An In-Vitro Evaluation of Microleakage at the Cervical Margin Between two Different Class II Restorative Techniques Using Dye Penetration Method

Noor-Ul-Ain Jawaed, Syed Yawar Ali Abidi, Fazal-Ur-Rehman Qazi and Shahbaz Ahmed

ABSTRACT
Objective: To evaluate the coronal microleakage of packable composite using conventional incremental and posterior bulk fill flowable composite using Smart Dentine Replacement Single Step technique in the cervical margins of class II cavities in dentine using the dye penetration method.

Study Design: In-vitro Intervenational study.

Place and Duration of Study: Department of Operative Dentistry, Dr. Ishrat-ul-Ebad Khan Institute of Oral Health Sciences (DIKIOHS), Karachi, from November 2012 to April 2013.

Methodology: One hundred and twenty extracted teeth (molars and premolars) were collected and randomly divided into two experimental groups (n=60 each) and were stored in normal saline until used. Fractured samples were excluded. Standardized class II proximal box only cavities were prepared and restored with conventional methacrylate based composite using incremental technique (Group A, n=40) and low stress methacrylate resin based composite SDR using single step technique (Group B, n=40). Samples were sectioned horizontally below the cervical margins and specimen disks were prepared. The specimens were thermocycled and sealed with acid resistant varnish leaving a 1-mm interface around cervical margin and immersed in 2% methylene blue buffered solution for 24 hours. Leakage was scored 0 - 4 and measured in mm. It washed and sectioned to evaluate under stereomicroscope.

Results: Mean penetration was 2.4280 ±0.79 mm for Group A and 1.015 ±0.45 mm for Group B (p < 0.001). Maximum dye penetration score for group A was 4 and group B was 3.

Conclusion: SDR technique in combination with total etch technique at the cervical margin of class II restorations improved the marginal seal, when were placed in dentine and thermocycled.

Key Words: Dental composite. Microleakage. Dye penetration method. Smart dentine replacement (SDR) composite.

INTRODUCTION

Long-term adhesion of bonded dental biomaterials to tooth hard tissues is an important factor for clinical success of resin based restorative materials.1,2 Both initial and residual polymerization stresses may lead to gap formation, leakage, postoperative sensitivity, recurrent caries, and may be retention loss.2-4 Furthermore, internal stress of the composite has the potential to initiate micro-cracking within the restoration.5-7 Therefore, a tight marginal seal still has to be the primary goal for the clinician, because gap formation cannot be counteracted with restorative materials.6,7 Despite many new and innovative developments in the adhesives, a 100% perfect margin is not realistically achievable.

In adhesive dentistry, the chemistry of biomaterials and clinical steps of dental composites had been constantly advancing to minimize microleakage.1-8 However, incremental layering technique is still mandatory to meet the above mentioned prerequisites for effective sealing of margins of resin composite restorations.1-8 SDR or Surefil SDR was introduced to the market as flowable bulk fill resin composite, claiming that it would allow a 4 mm bulk placement in one layer due to reduced polymerization stress, being mandatorily covered by a 2 mm layer of conventional resin composite. Although flowable resin composite materials have been repeatedly discussed to act as stress breakers or adaptation promotors, clinical investigations could not confirm this issue so far.

Therefore, the objective of the present study was to evaluate and compare the cervical microleakage of packable composite resins using conventional incremental technique with novel flowable low-shrinkage-stress resin composite using Smart Dentine Replacement Single Step technique, when used as 4 mm dentine replacement in the cervical margins of class II cavities being bonded with total etch.

METHODOLOGY

This in-vitro study was carried out at Operative Dentistry Department at DIKIOHS (Dr. Ishrat-ul-Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi.)

Correspondence: Dr. Noor-Ul-Ain Jawaed, Assistant Professor, Department of Operative Dentistry, Dr. Ishrat-ul-Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi.
E-mail: dr_noorulainkharram@yahoo.com

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Institute of Health Sciences), Karachi, from November 2012 till April 2013. Microscopic evaluation of samples were done in the Department of Materials at NED University, Karachi, Pakistan.

A total of hundred and twenty intact extracted human molars and premolars were collected which were devoid of caries, restorations, and cracks. ISO/TS 11405 standard was followed to store in normal saline until used and handle the extracted teeth. Forty samples fractured during sectioning, which were excluded from testing. Standard class II cavities were prepared using a high-speed hand piece under air-water spray and burs used were:

- No. 271 tapered fissure tungsten carbide bur with the tip diameter of 0.8 mm (for occlusal and proximal cavity).
- No. 169L tapered fissure tungsten carbide bur with the tip diameter of 0.5 mm, and No. 8862 flame shaped finishing diamond to provide the occlusal cavosurface bevel.

