ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 7, Issue – 5, October – 2024, Page No. : 342 - 350

Microleakage in Class I Composite Resin Restorations With and Without Bevel– An in-Vitro Stereomicroscopic Study

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Citation of this Article: Dr. Arijit Nandy, Dr. Aditya Mitra, Dr. Trishagni Chaudhury, Dr. Abhisek Guria, "Microleakage in Class I Composite Resin Restorations With and Without Bevel– An in-Vitro Stereomicroscopic Study", IJDSIR- October – 2024, Volume –7, Issue - 5, P. No. 342 – 350.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim: To compare and evaluate the Cavosurface Microleakage at in class I composite resin restoration prepared with and without bevel.

Materials and Methods

40 freshly extracted intact human mandibular molar teeth are taken and are randomly assigned into 2 different groups to be restored with: Group A Nanohybrid composite-(Ivoclar Tetric N Ceram) and Group B Packable Composite- (3M Filtek P 60) (n=20 in each group). Standardised Class I Cavity preparation for composite resin restorations (6x2x2 mm dimensions) were prepared in all the samples. A buccal occlusal bevel of 0.5mm depth, 1mm width was given along the occlusal enamel cavosurface margins in 10 samples of each Group A and B (Groups A1 and B1, n=10 each). The rest of the samples (A2 and B2) had no occlusal bevel in them. Teeth in each group were restored with respective Composite resin and Light cured. Samples were coated with nail varnish on all surfaces except the occlusal restorative material area and immersed in Rhodamine B Dye for 24 hrs. Longitudinal sections were taken from all the samples and mounted on glass slides. Dye penetration at the composite resin-tooth

interface was evaluated and scores were assigned for all the samples under a stereomicroscope. Statistical Analysis of the data obtained was done using One-Way ANOVA test.

Results: 3M Filtek P 60 (Packable composite) with bevel (Group B1) showed the maximum microleakage followed by Ivoclar Tetric N Ceram (Nanohybrid composite) with Bevel (Group A1) and 3M Filltek P60 without Bevel (group B2) and least microleakage was seen in Ivoclar Tetric N Ceram Nanohybrid composite samples without occlusal bevel (Group A2).

Keywords: Cavosurface microleakage, Nanohybrid composite, Occlusal bevel, Packable composite

Introduction

The goal of restorative dentistry, undoubtedly, is to restore the tooth to its form and functions. One of the requisites of a restorative material is to adapt itself to cavity walls. Among the various restorative materials currently used, with tremendous improvements in means and technologies, none of the material could actually fully bond chemically with the tooth surface with a leak-free interface.

Good adhesion between the adhesive resin and the dental hard tissue is of utmost importance for the success of a composite resin restoration.

The gap left between the cavity walls and the restorative material plays an important role in the prognosis of the restorative treatments. In the past, pulpal reactions to dental procedures were thought to be induced by mechanical irritation, like heat, vibration, galvanism, etc. and/or chemical irritation by the restorative material and its components.

Various authors have demonstrated that the bacterial leakage was a greater threat to the pulp than the toxicity of restorative materials. Since then the concept of microleakage has drawn widespread attention. Different authors have termed 'leakage' as marginal percolation, liquid diffusion, fluid exchange, capillary penetration, etc.

Microleakage has been defined as the marginal permeability to bacterial, chemical, and molecular invasion at the tooth/material interface and is the result of a breakdown of the tooth–restoration interface, causing discoloration, recurrent caries, pulpal inflammation, and possible restoration replacement. [1]

The cavity–restoration interface is not a fixed, inert or an impenetrable border; but a dynamic microcrevice, which allows free movement of ions and molecules. It has been established that a minimum of 10.0 micro-metre space is left at the tooth– restoration interface even after employing the adhesive liners and materials.

Restorative margin collapse, cosmetic deterioration, secondary caries, pulpal pathosis and eventually the need to replace the restoration might result from marginal leakage around the margins.

