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Research Article

SPECTROPHOTOMETRIC EVALUATION OF MICROLEAKAGE USING BULKFILL LINERS CURED WITH QTH AND LED LIGHTS

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A B S T R A C T

Introduction: Polymerization shrinkage and microleakage primarily cause failure of composite restorations. Bulkfill flowable composite liners have lesser polymerization stress than the conventional flowables. Authors have differing opinions as to the effect of QTH and LED lights on microleakage.
Aim: This study evaluated Spectrophotometrically if bulkfill flowable composite liners reduced microleakage compared to conventional flowable composites liners and if curing lights (QTH versus LED) affected microleakage.
Methodology: 72 standardised class V cavities on the buccal surface of premolars with occlusal margins in the enamel and cervical margins in the cementum, were restored with 1mm of the following liners depending of the group they were assigned to, after etching and bonding was done according to the manufacterer's instructions:

- Group 1:Filtek™ Z350 XT Flowable Restorative (3M ESPE, USA)
- Group 2: x-tra base (VOCO, Cuxhaven, Germany)
- Group 3: Smart Dentin Replacement (SDR) (DENTSPLY, Germany)

Liners were with overlaid with Filtek™ Z 350 XT Universal Restorative. Each group was divided into subgroups A and B cured by QTH and LED lights respectively. Microleakage was evaluated by the dye extraction technique Spectrophotometrically.
Result
There was statistically no significant difference in the microleakage seen among the liner groups or the curing light subgroups.

INTRODUCTION

Resin composites, despite their good aesthetic properties, conservative tooth preparation, micromechanical and chemical bonding, suffer from the major drawback of polymerization shrinkage that results in microleakage and the eventual failure of the resoration. (Arslan *et al* 2013)

Flowable resin composites, due to their lower modulus of elasticity values have been recommended as liners under conventional packable composites to reduce polymerization shrinkage stress and hence microleakage. (Lokhande *et al* 2014.)

Newly introduced bulk filled flowable resin composites (e. Smart Dentin Replacement SDR, x-tra- base) that guarantee lesser (60- 70%) polymerization stress than their conventional counterparts can possibly further reduce microleakage when used as liners. (Arslan *et al* 2013)

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QTH and LED lights have been used in equal propensity. While QTH lights come with their advantage of low cost, LED lights have longer life spans and are capable of polymerizing composites with newer photoinitiators. (Sadeghi 2009, Menees *et al* 2015)

This study was done to see if the use of bulk fill flowables (Smart Dentin Replacement, x-trabase) as liners reduce microleakage when compared to a conventional flowable liners (Filtek Z350 XT Flowable Restorative). Curing was done with QTH and LED light cure units to evaluate if the type of light used has any effect on microleakage.

MATERIALS AND METHODS

This study was carried out in the Department of Conservative Dentistry and Endodontics, JSS Dental College, Mysore after obtaining ethical clearance from the Institutional Ethical Committee.

Specimen preparation

A total of 72 class V cavities (4mm width X 4mm height X 2mm depth) were prepared on the buccal surface of premolars extending into the cementum. Etching with 37 % phosphoric acid (SUPER ETCH SDI, Australia) for 15 seconds was followed by the application, agitation (15 seconds), airblowing (5 seconds) and curing (10 seconds) of Adper^{TM} Single Bond 2 (3M ESPE, USA). The samples were then assigned to groups 1, 2, 3 as shown in the flowchart according to the liner used. Liners were applied in 1 mm thickness. Each group was then further subdivided into two subgroups (A, B) depending on the curing light used (QTH or LED.) (Figure 1)

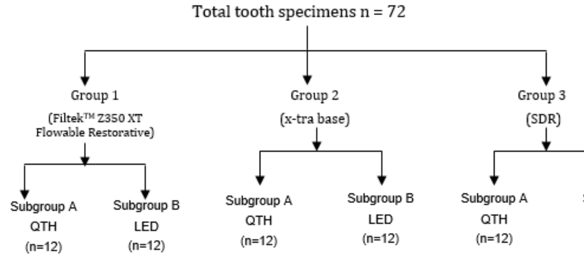

Figure 1 Flow chart showing the flowable conventional (Group 1) and bulk filled composite liners used (Groups 2 & 3)

