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Composition and Performance of Self-Adhesive Bulkfill Composite Restorations: Review Article

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A novel category of dental restoration was introduced in 2010 of so-called ‘‘bulk-fill’’ materials designed to simplify placing resin composites in clinical applications by enabling the curing of 4-5 mm layers at a time. Different formulas of bulk-fill materials, such as flowable and full-body, are available on the market. Over 200 brands of resin composites produced by various manufacturers may be found on the market. Using a bulk-fill resin composite requires a similar time to that for a dental amalgam restoration and a shorter time to perform restorations in posterior teeth than conventional resin-based composites (RBC) placed incrementally.

1. Introduction

A novel category of dental restoration was introduced in 2010 of so-called ‘‘bulk-fill’’ materials designed to simplify placing resin composites in clinical applications by enabling the curing of 4-5 mm layers at a time. Different formulas of bulk-fill materials, such as flowable and full-body, are available on the market. Over 200 brands of resin composites produced by various manufacturers may be found on the market. Using a bulk-fill resin composite requires a similar time to that for a dental amalgam restoration and a shorter time to perform restorations in posterior teeth than conventional resin-based composites (RBC) placed incrementally. (1)

Teeth that are treated using conventional composite materials applied incrementally show significantly greater means of cuspal deflection values compared to teeth restored with bulk-fill resin restorative material. (2) Cavity size and type, condition of the tooth restored, and other factors may determine the choice of the suitable bulk-fill material. Flowable bulk-fill materials may be suitable for increasing the fracture strength of endodontically treated teeth when used as vase material for endodontic cavities. (3) Also, thanks to better flowability in less accessible cavity configurations, flowable base bulk-fill composites seem most suitable for deep and narrow cavities. (4)

Scotti et al. (5) evaluated the influence of operator experience on the clinical performances of RBC restoration and found that operator experience affected the results statistically which focus on the need for simpler and less technique-sensitive restorations.

Soto-Montero et al. (6) compared the operative time and presence of air voids on Class II restorations using incremental and bulk-filling techniques and found that bulk-filling techniques may reduce chair time and produce a volume of air voids similar to the incremental technique.

2. Composition and Microstructure

Bulk-fill materials have a similar chemical composition to the conventional RBCs with some variations, related to the filler particles and resin matrix to understand the composition of bulk-fill composites, the composition of RBC must be discussed first.

2.1. Organic Phase (Resin matrix) of Conventional Composite Monomer

The organic phase constitutes about 20-40 % of a resin-composite material's weight and mainly comprises monomeric compounds, including base monomers, co-monomers, and additives.(7) Commercial dental composites were introduced and indicated for restoring anterior teeth in the mid-1960s after the synthesis of Bisphenol A Glycidyl Methacrylate (BisGMA) in 1956, which was followed by US patents for dental filling materials in 1962 and 1965. The organic phase, comprised mainly of the base monomer BisGMA, has largely remained unchanged for a long time. Other monomers were triethylene, primarily glycol dimethacrylate (TEGDMA), Urethane dimethacrylate monomer (UDMA), and Ethoxylated bisphenol A dimethacrylate (BisEMA). In contrast, other methacrylate monomers or other types of monomers were rarely used in commercial composites.

BisGMA is a highly viscous monomer ($\eta = 909.93$ Pa.s) due to its hydroxyl groups, increasing its polarity and resulting in strong intermolecular attraction.(8) it is usually diluted with a low molecular weight linear monomer TEGDMA ($\eta = 0.006$ Pa.s).(9) This mixture exhibits enhanced conversion and cross-linking compared to BisGMA alone.(10) Furthermore, reducing its viscosity improves its handling properties and allows more filler fraction to be loaded into the resin. However, BisGMA dilution with TEGDMA is associated with increased polymerization shrinkage and water sorption.(11)Also, the use of Bis-GMA, which is a bisphenol A derivative, in dentistry is being questioned after bisphenol A was found to exhibit estrogenic activity.(12)

UDMA, which has a lower molecular weight and higher flexibility than BisGMA, has been introduced as its replacement. When replacing BisGMA with UDMA, the new mixture is less viscous, hence reducing the need for a diluent, and the monomer-to-polymer conversion and mechanical strength are generally greater.