A number of techniques and modifications in the material have been proposed to minimize polymerization shrinkage and microleakage. These include changes in filler content, use of expanding resin matrices, use of glass and fiber inserts and modifications in curing techniques like soft curing, dual curing, ramp and delayed curing. [2]

The benefit of a full thickness occlusal bevel at the enamel cavosurface margin in a Class I Cavity in reducing microleakage is still controversial and requires clarity.

The results of a study conducted by Shagun Patanjali et.al. demonstrated that enamel beveling and the self-etch adhesive system could eliminate microleakage in 35% of primary and 70% in permanent teeth. The use of an enamel bevel significantly resulted in a decrease in microleakage using the same adhesive system and the same tooth substrate (primary/permanent).

Beveling results in the removal of the aprismatic superficial enamel layer, which is also richer in the fluoride content, favoring the acid etching; increasing the free surface energy, favoring surface wetting; enhancing the surface area of exposed enamel; providing better marginal seal; better esthetic results; and improving the material retention. [3]

Now a days, according to several authors, incorporating a occlusal cavosurface bevel in Class I Composite restorations is contraindicated as it may result in thin composite on the occlusal surface in areas of potentially heavy contact which in turn leads to improper adhesion at the tooth-restoration interface resulting in failure of the restoration in the long run. Further due to the occlusal surface enamel rod direction, the ends of the enamel rods are already exposed by the preparation which further reduces the need for occlusal bevels. [4]

So this in-vitro study was done to judge the effect of occlusal cavosurface bevel in Class I composite resin restorations on the microleakage of two different composite resins.

Aim and Objectives

To compare and evaluate the Microleakage at Occlusal cavosurface margin with and without bevel in class I composite resin restorations using two different composite resins.

Materials and Methods

Forty freshly extracted human mandibular molars have been collected from Department of Oral and Maxillofacial Surgery for orthodontic and periodontal reasons. The extracted teeth were cleaned of calculus and soft-tissue remnants employing an ultrasonic scaler and were disinfected using 5.25 % sodium hypochlorite for at least 30 min and rinsed with distilled water. The teeth were stored in Thymol solution until use in a beaker. They were checked for abrasion, attrition, caries and other enamel defects. Every sample was wax-mounted. Standardised Class I cavity preparation of measurements of 6 mm for height, 2 mm for width, and 2 mm for depth were done in all the twenty samples. Full thickness enamel cavosurface bevel of 0.5mm depth and 1mm width was given using a Flame shaped diamond bur at 45 degree to the prepared walls in 20 samples. Samples were then divided into 2 groups with 2 subgroups in each.

Group A: Ivoclar Tetric N Ceram (n=20)

Group A1: Tetric N Ceram with Occlusal Bevel (n=10)

Group A2: Tetric N Ceram without Occlusal Bevel (n=10)

Group B: 3M Filtek P60 (n=20)

Group B1: Tetric N Ceram with Occlusal Bevel (n=10)

Group B2: Tetric N Ceram without Occlusal bevel (n=10)

37% phosphoric acid gel was used to etch onto the tooth surface for 15 seconds and then rinsed with water for 30-seconds. The surface was then blot dried and dentin bonding agent was applied and light cured for 20 seconds for all samples of Group A & B.

All samples were coated with nail polish except on occlusal restorative material, the samples were submerged in a 0.5% Rhodamine B solution for 24hrs. Samples were sectioned longitudinally and mounted on a slide.

Under a stereomicroscope with 20x magnification, sectioned restorations were inspected.