Materials used in the study **Table 1**

expected concentration of methylene blue in the unknown were prepared. The concentrations of the standards were within the working range of the technique (instrumentation) being used. Each of these standards was analyzed using the spectrophotometer producing a series of measurements of their absorbance. From this, a scatter plot was obtained. This is the calibration curve. From this, coefficient of correlation (R) between dye concentration and absorbance of standard solutions was calculated. To estimate the dye concentration of the experimental solutions, a linear regression was obtained and generically expressed as: y= 1.1145x + 0.0591. (Figure 2) (Where y is the absorbance and x is the dye concentration.)

Samples were then coated 1 mm short of the restoration margins with two layers of nail varnish and the root apices were sealed with sticky wax. Then the samples were immersed in 2% methylene blue solution for 24 hours after which they were rinsed under tap water for 30 minutes. Soflex discs were used to remove the superficially stained composite material. The samples were then placed in test tubes containing 5000 microlitres of 65 wt % nitric acid for 3 days. (Figure 3)

Table 1 Materials used in this study

Sr. no	Material	Manufacturer	Composition
1.	Filtek^{TM} Z350 XT Universal Restorative. (Conventional packable composite.)	3M ESPE, USA	Monomers: Bis-GMA, UDMA, TEGDMA, and bis-EMA, PEGDMA, Fillers: non-agglomerated/non-aggregated 20 nm silica filler, non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, and aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles), 78 wt %.
2.	Filtek^{TM} Z350 XT Flowable Restorative. (conventional flowable composite resin)	3M ESPE, USA	Monomer: Bis-GMA, TEGDMA, Bis-EMA, dimethacrylate polymer. Filler: zirconia (5-10nm) nanofiller and Silica (75nm): 65 wt %(55 vol %).
3.	x-tra base (bulkfill flowable composite resin.)	VOCO, Cuxhaven, Germany	Resin: No info available Filler: • 75% by weight • No other compositional info available
4.	Smart Dentin Replacement (SDR) (bulkfill flowable composite resin.)	Dentsply, Germany	Monomer- modified urethane dimethacrylate resin, ethoxylated bisphenol A dimethacrylate (EBPADMA), triethylene glycol dimethacrylate (TEGDMA),. Fillers: 68 wt. % of fillers Barium aluminofluoroborosilicate glass, strontium aluminofluorosilicate glass, Photo-initiator: camphorquinone Inhibitor: Butylated Hydroxy Toluene (BHT). UV stabilizer, titanium dioxide, and iron oxide pigments. 68 wt. % of fillers
5.	Adper Single Bond 2 Adhesive (5th generation Total etch single bottle bonding agent.)	3M ESPE, USA	Bis- GMA, HEMA, dimethacrylates, ethanol, water, photoinitiator, functional copolymer of poly acrylic and poly (itaconic acid), 10 wt % 5nm spherical silica particles.

A final increment of Filtek^{TM} Z350 XT Universal Restorative (3M ESPE, USA) was placed using oblique incremental technique. 1000 cycles of thermocycling were done in a water bath at 5^{o}C and 55^{o}C with a dwell time of 30 seconds.

Dye extraction

Dye extraction technique make use of the Spectrophotometer to evaluate the absorbance of the leaked dye

Spectrophotometer is an instrument for physical analysis, and provides wavelength-by-wavelength spectral analysis of the reflecting and/ or transmitting properties of objects without interpretation by human. It consists of a sensor plus data processor or computer with software.

Prior to this, the absorbance values of known concentrations of methylene blue dye have to be determined. The general method for determining this is by making use of the calibration curve.