BisEMA is another BisGMA analogue with lower viscosity due to the absence of hydroxyl groups, which are available in different molecular weights depending on the ethylene oxide chain length between the aromatic core and the functional methacrylate groups. Increasing the degree of ethoxylation of BisEMA further reduces its viscosity and increases conversion, but it also increases water sorption and decreases flexural strength.(7)

Yoshinaga et al. (12) Compared the mechanical properties of five urethane acrylic monomers synthesized in the study as (meth)acrylic monomer substituents to replace Bis-GMA and UDMA and found that the cured urethane acrylic monomer-based resin exhibited higher elastic modulus (up to 40%) and strength (up to 21%) compared to the cured UDMA-based resin. The viscosity and refractive index of the urethane acrylic monomers were between those of UDMA and Bis-GMA.

Par et al. (13) evaluated the degree of conversion, light transmittance, and depth of cure of two experimental light-curable bioactive glass-containing composite series based on either Bis-EMA or UDMA resin and found the Bis-EMA series demonstrated clinically acceptable curing potential only for 0-10wt% of bioactive glass loading, an excellent curing potential in the UDMA series was observed for a wide range (0-40wt%) of bioactive glass loadings.

2.2. Organic Phase (Resin matrix) of Bulk Fill Monomer and its Modifications

All bulk fill composites share a common characteristic of being applied and polymerized in layers that are 4 mm thick and, in some cases, even 5 mm thick for certain products. Various alterations have been implemented to the bulk fill formulations, mainly concentrating on transparency, incorporating a polymerization modulator, and a different photoinitiator. There is no generalized composition for all bulk-fill materials varying widely in their properties from each other. One such material, SureFil SDR (Dentsply), is based on a modified UDMA stress-decreasing resin system with an incorporated polymerization modulator photoactive group.(7)

The resin matrix of Tetric EvoCeram Bulk Fill (Ivoclar Vivadent) has been optimized with a specific monomer composition for better hydrophobicity, enhanced polymerization characteristics for deeper curing, reduced polymerization shrinkage, and a higher degree of conversion, all of which contribute to its improved performance over conventional resin-based composite materials.(14)

Another example is the composition of Filtek bulk-fill flowable (3M ESPE) is derived from a blend of four distinct monomers: Bis-GMA, UDMA, Procrylat, and Bis-EMA. The UDMA-based monomer possesses a high molecular weight of 849 g/mol, reducing polymerization shrinkage.(15) The monomer is altered by including a photoactive group, which the manufacturer designates as the "polymerization modulator." Exposure to light reduces polymerization shrinkage by cleaving the photoactive groups. Simultaneously, the oligomer chain breaks, which contains the stress while generating radicals that can promote more conversion and crosslinking of the material, maintaining the polymerization rate or degree of conversion.(16) Additionally, the Procrylat monomer is responsible for more fluidity, reducing polymerization stress.

Alshali et al.(7) Assessed the resin matrix monomer composition of bulk-fill and conventional resin-composite materials and found that the resin composition of bulk-fill resin-composite

(SureFil SDR) differs from all resins in all tested RBCs.

Guo et al.(17) We compared the polymerization stress of a bulk-fill flowable composite (Filtek bulk-fill flowable) to a packable composite and found that a bulk-fill flowable composite produced lower polymerization stress.

2.3. Inorganic Phase (Fillers) of Conventional Composite Monomer

The fillers used in the RBCs generally consist of inorganic particles. Among the various inorganic particles, silicon dioxide (SiO2) is commonly used in RBCs. It is mostly used as a filler since it has a refractive index that matches the resin matrix, possesses good stability and mechanical qualities, and is easy to produce.(18) Because of a poor interfacial connection between the resin matrix and the fillers, it is necessary to modify these inorganic particles using silane coupling agents.(19)

Resin-based composites are often classified based on filler size, shape, and distribution. Filler size varies between 0.01 μm and 85 μm, while its morphologies depend on its development process. Filler loading is expressed in percentages by weight or volume. Generally, the filler load of RBCs ranges between 35 and 70 % by volume or 50 and 85 % by weight.(20)