Table 1: Composition of the materials used in the in-vitro study:

Materials	Composition	Company
TETRIC -N -CERAM	**Monomer matrix-** Dimethacrylates (19-20 weight %) **Fillers** contain barium glass, ytterbium trifluoride, mixed oxide, copolymers **(80-82 weight %)** Additives, catalysts, stabilizers and pigments	Ivoclar Vivadent, Schaan, Liechtenstein
FILTEK P 60	Monomer matrix: **Bi-GMA, Bis-EMA, UDMA** Fillers: **Silica/Zirconia filler with mean particle size** 0.01-3.5 μm **Microns (61 wt%), aluminium oxide**	3M ESPE St. Paul,MN, USA
TE ECONOM BOND	HEMA, di and monomethacrylates, inorganic fillers, initiators, stabilizers in alcohol solution	Ivoclar Vivadent, Schaan, Liechtenstein
SINGLE BOND UNIVERSAL	MDP phosphate monomer, Dimethacrylate resins, HEMA, Vitrebond copolymer, filler, ethanol, water, initiators, silane	3M ESPE St. Paul,MN, USA

The depth of dye penetration was assessed using a 0–3 scale grading system.

Scoring System (by Shih et. al.):

Score 0: No dye penetration

Score 1: Dye penetration only to enamel

Score 2: Dye penetration to dentin but not to pulpal floor

Score 3: Dye penetration into pulpal floor or Axial wall

The stereomicroscope images showed that, to varying degrees, Rhodamine B dye penetration indicated microleakage in each specimen.

Results and Statistical Analysis

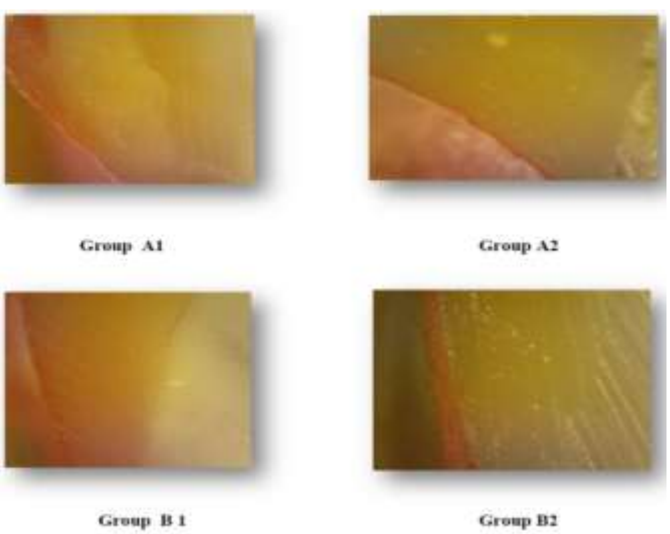


Figure 1: Stereomicroscopic Images of the Specimens

The values thus obtained were tabulated in a spreadsheet using Microsoft Excel 2019 and then statistical analysis was carried out using Prism for Windows, Version 9.5 (GraphPad Software, La Jolla California USA). A Shapiro-Wilk's test and a visual inspection of the histograms, normal Q-Q plots, and box plots showed that the collected data were approximately normally distributed for all the groups. Data were analyzed using the one-way ANOVA and the post-hoc Tukey's test. The *P* value of ≤0.05 was considered as the level of significance

Table 2: Descriptive statistics of the microleakage values for the study groups with and without bevel preparation

Resin Composite	Bevel given	Mean±S.D.	Median(IQR)	*P* value
Tetric-N-Ceram	Present(n=5)	2.4±0.548 a	2(2-3)	<0.0001**
	Absent(n=5)	0.6±0.548 b	1(0-1)	
Filtek P60	Present(n=5)	2.4±0.548 a	2(2-3)	
	Absent(n=5)	0.4±0.548 b	0(0-1)	

S.D.-: standard deviation; IQR: Inter-quartile range

n=number of samples per group

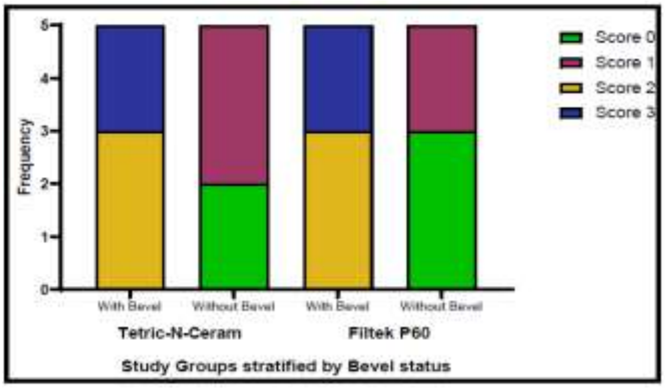
Total sample size=20; *n*: sample size per group

