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# **Polymerization shrinkage of resin-based composites**

A Project Submitted to

The University of Baghdad, College of Dentistry, Department of Restorative & Aesthetic Dentistry in Partial Fulfillment for the degree of Bachelor of Dental Surgery

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## **Certification of the Supervisor**

I certify that this project entitled "**Dimensional changes in resin-based composites**" 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 dental surgery.

**Supervisor's name: Abeer Ghalib**

**Date:**

## **Dedication**

To the powerful woman who raised me, my strength source and fuel, my beautiful mother.

To my father, who I know is looking down at me with proud eyes.

To my beautiful sisters Ruqaya, Sarah, Zainab and Danya.

and finally to my wonderful unique friends, Maryam, Farah, Kawther, Mina, Mohammed and Omar who made everything simpler, easier and definitely more fun with their unconditional love and support.

## **Acknowledgements**

I would like to thank God Almighty, for without the power he gave me to move on through many hard times, I would've given up a long time ago.

I would like to thank (Dr.Abeer Ghalib) for supervising my project, for her directives and guidance to accomplish this work.

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## 1. Introduction

Composite resin has been introduced since the late 1950s and is widely used as a restorative material in dentistry (**Schneider *et al.*, 2010**). It has several advantages over amalgam such as better aesthetic properties, ability to bond to the tooth structure, and allowing for better conservation of tooth structure (**Kaisarly and Gezawi., 2016**). Due to all these advantages, the use of composite resin has increased drastically in modern preventive and restorative dentistry.

Despite the continuous advancements in composite resins, it still suffers from polymerization shrinkage that ranges from 2 to 5% (**Braga *et al.*, 2005**). Polymerization shrinkage of composite resins occurs mostly due to the conversion of monomer into polymer chain in which the van der Waals forces are replaced by covalent bonds that pull the particles closer (**Kaisarly and Gezawi., 2016**). This leads to interfacial polymerization stresses, causing gap formation at the dentine-bond interface, increasing the risk of recurrent caries and consequently restoration failures (**Al Sunbul *et al.*, 2016**).

A gradual increase in viscosity of the resin material also occurs during the conversion, resulting in loss of its fluidity (gel-point) and flowing ability (vitrification) (**Versluis *et al.*, 2009**). Prior to vitrification, these materials are able to flow and partially relieve stresses. After the polymerizing material loses its ability to flow, its elastic properties increase and, consequently, any restraints on the polymerization shrinkage (for example by the bonding between restoration and tooth structure) will generate residual shrinkage stresses (**Pereira *et al.*, 2015**).

Several methods have been described to reduce polymerization shrinkage such as using incremental placement of composite resin, soft start light-curing technique, stress absorbing liners, use of composite resin with higher filler content, or modifying the resin component in composite resin (**Marchesi *et al.*, 2010**). The degree of conversion also has a major impact on the success of composite resin restorations (**Tarttle *et al.*, 2015**). The physical and mechanical properties of composite resins are directly influenced by the level of conversion during polymerization (**Moraes *et al.*,**

2008).

The development of new resinous materials and the inevitable clinical signs and symptoms associated with polymerization shrinkage make this topic an important issue for clinicians and researchers. Therefore, this review article will focus on polymerization shrinkage, polymerization stress, their consequences and strategies used by companies and clinicians to minimize the effects.

## 2. Polymerization shrinkage:

A polymer occupies less volume than the monomers, the effect of which is well known as polymerization shrinkage (**Kim *et al.*, 2015**).

During the process of polymerization, the weak physical van der Waals attraction between the monomer molecules are replaced by a stronger covalent bond and thus development of shrinkage (**Pratap *et al.*, 2019**).

A gradual increase in viscosity of the resin material also occurs during the conversion, resulting in loss of its fluidity (gel-point) and flowing ability (vitrification). Prior to vitrification, these materials are able to flow and partially relieve stresses. After the polymerizing material loses its ability to flow, its elastic properties increase and, consequently, any restraints on the polymerization shrinkage (for example by the bonding between restoration and tooth structure) will generate residual shrinkage stresses (**Bicalho *et al.*, 2014**).

