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 – 4, August – 2024, Page No. : 99 - 105

Comparative Evaluation of Adaptation & Microleakage of Light Cured Resin Composite When Placed Over Bioactive Liners - An Invitro Study

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Citation of this Article: Dr. Vidhyamol V, Dr. Sapna Konde, Dr. Sahana Prasad, Dr. Swathi K, Dr. Manisha Agarwal, Dr.Ruthuparna Shaji, "Comparative Evaluation of Adaptation & Microleakage of Light Cured Resin Composite When Placed Over Bioactive Liners - An Invitro Study", IJDSIR- August – 2024, Volume –7, Issue - 4, P. No. 99 – 105.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Introduction: Use of a liner under composite restorations could provide better cavity adaptation with less gap formation, as a stress-absorbing layer and decrease the polymerization shrinkage at the tooth-restoration interface. This study aimed to compare and evaluate surface adaptation, marginal adaptation and microleakage of bioactive liners viz. BIODENTINE, THERACAL LC, VITREBOND LC and DYCAL with nanohybrid composite resin

Method: Class V cavity design was prepared on the buccal surface of 48 extracted human premolars. These samples were randomly divided into four groups of 12 teeth each based on the liner used and were restored with nanohybrid composite. Samples were then stored in normal saline until subjected to Micro CT analysis to evaluate surface and marginal adaptation. They also underwent dye penetration test using stereomicroscope to evaluate microleakage.

Result: Biodentine group showed significantly higher surface and marginal adaptation as well as least microleakage compared to other study groups. Biodentine was followed by Theracal LC, Vitrebond LC and Dycal. There was no significant difference between Theracal LC and Vitrebond LC. Dycal showed the least surface and marginal adaptation and highest microleakage score.

Conclusion: The results suggests that Biodentine is a promising liner, that can be used under composite restoration.

Keywords: Bioactive materials, Biodentine, Dycal, Theracal LC, Vitrebond LC

Introduction

Resin composites have been gaining increasing popularity over the past few decades because of its favourable aesthetic and mechanical properties. However, success of light cure composite resins depends on perfect marginal adaptation to cavity walls and gap free internal bond between composite resin and dentin.1 An intermediate liner application with a low elastic modulus has been recommended to reduce polymerization shrinkage as well as gap formation of composite resins.2 Hence, aim of this study is to compare and evaluate surface adaptation, marginal adaptation and microleakage of bioactive liners viz. BIODENTINE, THERACAL LC, VITREBOND LC and DYCAL with nanohybrid composite resin.

Materials and Method

Inclusion Criteria

- Teeth should have completely formed root apices.
- Teeth extracted for orthodontic reasons.
- Teeth with no cracks, fractures, caries, calcifications or fused roots.

Exclusion Criteria

- Teeth with dental caries, calcifications, immature apex, fused roots and fractured teeth.
- Teeth which were restored.
- Teeth with developmental anomalies

48 extracted human premolars fulfilling the selection criteria was cleaned in running water and stored in normal saline at room temperature. Class V cavity design was prepared on the buccal surface of these teeth with 330 carbide bur using aerotor hand piece. Approximate dimensions of cavity were 5 mm mesiodistal width, 3 mm occlusal -gingival height and 1.5 mm axial depth. Williams probe was used to check the depth of preparation. Samples were then randomly divided into four groups of 12 teeth each (n=12). Different liners(as mentioned below) were placed on the floor of cavities and restored with nanohybrid composite.

Group 1 - Biodentine. group

Group 2 - Theracal LC group

Group 3 - Vitrebond LC group

Group 4 - Dycal group

The samples were stored in normal saline until subjected to Micro CT evaluation to assess surface adaptation of following interfaces-between dentin and liner, liner and composite, liner and surrounding dentin at margins.

Micro-Ct Evaluation

Each tooth sample was mounted on the scanning platform of Micro CT vertically. The teeth were scanned using a high-resolution Micro CT system (MI labs). The tube current and voltage was 0.24 mA and 50 kV respectively. Scan angle was set at full and scan mode was normal. Image formed with scanner was then reconstructed using 3D reconstruction software by MI labs. The actual values of gap was calculated from the margin of the cavity to the liner, between composite and liner, using the Imaging program software (Image J software and Image Analytical software). Ten points of maximum gaps in each sample, between liner and dentin, composite and liner was selected and measured using Image J software. Marginal gap of liner and surrounding dentin was measured in each sample. The mean of each sample from each group was noted and subjected to statistical analysis.