Samples were finished with a 25 mm finishing diamond bur (one pair of diamonds / four cavities). Measurements of the cavity preparations were standardized using metallic scale and calibrated periodontal probe. Class II cavities were prepared on either of the proximal surfaces of each tooth (4 mm bucco-lingual width and 2 mm mesio-distal depth) with the gingival cavosurface margin 1 mm apical to the CEJ with the cervical cavosurface margins as butt joint.

Each tooth was mounted in a training typhodont model. The mounted acrylic teeth were unscrewed and removed from the model; and extracted teeth were mounted using alginate with one acrylic premolar and one molar on the mesial and distal sides, respectively, to simulate the posterior teeth alignment. The tooth samples were divided into two experimental groups of each, according to the restorative material and techniques used. Group A was subjected to conventional incremental technique and Group B to SDR Single step technique. Prior to restoration, the palodent band and single component total etch adhesive matrix band was removed. Light curing was done using Cool Blue™ LED (Milestone Scientific, Livingston, NJ, USA) with a light intensity of 400 mW/cm².

In Group B, etching enamel and dentin, application of matrix band and single component total etch adhesive application to the etched surface was done as described in group A. The cavities were restored using SDR Single step technique (Detrey Dentsply Germany) which was placed in 4 mm layers. The restoration was then light cured for 20 seconds from the occlusal aspect. Universal packable composite (Filtek Z350, 3M ESPE) was placed as a capping material and cured for 20 seconds from the occlusal aspect.

Following completion of the restoration, the restoration was finished and polished with a fine diamond point and a series of abrasive disks (Shofu). Teeth were sectioned at cemento enamel junction horizontally using sectioning disk (Noritake Dental Supply Co. Ltd) in straight slow speed hand piece.

According to the thermocycler size of sample testing tube available was 0.1 ml. Samples were prepared in the form of small disks using Micrarcut 125 and samples grinding machine.

The teeth were placed in isotonic saline in a water bath at 37°C for 24 hours and thermocycle tested for 1500 cycles with temperature range of 5°C to 55° ± 2°C with a dwell time of 60 seconds for each bath. After the thermocycling, the specimens were sealed with acid resistant varnish leaving 1 mm window around the cervical margin interface. The specimens were stored for 24 hours in 100% humidity at 37°C. Each specimen was subsequently immersed in a freshly prepared 2% aqueous methylene blue dye solution (ph 7.0) at 37°C for 24 hours, and stored in incubator. After removal from the dye solution, they were thoroughly washed under tap water and were mounted and sectioned mesiodistally into halves along their long axis using a diamond disc with water coolant. Coronal leakage was assessed by computing linear extent of the methylene blue dye infiltration in millimeters in coronal-apical direction. To eliminate bias, two evaluators made independent assessments and a mean of their readings was considered as the final value. A stereo-microscope (Motic, Hong Kong) was used for visual analysis of sectioned specimens. Motic Image Plus 2.0 ML software was used for measurement of linear dye leakage in all study groups.

The cervical marginal microleakage was recorded as:

- S0 = no dye penetration,
- S1 = dye penetration limited to enamel,
- S2 = dye penetration beyond the dentino enamel junction but limited to two-third of the cervical wall length,
- S3 = dye penetration beyond two-third of the cervical wall length but not to the pulpal wall, and
- S4 = dye penetration to the pulpal wall.
Data was analyzed using SPSS version 16 (SPSS, Chicago, IL, USA). Descriptive analysis such as mean and standard deviations were calculated for the amount of dye leakage, whereas frequency of leakage was calculated from the grading system. The difference in mean of both groups was calculated using the ANOVA at a level of significance 0.001.

RESULTS

Group A demonstrated higher leakage value (2.42 ±0.79 mm) than Group B (1.01 ±0.45 mm, Figure 1). Between both groups was statistically significant (p < 0.001).

Table I represents the dye leakage in terms of scoring criteria mentioned in this study. About half of the samples of group B (n=40) exhibited grade 1 leakage (52.5%); however, the highest leakage of Group A (n=40) samples was of score 2 (n=15, 37.5%).

