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Flowable Composite

A Project Submitted to

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By:

Farah Badri Mahdi

Supervised by:

Dr. Hussain Muhammed Wajih

B.D.S., M.Sc., (Conservative dentistry)

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Certification of the Supervisor

I certify that this project entitled "**Flowable Composite**" was prepared by the fifth-year student "…………………." under my supervision at the University of Baghdad, College of Dentistry in partial fulfillment of the graduation requirements for the Bachelor Degree in Oral Surgery.

Supervisor name:- Dr.Hussain Muhmmad Wajih

Date:-

Dedication

This review is dedicated to my beloved family, especially my parents, who gave me all the love and support that I have ever needed. I cannot describe how grateful I am for having you in my life.

To my beautiful sisters, Sheeren and Rangeen who supported me through this long and hard journey and helped me pass all the difficulties that I have ever faced.

And finally, to my dear friends, Fatima, Kawther, Mina, Maryam, Omar and Yousif, thank you for always being there for me, helping me and encouraging me whenever I doubted myself, I cannot Imagine going through college without your endless support.

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1.1.Introduction:-

The early 1990s hallmarked the use of composite materials in dentistry. The initial composites were usually quartz-filled with large filler particles, making restorations rough and difficult to polish. With polish ability being a major aesthetic concern, a variety of newer materials have emerged in response to the ever growing needs expressed by dental practitioners **(Burgess *et al*,. 2002).**

The purpose of increasing the filler load is to improve the resistance to functional wear and physical properties. Viscosity increases with increase in filler loading. Most direct restorative composite have a putty like consistency which is desirable for clinical situations but there is a need to have a less viscous composite resin for better adaptability with the cavity wall. For this reason, a new class of “flowable composite resins” was introduced in late 1996 **(Hervás *et al*,.2006)**.

Flowable resin-based composites are conventional composites with the filler loading reduced to 37%-53% (volume) compared to 50%-70% (volume) for conventional minifilled hybrids. This altered filler loading modifies the viscosity of these materials. Most manufacturers package flowable composites in small syringes that allow for easy dispensing with very small gauge needles. This makes them ideal for use in small preparations that would be difficult to fill otherwise **(Baroudi and Rodrigues, 2015)**.

1.2. Classification of dental composite according to its viscosity:-

For a given restoration, the consistency of a composite is one of the practitioner's selection criteria. During the same operation, the practitioner can use several composites with very different consistencies. These are the result of an adjustment of the compositions by the manufacturers. Composites currently available on the market can be classified into three categories:

1.2.1 Medium viscosity composites:

These easy-to-handle composites (microhybrids) are said to be “universal”. Their viscosity is suitable for a large number of indications, both anterior and posterior. Moreover, their opacity is adjusted, by the manufacturers, according to the targeted clinical indication and/or the complexity of the colour shades to be reproduced (enamel, dentin and intermediate opacity). The filler loading of these composites is of the order of 78% by weight; 60% by volume **(Fréderic and Anne-Charlotte 2021)**.

1.2.2 Flowable composites

These composites, which are mostly hybrids, are recommended for specific clinical indications. Due to their fluidity, they show easy spreading, associated with good adaptation to cavity walls. These composites are useful for thin films. However, it must be taken into account that they exhibit significant polymerization induced shrinkage and reduced mechanical properties (compared to universal composites) due to their low level of fillers **(Radz, 2006)**.

1.2.3 Condensable/packable composites:

These composites were developed in the 1990s for posterior restorations in order to replace amalgams while trying to maintain their conditions of use (ease and speed of handling). Due to a high failure rate in clinical use, this type of composite has been phased out **(Fréderic and Anne-Charlotte, 2021).**

1.3. Properties of flowable composite

1.3.1 Strength and fracture toughness

Visible Light Cured flowable resin-based composites have a filler loading of 37%-53% by volume in comparison with 50%-70% by volume for conventional minifilled hybrids **(Hervás *et al*,. 2006).** Bayne et al., evaluated the filler percent, wear, compressive strength, diametral tensile strength, indented biaxial flexure strength and toughness of eight flowable and two hybrid composites. Mechanical properties were about 60 to 90 percent than those of conventional composites. Thus, concluding that flowable materials should be used with caution in high-stress bearing areas **(Bayne *et al.*,1998).**

1.3.2 Wear Resistance & polishability

Fernanda et al., measured the mass loss and surface roughness changes of different brands of flowable resin composites in comparison with conventional micro filled composites after a simulated tooth brushing test, flowable composites proved to be inferior to the control groups **(Garcia *et al.*, 2004)**. Linilin et al., evaluated the morphological changes of the surfaces of flowable resins eroded by orange juice and alcoholic drinks. Decomposition of the matrix resin and fallout of the fillers were observed in flowable resins that were eroded with acidic and alcoholic drinks **(Han *et al.*, 2008)**. Thus, based on the few studies evaluating surface abrasion it can be concluded that the reduced filler content increases better polishability but reduces the overall wear resistance of flowables.

1.3.3 Flow

The fluidity of flowable composites is a characteristic property of this material. The amount of fluidity varies significantly from one product to another **(Burgess *et al* 2002)**. As a result of differences in viscosity, flowable composites vary considerably in polymerization shrinkage, stiffness, and other physical properties.

Kusai Baroudi et al., evaluated the creep behaviour of flowable composites in relation to their filler fraction and post-cure period. Flowables that had the highest percentage of filler produced the lowest creep strain. The creep response decreased with 1 month of preload storage. Clinically, the finding of this study suggests that flowable composites are unsuitable for stress-bearing areas. Hence, when the flowability increases the filler loading is reduced which affects the overall strength of flowables **(Baroudi *et al.*, 2008)**.

1.3.4 Polymerisation shrinkage

Most flowable composites have an average volume polymerization shrinkage rate of 5 % **(Radz *et al.*, 2006)**. Kusai Baroudi et al., concluded that the polymerization shrinkage-strain of flowable composites should be taken into consideration in combination with their filler-fraction, which highly influences their shrinkage behavior. Lower filler loading materials, are more likely to be highly fluid **(Baroudi *et al.*, 2007).** Even though these materials exhibited substantial polymerization shrinkage, they might be successfully used in microconservative occlusal cavities, as the consequences of polymerization shrinkage would be low because of the limited volume of the material used.