Dye Penetration Test Using Stereomicroscope

The samples were then subjected to dye penetration test using stereomicroscope to evaluate microleakage. All surfaces of teeth were covered with nail varnish except the restored area and 1mm around it. Varnished area of the sample was then covered with a thin layer of sticky wax. Prepared samples were immersed in 2% methylene blue dye and stored in an incubator at 37°C for 72 hrs. After removal from the dye solution, they were thoroughly washed under tap water. Varnish and sticky wax coating was then removed with a scalpel blade and sectioned into halves along their long axis (including restoration) using diamond disc. These sections was mounted on glass microscopic slides and depth of dye penetration was assessed using Stereomicroscope of magnification 40x. The amount of microleakage was evaluated according to Scoring criteria for micro leakage given by Pop off et al.[3]

Scoring Criteria

Score 0 = No dye penetration

Score 1 = Dye penetration limited to enamel

Score 2 = Dye penetration beyond DEJ but limited to 2/3rds of the cervical wall length

Score 3 = Dye penetration beyond 2/3rds of the cervical wall length but not to the pulpal wall

Score 4 = Dye penetration to the pulpal wall

Statistical Analysis

One-way ANOVA test followed by Tukey's post hoc analysis was used to compare the mean volume of marginal gap between 4 groups. Kruskal Wallis test followed by Mann Whitney Post hoc test was used to compare the mean micro leakage scores between 4 groups. The level of significance [P-Value] was set at $P < 0.005$.

Results

Table 1 compares mean surface gap between composite and liner in all four groups. The mean surface gap between Composite & Biodentine was 0.0747 ± 0.0128, Theracal LC was 0.1732 ± 0.0149, Vitrebond LC was 0.1854 ± 0.0138 & Dycal was 0.2363 ± 0.0267. The difference between the 4 groups was statistically significant at $p<0.001$.

Table 2 compares mean surface gap between Liner and Dentine in all four groups. The mean surface gap between dentine and Biodentine was 0.0106 ± 0.0205, Theracal LC was 0.0608 ± 0.0167, Vitrebond LC was 0.0763 ± 0.0192 & Dycal was 0.1082 ± 0.0146. The difference between all 4 groups was statistically significant at $p<0.001$.

Table 3 compares mean marginal gap between Dentinal wall and liner among all four groups. The mean margnal gap between Dentinal Wall and Biodentine was 0.0556 ± 0.0185, Theracal LC was 0.0928 ± 0.0106, Vitrebond LC was 0.1103 ± 0.0307 & Dycal was 0.1343 ± 0.0128. The difference in mean marginal gap between 4 groups was statistically significant at $p<0.001$.

Table 4 compares the mean microleakage scores in all four groups. The mean microleakage scores in Biodentine was 1.00 ± 0.74, Theracal LC was 2.50 ± 0.91, Vitrebond LC was 2.75 ± 0.97 & Dycal was 3.75 ± 0.45. The difference between the 4 groups was statistically significant at $p<0.001$.

Discussion

Visible light polymerizing composite resins contract during photo polymerization, causing dimensional changes called polymerization shrinkage.[4] Zero polymerization shrinkage is crucial for dental restoratives to prevent debonding or fracture. Low elastic modulus/low viscosity liners can improve cavity adaptation and reduce polymerization shrinkage.[5] Hence bioactive liners viz. BIODENTINE, THERACAL LC, VITREBOND LC and DYCAL with nanohybrid composite resin were assessed for their surface adaptation, marginal adaptation and microleakage. Nanohybrid resin composite restorations are most popular, as they improve the distribution of fillers in matrix by combining nanoparticles with submicron particles to achieve better mechanical, chemical, and optical properties.[6]

Calcium hydroxide (Dycal) has been used as a liner and is considered as gold standard for a long time and enjoys the greatest popularity among general dentists. RMGIs (Vitrebond LC) have shown improved seal over conventional glass ionomer liner due to its ability to adhere immediately to dentin. The most common bioactive materials used for restorative dentistry are calcium silicate cements. Biodentine (Septodont, Saint-Maur-des-Fosses, France), Thera Cal (Bisco, Schamburg, IL, USA) are examples of new commercially available calcium silicate cements. They set with water, are dimensionally stable, and form alkaline hydroxide within the hydrated cement matrix.[7]

Liners were applied to the dentine surface without prior etching. Camilleri J. et al in their study showed that acid etching of liners might degrade the microstructure and could cause leakage through the biomaterial-composite interface.[8] In the present study etching was done only on dentinal walls and not on liner surface. Abdullah HA et al stated that a reliable bonding system is beneficial as it increases shear bond strength.[9] This study used 2 layers of Fusion BOND 5 over the liner.

Present study used Micro CT for Gap width grading to evaluate surface and marginal adaptation of various liners under composite restoration. It is a non-destructive approach, where the same sample can be tested several times.[10] In addition it facilitates more precise measurements. However, it does have the disadvantage of high cost, long scanning and reconstruction time.[11]

Dye penetration for microleakage assessment was done as it has the ability to detect marginal discrepancies. However, it does have the disadvantages of specimen destruction, partial analysis of the interface due to the cutting procedure & non standardized methodology. [12]

Present study showed that Biodentine had the least surface gap, marginal gap as well as microleakage followed by Theracal LC, Vitrebond LC and Dycal. There was no statistically significant difference between Theracal LC and Vitrebond LC.