In this study, a series of standards across a range of concentrations (0%, 0.01%, 0.05%, 0.1%, and 0.5%) near the

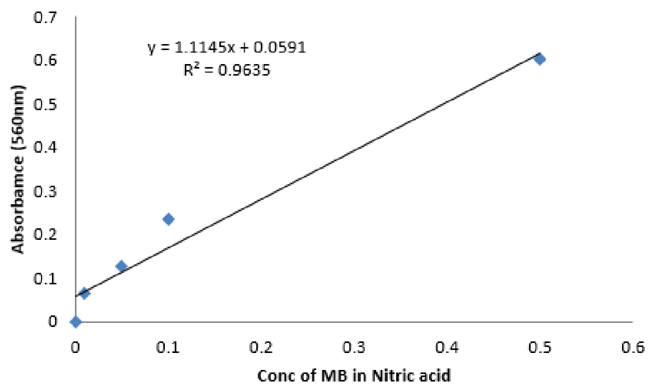

Figure 2 Calibration curve

Figure 3 Dye extracted from the composite tooth interface into 65% nitric acid

The vials were then centrifuged at 14,000 rpm for 5 minutes after which dye absorption was measured by a semi- automatic spectrophotometer at 560 nm using concentrated nitric acid as a blank. (Figure 4)

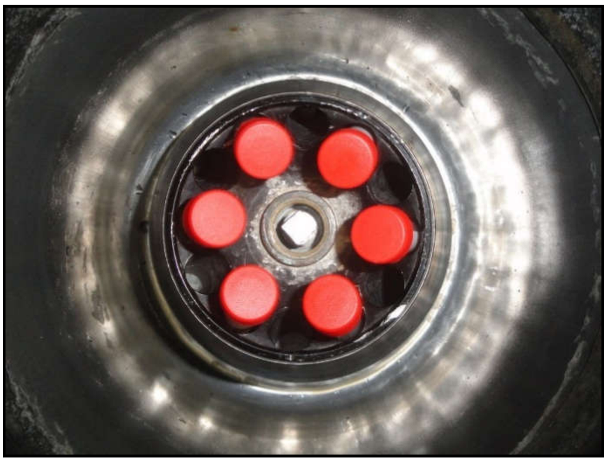

Figure 4 Centrifugation

The optical density value attained using the Spectrophotometer (Figure 5) was converted to the concentration using the equation obtained above and expressed as percentage (%).

Figure 5 Spectrophotometer used for dye extraction method of microleakage detection. (SHIMADZU, Model No.UV- 1800)

Statistical analysis

The obtained results were subjected to the following analyses: Mean and Standard Deviation were used for Descriptive statistics.

Mann- Whitney U test
Kruskall- Wallis test
Analysis was done using SPSS Software version 22.

RESULTS

No statistically significant differences were found when subgroups within each individual group were compared with one another. (p= 0.05)

On applying the Mann Whitney U test, no statistically significant difference was found between subgroups of group 1 (p= 0.843), group 2 (0.630) and group 3(0.347.)

This bar graph shows the means of subgroups A and B of all the three groups. The y- axis gives the various concentrations of methylene blue dye that has leaked during the dye extraction process while the x- axis shows the various groups and subgroups. (Figure 6)

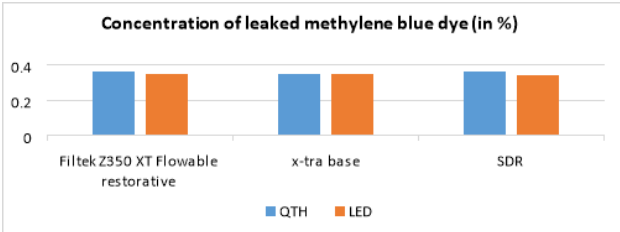

Figure 6 mean concentration of leaked methylene blue dye (in %) in the experimental group

When the dye concentration of subgroup A (QTH) of all the groups were compared using the Kruskall Wallis test, no statistically significant different results were obtained (p=0.815)

When the dye concentration of subgroup B (LED) of all the groups were compared using the Kruskall Wallis test, no statistically significant different results were obtained (p=0.643)

DISCUSSION

The concept of liners (glass ionomer, conventional flowable composite etc) was introduced in an attempt to reduce polymerization stress and microleakage. (Radhika *et al* 2010, Arslan *et al* 2013)

My study was undertaken taking this into consideration.
In this study, recently launched flowable bulk filled composites (SDR, x-tra base) with the promise of reduced polymerization stress, have been used as liners in comparison with conventional flowable liner (Filtek Z350 XT Flowable Restorative.)