However, in deep bulk-filled cavities fractures along the cavosurface enamel margin and cracks along the enamel wall have been detected. In general the higher the monomer content and the more flowable, the higher the shrinkage **(Radz *et al.*, 2006)** and the faster the conversion rate to the gel phase **(Stavridakis *et al.*, 2005)**. The higher shrinkage of flowable composites over that of hybrids may indicate a potential for higher interfacial stresses. It can be concluded that many factors might have an influence on the volumetric shrinkage of a material i.e., filler content, filler size, type of monomers, monomer content, organic matrix type, organic matrix conversion factors, power intensity of the curing unit, thickness of the material/depth of the cavity and technique of placement of the material **(Braga *et al.*, 2005).**

1.3.5 Radiopacity

Radiopacity is an essential property which allows the dentist to distinguish radio graphically, existing restorations and primary caries, to evaluate contours, overhangs, and major voids in restorations, and to assist in the identification of recurrent caries. According to Bayne et al., the low filler content of flowable composites is a reason for their low radiopacity compared to the traditional hybrid composites. Radiographic assessment is important to detect interstitial and recurrent caries. To improve their clinical detection, the minimum radiopacity level of composite resin restorations should be higher than that of dentine or slightly in excess than that of enamel. In clinical practice, it is not unusual to encounter patients who have flowables of low radiopacity present in their mouths. For this reason clinicians should be careful in selecting the material as not many exhibit a radiopacity equal to or greater than that of enamel **(Yu and Lee, 2008).**

1.3.6 Color stability

The colour stability of flowables is an important factor to maintain the longevity of these restorations relating to aesthetic concerns. However, only a few studies have been reported evaluating colour stability. Bin et al., evaluated the optical properties such as colour, translucency and fluorescence of flowable resin composites, and compared them with the corresponding shade of universal resin composites of the same brand. The authors concluded that the optical properties of flowable and universal resin composites were significantly different; therefore, these differences should be considered for clinically acceptable colour matching **(Fortin *and* Vargas, 2000)**.

According to Yonca et al., effects of aging on colour of flowable composites were shade dependent. Translucency was not affected by accelerated aging **(Korkmaz *et al.*, 2014).**

In another study, the influence of fluoride-containing solutions on the translucency of flowable composite resins was evaluated. It was found that fluorides altered the inherent translucency of the materials tested. Flowables have a composition with lower load particles than micro-hybrid and micro particle resins. Thus, there is a higher proportion of matrix resin, which can benefit dye retention from various intraoral solutions used **(Dos *et al.*, 2003).**

1.3.7 Biocompatibility

Flowable composites are known to produce a higher level of cell toxicity compared to their conventional counterparts. This increase in toxicity has been attributed to the presence of increased resin diluents that are added to achieve higher flow **(Al-Hiyasat *et al.,* 2005)**. According to a recent in vitro study done by MN Hegde et al., it was concluded that a significant release of BisGMA and

TEGDMA resin was released from the flowable composite materials tested **(Hegde et al., 2015)**. However, Muhammet Yalcin et al., evaluated the cytotoxicity of six different flowable composites and found them to be less toxic **(Yalcin et al., 2013)**. More future studies need to be performed to confirm these results.

1.4. Types of flowable composite

1.4.1 First generation flowable composite

The first generation of flowable composites was introduced in 1996 nearly in the same period as packable composites. These composites retained the same small particle size of traditional hybrid composites, but reduced the amount of filler content in order to reduce the viscosity of the resin mixture **(Bayne *et al.*, 1998).**

1.4.2 Self adhering flowable composite

Because of the considerable progress in adhesive technology and resin-based materials, the concept of aesthetic dentistry has changed. Resin composites are widely used in daily practice to answer the increasing aesthetic demand of patients. No matter how nice the shape and the shade are; a good restoration does not last long without a good adhesive. A bonding layer applied on the walls of the cavity ensures the retention of the composite to the tooth structure. But the bonding process is technique sensitive and involves different steps (moisture control, etching, rinsing, drying, bonding application, etc.). In order to simplify and shorten the procedure and thus minimize the risk of errors, self-etch adhesives were developed, followed by self-adhesive resin cement. So, it was expected that self-adhesive restorative composites would follow shortly **(Ozel *et al.*, 2013).**

VertiseTM Flow is the first self-adhering light-cured resin composite used for direct restorations. Its formulation incorporates the OptiBond® adhesion technology eliminating the different steps of etching, rinsing, priming and bonding. Consequently the application procedure is really shortened and made easier, and can be applied in different clinical situations for paediatric and conventional dentistry. This type of flowable composite is available in nine different shades that cover all the indications. It is a biocompatible and radiopaque product that can bond well to many different substrates including enamel, dentin, porcelain, metals, amalgam and composite. VertiseTM Flow has numerous clinical indications, summarized in two main applications; restorative material for small class I or cavity liner for class I and class II. It is also used in pediatric dentistry as pits and fissures sealants **(Sabbagh and Souhaid, 2011)**.

1.4.3 Bulk fill flowable composite

In order to simplify and speed-up the placement of large posterior compostie, manufacturers have produced a range of resin based composite materials which can be placed in single or deeper increments, known as bulk-fill resin based composites. Over a relatively short period of time many bulk-fill composite resins have been marketed quoting increment depths between 4–10 mm. The placement of these larger increments of composite may reduce the time needed when placing posterior restorations and thereby reduce technique sensitivity. The appearance, handling, and mechanical properties of bulk fill composite vary between flowable and high viscosity materials **(Chesterman *et al.*, 2017)**.

It is widely accepted that conventional RBC restorations should be placed and cured in 2 mm increments to allow adequate conversion of the unpolymerised resin **(Park *et al.*,2008)**. The real depth of cure achieved for a given material can vary with the shade and translucency; darker shades with greater opacity actually have a shallower depth of cure compared to lighter more translucent resins. The majority of bulk-fill materials on the market are purely light-cured, although some are dual-cure. Manufacturers have attempted to increase the depth of cure by a variety of methods including, reducing the filler content, increasing filler particle size, and the use of additional photo-initiators **(Ilie *et al.*, 2013).**

1.4.3.1 Smart dentin replacement (SDR)

Another system recently, introduced in the field of dentistry, Smart dentin replacement (SDR), includes a photoactive group in a modified urethane dimethacrylate resin. Activated resin has demonstrated a relatively slow radical polymerization rate, suggesting that the photoinitiator incorporated into the resin affects the polymerization process; moreover, the incorporation of activated resin results in 60-70% less shrinkage stress when compared to conventional methacrylatebased resins **(Ilie and Hickel, 2011)**.

SDR, developed by Dentsply, is the first posterior composite for dentin replacement combining the handling properties of a flowable composite with minimal shrinkage stress. As a result, it can be placed in increments of up to 4mm. The ‘Smart Dentin Replacement’ layer is applied as a base in Class I and II cavities following the use of a conventional dentin/enamel adhesive. It is chemically compatible with all methacrylate-based universal/posterior composites used to replace the occlusal enamel layer and complete the adhesive filling. SDR offers interesting advantages in everyday practice, because it allows dentists to provide their patients with high-quality aesthetic posterior restorations in a cost-effective way.