Typically, dental composites used in restorative procedures exhibit volumetric shrinkage ranging from less than 1% up to 6%, depending on the formulation and curing conditions (**Soares *et al.*, 2013**). A consequence of shrinkage stress can be debonding along the restoration/tooth interface or at the restoration margins, resulting in internal and marginal gaps, micro-cracking of either or both the restorative material and tooth structure, marginal stain cuspal movement (**Soares *et al.*, 2013**). When indirect restorations are cemented to a vital tooth, polymerization shrinkage may result in postoperative sensitivity or marginal debonding that contributes to marginal staining, which is often erroneously used as a criterion for replacement of indirect



and direct composite restorations (**Pereira *et al.*, 2015**).

### **3. Polymerization mechanism:**

Following activation by the blue light, the photo initiator camphoroquinone in the composite resin is converted to an excited state. This excited camphor quinone reacts with the co- initiator amine to produce free radicals (**Stansbury., 2000**).

These free radicals start the polymerization process by reacting with the monomer molecules in the resin forming active centers (**Weinmann *et al.*, 2005**).

The polymerization continues by constant addition of monomers to the active centers forming long cross linking polymer chains. The Monomer molecules which are held together by Van der Waals forces with the intermolecular distance of 0.3 nm - 0.4 nm are replaced by covalent bonds after their polymerization where the intermolecular distance is reduced to 0.15 nm. This reduction in the distance between the molecules leads to volumetric polymerization shrinkage (**Son *et al.*, 2014**). Resin composites applied in dentistry shows volumetric shrinkage values from 1% to 6% (**Wang and Chiang., 2016**).

Polymerization mechanism could be categorized into addition and condensation polymerization. In mechanism of addition polymerization, the chain grows without by-product formation. It can be classified into free radical (as in Bis-GMA dental composites) and ring-opening reactions (as in silorane-based resin). While, in the condensation polymerization, elimination of a small molecule occurs upon reaction producing a larger one without involvement of free radicals. Water is mainly formed during the chain growth as a by-product (**Marghalani., 2016**).

#### **3.1. Free radical polymerization:**

This mechanism is referred alternatively as addition polymerization because molecules are added to the polymer during propagation. Methacrylates- based dental resin composites are polymerized by this type of polymerization reaction. It includes three stages which are; activation, initiation which requires activation by external source as light to produce a free radical which attacks the functional or reactive group

(carbon double bond) in the monomer, resulting in the formation of a carbon single bond and an unpaired electron. The reaction proceed and propagation take place. The chain growth continued till no free radicals are combined to it, resulting in the polymerization termination (**Marghalani., 2016**).

### **3.2. Ring-opening polymerization:**

The cationic reaction began with the initiation stage of the acidic cation, where the oxirane ring is opened and produces a new acidic center. Addition of oxirane monomer. The epoxy ring is then opened forming a chain, thus formation of polymer network (**Marghalani, 2016**).

## **4. Shrinkage stress :**

Clinically composite strain is hindered by the confinement of the material bonded to the tooth; as a result, shrinkage manifests itself as stress. It is widely accepted this condition often results in heavily pre-stressed restorations which may have adverse clinical consequences such as the following (**Versluis et al, 2003**):

**4.1.** Polymerization contraction stress is transferred to the tooth and causes deformation. This tooth deformation may result in enamel fracture, cracked cusps, and cuspal movement (**Suliman et al, 1994**).

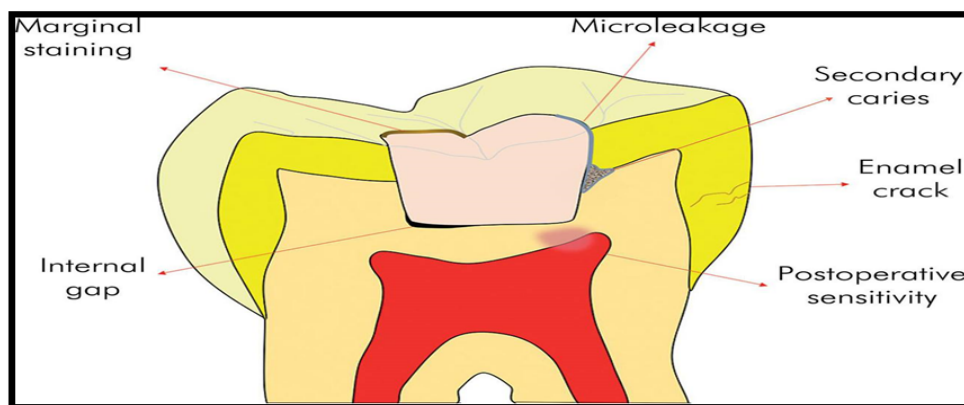
**4.2.** Polymerization shrinkage stress has the potential to initiate failure of the composite- tooth interface (adhesive failure) if the forces of polymerization contraction exceed dentin bond strength (**Condon et al, 1997**).

