COMPARATIVE EVALUATION OF MARGINAL ADAPTABILITY OF FIBER REINFORCED COMPOSITES AND NANOHYBRID COMPOSITE RESINS USING BULK FILL AND LAYERING TECHNIQUES: IN-VITRO SEM ANALYSIS

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ABSTRACT

Background: Resin based composites are possibly the most universal material available in dentistry as they are used in huge variety of clinical application. Composite resins have their own disadvantages out of which the primary disadvantage of using composite resins is polymerization shrinkage. The growth of bacteria, secondary caries and pulpal damage or marginal imperfections may occur at the site of gap formation. There are only fewer studies comparing marginal adaptation of newer composite material with different restorative technique. There for this study was undertaken to analyse and compare marginal adaptation of fiber-reinforced and nanohybrid composite resins in layering and bulk filling placement technique.

Aim: Compare marginal adaptability of fiber-reinforced and Nanohybrid composite resin placed using layering and bulk placement technique.

Objective: SEM dimensional analysis of marginal adaptability of class I restoration with fiber reinforced and nanohybrid composite resin in extracted maxillary premolars with layering and bulk filling restorative technique.

Methods: Teeth collected Were stored in 0.9% saline.Standardised class I cavities were prepared in collected maxillary premolar teeth using 245 tungsten carbide bur. The teeth randomly divided in to four groups (20 each) . Group 1A - restored with fiber-reinforced composite in layering technique, Group 1B- restored with fiber reinforced composite in bulk filling technique, Group 2A- restored with nanohybrid composite in layering technique, and Group 2B - restored with nanohybrid composite in bulk filling technique. After the preparation of each tooth, the cavity was dried using gentle air blast. Phosphoric acid etchant gel 37% was applied to the enamel and dentin, and left for 15 seconds. After that it was washed with water spray for 10 seconds and air dried by oil free compressed air. 3M Adper bonding agent was applied to the etched enamel and dentin using a disposable applicator tip for 20 seconds. The excess was gently air thinned for 5 seconds until a uniform glossy appearance was obtained. Then bonding agent was light cured, for 10 seconds with a light curing unit.

Results: Mean width of the gap was found to be least in group 1A (1.4970µm) samples ie. The fiber-reinforced composite in layering technique found to be maximum when compared with Nanohybrid composite. The incremental layering technique enhanced the marginal adaptation in all the samples in subgroup IA, IIA. Marginal adaptation of fiber reinforced composite in layering technique found to be maximum when compared to other group. Marginal adaptation of Nanohybrid composite in bulk filling technique found to be minimum among the groups.

INTRODUCTION

An important milestone in the history of modern restorative dentistry is the composite resins. Their development in the 1970s heralded a period of rapid progress in the field of colored restorations.[1] Light cured Dental composite are the material of choice for most patients and dental practitioners for direct restoration based on their superior esthetics, ease of use, higher potential of bonding to tooth structure, and their improved mechanical properties. However these materials have impediments related to marginal integrity and leakage due to polymerization shrinkage. [2] Composite resins are
widely used to repair decayed or damaged teeth because of their superior properties compared to other restorative material. However during setting or polymerization the resin composite shrinks, producing shrinkage stresses. If the internal shrinkage stress is high enough debonding will occur causing problem such as increased microleakage and reduced fracture resistance.[6] The magnitude of the stress depends on several factors including composite resin material, resin modulus of elasticity, irradiation time and intensity, elasticity of dentine and enamel substructure, rate of polymerization, restorative technique used as well as cavity configuration factor.[4] Clinical studies have identified the loss of interfacial integrity is one of the main cause for composite restoration failure.[7]

In any repair of tooth with permanent restorative material, the interface is always a sensitive region. [5] Good marginal adaptation is an important issue for the long term success of restoration.[6] Good marginal seal decreases the micro leakage, post-operative sensitivity, secondary caries and thus increases the longevity of restoration.[5] Dentist and researchers are aware of the adverse effects of composite resin polymerization shrinkage stresses. Several efforts have been made to decrease the stresses. These efforts were directed towards improving composite resin formulation, photo curing method and restorative placement technique, as a result of these newer materials and method evolved, to enhance the interfacial integrity of the restoration.[4]