The product technology is based on ‘Stress Decreasing Resin’ technology. This means that a substance described as a ‘polymerisation modulator’ is chemically embedded in the backbone of the polymerisable resin. The polymerisation modulator synergistically interacts with the camphorquinone photo-initiator to result in a slower elasticity modulus development, allowing for stress reduction without a decrease in the rate of polymerisation or degree of conversion. SDR has the required physical and mechanical properties for use as a posterior bulkfill flowable base. Moreover, the integration of these modifications in the well-proven methacrylate chemistry makes SDR compatible with methacrylate-based adhesives and composites, which are widely used in dental practice **(Hermeler, 2017)**.

1.4.4 Next generation flowables

Due to the use of nanotechnology, newer generations of flowable composites have enhanced properties like those of the newer conventional resin composites. This means better adaptation, more elasticity, and better polymerization, along with minimized polymerization shrinkage. These enhanced physical and mechanical properties of the newer flowable composites have enabled clinicians to incorporate them in all aspects of restorative care with less concern than ever **(Troy, 2021)**. These next generation flowables benefit from a composition that features a unique filler technology. Unlike other flowable composites, these materials have a higher filler load and a homogeneous dispersion of fillers. The resulting improved strength and wear resistance are two key features of these flowable materials, opening up the potential for a broader use than standard flowables **(Salerno *et al.*, 2011).**

1.4.5 Fluoride releasing flowable composite

Giomers were developed with the desire to combine the esthetics of composites with the antibacterial protection of glass-ionomers and they are available in a wide range of colors classified by the VITA Classical shade guide system in the four hue groups (A, B, C and D, each with subgroups of saturations), with some variations depending on the type of material. Giomers have shown ideal properties for restoring cervical carious and non-carious lesions, one of the main challenges of direct restorative dentistry due to the quality of adhesion at the cervical level **(Rusnac *et al.*, 2019)**. Moreover, for these lesions, flowable materials would be indicated, as they have higher flexibility and are less likely to be displaced from high-stress areas **(Yu and Lee, 2008)**.

Beautifil Flow is the original fluoride-releasing Giomer composite designed to provide the ease of handling and placement. Beautifil Flow Plus X is the latest bioactive injectable hybrid restorative in the Beautifil product line with a newly developed patented nano S-PRG filler. Beautifil Flow Plus X has all of the Giomer chemistry attributes, including fluoride release and recharge, now with improved handling and effortless polishing that maintains a long-lasting shine **(Abdel-Karim *et al.*, 2014).**

1.4.6 Fiber reinforced flowable composite

Recently, a new short fiber-reinforced flowable resin composite (SFRC) was introduced as a restorative material. This resin composite is intended to be used as dentine replacing material in high stress bearing areas especially in large cavities of vital and non-vital posterior teeth. It consists of a combination of a resin matrix, randomly orientated glass microfibers and inorganic silanated particulate fillers **(Lassila *et al.*, 2020)**.

EverX Flow is a short-fiber reinforced flowable composite indicated for dentin replacement in direct restorations (together with a conventional composite as enamel layer), and for core build-up.

Due to the short fibres it contains, everX Flow efficiently reinforces restorations and displays exceptionally high fracture toughness. Fibres also help to redirect cracks and avoid catastrophic failures, which makes EverX Flow an optimal material to use in weakened or cracked teeth, for instance after amalgam removal, EverX Flow has a very thixotropic viscosity which allows it to flow and adapt perfectly to the cavity floor, but without any slumping, even when used in upper molars. This optimal consistency makes the restorative treatment both faster and easier. EverX Flow is available in two unique shades to answer all the clinical needs. The Bulk shade displays a depth of cure of 5.5mm and is perfect for deep cavities, or whenever speeding up the treatment is needed. The Dentin shade has a higher opacity and requires to be layered, and will be the best choice when looking for the best possible aesthetic results **(Abouelleil et al., 2019).**

1.5. Placement techniques of flowable composite

1.5.1 Injectable composite resin technique

This technique can be performed intraorally without anesthesia. A clear polyvinyl siloxane (PVS) impression material is used to replicate the diagnostic wax-up or the anatomical form of the natural dentition of a preexisting diagnostic model. The clear matrix can be placed intraorally over the prepared or unprepared teeth and used as a transfer vehicle for the flowable resin composite to be injected and cured **(Terry and Powers, 2014).**

In some cases, complicated layering techniques are required that are dependent on the clinician's skill and artistic ability. The injectable resin composite technique provides a simplified, precise, and predictable method for developing natural esthetic composite restorations while reducing chair time. Although not a panacea to all restorative challenges, this technique provides the patient and clinician with an alternative approach to various clinical situations. Furthermore, this noninvasive technique is an integral tool for enhancing communication between the patient and the restorative team during treatment planning **(Terry, 2012)**.

A **B**

Figure (1): Injection molding technique A) Silicon index over the teeth. B) Insertion of the tip of the flowable composite syringe in the silicon index **(Yepi et al., 2020).**

1.5.2 Snowplow technique

The snowplow technique involves the placement of a layer of flowable composite on the pulpal floor and the gingival margin of the proximal box of a posterior composite resin restoration. However, the layer of flowable composite is not cured prior to placement of a denser-filled composite resin restorative material. In this way, the flowable is pushed into a very thin layer, and the excess is pushed out of the preparation. Reportedly, this will leave a very thin film of the high-shrinking flowable composite in a location that may contain porosities if a denser-filled composite was used by itself **(Opdam *et al.*, 2003)**. The flowable and the initial heavier-filled composite layer are light cured as one increment **(Presicci, 2012).**

In contrast, a flowable composite cured in the traditional manner prior to subsequent incremental placement has been shown to increase the polymerization stress at the adhesive interface leading to possible adhesive failure **(Castañeda *et al.*, 2007)**. A concern when using the snowplow technique is whether the flowable composite polymerizes adequately due to the greater thickness of the restorative materials. However, microhardness tests have shown that the polymerization is similar between the bulk fill and the incremental fill of restorations of a light shade composite **(Lazarchik *et al.*, 2007)**.

1.5.3 Inverse injection technique

This inverse injection composite layering technique provides a precise and predictable method for translating a diagnostic wax-up or a pre-existing diagnostic model into composite restorations by mixing various hues and opacities of highly filled flowable materials that provides natural aesthetics and forms **(Terry, 2022)**.

1.5.4 Injection overmolding

After the removal of biofilm, clear matrices are applied and overmolded using flowable composite. This method is unique in that the loading zone (injection zone) is left with intentional excess, while the difficult areas (such as interproximal and subgingival areas) are essentially "porcelainesque" by virtue of the composite-to-Mylar finish effect. The goal is to then safely and quickly grind back the loading zone, marrying it to the glassy smooth bioclear Mylar finish zone **(Clark, 2014)**.