Such gaps between the resin and cavity walls may cause post- operative sensitivity, micro-leakage, and secondary caries (**Meredith et al, 1997**).

**4.3.** Stress has the potential to initiate micro- cracking of the restorative material (If the bonding to the cavity walls was strong enough to avoid gap formation during hardening, the stress concentrated inside the composite material would produce micro-cracks before complete setting (**Meredith et al, 1997**). However, this never

occurs since the compliance of the surrounding structures sufficiently reduces the setting stress to a level below the cohesive or adhesive strength. The remaining stress (residual stress) is maintained by the total elastic deformation of all materials involved in the tooth is restoration. As a result of this phenomenon, a restored tooth remains under stress even when there is no functional loading on it. This, therefore, implies a greater risk of failure during the tooth's function (**Silikas et al, 2000**).

**4.4.** The shrinkage stress depends on the size of the restoration and, therefore, on the thickness of the cavity wall. The tooth's resistance to polymerization shrinkage diminishes with loss of hard dental tissue. Larger restorations result in lower stress levels in the restoration and tooth- restoration interface but increase stress in the tooth (**Braga and Ferracane, 2002**).



**Fig 1.** Polymerization shrinkage stress

## **5. Factors that affect polymerization shrinkage:**

### **5.1. Modification in composition of resin composite:**

The two major components of dental composites are the polymer matrix and the filler particles. Changes in composition and chemistry of the constituent monomers and filler can alter the physical properties of the materials (**Finer and Santerre, 1999**).

### **5.1.1. Modification of Resin Matrix:**

The amount and types of monomer are greatly affect the polymerization shrinkage of dental composites (**Kamalak et al., 2018**). Evolving improvements in resinous phase of the dental composites were progressed to decrease the polymerization shrinkage to the least value.

#### **5.1.1.1. Use of thiol-ene-based monomers:**

Thiol-ene monomers were developed as an alternative to methacrylate-based systems. The mechanism of polymerization relies on radical-mediated step-growth between thiol and vinyl monomer. During the initiation stage, a thiyl radical is produced, which adds to a vinyl group, leading to a carbon-centered radical. Thus, formation of a thioether and a thiyl radical. The step-growth polymerization mechanism resulting in delayed gelation compared to the chain-growth mechanism of methacrylates with a significant polymerization shrinkage reduction (**Machado et al., 2017**).

#### **5.1.1.2. Use of silorane-based monomers:**

Silorane-based resin revealed a lower polymerization shrinkage compared to the dimethacrylates such as (Bis-GMA, UDMA, and TEGDMA). Silorane molecules polymerize through cationic ring-opening intermediates, instead of free radical cross-linked polymerization of dimethacrylate monomers, which in turn may produce polymerization shrinkage values less than 1% (**Van der laan et al., 2019**). The epoxy ring of the oxirane monomer rings are responsible for the reduced polymerization shrinkage. During polymerization it is opened to produce a linear chain with volumetric expansion that may compensate for volumetric shrinkage to some extent (**karaman et al., 2017**).

### **5.1.2. Modification of filler:**

Generally, the increase in the inorganic filler load on the expense of the resin matrix will consequently reduce the polymerization shrinkage. However, the addition of inorganic fillers to polymer resin has a certain limitation in order to achieve an adequate wettability of the resinous matrix to the fillers without creation of weak interface between these two phases **(Fronza et al., 2019)**.

Inorganic fillers modification is considered as the ultimate goals in evolution of dental resin composites, because filler type, load, size, and distribution will greatly affect the dental composites clinical success. Vast approaches have been done to improve the filler component load and quality **(Cramer et al., 2011)**:

#### **5.1.2.1. Incorporation of nanogels:**

Nanogels are a prepolymerized polymer in nanosized that cross-linked with the resin matrix and chemically attached to the inorganic filler surface, forming interphase structure between resin matrix and fillers. Nanogel prepolymer utilization in resin composite manufacturing considered as a versatile approach promote the incorporation of inorganic filler into resin matrix. Although, their polymeric origin, nanogels have been exposed to enhance mechanical properties of nanogel-modified composites. Moreover, they reduce the polymerization shrinkage associated with high nanogel content **(Fronza et al., 2019)**.

