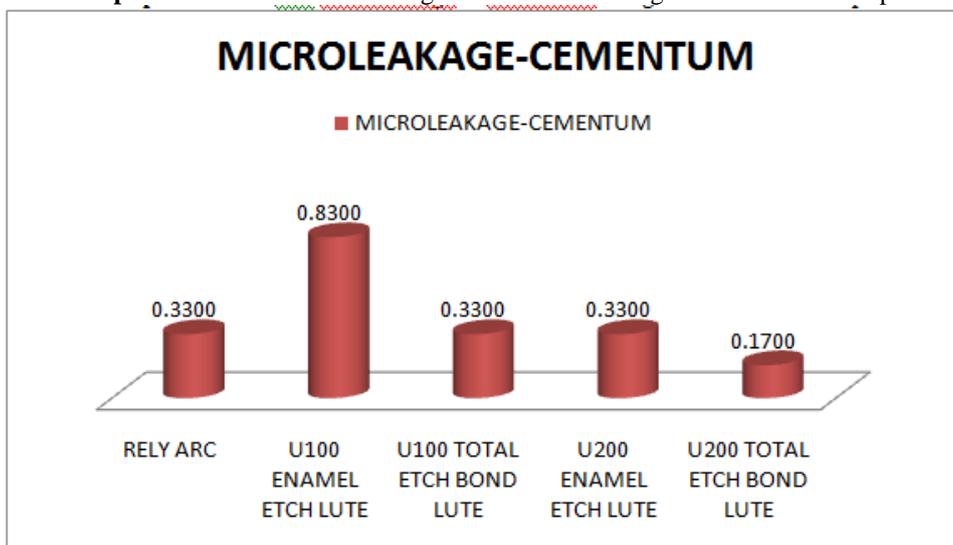
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Figures

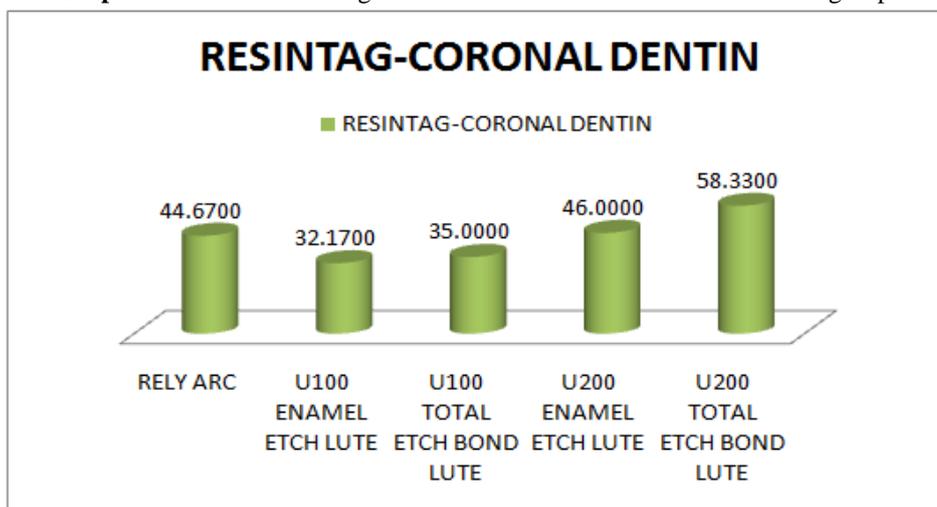
Graph 1: Shows The Microleakage In Enamel Margin For All The Groups



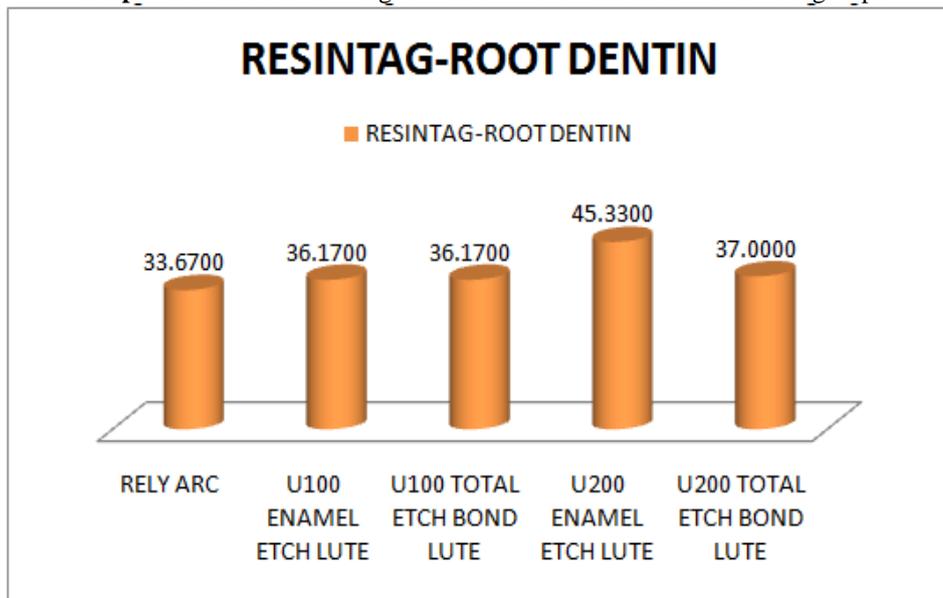
Graph 2: Shows The Microleakage In Cementum Margin For All The Groups



Graph 3: shows the resin tag formation in the coronal dentin for all the groups



Graph 4: shows the resin tag formation in the root dentin for all the groups



*Arunajatesan Subbiya. "In Vitro Evaluation of Microleakage And Resin Tag Formation for Resin Cement of Composite Inlay." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) 16.11 (2017): 83-89