1.6. Clinical applications of flowables

1.6.1 Minimally invasive class I

Flowable composite resin materials are ideal to restore what have been termed, "Preventative Resin Restorations" (PRR's) because these are the most minimal of the Class I types and the needle tip placement into these small preparations assures a well-adapted restoration. Nonetheless, angled incremental deposition is important in order to minimize the contraction force from the setting composite **(Cohen *and* Newton, 2008)**. According to a survey conducted by Savage et al., flowable composites are one of the most widely used restorative materials for PRR's with more than 30% of paediatric dentists using a flowable composite or a combination of flowable and packable composite **(Savage *et al.*, 2009)**.

1.6.2 Sealants and preventive dentistry

These materials can be cured in a thin film and with a minimal air-inhibited layer and are designed to seal any cracks or microscopic porosities that may have formed during the finishing procedures of direct and indirect restorations as well as any occlusal pits and fissures. These formulations have the potential to increase the wear resistance of posterior resin composite restorations, thus providing more reinforcement and protection of the resin matrix **(Turssi *et al.*, 2005)**.

1.6.3 Cavity liners

There is a growing trend of using flowable composites as cavity liners. Clinical research shows no difference in postoperative sensitivity between solely using an adhesive as compared to just using a flowable composite as a liner **(Perdigão *et al.*, 2004)**.

Rainer et al., evaluated the use of flowable composite liners in large extended class I restorations and concluded that large Class I restorations without dentin support showed high amount of marginal enamel fractures. Lining with flowables improved the initial marginal integrity **(Haak *et al.*, 2003)**.

1.6.4 Minimally invasive class II restorations and inner layer for class II posterior composite resin placement in sealing the gingival margin to avoid deficiencies

For conservative preparation of Class II interproximal caries with only initial caries on the proximal surface and no caries on the occlusal surface, a facial approach for the cavity preparation will leave the marginal ridge intact. Flowable composites are also ideally suited for such facial approach Class II cavity preparations. Another use for flowable composites is in conjunction with placement of viscous packable composites. Leevailoj et al., evaluated packable composite resin placement with and without a flowable composite and found that there was significantly less microleakage in teeth restored with the flowable composite resin as the first increment in the proximal box **(Majety *et al.*, 2011)**.

1.6.5 Minimally invasive class III

Placement of physiologically contoured, esthetic Class III composite restorations can be a deceivingly difficult procedure. Oftentimes, these types of lesions present with limited clinical access, making traditional paste composites tough to place without creating marginal voids. Although flowable composites are better suited for this task due to their ease of placement, their use becomes limited when the depth of the preparation is greater than 2 mm from the facial to the lingual aspects **(Roggendorf *et al.*, 2011)**.

1.6.6 Composite mock up

The composite mock-up is an excellent tool for increasing the patient's understanding of the clinical procedure through a visual prototype. An indirect/direct technique that uses a clear matrix can be used to translate this information to the oral cavity. This process can be performed intraorally without anesthesia and can provide proper lip position and phonetic considerations. A clear polyvinyl siloxane (PVS) impression can be used to replicate the diagnostic wax-up. The matrix can be placed intraorally and used as a transfer vehicle for the flowable composite to be injected **(Terry, 2017)**.

1.6.7 Provisional restoration

Composite provisional restorations can be efficiently fabricated by making an initial impression of the preoperative stone or diagnostic wax-up model with a clear PVS impression material. After a separating medium is applied to the preparation, the clear matrix is placed, and a flowable resin composite can be injected into the coronal space with a predetermined shape and contour. Modifications in shape, length, and contour as well as the elimination of any surface defects can be accomplished by the incremental application of flowable resin composite after surface preparation. In addition, provisional restorations can be esthetically enhanced by cutting back the facial or buccal surface and placing a final flowable composite layer after surface preparation with a composite primer and any internal characterizations have been completed **(Patras *et al.*, 2012).**

1.6.8 Stabilizing, securing, and sealing the dental dam clamp

This procedure allows retention and stabilization of the dental dam clamp with flowable resin composite. The clamp can be positioned before or during dental dam placement and should be positioned and stabilized digitally before bonding. This usually done when there's insufficient tooth structure to maintain a clamp **(Liebenberg, 1996)**. Also, when a clamp is slightly rocking on the tooth surface, flowable composite can be placed on the jaws of the clamp and cured without etching and bonding to improve its stabilization **(Bhatia and Kohli, 2021).**

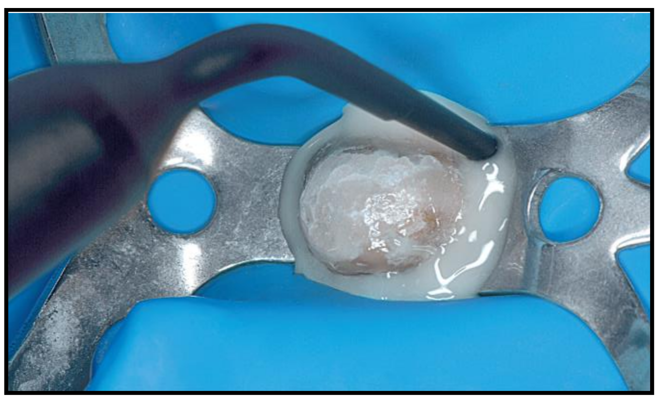

Figure (2): Using flowable composite for securing the rubber dam clamp. **(Terry, 2017)**

1.6.9 Bonding fixed orthodontic appliances

The demand for esthetics by the discriminating patient and orthodontist has placed demands on the industry to produce smaller and less visible appliances, and this requires innovative adhesive materials and techniques. The use of new-generation highly filled flowable composite materials and nanofilled adhesive resins may provide greater cohesive strength and a reduced bond failure rate to these surfaces **(Gange, 2015)**. In addition, these highly filled flowable materials provide excellent consistency while reducing the potential for movement and excess material around the positioned bracket **(Morais *et al.*, 2015)**.

1.6.10 Composite tooth splinting

Provisional splinting is a technique used for the stabilization and immobilization of teeth. It provides tooth fixation through application of a light-cured flowable or chemically cured composite material to acid-etched enamel surfaces in combination with flexible stainless steel wire, orthodontic brackets, or fiber-reinforced ribbon **(Strassler et al., 2007)**.