#### **5.1.2.2. Incorporation of bioactive nano-sized fillers:**

Polymerization shrinkage of dental resin composite could be reduced by decreasing the resin/filler ratio, which may be achieved by incorporation of more reinforcing inorganic filler, while at the same time get the unique benefit of the added fillers **(Par and Tarle., 2018)**. A novel type fillers were advocated as a possible solution to induce bioactivity, remineralization capability and to enhance mechanical feature of the restoration such as: Nano-hydroxyapatite **(Hamdy et al., 2015)**, bioactive glass **(Mass et al., 2017)**, calcium silicates, calcium phosphates, and other calcium-based derivative **(Abdelnabi et al, 2020)**.

### **5.1.2.3. Organic filler:**

The incorporation of pre-polymerized resin fillers (organic fillers) decreases the volume fraction of the polymerizable resin and increases the filler volume fraction resulting in reduction of the polymerization shrinkage.

### **5.1.3. Modification in the photo initiator system:**

Increasing the inhibitor concentration reduces polymerization shrinkage without altering the final degree of conversion. Camphoroquinone substituted by phenylpropane Dione reduced the stress produced by polymerization (**Schnieder et al., 2008**).

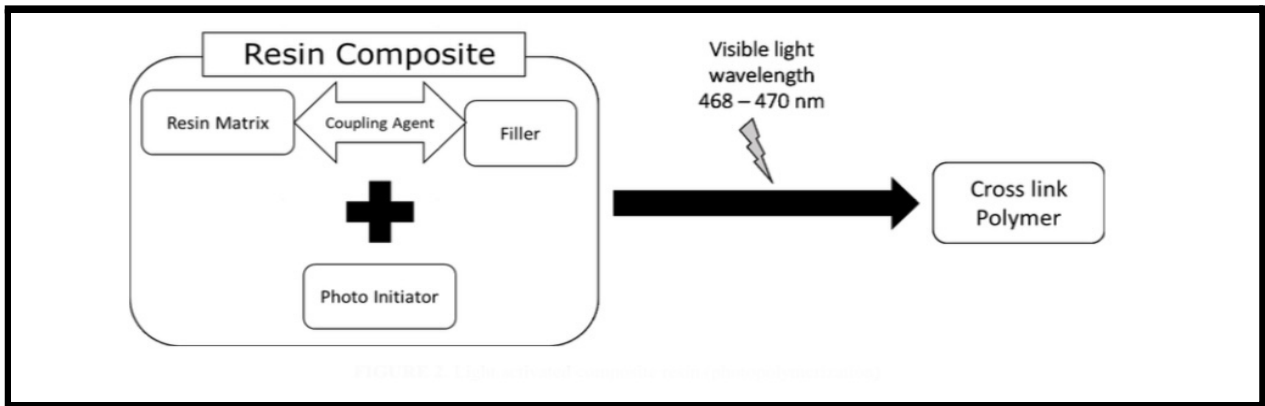
### **5.2. Intensity of curing light:**

Light activated composite resin consists of one type of paste in a syringe, the composition and the reaction of the light activated composite resin was shown in Fig.1. The paste consists of photosensitizer and amine initiator (**Anusavice et al, 2013**). When the composite resin paste is illuminated with the wavelength 468-470 nm, the resin will form free radical. The photosensitizer commonly used is Camphorquinone which can absorb light with the wavelength of 400-500nm and composition in the resin is less or equal to 0.2% of the weight of composite resin paste. When composite resin is illuminated with camphorquinone, it will excite and interact with DMAEMA to produce free radicals (**Rueggeberg et al., 2017**).

Higher the light intensity, greater the polymerization shrinkage. This is due to the greater degree of conversion. The slower polymerization retards the gel point, which provides time for stress relaxation (**Giachetti et al., 2006**).

Controlled polymerization can be achieved by the application of short pulses of energy (pulse) or pre-polymerization in low-intensity light followed by a final cure in high-intensity light with a soft-start technique (two-step and ramped/exponential) or a combination of the two (pulse delay) (**Mehl et al., 1997**).