The newly evolved particulate filler composite resin enables the clinician to cover a much larger spectrum of restorative indications. The ability to bond particulate filler composite to tooth structure makes it as a desirable material to use. The fiber reinforced composite have highly favorable mechanical properties.[7] Fiber reinforced composite restorations are resin based restorations containing fibers aimed at enhancing their physical properties. Fiber inserts increases the quality of marginal zone providing improved marginal seal.[8]

The recent application of science of nanotechnology to the field of dentistry has resulted in development of resin materials with more favorable mechanical properties. The term nanotechnology refers to the science of producing functional materials and structures in the size range of 0.1 to 100 nanometers by using various chemical and physical processes, the materials microstructure modified by arranging individual atom and molecules. The application of nanotechnology to the field of dentistry resulted in dental composite resin with greatly improved, physical, mechanical, esthetic and optical properties. More filler can be accommodated if smaller particles are used for particle packing. Theoretically, with the use of nanofillers, filler levels could be as much as 90 - 95% by weight. However, the increase in nanofillers also increases the surface area of the filler particles that limits the total amount of filler particles, because of the wettability of the fillers. Since polymerization shrinkage is mainly because of the resin matrix, the increase in filler level results in a lower amount of resin in Nanohybrid composite and will also significantly reduce polymerization shrinkage and dramatically improve its physical properties. Nanohybrid composite today serves as universal restorative material in the anterior and posterior region.[9]

The insertion method of the resin into the cavity is important regarding the stress created on it to reduce shrinkage stress effects, different restorative technique have been suggested. Marginal adaptation mostly influenced by Restorative placement techniques. Also, the stress distribution in the restoration and tooth tissues is strongly dependent on a shape of the filling layers.[10] When applying the bulk filling technique, a composite resin placed in to the cavity in a single layer, in up to thickness of 4mm. following the formation of masticatory surface, the whole filling is cured with light.[11] Incremental layering placement technique are widely recognized as a major factor in the reduction of shrinkage stresses, these technique include, horizontal, oblique and vertical. Incremental oblique technique accomplished by placing a series of wedge shaped composite increment, each increment photo cured. This technique reduces the C-factor and prevents distortion of walls.[4] Studies demonstrated that incremental placement technique definitely reduces microleakage when compared to bulk technique.[12]

The purpose of the study was to compare and evaluate the marginal adaptation of two newer composite resin restorative materials in two different restorative placement techniques.

**METHODOLOGY**

**MATERIALS**

Selection of samples

80 freshly extracted human maxillary premolar were used in the study.

**Inclusion criteria**

- Freshly extracted
- Intact
- Non carious
- Extracted for orthodontic reason

**Exclusion criteria**

- Teeth with caries
- Fracture
- Previous restorations
- Endodontically treated tooth

**List of Materials**

- Fiber-reinforced composite (ever-x posterior)
- Nanohybrid composite (3M filtek supreme)
- Etchant (3M ESPE ScotchbondTM Universal)
- Bonding agent (3M ESPE Adper)
- Normal saline solution 0.9%

**List of Instruments**

1. Micromotor hand piece (NSK, Japan)
2. Aiotor hand piece (NSK, Japan)
3. Diamond disc
4. 245 tungsten carbide bur
5. Curing light (3M ESPE eliparTM 2500)
6. Gold auto fine sputter coater (HITACHI E-1010)
7. Scanning Electron Microscope (HITACHI E–SU6600)

METHODOLOGY

80 extracted maxillary premolar teeth, extracted for orthodontic reason collected by purposive sampling technique. Teeth cleaned off tissue fragments, visible debris using ultrasonic scaler and stored in 0.9% saline. Standardized Class 1 cavities prepared on occlusal surface of teeth with depth of 1.5 mm and width 1 mm using 245 tungsten carbide bur, high speed airrotor hand piece and copious air water spray.

The 80 teeth randomly divided in to four groups (20 each)

Group 1A—restored with fiber reinforced composite in layering technique.
Group 1B—restored with fiber reinforced composite in bulk filling technique.
Group 1IA—restored with nanohybrid composite in layering technique.
Group 1IB—restored with nanohybrid composite in bulk filling technique.