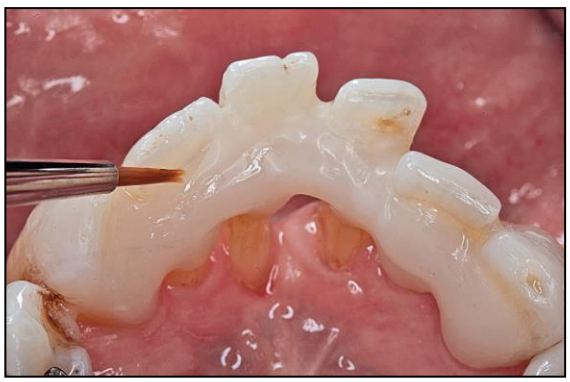

Figure (3): Splinting of periodontally compromised teeth with flowable resin composite **(Terry,2017)**.

1.6.11 Eliminating cervical tooth sensitivity

Cervical tooth sensitivity occurs when the enamel or cementum layer is removed and the underlying dentinal tubules are open and exposed to the oral environment **(Grippo, 1991)**. Adhesive resin impregnation is a clinical technique that has increased in popularity in recent years and is currently considered one of the most definitive and rapidly acting methods of desensitization. This procedure reduces sensitivity with the application of a dentin adhesive and flowable composite that form a hybrid layer, and this resin barrier prevents continued diffusion of toxins and bacterial invasion toward the pulp while producing minimal adverse pulpal inflammation **(Perdigao *et al.*, 2004)**.

1.6.12 Class V abfraction lesions

These are small angular Class V lesions attributed to the forces of tooth flexure. When restored with a stiff hybrid composite resin, the clinical success rate was only 70% **(McCoy, 1998)**. The high failure rate was attributed to the stiffness of the composite used. Thus, using a flowable composite resin with a lower biaxial flexural strength than traditional hybrid composites was assumed to improve the clinical success of these restorations. A one year clinical study evaluating Class V restorations using a flowable composite demonstrated that all restorations were intact and showed no signs of postoperative sensitivity after one year **(Estafan , 1999)**. Many studies have concluded that the use of flowable composites for non-carious Class V lesions is a good choice **(Kubo et al., 2010)**.

1.6.13 Immediate dentin sealing technique

Management of the dental tissues between preparation and the provisional phase of restorative treatment plays a pivotal role in the success of indirect adhesive restorations. Immediately after cavity preparation, exposed vital dentin is susceptible to insult from bacterial infiltration and microleakage during the provisional interim. Bacterial and fluid penetration through these tubules can result in colonization of microorganisms, postoperative sensitivity, and the potential for subsequent irritation of the pulp **(Terry, 2004)**. The most effective way of managing these possible sequelae and protecting this pulp-dentin interface is by sealing the exposed dentin tissue immediately after preparation and before impression taking and provisionalization. The immediate dentin sealing technique allows the development of a hybrid layer on vital teeth immediately after cavity preparation **(Magne, 2014)**. This hybrid layer is described as a polymerized resin intermingled with collagen fibers. This resin-infiltrated layer seals the dentin, preventing microleakage; protects the pulp from mechanical trauma, thermal stimuli, and bacterial invasion; and thus prevents hypersensitivity during impression taking, provisional restoration fabrication, and final cementation **(Terry, 2014)**. Alternatively, the resin coating technique involves the application of a dentin bonding system followed by a low-viscosity flowable resin composite on the prepared cavity. This procedure reduces the oxygen-inhibition layer of the uncured resin by diffusion of the free radicals from the flowable resin composite.

1.6.14 Creating a vertical stop for interocclusal records

Flowable resin composite can be used to facilitate accurate interocclusal records for the orientation of models for fixed prosthetic restoration. Conical stops of resin composite are prepared in the enamel of the abutment tooth to maintain the vertical dimension of occlusion and act as a third point of reference for a stable occlusal relationship when occluding the definitive stone models **(Sato *et al.*, 2000).**

Figure (4): Conical stop made with flowable resin composite **(Terry,2017).**

1.6.15 Repairing denture teeth

Denture teeth are fabricated from several different materials (ceramic, acrylic, composite), and there are an infinite number of shades, shapes, and sizes. Replacement can be achieved with relative ease in the laboratory with an adequate inventory of denture teeth. Or, with the proper surface treatment, these fractures can be repaired with next-generation flowable resin composites at chairside **(Lagouvardos *et al.*, 2003)**.

Figure (5): Using Flowable composite in repairing fractured ceramic central incisors on a mandibular denture. **(Terry, 2017)**

1.6.16 Sealing endodontic access openings

When the coronal portion of the root canal system is not properly sealed, it can become a potential source of bacterial invasion and lead to failure of the endodontic treatment. Thus, complete sealing of the endodontic access opening between appointments and after endodontic treatment is essential for achieving endodontic success **(Bailón *et al.*, 2011)**. Various intermediate materials (eg, Cavit G [3M ESPE], zinc oxide eugenol, and glass ionomers) used to close the existing coronal restoration may not provide an adequate seal, and some may interfere with required future adhesive procedures **(Jenkins *et al.*, 2006)**. A simple technique for sealing the endodontic access opening involves self-etch adhesives and/or next-generation flowables. This bioadhesive procedure can restore or provide a transitional seal until a new restoration can be placed **(Terry, 2017).**

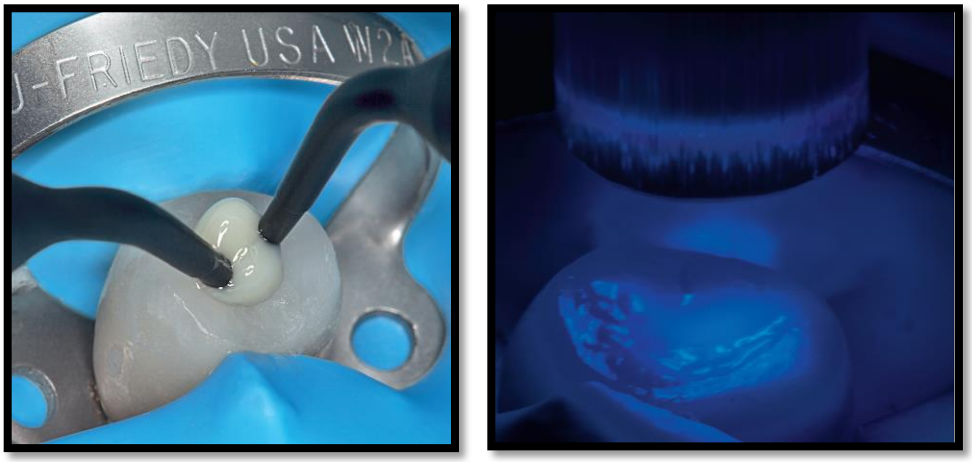

Figure (6): Using flowable composite in sealing endodontic access opening **(Terry, 2017).**

1.6.17 Bonding indirect restorations

Adhesive cementation involves cement adaptation to surface irregularities in a manner that prevents the restoration's dislodgement. The primary objective of each cementation procedure is to achieve a durable bond and a good marginal adaptation of the luting material to the restoration and the tooth. Successful cementation of the luting material to both is essential for retention, clinical performance, and longevity of indirect restorations **(Burke, 1999)**.