After the introduction of hybrid composites, which consist of a heterogeneous aggregate of filler particles, it was possible to restore anterior and posterior teeth with the same composite because small filler particles in hybrid composites allowed the decrease in interparticle distances, which in turn improved wear resistance and mechanical properties in general and maintained good polishability and esthetic properties of microfilled composites. The filler load of these composites ranges from 70-80% by weight, with the size of the fillers ranging from 0.04 μm to 1-5 μm. Hybrid composites often have an average particle size greater than 1 μm, so they fail to maintain their gloss.

In the present day, the hybrid category is the most commonly used resin composite. About ten years ago, nanofilled composites or nanohybrids were introduced into the dental market. These composites contain nanoparticles that range in size from 0.005 to 1 μm or 5-100 nm. These nanoparticles are grouped in what is known as a "nanocluster". They are believed to create a composite restoration with a similar strength to hybrid composites but with smoother surfaces and a high gloss, resulting in excellent aesthetics.

A systematic review and meta-analysis by Maran et al.(21) Assessed the color match and surface texture of nanohybrid and hybrid composite restorations. It found no significant differences in the evaluated clinical parameters, suggesting that nanohybrids can perform similarly to hybrids with the potential for smoother surfaces and high gloss.

Amaya-Pajares et al.(22) reviewed research on the development and maintenance of surface gloss of dental composites and the effects of composition and polishing techniques. And concluded that nano-filled and suprananofilled composites tend to show the smoothest and glossiest surfaces compared to hybrids, maintaining their aesthetics better over time

2.4. Inorganic Phase (Fillers) of Bulk-Fill Monomer and its Modifications

Flowable bulk-fill composites have a lower filler content, which renders the surface less wear-resistant; hence, capping with a conventional composite is required.(23) The full-body bulk-fill composites can be regarded as the only true bulk-filling type since the whole restoration can be placed simultaneously without requiring any coverage.(4) These materials generally have higher filler loads, which make them highly viscous; for this reason, these materials are often referred to as past-like bulk-fill composites.

Depth of cure is inversely correlated to the material's translucency. In order to increase the depth of cure, all bulk-fill composites (except for SonicFill by Kerr and dual-cure bulk-fill composites) exhibit an increased translucency, which reduces esthetic properties. Matching between refractive indices of matrix and filler changes in filler size, shape, and coating can all influence the light transmittance through a composite. The strategies employed by the manufacturers differ for the different bulk-fill composites. SDR (Dentsply), X-tra base, and X-tra fil (both from Voco) contain larger filler particles. Regarding their shape, a rounded, regular shape, such as in Tetric EvoCeram Bulk Fill (Ivoclar Vivadent), improves the translucency. On the other hand, nanofillers with a diameter less than the wavelength of the light passing through are unable to scatter light, thus possibly improving translucency.(4)

Gilli et al.(24) investigates the quality of cure in depth of bulk-fill composites using various mechanical and biological methods, and finds significant inter-material differences were observed, indicating that the absolute property values are crucial, not just their relative evolution concerning layer thickness.

Ludovichetti et al.(25) investigate the depth of cure of various types of composites. The study compares two bulk-fill flowable composites, two conventional flowable composites, and one high-strength universal injectable composite and finds that bulk-fill flowable composites showed significantly higher depth of cure values compared to conventional flowable composites and high-strength universal injectable composites. The depth of cure for bulk-fill flowable composites was more than 4 mm.

3. Self-Adhesive Bulk-fill Composites

Self-adhesive resin composites have been developed with the goal of simplifying the composite restorative procedure by eliminating its most technique-sensitive step: the adhesive application. Self-adhesive materials are highly desired by clinicians owing to their efficiency and use for treating challenging situations such as uncooperative patients, cases where prolonged moisture control is unfeasible, or patients who cannot tolerate lengthy dental treatment due to chronic medical conditions.