After the preparation of each tooth, the cavity was dried using gentle air blast. Phosphoric acid etchant gel 37% was applied to the enamel and dentin, and left for 15 seconds. After that it was washed with water spray for 10 seconds and air dried by oil free compressed air. Excess water was removed without over drying the dentin. 3M Adper bonding agent was applied to the etched enamel and dentin using a disposable applicator tip for 20 seconds. The excess was gently air thinned for 5 seconds until a uniform glossy appearance was obtained. Then bonding agent was light cured, for 10 seconds with a light curing unit (3M ESPE EliparTM 2500). Oblique layering technique was performed using 3M ESPE EliparTM 2500 Halogen curing unit. Two reference points taken. Point A apical and point B coronal respectively. The sections were dehydrated by a series of graded ethanol solutions and then coated with a gold layer in an Auto Fine Sputter Coater (Hitachi E-1010) after drying. The selected points were viewed under SEM (HITACHI E–SU6600) at 1000X magnification.

Marginal adaptation was assessed by measuring the gap between the tooth and restoration. Statistical analysis was performed using TWO WAY ANOVA and the results were obtained.

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Sample Analysis
RESULTS

Mean width of the gap was found to be least in group 1A (1.4970 µm) samples ie. The fiber-reinforced in layering technique. This was followed by group 1B (5.1120 µm) (fiber-reinforced in bulk fill technique), group 2A (10.1850 µm) (Nanohybrid composite in layering technique) with group 2B (18.2935 µm) exhibiting the largest values (Nanohybrid composite in bulk fill technique). The values were compared statistically using ANOVA and found to be significant with $p < 0.05$.

DISCUSSION

Direct composites have become increasingly popular as tooth-colored restorations for extensive lesions in posterior teeth. Adaptation of the restorative material to cavity margins (marginal adaptation) and internal cavity surfaces (internal adaptation) is crucial for the long-term performance of any restoration. [16] The composition of resin based dental composites has evolved significantly since the materials were introduced to dentistry more than 50 years ago[17]. Composites are widely used to repair decayed or damaged teeth because of their superior esthetics, ease of use and ability to bond to tooth tissue.[3] The advantages of using composite resins are: esthetics, minimum tooth preparation, micromechanical bonding to tooth structure resulting in good adhesion, very low thermal conductivity, extended working time, reparability and ability to be polished in the same appointment.[17]

Composite resins have their own disadvantages out of which the primary disadvantage of using composite resins is polymerization shrinkage. The procedure is technique sensitive and time consuming. Composite resins also have a high coefficient of thermal expansion so if bonding is inadequate it may lead to micro leakage. Amongst all the disadvantages the primary concern is polymerization shrinkage. Polymerization shrinkage is the pulling away of the material from the cavity walls during polymerization due to shrinkage of the composite resin. During polymerization or setting the resin shrinks, producing shrinkage stress with in tooth and composite. [17] If the internal shrinkage stress is high enough, debonding between tooth and restoration will occur.[3] This process is responsible for the formation of a gap between the composite resin restoration and the cavity wall. The gap may vary from 1.67 to 5.68 % of the total volume of restoration. The gap formed leads to ingress of oral fluids and bacteria that are responsible for hypersensitivity, staining at the margins and recurrent caries.[17]. Clinical studies identified loss of interfacial integrity is one of the main causes for replacement of composite restoration.[3]
Polymerization shrinkage stress is the exothermic reaction created when monomer converts to polymer. As the polymer formed, the resin matrix changes from a paste or pregel state to a viscous solid and the composite resin contracts by about 1.5% to 6%. The gel point is the point at which the resin changes from a viscous paste to an elastic solid. When gel point is reached, the stress is transmitted from the composite resin to surrounding tooth structures. As curing begins material flow from unbound surface to accommodate for shrinkage. As the composite resin becomes more rigid because of increasing modulus of composite, flow stops and the bonded composite resin transmits shrinkage stresses generated to surrounding tooth. The factors influencing the amount of polymerization contraction stress include cavity volume and type of cavity, the amount of and quality of residual mineralized tooth tissue, location of cavity margin, bond strength of adhesive, material composition, shade and opacity of composite resin, curing mode, and water sorption of composite. 