Studies have shown that these polymerization modes may result in smaller marginal gaps and increased marginal integrity (**Kancha et al., 1999**).



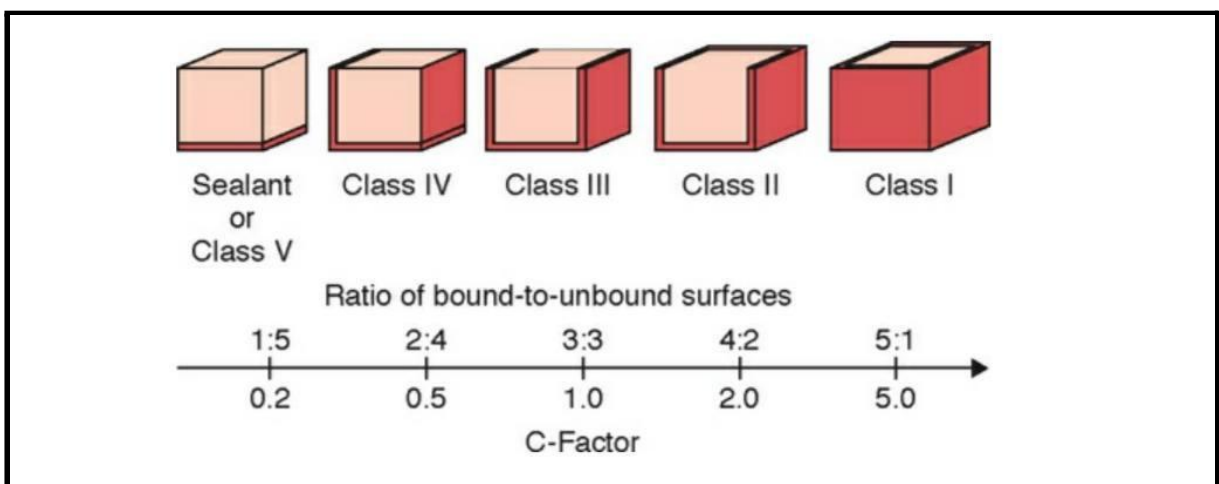
**Fig.2** Light activated composite resin

### 5.3. Configuration factor (C factor):

The C-factor is the ratio of bonded surfaces to the un-bonded, or free surfaces in a tooth preparation.

The higher the C-factor, the greater is the potential for bond disruption from polymerization effects (Ikemi and Nemoto., 1994).

Class I and class V cavity exhibit greatest stress because the restoration is bonded to five walls of the cavity. High C – factor results in de bonding of the restoration. Lowest stress is seen in class IV cavity because it has enough un bonded surfaces providing stress relief. Hence it is important to have lower configuration cavity (Combe *et al.*, 1999).



**Fig.3** Configuration factors (C-factors) associated with polymerization shrinkage for different situations using dental restorative materials.

#### **5.4. Material properties:**

There are three inherent properties of the resin composites that are crucial over the magnitude of stress:

**5.4.1. volumetric shrinkage**

**5.4.2. material stiffness (elastic modulus)**

**5.4.3. degree of conversion from double bonds to single bonds (Wand and Chiang, 2016).**

##### **5.4.1. volumetric shrinkage:**

This point has already been discussed.

##### **5.4.2. material stiffness (elastic modulus):**

In vitro studies have shown the interfacial stress during the setting shrinkage of a resin composite is positively correlated with the stiffness rate of the setting material known as elastic modulus or Young's modulus (**Feizler *et al.*, 1990**). Therefore, at a given shrinkage value, the most rigid material (the material showing the highest elastic modulus) will cause the highest stress. Obviously, the elastic modulus also increases as the polymerization reaction proceeds (**Sabbagh *et al.*, 2002**).

The higher the elastic modulus and polymerization shrinkage of the composite, the higher the contraction stress. Stress is determined by the volumetric shrinkage multiplied by the elastic modulus (Hooke's Law) (**Van *et al.*, 1993**).

##### **5.4.3. Degree of conversion:**

The degree of conversion (DC) can be defined as the extent to which monomers react to form polymers or as the ratio of C=C double bonds that are converted into C-C single bonds (**Iile and Hickel., 2011**).