In the past, replacing resin cements with prewarmed conventional resin composites has been indicated for bonding indirect restorations. Recent literature suggests that there are potential benefits in elevating the temperature of the resin composite prior to placement of the indirect restoration **(Helvey, 2009)**. These include improving the flow characteristics of the resin composite, increasing the degree of monomer-to-polymer conversion, and reducing the amount of polymerization contraction stress by reducing the light exposure time **(Daronch *et al*., 2005)**. These benefits are attained through the use of a unit for warming resin composite material. Because the extent of flow varies with different materials, preheating specific resin composites that demonstrate a significant increase in flow rate allows them to be used as luting agents. Furthermore, recent studies indicate that the clinical performance of specifically tested flowable resin composites is similar or better than that of specifically tested universal resin composites **(Torres et *al*., 2014)**. With improved mechanical, physical, and optical properties, next-generation highly filled flowable composites may be used with elevated temperatures to bond indirect restorations.

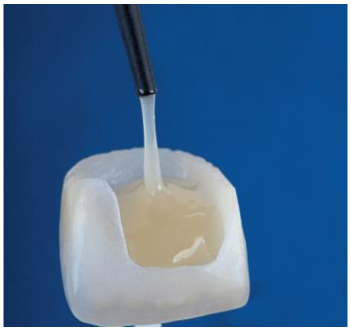

Figure (7): Injecting flowable composite onto the prepared internal surface of each ceramic veneer before placing it on a composite warmer. **(Terry, 2017)**

2. Conclusion

Flowable composites form an inhomogeneous group of materials. They exhibit a wide variety in their composition and consequently a variety in mechanical and physical properties. Clinicians must be aware of this variability, thus selecting the most appropriate material based on a particular clinical situation.

Modern aesthetic techniques and flowable composite resin materials, used properly for purposes such as those presented in this review, will serve to broaden the scope of all branches of dentistry, and especially aesthetic dentistry.

References:

A

1. Abdel-Karim, U.M., El-Eraky, M. and Etman, W.M., 2014. Three-year clinical evaluation of two nano-hybrid giomer restorative composites. Tanta Dental Journal, 11(3), pp.213-222.
2. Abouelleil, H., BONHOMME, R., Goujat, A., MAINJOT, A., Colon, P. and Grosgogeat, B., 2019. MECHANICAL BEHAVIOR AND SHRINKAGE STRESS OF FIBER REINFORCED FLOW COMPOSITE.

3. Al-Hiyasat, A.S., Darmani, H. and Milhem, M.M., 2005. Cytotoxicity evaluation of dental resin composites and their flowable derivatives. *Clinical oral investigations*, *9*(1), pp.21-25.

4. Ammannato, R., Rondoni, D. and Ferraris, F., 2018. Update on the 'index technique'in worn dentition: a no-prep restorative approach with a digital workflow. *Int J Esthet Dent*, *13*(4), pp.516-37.

B

5. Bailón Sánchez, M., González Castillo, S., González Rodríguez, M., Poyatos Martínez, R. and Ferrer Luque, C.M., 2011. Intraorifice sealing ability of different materials in endodontically treated teeth.

6. Baroudi, K. and Rodrigues, J.C., 2015. Flowable resin composites: a systematic review and clinical considerations. *Journal of clinical and diagnostic research: JCDR*, *9*(6), p.ZE18.

7. Baroudi, K., Silikas, N. and Watts, D.C., 2007. Time-dependent visco-elastic creep and recovery of flowable composites. *European Journal of Oral Sciences*, *115*(6), pp.517-521.

8. Baroudi, K., Silikas, N. and Watts, D.C., 2008. Edge-strength of flowable resin-composites. *journal of dentistry*, *36*(1), pp.63-68.

9. Bayne, S.C., Thompson, J.Y., Swift Jr, E.J., Stamatiades, P. and Wilkerson, M., 1998. A characterization of first-generation flowable composites. *The Journal of the American Dental Association*, *129*(5), pp.567-577.

10. Bhatia, S. and Kohli, S., 2021. Placement with modifications. British Dental Journal, 231(1), pp.3-3.

11. Braga, R.R., Ballester, R.Y. and Ferracane, J.L., 2005. Factors involved in the development of polymerization shrinkage stress in resin-composites: a systematic review. *Dental materials*, *21*(10), pp.962-970.

12. Burgess, J.O., Walker, R. and Davidson, J.M., 2002. Posterior resin-based composite: review of the literature. *Pediatric dentistry*, *24*(5), pp.465-479.

13. Burke, F.J.T., 1999. Maximising the fracture resistance of dentine-bonded all-ceramic crowns. *Journal of dentistry*, *27*(3), pp.169-173.

C

14. Castañeda-Espinosa, J.C., Pereira, R.A., Cavalcanti, A.P. and Mondelli, R.F.L., 2007. Transmission of composite polymerization contraction force through a flowable composite and a resin-modified glass ionomer cement. *Journal of applied oral science*, *15*(6), pp.495-500.

15. Chesterman, J., Jowett, A., Gallacher, A. and Nixon, P.J.B.D.J., 2017. Bulk-fill resin-based composite restorative materials: a review. British dental journal, 222(5), pp.337-344.

16. Christensen, G.J., 2002. Preventing postoperative tooth sensitivity in class I, II and V restorations. *The Journal of the American Dental Association*, *133*(2), pp.229-231.

17. Clark, D., 2014. Injection overmolding for aesthetics and strength, Part 2. Treating black triangles in post-ortho cases. Dentistry Today, 33(9), pp.108-110.

18. Coachman, C., De Arbeloa, L., Mahn, G., Sulaiman, T.A. and Mahn, E., 2020. An improved direct injection technique with flowable composites. A digital workflow case report. Operative Dentistry, 45(3), pp.235-242.

19. Cohen, R.G. and Newtown, P.A., 2008. The expanded use of improved flowable composite. *Dent Town*, *64*, pp.25-35.

D

20. Daronch, M., Rueggeberg, F.A. and De Goes, M.F., 2005. Monomer conversion of pre-heated composite. *Journal of dental research*, *84*(7), pp.663-667.

21. Dos Santos, P.A., Palma Dibb, R.G., Corona, S.A.M., Catirse, A.B.E. and Garcia, P.P.N.S., 2003. Influence of fluoride-containing solutions on the translucency of flowable composite resins. *Journal of materials science*, *38*(18), pp.3765-3768.

E

22. Eldesouky et al. "Microleakage of Giomer and Compomer in Primary Teeth". Alexandria Dental Journal. (2016) Vol.41 Pages: 188-193.