4. Self-Adhesive Resin Composites with Acidic Resin Matrix

One of the earliest commercially available self-adhering flowable composites (Vertise Flow, Kerr) enabled rapid placement of materials without the need for complicated bonding procedures. Vertise Flow consisted of adhesive monomers such as phosphoric-acid ester methacrylate and glycerol phosphate dimethacrylate (GPDM). The low pH of GPDM (pH~1.9) may enhance the self-etching effect on the tooth surface and promote hybrid layer formation between the composite and dentin.

Fusio Liquid Dentin (Pentron, Orange, CA, USA) is another commercially available self-adhering flowable resin composite, which is composed of 4-methacryloyloxyethyltrimellitic acid (4-MET), UDMA, and TEGDMA. Although 4-MET is the adhesive monomer that chemically bonds to the tooth, UDMA and TEGDMA provide mechanical strength and flexibility to the polymer network of the set restorative material, which also has poor bonding properties and clinical performance.(26, 27)

According to Oliveira et al.(28) A randomized controlled trial compared postoperative sensitivity between restorations with Vertise Flow and conventional resin composite with self-etching adhesive. Both materials showed similar results regarding postoperative sensitivity, with mild pain observed, especially after 15 days.

Brueckner et al.(29) Vertise Flow exhibited lower shear bond strength and more significant microleakage than conventional flowable composites. Several other studies have concluded that its' retention and bond strength to dentin and interfacial adaptation to enamel and dentin have been sub-optimal.(30, 31)

Maj et al. (32) Investigates the clinical performance of Vertise Flow compared to other dental restorations. The study involved 37 patients with 64 fillings. The results showed that Vertise Flow presented the weakest results in marginal adaptation and smoothness over 24 months.

5. Self-Adhesive Composite Hybrid

Self-adhesive Surfil One (dentsply sirona) was recently introduced to the market. It uses the principles of resin composite materials as structural monomers, reactive diluents, and silanated glass fillers combined uniquely with the self-adhesive properties of polyacids known from glass ionomers.

The self-adhesive property was obtained by modifying polyacids by adding a radically polymerizable group to allow the polyacids to contribute to the radically polymerizing network to the manufacturers' so-called modified polyacid system (MOPOS). The high number of carboxylate groups within MOPOS allows adhesion with enamel and dentin via ionic bonds with calcium ions within the tooth structure. Furthermore, acidic groups in MOPOS can bond the structural monomer to the glass fillers.

Polyacids are insoluble in traditional composite resin compositions, so water is required. Adding water to a formula has significant implications for its chemistry because every composite component must be compatible with water and stable in an aqueous environment. The manufacturer names water-soluble, hydrolytically stable cross-linkers BADEP, which is a low-viscosity cross-linker with two polymerizable groups that can crosslink with the reactive diluent.

Acrylic acid represents a key monomer in surefil, which has multiple roles; it acts as a primer for dentin dissolving the smear layer and as a reactive diluent. It also contributes to the etching of the tooth substrate (enamel and dentin) and the adhesion to these substrates. As a bifunctional monomer, it contributes to the covalent polymer network through its polymerizable double bond and to the ionic network formed by cations released from the filler. Consequently, acrylic acid significantly contributes to the strength and adhesion of surefil one.

Silanated reactive glass fillers, which have a lower refractive index than Ba-glasses used in RBCs (which can not be used because of water in the composition), are used in Surefire One.

This enables more aesthetic outcomes in posterior teeth. The low refractive index filler system used in SF-I contains aluminium-phosphor-strontium-sodium-fluorosilicate glass, highly dispersed silicon dioxide, and ytterbium fluoride. These glass fillers also contribute to strength via copolymerization of the functional groups in both MOPOS and acrylic acid.

The initiator system of surefil one consists of two different photoinitiators, Camphorquinone and potassium persulfate, for redox curing and two different reducing agents, which are needed as co-initiators. This initiator system allows this material to be available in both light-cure or self-cure modes. The dark cure initiator system in Surefil makes it possible to use this material in the bulk fill technique without layering.

Abouelleil et al. assessed fluoride release and the mechanical and physical properties of surefil one compared to Cention Forte (Ivoclar Vivadent). This study showed comparable results to each other Cention Forte exhibits slightly better mechanical properties and sealing ability.