In any repair of tooth with permanent restorative material, the interface is always a sensitive region. Good marginal adaptation is an important issue for the long term success of restoration. Good marginal seal decreases the microleakage, post-operative sensitivity, secondary caries and thus increases the longevity of restoration. Strategies to reduce polymerization shrinkage include altering composite formulation, incremental layering technique, light curing procedures, stress absorbing layers with low elastic modulus and preheating composites. Dr. Divakar et al mentioned different techniques to minimize the polymerization shrinkage by placement techniques, materials used and curing techniques.

It has been stated that posterior class II and especially class I cavities with a high C-factor will result in greater stresses due to a larger number of bonded surfaces. In 1987, Feilzer et al. postulated that the geometric configuration plays an important role in the adaptation of resin composite restoration. The cavity configuration (C-factor) is defined as the ratio of bonded to unbounded surfaces. A high ratio denotes high polymerization stresses, which are accompanied by increased shrinkage stresses. Among many of the factors contributing to the shrinkage stresses, C-factor is an important one. Several techniques have been suggested to improve marginal adaptation of high C-factor preparation, including adhesive systems that potentially resist composite shrinkage, placement techniques for resin composites, protocols for polymerization and different cavity preparations. Resin composite with lower modulus of elasticity or slower curing rate may reduce the polymerization stress, therefore, several modified insertion and light curing techniques have been introduced during the past few years to decrease the marginal stress and enhance marginal adaption, extensive efforts have also been made to develop low shrinkage resin composites by changing filler amount, size, and shape, monomer structure or chemistry and by modifying the polymerization reaction.

Fiber reinforced composite restorations are resin based restorations containing fibers aimed at enhancing their physical properties. This material is very heterogeneous depending on nature of the fiber and the overlying resin used. The role of the fibers increases the structural properties of the material. Resin fibers fix and hold the fibers in predetermined position to provide optimal reinforcement. Fiber inserts increases the quality of marginal zone. First, the fibers replace the part of composite increment at this location, which decreases overall volumetric polymerization contraction, the fibers assist the initial increment of composite in resisting pull away from margin towards the light sources, the fibers may also have a strengthening effect on composite margin which resist dimensional change or deformation occur during thermal and mechanical loading and thus improve marginal adaptation.

Fiber reinforced resin composites may be based on various fabric configurations. The types of reinforcement may consist of unidirectional fibers, biaxial or triaxial braided fibers and leno-woven Fibers. The unidirectional configuration provides significant enhancement of strength and stiffness in the Fiber direction, but it has poor transverse properties, resulting in the tendency toward longitudinal splitting and premature failure. Rich-resin areas may also result from architecture modification during handling. Fiber orientation of biaxially braided material may also change after cutting and embedding into the composite when adapting to tooth contours. The fibers in the ribbon spread out and separate from each other, losing the integrity of the fabric architecture. Conversely, leno-woven and triaxial braided with no architecture alteration; the fiber yarns maintain their orientation and do not separate from each other when closely adapted to the contours of Teeth. Belli and others described a toughening mechanism for the leno-woven reinforced composite in MOD Cavities of endodontically-treated teeth. They supported the favorable fiber elastic modulus and the interwoven Nature of the fabric, allowing for distribution of The force over a wider area, thus decreasing stress Levels.

Use of fibers along with composite restoration increases flexural strength and modulus of elasticity of composite resin and also decreases cavity c-factor effect leading to lower polymerization shrinkage. Effect of fibers in FRC increases, the modulus of elasticity, as modulus of elasticity increases polymerization shrinkage decreases. Fiber reinforced composite have elastic modulus very close to dentine, which act as a stress breaker between composite and dentine. Linear coefficient of thermal expansion of a material is another important contributing factor to micro leakage. FRC got almost similar coefficient of thermal expansion that of tooth.