**: Statistically highly significant (*P*<0.01)

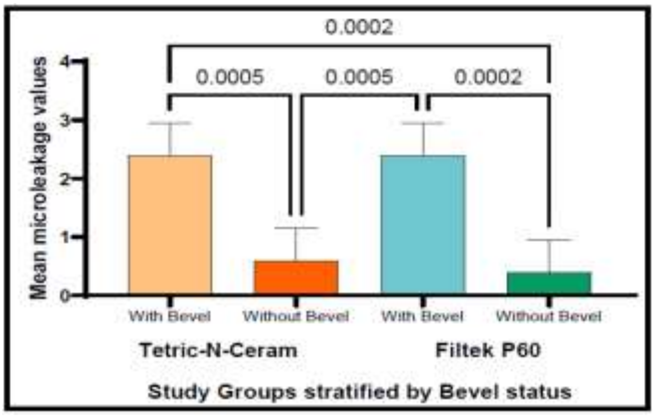
Different subscript letters denote a statistically significant difference (*P*<0.01)

It was observed that the highest amount of microleakage values were exhibited by both the composite resin groups with bevel preparation (2.4±0.548), followed by Tetric-N-Ceram without a bevel preparation(0.6±0.548) and the least by Filtek P60 without a bevel preparation (0.4±0.548)

The difference in the microleakage values was compared using the one-way ANOVA test which inferred that a significant difference existed for the follow-up time intervals [F (3, 16) = 20.2, *P*<0.0001]. Tukey's HSD test was carried out as a part of a *post-hoc analysis* and it indicated that there was a statistically significant difference between preparation consisting of a bevel and those without. Also, among the teeth without a bevel preparation, microleakage values in Filtek P-60 were significantly lesser when compared to Tetric N-Ceram (*P*<0.01)



Graph 1: Bar graph showing microleakage scores for the study groups with and without bevel preparation



Graph 2: Bar graph showing comparison of the microleakage values for the study groups with and without bevel preparation

Group A2 (Ivoclar Tetric N Ceram without Bevel) showed the least microleakage at the tooth-resin interface followed by Group B2 (3M Filtek P60 without Bevel) and Group A1 (Ivoclar Tetric N Ceram with bevel) and The highest degree of microleakage was demonstrated by Group B1 (3M Filtek P60 with Bevel) which was statistically significant. ($p<0.05$)

Discussion

Microleakage in composite resin restorations can be a significant concern as it can lead to various complications and compromises the longevity of the restoration.

Microleakage refers to the passage of bacteria, fluids, molecules, or ions between a dental cavity wall and the restorative materials placed to repair the tooth. It occurs when there is imperfect adhesion or bonding between the dental restoration (such as a filling or crown) and the natural tooth structure. Dentists strive to minimize microleakage by using techniques and materials that promote strong adhesion between the restoration and the tooth structure. [5]

Some measures to reduce microleakage around composite resin restorations include:

1. Choosing the composite resin: Microfilled composites provide better adaptation over macrofilled resins due to the greater flexibility of the microfillers during polymerization shrinkage decreasing the contraction forces that tend to weaken the dentinal bond.
2. Proper cavity design: Avoiding extensive preparations and opting for conservative designs, placement of bevels, reduced depths and rounded internal line angles reduce leakage.
3. Proper acid etching and bonding raises surface energy and reactivity of enamel and increases surface area for bonding allowing polymer tags to create micromechanical interlocking to reduce leakage.
4. Soft start polymerization with prolonged curing time reduces marginal gap and improves marginal integrity. [6]