The evidence about the bonding effectiveness of surefil one-to-tooth structure is limited. In a study by Yao et al. (33) Showed comparable bonding performance to other systems like Fuji II LC (GC) and Cention N (Ivoclar Vivadent), particularly when used in light-cure mode when applied to flat dentin. However, it had less favorable results when applied to high C-factor class-I cavities in light-cure mode, which was mitigated in self-cure mode.

Another study by Aldowsari et al. (34) that aims to assess the shear bond strength of RBC, Surefil one, and resin-modified glass ionomer cement (RMGIC) of dentin of extracted permanent teeth treated with 38% silver diamine fluoride (SDF) and concluded that RBC had a significantly stronger shear bond strength to demineralized dentin surfaces of permanent molar teeth treated with SDF when compared to Surefil one and RMGIC.

Latta et al.(35) Evaluated the shear bond strength and shear fatigue strength of self-adhesive restorative materials (including surfil one) compared to composite resin bonded with a universal adhesive and concluded that while self-adhesive materials provide satisfactory bond strength, they generally perform lower than composite resin bonded with a universal adhesive, especially on dentin. Nonetheless, shear bond strength values of SF-I (21–26 MPa) may be within clinically acceptable values and similar to materials with favorable long-term clinical success.

Regarding wear resistance, another study by Latta et al.(36) evaluated the wear resistance of several self-adhesive restorative materials (including surefil one), surefil one exhibited less localized and generalized wear compared to GI, RMGI, and bioactive RMGI materials.

Akher et al. (37) Evaluated marginal adaptation of self-adhesive surefil one and two conventional bulk-fill composites; surefil one showed inferior results. Another study by the same group (38) Evaluated abrasive resistance and microhardness of self-adhesive surefil one and conventional bulk-fill composites. According to this study, Surefil has lower abrasive resistance than the other tested composites. In terms of microhardness, Surefil one performance was comparable to the other tested restoratives.

Rathke et al.(39) Evaluated one-year clinical results of the performance of Surefil One in restoring cavities. Surefil One performed well in this study, demonstrating a low failure rate and good clinical acceptability in various types of cavities over one year.

A randomized clinical trial by Albelasy et al. (40) Evaluated and compared the 2-year clinical performance of two ion-releasing bulk-fill composites (Cention N and Surefil One) with that of a conventional bulk-fill resin composite. Surefil One demonstrated excellent clinical performance over the two years, showing high retention rates, no postoperative sensitivity, and good aesthetic outcomes. Minor discrepancies and slight increases in marginal staining over time were observed but did not significantly impact the overall success of the restorations.

6. Alkasite Restorative Material

The word "alkasite" refers to a new type of filling material that is a subgroup of the class of composite materials. It has an alkaline filler that can release ions that neutralize the acid. Cention forte (Ivoclar Vivadent) is a self-curing, radiopaque filling material with a light-curing option for the direct restorative treatment of anterior and posterior teeth to restore occlusal surfaces. Cention forte are designed for capsule mixers. cention primer is specially designed for use with cention forte which is a self-etching, self-curing primer for tooth structure.

Cention forte consists of four different dimethacrylates representing a combination of UDMA, Tricyclodecan-dimethanol dimethacrylate (DCP), an Tetramethyl-xylylen diurethane dimethacrylate (aromatic aliphatic-UDMA), and Polyethylene glycol 400 dimethacrylate (PEG-400 DMA). UDMA is the main component of the monomer matrix. It exhibits moderate viscosity and yields strong mechanical properties, DCP is a low-viscosity, difunctional, methacrylate monomer that works as a diluent. Aromatic aliphatic-UDMA, a partially aromatic urethane dimethacrylate is a hydrophobic, high-viscosity cross-linker that combines the favorable properties of aliphatic (low tendency to discolor) and aromatic (stiffness) PEG-400 DMA, is a liquid monomer that enhances the flowability of Cention forte.