DISCUSSION

This in-vitro study evaluated the sealing performance of two different class II restorative techniques for restoring class II restorations with resin composite and SDR Material. The null hypothesis had to be rejected, as the SDR single step technique demonstrated significantly less dye penetration than the traditional incremental technique. This finding is in agreement with the outcome of a previous study of Reiss, in which the traditional incremental technique was reported to require greater operator skills and achieve poorer marginal adaptation. However, clinicians routinely use flowable resin composite in the cervical margins of class II resin restorations in association with the centripetal build-up technique.

The use of a relatively thick layer of a viscous bonding agent or a flowable resin composite has been advocated to absorb volumetric changes associated with polymerization. It is assumed that a low-viscosity material can fill irregular margins of proximal boxes. Flowable composites are recommended as liners beneath class II resin composite restorations due to their low viscosity, elasticity, and wettability. Additionally, these materials have a thermal expansion coefficient, similar to tooth tissue. Flowable composites exhibit a substantially lower modulus of elasticity that enables elastic deformation to absorb polymerization shrinkage stresses, reducing the tendency of open margins. This ability seems to be most important when the gingival margin of a restoration is placed in the absence of enamel, where a less stable cementum-dentin substrate for bonding is present. The majority of microleakage studies report greater dye tracer penetration in sites where the margin is in dentin, as compared with those located in enamel.

In this weak area, the SDR Novel technique probably permits a better seal, compared to the use of flowable resin composite, as minimal stress is created at the cervical margin. In the literature, the use of a flowable resin composite at the gingival margin is claimed to reduce stress by 18% - 50% and limit microleakage.

Microleakage studies can be realized as a part of an in-vitro screening of new adhesive restorative materials, preliminarily to clinical testing. It should be pointed out that laboratory data provides less reliable evidence than in-vivo trials. As a matter of fact, the contribution of microleakage to restoration failure remains controversial and the clinical relevance of interfacial dye penetration is still the object of discussion. No operative technique or adhesive system has been proven to prevent microleakage completely, and no correlation between gap with hand tracer penetration was reported in a recent laboratory study. In the current study, none of the specimens obtained with either restorative procedure was dye penetration completely impeded. Moreover, the methods of microleakage testing have not yet been standardized. As an example, different dye tracers are available for use in microleakage studies.

Methylene blue is one of the most common tracers and can be used in different concentrations, from 0.5% up to 5%. It was pointed out that, because of the small surface area of the particles (approximately 0.52 nm²), methylene blue may lead to an overestimation of leakage at the tooth-restoration interface, particularly with self-etch adhesives in relation to their increased hydrophilicity. It is also disputed, how many sections per tooth should be evaluated in dye penetration scoring. However, it is believed that the use of three cuts of one specimen may avoid under-estimation of in-vitro microleakage. Still another controversial issue is the...
dwellling time in the dye tracer. It has been reported that storage time in the tracer is not a relevant factor.\textsuperscript{21-25} Conversely, another study documented that longer dwelling periods can lead to over-diffusion of the tracer and higher microleakage scores. There is also no standardized protocol for thermocycling, as several different regimens have been proposed to simulate clinical function.\textsuperscript{18-25}

Hence, the result of this study confirms that the bulk (4mm) placement of low stress methacrylate resin with 2-3\% nanohybrid glass filler by weight fillers in combination with methacrylate based adhesives and composite performs, statistically better to that of the traditional, incrementally placed, 1 mm of flowable with packable composite. Observations under stereo-microscope showed a better marginal adaptation and less cervical voids in SDR novel technique specimens. However, use of a low stress flowable resin composite is to be restricted to areas free of occlusal contacts, such as cervical margins, due to the high wear rate of the material.

Limitations of this \textit{in-vitro} study were three-fold. Only vertical sectioning was performed in the mesial-distal direction. It has been suggested that a more accurate way to evaluate the total leakage is to completely remove the restoration and evaluate the total amount of leakage, as this can vary from different sections. Mechanical loading was also not done to simulate the intra-oral conditions. The present study utilized only materials from one manufacturer, which would be difficult to follow in a clinical setting. Since great variability exists in the material composition from one manufacturer to the other, the results cannot be generalized to include other combinations. Further studies would be beneficial in this regard.

**CONCLUSION**

Within the limitations of this \textit{in-vitro} study, it was concluded that SDR in combination with total etch technique at the cervical margin of class II restorations improved the marginal seal.

**REFERENCES**