There is a direct relationship between degree of conversion and shrinkage (**Silikas *et al.*, 2000**). For a given composite, a reduction in the final degree of conversion will lead to lower shrinkage and lower contraction stress. However, a low degree of conversion might compromise some of the materials mechanical properties. In



contrast, small increases in the degree of conversion will produce substantial increases in stress but will improve the mechanical properties of the material (**Braga and Ferracane., 2002**).

### **5.5. Thickness of composite resin:**

Incremental curing produces lesser polymerization shrinkage stress than bulk curing (**Giachetti *et al.*, 2006**).

## **6. Measurement of polymerization shrinkage:**

Several experimental methods have been developed to measure polymerization shrinkage of composites and resin cements. Most methodologies record total shrinkage, which include both pre- and post-gel shrinkage. In contrast, **the strain gauge technique** was proposed to isolate the post-gel shrinkage, which is more directly related to shrinkage stress development. Experimentally, the effects of polymerization shrinkage and shrinkage stress can be studied by a method such as **micro-CT** to measure internal gaps, while forces exerted by polymerization shrinkage can be measured using **load cells**. Shrinkage stress itself, however, cannot be measured directly because it is not a material property or physical response but a calculated engineering factor that expresses the state within a material depending on local deformation and material properties. Shrinkage stress and stress distribution can be calculated using **finite element analysis** (**Versluis and Tantbirojn., 2009**).

## **7. Clinical procedures to reduce shrinkage stress:**

The concurrent clinical and market trends such as desire to place of fewer increments, the development of lower shrinkage stress materials to address bulk curing, higher intensity light sources coupled with some claims of shorter cure time are the result of more recent research, and development efforts that have addressed the issue of polymerization shrinkage (**Lee *et al.*, 2007**).

Many clinical methods have been proposed to reduce shrinkage stress, such as

incremental layering techniques, control of curing light irradiance, and flowable resin liner application. However, no method has been shown to be totally effective in abating the effects of polymerization shrinkage (Uno and Asmussen ., 1991).

### 7.1. Incremental layering technique:

Many researchers have suggested the use of “incremental layering techniques” for resin-composite restoration to reduce the polymerization shrinkage stress and cusp deflection (Park J *et al.*, 2008). The rationale is that shrinkage may be less detrimental when there are fewer bonded cavity walls involved at each stage of the restoration procedures. Incremental curing may enhance the degree of cure in thick sections and may undergo higher degree of cure due to lower light attenuation. It depends on many factors such as the optical properties of the material, light source intensity, and exposure time, etc. This yields better mechanical properties but higher shrinkage as well; however, the C-factor changes as well (Feizler AJ *et al.*, 1994).

Nevertheless, the literature is not conclusive concerning the advantages promoted by the incremental layering technique over the effects of resin-composite polymerization shrinkage. Despite the controversy over the advantages of incremental build-up of resin composites, this technique has been broadly recommended in direct resin-composite restoration because it is expected to decrease the C-factor, allowing a certain amount of flow to partially dissipate the shrinkage stress (Uno and Asmussen ., 1991).