Biodentine group had a significant lower surface gap than all liners. Hashem et al stated that 10-MDP monomer of adhesive may bind chemically to the calcium in Biodentine hence promoting chemical adhesion in addition to micromechanical attachment between Composite and Biodentine.[13]

A combination of the chemical bond and a micromechanical anchorage provided by the infiltration of cement tags into the dentinal tubules are believed to be responsible for bonding of Biodentine to dentine.[14]

Atmeh AR et al in their study confirmed confocal images of the Biodentine samples that showed an interfacial layer within the structure of dentin, just beneath the cement. This layer, was called by them as the “mineral infiltration zone” (MIZ). It was confirmed by SEM micrographs that showed a band of structurally altered dentin, rich with carbonate ions due to intertubular diffusion of carbonate immediately beneath the Biodentine. [15]

As Theracal and Vitrebond are resin-based light cure cements they attain early cohesive strength on photo activation. HEMA incorporated into the TLC and RM-GIC forms a chemical bond with the resin of the composite. Additional chemical union is due to copolymerization of unreacted methacrylate groups present in the oxygen-inhibited layer of TLC/RMGIC with those of composite resin. The resin bonding agent intermixes with both composite and TLC/RMGIC by true chemical bonding to create a strong interface.[16] Present study showed no statistically significant difference was seen between Theracal LC and Vitrebond LC.

TheraCal LC is reported to have an apatite-forming ability.[7] This ability could contribute to the chemical bond to dentine. Dentinal fluids absorbed, results in the release of calcium and hydroxide ions, to form apatite crystals which further penetrates into the dentin, thereby increasing the bond of the material.

An incomplete hydration, insufficient diffusion of moisture from the dentin-pulp complex and inclusion of resin (cause shrinkage after light-curing polymerization) could be the cause of lower adaptation in Thera Cal as compared to Biodentine. [17,18]

Combination of predictable bonding with protection of high fluoride release, tolerance to moisture contamination and minimal postoperative sensitivity have made Vitrebond LC attractive for use and provided a good seal to dentin.[19] Fukuda R et al have demonstrated chemical bonding of RMGI to HAP crystals in enamel and dentin by X-ray photo electron spectroscopy (XPS), while Watson TF have demonstrated the ability of these materials to bond micromechanically and form hybrid layers by confocal microscopy. [20]

According to Roshni et al, both Theracal LC and Vitrebond LC are equivalent to each other in terms of feasibility and cost-effectiveness but Thera Cal LC is preferred due to better handling and ease of use thereby reducing treatment time. [21]

Dycal showed least surface adaptation to composite and dentine. N. Sultana et al stated that since Dycal lacks the resin content in its structure and its bond to resin composite is totally micromechanical, indicating that penetration and interlocking of the adhesive systems into the surface irregularities play a crucial role in bonding.[22]

Unfavorable effects of calcium hydroxide, such as the weak physical properties, tunnel defects, high solubility, and gradual dissolution has led to a decline in its use as a liner with time. John et al stated that Dycal as a liner showed marked gaps with dentin[1]

Results of the present study showed Biodentine had the least microleakage with excellent adaptation.

However, there are a few limitations in this study. As it was an invitro study, it is necessary to conduct a few invivo studies to discern the clinical efficacy of these materials as many confounding factors can affect its clinical performance.

Conclusion

Among various bioactive liners assessed biodentine showed excellent adaptation with least microleakage. Biodentine with its combination of chemical bond and micromechanical anchorage adheres well with both dentin and composite, thus can be used as an ideal lining material.

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Legend Tables

Table 1:

Table 1 Comparison of mean Surface gap (in mm) between Composite and Liner between 4 groups using One-way ANOVA Test

Groups	N	Mean	SD	Min	Max	p-value
Group 1	12	0.0747	0.0128	0.059	0.099	<0.001*
Group 2	12	0.1732	0.0149	0.140	0.190	
Group 3	12	0.1854	0.0138	0.168	0.210	
Group 4	12	0.2363	0.0267	0.200	0.290	

Table 2:

Table 2 Comparison of mean Surface gap (in mm) between Liner and Dentine between 4 groups using One-way ANOVA Test

Groups	N	Mean	SD	Min	Max	p-value
Group 1	12	0.0106	0.0205	0.002	0.075	<0.001*
Group 2	12	0.0608	0.0167	0.038	0.085	
Group 3	12	0.0763	0.0192	0.050	0.102	
Group 4	12	0.1082	0.0146	0.086	0.130	

Table 3:

Table 3 Comparison of mean Marginal gap between Liner and Dentinal Wall (in mm) between 4 groups using One-way ANOVA Test

Groups	N	Mean	SD	Min	Max	p-value
Group 1	12	0.0556	0.0185	0.033	0.090	<0.001*
Group 2	12	0.0928	0.0106	0.076	0.112	
Group 3	12	0.1103	0.0307	0.078	0.185	
Group 4	12	0.1343	0.0128	0.116	0.158	

Table 4:

TABLE 4 Comparison of mean Microleakage scores between 4 groups using Kruskal Wallis Test

Groups	N	Mean	SD	Min	Max	p-value
Group 1	12	1.00	0.74	0.0	2.0	<0.001*
Group 2	12	2.50	0.91	1.0	4.0	
Group 3	12	2.75	0.97	1.0	4.0	
Group 4	12	3.75	0.45	3.0	4.0	