The inorganic fillers comprise a barium aluminum silicate glass filler, ytterbium trifluoride, an Isofiller, a calcium barium aluminum fluorosilicate glass filler, and a calcium fluorosilicate (alkaline) glass filler, with a particle size of between 0.1 µm and 35 µm. In restorative materials, the bioactive glass filler system is the reactive component and responsible for releasing, upon degradation at neutral pH, calcium and phosphate ions, leading to the formation of an apatite-like phase to fill the marginal gap.

Cention forte includes a special patented filler (partially functionalized by silanes) which keeps shrinkage stress to a minimum. This Isofiller, which is also used in Tetric N-Ceram Bulk Fill (Ivoclar Vivadent), the manufacturer claims that it is acting as a shrinkage stress reliever that minimizes shrinkage force.

The material is primarily self-cured and utilizes thiocarbamide, hydroperoxide, and copper salt as chemical initiators. Light curing of CN is optional but effective to accelerate the setting of the material's surface layer (4 mm). The photoinitiator system is comprised of a dibenzoyel germanium derivative (Ivocerin) and an acyl phosphine oxide. Ivocerin exhibits a higher photocuring reactivity and light absorption in the 400–450 nm wavelength range as compared to camphoroquinone.

Cention N (CN; Ivoclar Vivadent, Germany) is an older version of a commercially available alkasite processed by hand mixing powder and liquid. The cention forte has, as the manufacturer claims, the same chemistry but as a capsule mix by an auto mixing device. Since cention forte is a newly released material the evidence regarding this material is very limited, but since it has the same chemistry as cention N the evidence regarding the latter will also be discussed.

Mazumdar et al.(41) compare the microleakage of three different direct restorative materials (amalgam, glass ionomer cements, and Cention N) in Class II restorations. Cention N displayed minimum microleakage compared to amalgam and glass ionomer cements.

Yao et al.(33) Evaluated the bonding strength of cention N compared to self-adhesive composite hybrid and resin-modified glass-ionomer. Cention N showed high bond strength and effective performance in both flat and class-I cavity dentin, demonstrating its potential as a reliable restorative material. It is important to mention that cention N is used with Adhese Universal (Ivoclar Vivadent, Germany) in self-etch mode.

Tiskaya et al.(42) purpose of this study was to characterize the ion release, pH changes, and apatite formation ability of two potentially bioactive composites Cention N and Activa Bioactive (Pulpdent, United States). Cention N showed better performance than Activa Bioactive including ion release and apatite formation.

Gupta et al. (43) evaluate and compare fluoride ion release by Cention-N (self-cure and light-cure) and conventional glass-ionomer cement at different pH and time intervals. This study concluded that Cention-N (self-cure) has the highest fluoride ion release and alkalizing potential in acidic pH as compared to Cention-N (light-cure) and glass-ionomer cement.

Rai et al. (44) assessed and compared the fluoride release and recharge capacity of Cention-N, Zirconomer (Shofo, Japan), and Gc Gold Label 9 Extra (GC, Japan) Cention-N released a significantly greater amount of fluoride than other tested materials and showed a better recharge capacity.

Ruengrungsom et al. (45) evaluated fluoride, calcium, and phosphate release of ion-leaching restorative materials, and their recharge efficacy. Cention-N had excellent capacity concerning ion release and recharge ability.

Donly et al. (46) examined the in vitro caries inhibition of a resin-modified glass-ionomer cement, and fluoride and calcium-releasing resin-based composite including Cention-N. The study suggests that Cention-N may inhibit caries at restoration margins.

A randomized clinical trial by Albelasy et al. (40) evaluated and compared the 2-year clinical performance of two ion-releasing bulk-fill composites (Cention N and Surefil One) with that of a conventional bulk-fill resin composite. Cention N showed acceptable clinical performance over the two-year period, with a high clinical success rate comparable to the other materials studied. However, it exhibited some drawbacks in terms of marginal integrity and postoperative hypersensitivity.

Park et al. (47) evaluate and compare the surface roughness and microbial adhesion to alkasite restorative material (Cention N), resin-modified glass ionomer, and composite resin. Cention N performs well in terms of both low surface roughness and reduced microbial adhesion after the finishing process.