Composite resins have been successfully used for dental restoration for over 50 years but polymerization shrinkage is still the major drawback. Polymerization shrinkage results in volumetric contraction, causing stresses in bonded restorations that can lead to deformation of the cusps, microleakage, decrease of marginal adaptation, enamel microcracks and postoperative sensitivity. [7]

The Tetric N-Ceram resin composite utilized in the study contains camphoroquinone as the main photoactivator, which absorbs blue wavelengths ranging from 420 to 495 nm, the Tetric N-Ceram resin composite is classified as a nano-hybrid, medium viscosity bulk fill material.

"Nano-hybrid" indicates that the composite contains nanoscale filler particles dispersed within the resin matrix.

The Tetric N-Ceram resin composite contains a patented light activator called Ivocerin. Ivocerin ensures the complete curing of the filling material when exposed to the appropriate curing light thus reducing microleakage. As a result, the Tetric N-Ceram resin composite developed several advantages such as efficient curing, esthetic properties, and good handling characteristics for class I restorations. [8]

The amount of filler particles incorporated into a restorative material can influence its strength, modulus of elasticity, and ability to reduce polymerization shrinkage.

These factors, in turn, can impact the degree of marginal leakage observed in dental restorations. [9]

Microleakage is three-dimensional phenomenon and is important to control and reduce its extent which can done with help of nanomaterial. [10]

Tetric N Ceram Nanohybrid composite resin has Nanofillers (80-81 weight%) distributed in resin matrix which leaves fewer spaces between adjacent particles and thus produces higher strength & Modulus of Elasticity and Reduces shrinkage when compared to 3M Filtek P60 Microhybrid composite resin.

Tetric N Ceram Nanohybrid composite exhibits Polymerization shrinkage of 2.09% due to its prepolymers and special shrinkage stress relievers.

The difference in volumetric shrinkage between dimethacrylate-based nanohybrid composite resin and Microhybrid composite resin ranges from 2% to 6%. This difference occurs because the matrix type of nanohybrid composite resin consists of conventional monomers such as Bis-GMA (bisphenol A-glycidyl methacrylate).

Nanohybrid composite resins contain filler material of different particle sizes. This difference in filler size causes the distribution of homogeneous fillers in the matrix. This composite contains two forms of nanoparticles: Single nanomers and nanoclusters. Single nanomers are individual particles that are generally round in shape and are usually 1 µm in size. Nanomeric particles are 20-75-nm-sized non-aggregated silica particles with uniform distribution. Nanoclusters are collections of single nanomers that range in size from 2 to 20 nm. Clusters have micron-sized porosities that are infiltrated by silane coupling agents, so that chemical bonding to the organic matrix is established. [11]

The nanoclusters offer better reinforcing action compared with the microfilled or nanohybrid systems. The filler particles can reach 69% by volume and 84% by weight, reducing shrinkage during polymerization. Nanocomposites has low polymerization shrinkage. [12]

Recently, a new composite resin 3M Filtek P60 has been developed. It uses blocks of siloxanes and oxiranes to provide a biocompatible, hydrophobic, low-shrinking silorane as base. In these resins, polymerization takes place by cationic ‘ring-opening’ mechanism resulting in minimal polymerization shrinkage of 1.8% after 5minutes and 2% after 30minutes. [13]

It reduces the disadvantages faced during use of methacrylate based material. Efforts made to improve the clinical efficiency and eliminate internal stresses formed during polymerization of methacrylate-based composite resins have led to the creation of new monomers such as siloranes and new nanoparticle fillers.[14]

Silorane-based composite resins are formed by reactions between oxirane and siloxane molecules; this type of composite resin has the capability of the polymerization reaction in the form of ring opening; therefore, the polymerization shrinkage is minimal. In addition, presence of siloxane results in a lack of solubility in the oral fluids and hydrophobic properties of the material increases. [15]