23. Estafan, D., Schulman, A. and Calamia, J., 1999. Clinical effectiveness of a Class V flowable composite resin system. *Compendium of continuing education in dentistry (Jamesburg, NJ: 1995)*, *20*(1), pp.11-5..

F

24. Fortin, D. and Vargas, M.A., 2000. The spectrum of composites: new techniques and materials. *The Journal of the American Dental Association*, *131*, pp.26S-30S.

25. Fréderic Chaput, Anne-Charlotte Faure, 2021. Dental composites. Techniques de l’Ingénieur. Technologies Biomédicales,. ffhal-03453701f.

G

26. Gange, P., 2015. The evolution of bonding in orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics*, *147*(4), pp.S56-S63.
27. Garcia, F.C.P., Wang, L., D'Alpino, P.H.P., Souza, J.B.D., Araújo, P.A.D. and Mondelli, R.F.D.L., 2004. Evaluation of the roughness and mass loss of the flowable composites after simulated toothbrushing abrasion. *Brazilian oral research*, *18*, pp.156-161.
28. Grippo, J.O., 1991. Abfractions: a new classification of hard tissue lesions of teeth. *Journal of Esthetic and Restorative Dentistry*, *3*(1), pp.14-19.

H

29. Haak, R., Wicht, M.J. and Noack, M.J., 2003. Marginal and internal adaptation of extended class I restorations lined with flowable composites. *Journal of Dentistry*, *31*(4), pp.231-239.
30. Han, L., Okamoto, A., Fukushima, M. and Okiji, T., 2008. Evaluation of flowable resin composite surfaces eroded by acidic and alcoholic drinks. *Dental materials journal*, *27*(3), pp.455-465.
31. Hegde, M.N. and Wali, A., 2015. BisGMA and TEGDMA Elution from Two Flowable Nanohybrid Resin Composites: An In vitro Study. *British Journal of Medicine and Medical Research*, *5*(9), pp.1096-1104.
32. Helvey, G., 2009. Porcelain laminate veneer insertion using a heated composite technique. *Inside Dentistry*, *9*(4), pp.38-45.
33. Hermeler, L. (2017). Smart dentin replacement. [online] Dentistry News UK. Available at: http://www.dentistry.co.uk/.

34. Hervás García, A., Lozano, M., Cabanes Vila, J., Barjau Escribano, A. and Fos Galve, P., 2006. Composite resins: a review of the materials and clinical indications.

I

35. Ilie, N. and Hickel, R., 2011. Investigations on a methacrylate-based flowable composite based on the SDR™ technology. Dental Materials, 27(4), pp.348-355.

36. Ilie, N., Bucuta, S. and Draenert, M., 2013. Bulk-fill resin-based composites: an in vitro assessment of their mechanical performance. Operative dentistry, 38(6), pp.618-625.

J

37. Jenkins, S., Kulild, J., Williams, K., Lyons, W. and Lee, C., 2006. Sealing ability of three materials in the orifice of root canal systems obturated with gutta-percha. *Journal of Endodontics*, *32*(3), pp.225-227.

K

38. Korkmaz Ceyhan, Y., Ontiveros, J.C., Powers, J.M. and Paravina, R.D., 2014. Accelerated aging effects on color and translucency of flowable composites. *Journal of Esthetic and Restorative Dentistry*, *26*(4), pp.272-278.

39. Kubo, S., Yokota, H., Yokota, H. and Hayashi, Y., 2010. Three-year clinical evaluation of a flowable and a hybrid resin composite in non-carious cervical lesions. *Journal of dentistry*, *38*(3), pp.191-200.

L

40. Lagouvardos, P.E. and Polyzois, G.L., 2003. Shear bond strength between composite resin and denture teeth: effect of tooth type and surface treatments. International Journal of Prosthodontics, 16(5).

41. Lassila, L., Keulemans, F., Vallittu, P.K. and Garoushi, S., 2020. Characterization of restorative short-fiber reinforced dental composites. Dental Materials Journal, 39(6), pp.992-999.

42. Lazarchik, D.A., Hammond, B.D., Sikes, C.L., Looney, S.W. and Rueggeberg, F.A., 2007. Hardness comparison of bulk-filled/transtooth and incremental-filled/occlusally irradiated composite resins. *The Journal of prosthetic dentistry*, *98*(2), pp.129-140.

43. Lee, I.B., Son, H.H. and Um, C.M., 2003. Rheologic properties of flowable, conventional hybrid, and condensable composite resins. *Dental Materials*, *19*(4), pp.298-307.

44. Leinfelder KF. Restoration of abfracted lesions. Compendium 1994;15:1396–1400.

45. Liebenberg WH. Successive cusp build-up: An improved placement technique for posterior direct resin restoration. J Can Dent Assoc 1996;62:501–507.

46. Lindberg A, van Dijken JW, Hörstedt P. Interfacial adaptation of a Class II polyacidmodified resin composite/resin composite laminate restoration in vivo. Acta Odontol Scand 2000;58:77–84

M

47. Magne, P., 2014. IDS: Immediate Dentin Sealing (IDS) for tooth preparations. *J Adhes Dent*, *16*(6), p.594.

48. Majety, K.K. and Pujar, M., 2011. In vitro evaluation of microleakage of class II packable composite resin restorations using flowable composite and resin modified glass ionomers as intermediate layers. *Journal of conservative dentistry: JCD*, *14*(4), p.414.

49. McCoy, R.B., Anderson, M.H., Lepe, X. and Johnson, G.H., 1998. Clinical success of class V composite resin restorations without mechanical retention. *The Journal of the American Dental Association*, *129*(5), pp.593-599.

50. Millar, B.J. and Nicholson, J.W., 2001. Effect of curing with a plasma light on the properties of polymerizable dental restorative materials. *Journal of Oral Rehabilitation*, *28*(6), pp.549-552.

51. Morais, D.R., Moresca, A.H.K., Losso, E.M., Moro, A., Moresca, R.C. and Correr, G.M., 2015. Shear bond strength of brackets bonded with nanofilled flowable resins. *RSBO Revista Sul-Brasileira de Odontologia*, *12*(1), pp.8-13.

52. Murchison, D.F., Charlton, D.G. and Moore, W.S., 1999. Comparative radiopacity of flowable resin composites. *Quintessence international*, *30*(3).

O

53. Olmez, A., Oztas, N. and Bodur, H., 2004. The effect of flowable resin composite on microleakage and internal voids in class II composite restorations. *Oper Dent*, *29*(6), pp.713-719.

54. Opdam, N.J., Roeters, J.J., de Boer, T., Pesschier, D. and Bronkhorst, E., 2003. Voids and porosities in class I micropreparations filled with various resin composites. *Operative Dentistry*, *28*(1), pp.9-14.