All the three composites used were Bis- EMA based. Studies have shown that Bis- EMA molecule has high molecular weight thus producing less shrinkage. (Nascimento *et al* 2016.) The past many years have seen QTH and LED light curing units being used in the world. (Sadeghi 2009). Thus this study was undertaken to see if these lights had any effect on microleakage.

In this study, class V cavities were chosen since this is the area most commonly associated with carious and non caries lesions and composite resins due to their low modulus of elasticity are preferred for usage here. (Soopararaju *et al* 2014, Lin *et al* 1992)

The prepared cavities were extended onto the cementum since that is where these lesions usually extend to in the clinical scenario. According to the existing protocols, the flowable materials were placed in 1 mm thickness as liners. (Soopararaju *et al* 2014)

Conventional packable composite Filtek^{TM}Z350 XT Universal Restorative was used to top the flowable liners as per instructed by the manufacturers. (Leprince *et al* 2014)

Composite placement was done using an oblique incremental technique as various studies have proved that this technique reduces microleakage. (Mirza *et al* 2013)

Finishing and polishing of the restoration was done to prevent overhanging margins and to prevent the bias regarding the microleakage assessment.(Chandrashekar *et al* 2011)

Various studies have suggested that to better simulate the clinical setting and thermal challenges in the oral cavity during eating and drinking, reliable techniques such as thermocycling are used. Thermocycling in water baths between 5 and 55°C best simulate oral environmental conditions. Hence, this study utilized these tempertures. (Akhavan-Zanjani *et al* 2014)

In this study, thermocycling done with 30 sec dwell time as studies have suggested that thermocycling regimens using short dwell times are more realistic. The present study used 1000 to simulate approximately 1 year work in mouth environment. (Pazinatto *et al* 2003, Daneshkazemi *et al* 2013.) Dye penetration, a technique commonly used to evaluate microleakage has drawbacks like operator error and readings may be affected by the presence of artefacts. In this present study, dye extraction method was used; its advantages being simplicity, ability to obtain fast and quantitative results, detection of even dilute concentrations. (Celik 2017)

Dye extraction method makes use of a Spectrophotometer to read the absorbance values.

In this study, 2% methylene blue was preferred because it has a molecular size of 120nm which is much smaller than the size of a bacterium. Its low molecular weight (318.85) which is even lower than the basic fuschin (323.45) helps it penetrate more deeply than other dyes. (Tamse *et al* 1992, Patel *et al* 2015)

Complete dissolution of dye into the nitric acid takes 3 days hence in the present study, the samples were placed in 65 % nitric acid for a period of three days as per the protocol followed by previous researchers. Following this, centrifugation was done at 14,000 rpm for 5 minutes so as to release the dye completely from the interface.(Kaya *et al* 2011) In the present study, no significant differences were observed in micro-leakage between teeth restored in bulk fill flowables like SDR, x-tra base and in Filtek Z 350 XT Flowable Restorative (conventional flowable composite) when evaluated by the spectrophotometer.