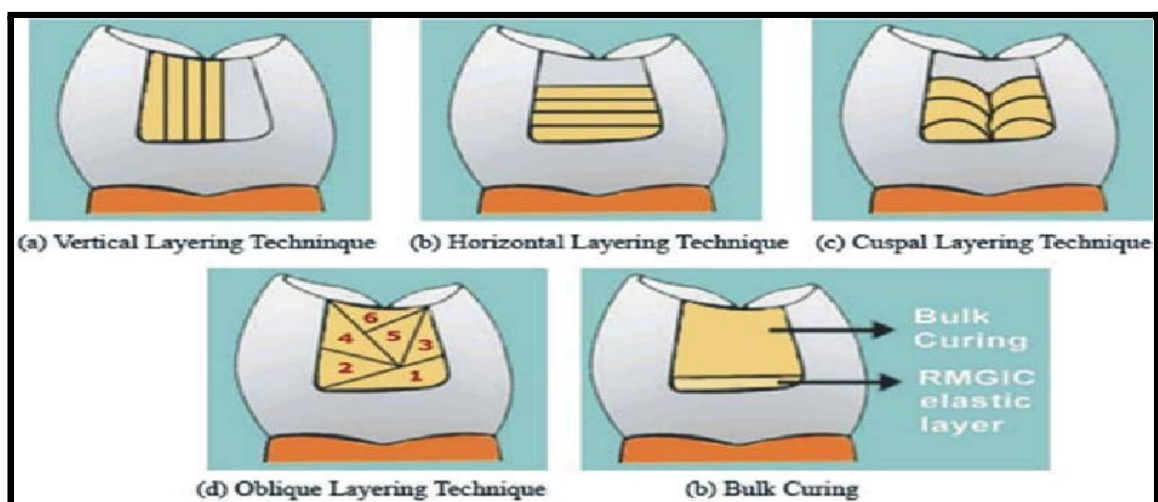


Figure 4. Incremental layering techniques

## **7.2. Light curing method:**

Diverse photoactivation protocols have been advocated to reduce the polymerization stress. In theory, stress release by viscous flow before the vitrification stage would be allowed to occur without compromising the final polymer properties (**Cavalcante *et al.*, 2009**).

Therefore, initial light exposure at lower irradiance values might lead to the formation of a reduced number of polymer growth centers, reducing the reaction rate and decreasing stress development due to the increased opportunity for resin flow before the vitrification stage (**Charton C *et al.*, 2007**).

The alternative light-curing protocols may not significantly affect final properties of the hardened material, some considerations should be noted:

- 7.2.1.** the flowability of a material during an extended preset stage, may have minimal consequences because most shrinkage stress is developed during and after the vitrification stage. Therefore, opportunities for polymer relaxation would be restricted during the short period of light activation (**Lu *et al.*, 2004**).
- 7.2.2.** Soft-start irradiation procedures give somewhat lower DC levels, associated with reduced stress (**Lu *et al.*, 2005**).
- 7.2.3.** A reduced polymerization rate is associated with decreased cross-link density, manifested as a greater solvent-softening and/or lower final elastic modulus (**Feng and Suh ., 2006**).

### **There are many types of alternative light-curing methods:**

#### **7.2.1. Pulse delay:**

In this method, each exposure is separated by a dark interval. During this phase the polymerization reaction takes place at a slow rate. The greatest reduction in the shrinkage is accomplished with the delay of 3 to 5 minutes.

Curing done for 10 seconds at 1-cm distance with a time gap of 10 seconds followed by 20 seconds curing in contact with the tooth surface proves to be a

suitable technique to reduce the polymerization shrinkage without compromising the degree of conversion (**Subbiya *et al.*, 2015**).

#### **7.2.2. Ramped curing:**

The intensity is gradually increased during the polymerization process. It is achieved by increasing the intensity with every 30 seconds either by bringing the light closer to the tooth or using a curing light designed to change its intensity. This allows the light curing material to have a prolonged gel phase during which the polymerization stresses are distributed readily (**Schneider *et al.*, 2008**).

#### **7.2.3. Staged curing / delayed curing:**

The restoration is initially cured at lower intensity until the contour and shape of the restoration is achieved. The second exposure with high intensity is applied to cure the final restoration. This provides substantial stress relaxation period. The longer the relaxation period, lower the stress generated (**Bassi *et al.*, 2016**).

### **7.3. Stress absorbing layers with low elastic modulus liners:**

Flowable composites are low-viscosity resin-based restorative materials, which differ from conventional resin composites in their filler load and resin content. These materials are less rigid and could have a modulus of elasticity 20% to 30% lower than conventional hybrid composites. The use of a flowable resin composite as an intermediate thin layer has been suggested as a mean of overcoming polymerization shrinkage stress based on the concept of an “elastic cavity wall” suggested for filled adhesives (**Braga *et al.*, 2003**). to the “elastic cavity wall concept,” the shrinkage stress generated by a subsequent layer of higher modulus resin composite can be absorbed by an elastic intermediary layer, thereby reducing the stress at the tooth-restoration interface manifested clinically as a reduction in cuspal deflection (**Cara *et al.*, 2007**).

However, actual implementation of such a “stress-absorbing” material is problematic. Flowable resin composites have shown shrinkage stress comparable to conventional resin composites, supporting the hypothesis that the use of flowable

materials does not lead to marked stress reduction and the risk of debonding at the adhesive interface as a result of polymerization contraction is similar for both type of materials (**Cadenaro *et al.*, 2009**).