55. Ozel Bektas, O., Eren, D., Akin, E.G. and Akin, H., 2013. Evaluation of a self-adhering flowable composite in terms of micro-shear bond strength and microleakage. Acta Odontologica Scandinavica, 71(3-4), pp.541-546.

P

56. Park, J., Chang, J., Ferracane, J. and Lee, I.B., 2008. How should composite be layered to reduce shrinkage stress: incremental or bulk filling?. Dental materials, 24(11), pp.1501-1505.
57. Park, S.B., Son, W.S., Ko, C.C., García-Godoy, F., Park, M.G., Kim, H.I. and Kwon, Y.H., 2009. Influence of flowable resins on the shear bond strength of orthodontic brackets. *Dental Materials Journal*, *28*(6), pp.730-734.
58. Patras, M., Naka, O., Doukoudakis, S. and Pissiotis, A., 2012. Management of provisional restorations' deficiencies: a literature review. Journal of esthetic and restorative dentistry, 24(1), pp.26-38.
59. Perdigao, J., Anauate-Netto, C., Carmo, A.R., Hodges, J.S., Cordeiro, J.D., Lewgoy, H.R., Dutra-Corrêa, M., Castilhos, N. and Amore, R., 2004. The effect of adhesive and flowable composite on postoperative sensitivity: 2-week results. *Quintessence International*, *35*(10).
60. Pescatore, C., 2000. The direct posterior esthetic restoration using state-of-the-art composite resin technology. *Compendium of Continuing Education in dentistry.(Jamesburg, NJ: 1995). Supplement*, (26), pp.14-8.
61. Presicci, A., 2012. Porosity Formation and Microleakage of Composite Resins Using the Snowplow Technique. UNIFORMED SERVICES UNIV OF THE HEALTH SCIENCES BETHESDA MD BETHESDA United States.

R

62. Radz, G., 2006. An Improved bonding system and flowable composite for fast, effective class V restorations. *Inside Dentistry*, *2*(5).
63. Roberson TM, Heymann HO, Swift EJ. Sturdevant’s The Art and Science of Operative Dentistry, ed 4. St. Louis: Mosby, 2002:203.

64. Roggendorf, M.J., Krämer, N., Appelt, A., Naumann, M. and Frankenberger, R., 2011. Marginal quality of flowable 4-mm base vs. conventionally layered resin composite. *Journal of dentistry*, *39*(10), pp.643-647.
65. Rusnac, M.E., Gasparik, C., Irimie, A.I., Grecu, A.G., Mesaroş, A.Ş. and Dudea, D., 2019. Giomers in dentistry–at the boundary between dental composites and glass-ionomers. Medicine and Pharmacy Reports, 92(2), p.123.

S

66. Sabbagh, J. and Souhaid, P., 2011. Vertise™ Flow Composite: A Breakthrough in Adhesive Dentistry. Oral Health, 101(3), p.48.
67. Salerno, M., Derchi, G., Thorat, S., Ceseracciu, L., Ruffilli, R. and Barone, A.C., 2011. Surface morphology and mechanical properties of new-generation flowable resin composites for dental restoration. Dental Materials, 27(12), pp.1221-1228.
68. Sato, Y., Hosokawa, R., Tsuga, K. and Kubo, T., 2000. Creating a vertical stop for interocclusal records. *The Journal of Prosthetic Dentistry*, *83*(5), pp.582-585..
69. Savage, B., McWhorter, A.G., Kerins, C.A. and Seale, S.N., 2009. Preventive resin restorations: practice and billing patterns of pediatric dentists. *Pediatric Dentistry*, *31*(3), pp.210-215.
70. Stavridakis, M.M., Dietschi, D. and Krejci, I., 2005. Polymerization shrinkage of flowable resin-based restorative materials. *Oper Dent*, *30*(1), pp.118-28.
71. Strassler, H.E. and Serio, C.L., 2007. Esthetic considerations when splinting with fiber-reinforced composites. Dental Clinics of North America, 51(2), pp.507-524.

72. Sumino, N., Tsubota, K., Takamizawa, T., Shiratsuchi, K., Miyazaki, M. and Latta, M.A., 2013. Comparison of the wear and flexural characteristics of flowable resin composites for posterior lesions. Acta Odontologica Scandinavica, 71(3-4), pp.820-827.

T

73. Terry DA. (2004). Prehybridization of indirect restorative preparations. Pract Proced Aesthet Dent ;16:661–662

74. Terry DA. (2012). Developing a functional resin composite provisional. Am J Esthet Dent 2:56–65.

75. Terry, D. and Powers, J., 2014. Using injectable resin composite: part two. *Int Dent Afr*, *5*, pp.64-72.

76. Terry, D.A. (2017). Restoring with flowables. Chicago Quintessence Publishing

77. Terry, D.A. (2022). An Adhesive Design Concept: The Inverse Injection Composite Layering Technique.

78. Terry, D.A., 2011. What other biomaterial has so many uses: Flowables. International Dentistry-Africa Edition, pp.42-58.

79. Torres, C.R.G., Rêgo, H.M.C., Perote, L.C.C., Santos, L.F.T.F., Kamozaki, M.B.B., Gutierrez, N.C., Di Nicoló, R. and Borges, A.B., 2014. A split-mouth randomized clinical trial of conventional and heavy flowable composites in class II restorations. *Journal of Dentistry*, *42*(7), pp.793-799.

80. Troy, Schmedding, 2021. Next-Generation Flowable Composites 7 Mins read 1.2 k Views.

81. Turssi, C.P., Ferracane, J.L. and Vogel, K., 2005. Filler features and their effects on wear and degree of conversion of particulate dental resin composites. *Biomaterials*, *26*(24), pp.4932-4937.

U

82. Ujiie, M., Tsujimoto, A., Barkmeier, W.W., Jurado, C.A., Villalobos-Tinoco, J., Takamizawa, T., Latta, M.A. and Miyazaki, M., 2020. Comparison of occlusal wear between bulk-fill and conventional flowable resin composites. Am. J. Dent, 33, pp.74-78.

Y

83. Yalcin, M., Ulker, M., Ulker, E. and Sengun, A., 2013. Evaluation of cytotoxicity of six different flowable composites with the methyl tetrazolium test method. *European Journal of General Dentistry*, *2*(03), pp.292-295.
84. Ypei Gia, N.R., Sampaio, C.S., Higashi, C., Sakamoto Jr, A. and Hirata, R., 2021. The injectable resin composite restorative technique: A case report. *Journal of Esthetic and Restorative Dentistry*, *33*(3), pp.404-414.
85. Yu, B. and Lee, Y.K., 2008. Differences in color, translucency and fluorescence between flowable and universal resin composites. *Journal of dentistry*, *36*(10), pp.840-846.