Panpisut et al. (48) assess monomer conversion, dimensional, biaxial flexural strength, and fluoride release of Cention N compared with resin-modified glass ionomer cements, and conventional composite. Cention N demonstrated a balanced performance with respectable monomer conversion, good dimensional stability, and significant fluoride release, along with a decent biaxial flexural strength, making it a competitive option among the evaluated materials.

A prospective study by Arora et al. (49) evaluated Clinical performance of Cention N was compared with GIC in 154 primary molars in children aged 5-8 years. The clinical performance of Cention N is comparable or superior to the other tested materials.

7. Fracture Resistance of Teeth with Class II Composite Restorations

The fracture resistance of teeth with Class II composite restorations has been evaluated in multiple studies, Class II restorations often require the removal of a substantial amount of tooth structure, which inherently weakens the tooth. The more tooth structure removed, the greater the reduction in fracture resistance. The design and extent of the cavity preparation influence the fracture resistance. Wider and deeper preparations generally result in lower fracture resistance due to increased loss of tooth integrity. Different restorative materials provide varying levels of support and fracture resistance. Effective bonding of restorative materials to both enamel and dentin can enhance fracture resistance. Techniques that improve the adhesion of the restoration to the tooth structure can mitigate some of the loss of strength due to cavity preparation. providing insights into the performance of different materials and techniques.

Hartanto et al. (50) Using Short Fiber-Reinforced Composite as an intermediate layer in Class II composite restorations significantly increases fracture resistance. A 4 mm thickness of Short Fiber-Reinforced Composite provided the highest resistance compared to a 2 mm layer and nanohybrid composite only.

Kucukyilmaz et al. (51) The use of different pulp capping materials showed no statistically significant effect on fracture resistance. However, the dovetail cavity design provided better fracture resistance compared to slot cavities.

Nahedh et al. (52) Using a 4 mm resin-modified glass ionomer cement base under composite restorations does not detrimentally affect fracture resistance. The highest fracture resistance was seen with Tetric N Ceram composite with an SDR base.

Farahanny et al. (53) Using a 4 mm resin-modified glass ionomer cement base under composite restorations does not detrimentally affect fracture resistance. The highest fracture resistance was seen with Tetric N Ceram composite with an SDR base.

These studies indicate that the choice of materials and techniques significantly impacts the fracture resistance of Class II composite restorations.

8. Importance of Cuspal Deflection Due to Polymerization Shrinkage

A key part of the success of composite restorations is the cuspal deflection that happens because of polymerization shrinking. As the composite material hardens and shrinks, polymerization shrinkage stress occurs. This can put stress on the bonded surfaces and cause the cuspal to deflect. To make composite restorations last longer and work better, it's important to understand and control this effect. Polymerization shrinkage can create internal stresses within the restoration and at the tooth-restoration interface, leading to potential marginal gaps, cracks, or debonding. This compromises the integrity of the restoration.

Vinagre et al. (54) conducted a study using fiber Bragg grating sensors to measure cuspal deflection induced by bulk-fill resin composites. The results indicated that the flowable resin composite SDR induced significantly less cuspal deflection compared to the conventional resin composite.

Aregawi et al. (55) developed analytical solutions to understand shrinkage stress and cuspal deflection in Class II restorations. They found that cuspal deflection increases with decreasing cavity wall stiffness and increasing resin composite stiffness.

Labib et al. (56) evaluated cuspal deflection in premolars restored with low shrinkable resin composites. They found that the silorane-based resin composites induced significantly less cuspal deflection compared to methacrylate-based composites.

Mossa et al. (57) investigated the effect of hygroscopic expansion on cuspal deflection and found that hygroscopic expansion reduced polymerization shrinkage in hydrophobic composites, while over-compensation occurred in hydrophilic composites causing tooth expansion.

Noaman et al. (58) studied the impact of fiber insertion on cuspal deflection and found that fiber inserts significantly reduced cuspal deflection in restorations.

Santis et al. (59) compared the effects of flowable and packable bulk-fill composites on cuspal deflection and found no significant difference between the two techniques. They highlighted that Young’s modulus of the composites played a role in balancing cusp distance variation.

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