In fiber reinforced composite the fibers act as a crack stopper, crack can propagate along fiber or the fiber can break, the fiber breakage and micro crack with in the matrix act as stress absorbing mechanism to ease stress resulted of polymerization shrinkage. A new fiber reinforced composite Ever-x contains E-glass fibers impregnated with the Nano hybrid composite. Total inorganic content is 76 wt% or 57 volume%. The short E-glass fibers present in Ever –X posterior composite prevent and arrest crack propagation. The application of nanotechnology to the field of dentistry resulted in dental composite resin with greatly improved, physical, mechanical, esthetic and optical properties. Nanocomposite today serves as universal restorative material.
in the anterior and posterior region. The Nano structures are used to produce composites with low shrinkage, high wear resistance, and biocompatibility.\(^\text{[24]}\) due to their small particle sizes, nanofillers can increase the overall filler level. More filler can be accommodated if smaller particles are used for particle packing. Theoretically, with the use of nanofillers, filler levels could be as much as 90 - 95% by weight. However, the increase in nanofillers also increases the surface area of the filler particles that limits the total amount of filler particles, because of the wettability of the fillers. Since polymerization shrinkage is mainly because of the resin matrix, the increase in filler level results in a lower amount of resin in Nanocomposite and will also significantly reduce polymerization shrinkage and dramatically improve its physical properties.\(^\text{[39]}\)

The insertion method of the resin into the cavity is important regarding the stress created on it. To reduce shrinkage stress effects, different restorative technique have also been suggested.\(^\text{[25]}\) Among these are different types of sandwich restoration, different incremental placement technique for resin composite and different light curing regimen. Various incremental techniques have been used for placement of composite resin restoration like oclusogingival layering, oblique layering, faciolingual layering and centripetal placement technique. Among these the oblique layering technique was found to show less microleakage than bulk or other incremental technique as demonstrated by Neiva IF \textit{et al} in 1998, Durate S and Saad in 2008.\(^\text{[24]}\) Also, the stress distribution in the restoration and tooth tissues is strongly dependent on a shape of the filling layers. It could be noticed that oblique first increment revealed less stress levels. The shape of the increment in the oblique technique covers less cavity wall surface than the horizontal technique does; this could have created less stress during this evaluation phase.\(^\text{[25]}\) A method used to reduce contraction is application and polymerization of resin in small layers, decreasing the stress on the cavity walls generated during the polymerization shrinkage and increasing the depth of cure. The distribution of the internal stresses in a composite restoration into a box-shaped cavity is considered to be unfavorable for the deep dentin bond.\(^\text{[55]}\)

When applying bulk filling technique, composite placed in a single layer up to a thickness of 4mm, and whole filling is cured with light. In case of class I cavity filling material placed in one bulk, it get contact with 5 walls, and only one free surface will remain, ε-factor is maximal and there for shrinkage is highest. Studies indicate this to be least advantageous in case of shrinkage.\(^\text{[11]}\)

In case of incremental technique, composite placed in multiple increments, and each increment light cured separately. In case of application in increment, polymerization shrinkage occur in each increment, shrinkage of single increment produce remarkably less tensile force than contraction of bulk, also ε-factor is much lower in this case which further reduces stress associated with polymerization shrinkage.\(^\text{[11]}\) The incremental placement techniques (occluso-gingival, oblique, facio-lingual, or U-oblique) have been recommended because they may reduce polymerization shrinkage stress due to; (1) the small volume of material that is polymerized at one time, (2) the reduction in the cavity configuration factor, and (3) the minimal contact of the restorative material with the opposing cavity wall during the polymerization process. No statistically significant differences were observed among the incremental placement technique in providing shrinkage stress relief at the tooth restoration interface.\(^\text{[29]}\)

Although it is generally accepted in the literature that the incremental placement techniques are desirable, the role of these techniques in reducing interfacial stress build-up in composite restorations has been questioned previously. In a study using finite element analysis, it was observed that all the incremental techniques for the placement of resin composite restorations caused more inward deformation of the cavity walls compared to the bulk placement technique. The incremental placement techniques resulted in cavities that were volumetrically filled with less composite resin compared to their original volume. They argued that the increased cavity wall deformation in an incrementally placed resin composite restoration resulted in a more stressed tooth restoration complex compared to the bulk-placed restoration. Although the incremental placement of resin composite has obvious benefits including thoroughness of light polymerization, allowing bond maturation, and ease of adaptation; its role in the total stress relief has not been demonstrated conclusively.\(^\text{[26]}\)