#### **7.4. Preheating:**

Recently, preheating resin composites have been advocated as a method to increase composite flow, improve marginal adaptation, and monomer conversion. The benefits of preheating composites may have an impact on daily restorative procedures as well, with the application of shorter light exposure to provide conversion values similar to those seen in unheated conditions (**Daronch *et al.*, 2005**).

The reasons for increased conversion are based on many factors. Increased temperature decreases system viscosity and enhances radical mobility, resulting in additional polymerization and higher conversion (**Ge *et al.*, 2005**).

#### **7.5. Fiber reinforced composite:**

Since shrinkage is an intrinsic resin property, reducing resin volume by adding non-monomer components such as organic or non-organic fillers has been considered as an effective way to reduce the magnitude of shrinkage (**Ferracane and Hilton., 2016**). Fiber- reinforced composite (FRC) is a material that carries such an effect on polymerization shrinkage, while enhancing physical properties of the composite and potentially acting as a crack stopping mechanism (**Deliperi *et al.*, 2017**). The mechanical properties and reinforcing capacity of FRC used in dentistry depend on the fiber type, fiber orientation relative to the load, fiber position in the restoration, fiber volume and impregnation of the fiber to the resin matrix (**Ellakwa *et al.*, 2002**).

The use of fiber-reinforced composites have been broadly evaluated in various studies. Chairside incorporation of ultra-high molecular-weight polyethylene fiber (UHMWPE) into resin composite has received a renewed attention for the direct restoration of structurally compromised teeth that require the use of a large amount of composite (**Deliperi *et al.*, 2017**); however, the combination of UHMWPE fiber and

bulk-fill composite resin in deep cavities has not been evaluated. The current study investigated whether an increment of composite placed with plasma-treated leno-weaved UHMWPE fiber (Ribbond Ultra, Ribbond Inc, Seattle, WA) at the base of a deep cavity affected the debonding of composite from the cavity floor, total gap formation in the composite and the microtensile bond strength (MTBS) of composite to deep cavity dentin. The null hypotheses were that the gap formation at the cavity floor and the bond strength were not affected by the placement technique (**Shimada et al., 2012**).

#### 7.6. **Cavity design:**

Cavity designs for composites should be as conservative as possible to overcome the disadvantages of polymerization shrinkage. Modified cavity designs, placement of bevels, reduced depth and rounded internal line angles are very effective in providing good marginal adaptation and reducing microleakage. The role of bevels on cavosurface margins in reducing microleakage remains controversial.

Bevelling provides exposed enamel rod ends to be obtainable for bonding. Bowen et al. found that the bevel compensates for polymerization shrinkage. This might be because bevel increases the surface area of cut enamel thereby making it more tough for fluids to permeate in the restoration-tooth interface. The enamel margins when bevelled it produces oblique sections of prisms, and the strength of the bond between enamel and resin increases. Also, the bevel area is more tightly bonded to resin which reinforces the enamel margins, resulting in an decrease in polymerization shrinkage in this area. On the contrary Retief et al. found no advantages of bevelling to reduce microleakage in anterior teeth, while various other have reported less leakage with the tooth having bevel (**Dos Santos et al., 2007**).

#### 7.7. **Composite movement during polymerization:**

In the earliest stages of setting the shrinkage is maximal, but the material is still weak and able to yield. Presumably, only chain formation takes place, and cross linking is not at full reaction. The molecules can slip into new positions (**Davidson.,**

**1984).**

When a layer of polymerizing composite is connected to many surfaces through adhesive bonding, the movement of the composite mass (flow) will be toward the surface that has the highest bond strength at the moment in time. This movement toward the best bonded surface will stress the weaker bonded surface and make them even weaker.

The pull toward the center of the polymerizing mass and the bond to the tooth are the factors that must be properly harmonized to create a bond that will endure. Both have certain strengths at certain time in their individual chemical reactions (**Hickel *et al.*, 2000**).

### **Conclusion:**

The use of composite restorations is increasing because of the benefits accrued from adhesive bonding to tooth structure, esthetic qualities, and almost universal clinical use. When done properly, a composite restoration can provide excellent service for many years. When used in posterior teeth, however, composite restorations are more difficult and sensitive to the operator's technique and ability than are amalgam restorations.

Polymerization shrinkage remains the main problem facing dentists when working with composites, yet several methods are developed to overcome this problem .

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