While the methacrylate-based composites exhibit 2.3-3% of volumetric shrinkage, this rate has been reported to be approximately 0.9% for silorane-based composite resin, which results in less stress on the cavity walls. [16]

According to a study by Tapan Satish Yeolekar et.al.(2015), Microleakage of Microhybrid low shrink silorane based composite resin had lesser polymerization shrinkage than other composites and compomers. The probable reason for less polymerization shrinkage and therefore lesser microleakage can be attributed to silorane system which uses 'ring opening polymerization' instead of free radical polymerization of dimethacrylate monomers. [17]

According to a study by Kazem Khosravi et.al.(2015),[18] silorane-based composite resin showed the lowest scores of microleakage at 24-h, it was not able to fully prevent microleakage, consistent with the results of a study by Bogra et al. [19]

In addition, in a study conducted by Usha et al. silorane-based composite resin, regardless of the method used to repair Class V cavities (split incremental approach or oblique incremental), showed some microleakage. [20]

Silorane-based dental composites showed the best results at the end of the aging period. This is probably due to their unique and low-shrinkage matrix and presence of fillers in the adhesive system. This filler containing adhesive creates the relatively strong hybrid layer which provides hydrolytic stability in the long term. In silorane adhesive system, the primer and bonding component are separately light-cured; in order to match with the hydrophobic silorane composite resin, the bonding agent has hydrophobic bifunctional monomers in its composition.

Water absorption in silorane composite resin is less than that in conventional methacrylate-based composites because hydrophobic siloxane backbone can be effective in reducing the washing and removal of unpolymerized monomer from the resin matrix. [21]

Silorane light polymerization is cationic and has a greater affinity for oxygen compared to free radical polymerization and does not form an air-inhibited layer. Therefore, not only polymerization shrinkage decreases, but also due to this effect, the degree of conversion in silorane adhesive component increases. [22]

Extension of enamel cavosurface bevel helps to improve the enamel peripheral seal by preventing the formation of marginal gaps due to polymerization contraction stresses at the resin–dentin interface, thereby improving the performance of restorations. An additional benefit of beveling is that the bevel provides a greater marginal surface to compensate for polymerization shrinkage, which will help to reduce microleakage. [23]

Swanson et al. supported that beveling the margins of all nonstress-bearing composite restorations reduces marginal microleakage in teeth, and margin beveling has a greater effect on minimizing microleakage than the type of adhesive used. [24]

Due to the occlusal surface enamel rod direction, the ends of the enamel rods already are exposed by the preparation which further reduces the need for occlusal bevels. Occlusal beveling may possibly extend the material to load bearing areas. Beveling also reduces the adaptation quality of a restoration at the tooth-restoration interface. It may result in thin composite on the occlusal surface in areas of potentially heavy contact which may lead to difficulty in adhesion of composite resins to tooth structure & these areas may be difficult to finish. [25] Due to these reasons, the beveled composite restoration samples might have resulted in more microleakage than the ones left unbeveled.

To summarise, The beveled composite groups has shown more microleakage than the unbeveled ones among which Microhybrid composite 3M Filtek P60 demonstrated maximum leakage. Among the two composite resins, Nanohybrid Composite resin Tetric N Ceram has demonstrated the lowest microleakage at the tooth-restoration interface

Conclusion

Among the various restorative materials available commercially, there is not a single material which can actually fully bond chemically with the tooth surface with a leak-free surface. All materials exhibit some degree of microleakage.

In restorative dentistry, choosing the correct material of choice according to the clinical scenario is one of the primary variables that determines the success. Microleakage is one of the factors that affects the performance of the material in the oral environment.

Tetric N Ceram Nanohybrid composite (Ivoclar) has exhibited lower microleakage than 3M Filtek P60 Microhybrid composite. Also the samples with unbevelled occlusal cavosurface margins has exhibited lower microleakage than the ones with bevelled margins.

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