**CONCLUSION**

**Remarks**

**Based on the result obtained and discussed, the following conclusions were drawn from the study**

1. All the groups exhibited gap between the restorative material and the prepared tooth.
2. Marginal adaptation of fiber reinforced composite was found to be maximum when compared with nanohybrid composite
3. Incremental layering technique enhanced the marginal adaptation in all the samples in subgroup IA, IIA.
4. Marginal adaptation of fiber reinforced composite in layering technique found to be maximum when compared to other group.
5. Marginal adaptation of nanohybrid composite in bulk filling technique found to be minimum among the groups.

**Limitation of study**

Many factors affect the integrity of tooth-restoration interface and they have a complex inter-relationship that makes it difficult to isolate the role played by any one factor in interfacial stress development and microleakage. The sample evaluated in this investigation was prepared with adequate visualization, moisture control, and ideal access, which may not be the situation in clinical case. Additional in vivo studies evaluating the long term clinical performance needed for a better insight into the efficacy of the restorative materials in class I cavity preparations.

**Clinical application**

Currently the resin composite based on dimethacrylates are inevitably linked with shrinkage that can compromise the
success and longevity of restoration particularly in stress bearing areas. However judicious case selection, advanced material such as fiber-reinforced composite and effective placement technique like incremental layering restorative technique can be used to create more successful composite restorations.

Reference

1. Ruchi Dhir Sharma et al. Comparative evaluation of marginal adaptation between nanocomposite and microhybrid composites exposed to two light cure units. Indian journal of dental research.2011 Aug:22(3);520-526
11. Andras Katona et al. Comparison of composite restoration techniques. Interdisciplinary description of complex systems .2016:14(1);101-115
15. A.M. El-Marhomy et al. Effect of different configuration factors on marginal gap formation of two composite resin systems. Tanta Dental Journal 2013:10;160-167
19. Jan W V Van Dijken et al. Randomized 3-year clinical evaluation of class I and II posterior resin restorations placed with a bulk fill resin composite and a one step self etching adhesive. The journal of adhesive dentistry.2015:17(1); 81-88.
34. Andreia A. Carvalho et al. Marginal microleakage of class II composite resinrestorations due to restorative techniques. Rev.odonto cienc.2010;25 (2):165-169
38. Radhika M etal. Effect of different placement techniques on marginal microleakage of deep class II cavities restored with two composite resin formulations. Journal of conservative dentistry.2010 jan-mar:13(1);9-15
40. Kumbuloglu Ovul et al. Marginal adaptation and microleakage of directly and indirectly made fiber reinforced composite inlays. The open dentistry journal.2011: (5);33-38.
44. Safa Tuncer et al. The effect of two bulk fill resin composites on microleakage in endodontically treated teeth. Journal of dentist.2013:1;8-15
47. Priyalakshmi S et al. A review on marginal deterioration of composite restoration. journal of dental and medical science.2014 jan;13(1);6-9
48. Prachi Singh et al. Overview and recent advances in composite resin; A Review. International journal of scientific study.2015 Dec:3(9);169-172
49. Tabassum Tayyab et al. The clinical application of fiber-reinforced composites in al specialties of dentistry an overview. International journal of composite material.2015:5(1);18-24
50. Sinval Adalberto RODRIGUES JUNIOR. Influence of different restorative techniques on marginal seal of class II composite restorations. JAppl Oral Sci.2010:18(1);37-43.
51. Meng zhang et al. E-Glass fiber-reinforced composite in dental applications. Silicon 2012:4(1);73-78
52. S Idriss et al. Factors associated with microleakage in class II resin composite restorations. Journal of operative dentistry.2007:32(1);60-66.
53. Dr irfan Ahmed. Deep resin, white fillings: Anew techniques for composite restorations. cosmetic dentistry.2013:1;12-17
54. Denise Sa Maia CASSELLI. Marginal adaptation of class V composite restorations submitted to thermal and mechanical cycling. journal of applied oral science.2013:21(1);66-73

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