This is in accordance with studies that got the same results as the present study and attributed them to the fact that although SDR shows lower polymerization stress compared to other conventional flowable composites, no differences have been found in volumetric shrinkage between SDR and other conventional flowable composites (3.5% volume).(Moorthy *et al* 2012, Arslan *et al* 2013, Lotfi *et al* 2015, Marurkar *et al* 2017)

Koltisko and Burgess have concluded that the chemistry of SDR is designed to slow the polymerization rate, thereby reducing polymerization shrinkage stress without affecting polymerization shrinkage levels. (Koltisko *et al* 2010, Burgess *et al* 2010)

Various other studies have found the polymerization shrinkage of Filtek Z 350 XT Flowable Restorative to be 3.53 % which is not very different from that of SDR. (Kim *et al* 2015)

One possible explanation for microleakage in x-tra base not being significantly different from the other groups despite having the highest filler content among them could, according to Nascimento, in fact be because of this very high filler content that possibly restricts mobility and produces diffuse scattering of the activating light.(Nascimento *et al* 2016)

All the three flowable composite resins used in this study, contain high molecular weight BIS- EMA,(540 g/ mol) hence showing no difference in the polymerization shrinkage. (Nascimento *et al* 2016)

The new generation flowable bulk fill composites (SDR, x-tra base) have shown 60% lesser polymerization shrinkage stress compared to conventional flowable composites. Despite this, there has been no reduction in microleakage in the bulkfill liner groups when compared with the conventional flowable liner group leading us to conclude that microleakage is not affected by polymerization stress but by polymerization shrinkage since all the composite resin liners used showed the same level of shrinkage.

Studies have shown a weak correlation values (0.49) between polymerization stress and polymerization shrinkage (perfect correlation value is 1) thus strengthening the inferences by Burgess, Arslan and Koltisko. (Kim *et al* 2015)

In the present study the curing efficiency of a light emitting diode curing unit- blue phase C8 (Ivoclar Vivadent) was compared with a quartz tungsten halogen light –Translux energy (Heraus Kulzer).

Light emitting diode curing light used in the present study showed a power intensity of 1080mW/cm^2±10% and quartz tungsten halogen light showed a light intensity of 820mW/cm^2. There has been no report of a different photo initiator apart from camphoroquinone (468 nm) being used in composites used in the present study. (AlQahatani *et al* 2015)

In the present study, when QTH and LED LCUs (Light Curing Units) were used to cure composite resins, no significant differences in microleakage were identified.

This result was in accordance to the studies carried out by authors who demonstrated that microleakage was not affected by the kind of light used for curing (whether LED or QTH) but by the material. (Attar *et al* 2007, Yazici *et al* 2008, Umer *et al* 2011, Chandurkar *et al* 2014, Yilmaz *et al* 2014, Oskoee *et al* 2017)

The results of the present study don't match those obtained by authors who demonstrated lesser leakage using LED light. (Oberholzer *et al* 2004, Tarle *et al* 2006, Zakavi *et al* 2014 and Kumar *et al* 2014)

This result achieved in my study can be attributed to the spectral emission of the lights. The photointiator in composite resin is the camphoroquinone (CQ) system, which absorbs visible light in the range of 375-500 nm, with a maximum absorption of about 468 nm. This highlights the fact that the effectiveness of light curing is not just dependent on the output intensity of the LCU but also includes the enveloping of the LCU absorption spectrum to that of the photoinitiator present in the materials. Also, studies have suggested that total energy delivered to a material was 'irrelevant' as reciprocity was material specific. (Fleming *et al* 2007, Park *et al* 2010 Santini *et al* 2011, Moosavi *et al* 2013)

The short comings of this study are that this is an in vitro study hence cannot exactly mimic the in vivo conditions like pulpal pressure, dentinal fluid and tooth dynamics. Furthermore, the absence of a group restored with only conventional packable composite makes it impossible to ascertain whether or not liners play a part in reducing microleakage.

CONCLUSION

Within the limitations of this in- vitro study, it could be concluded that:

There was no significant difference in microleakage values seen with conventional flowable liners (Filtek Z 350 XT flowable restorative) and bulkfill flowable composite liners (x-tra base, SDR) when evaluated using the Spectrophotometer.
Microleakage values were not affected by the choice of curing light (QTH vs. LED.)

Acknowledegements

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