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**THE COMPARISON OF RESIN-BASED COMPOSITES PHYSICAL PROPERTIES  
BETWEEN BULK-FILL TECHNIQUE AND INCREMENTAL TECHNIQUE  
(Review article)**

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**ABSTRACT:**

Composite resins are currently the most popular restorative material in dentistry. This is due to good aesthetics and maximum conservation ability. Behind these advantages, there are disbenefits of composite resin materials, such as polymerization shrinkage, which can lead to restoration failure. Various attempts have been investigated to reduce the shrinkage incidence of composite resins, one of which is the technique of placing the restorative material into the cavity. The restoration filling technique is recognized as a significant factor in shrinkage stress. By using a special filling technique, the polymerization shrinkage damage stress can be reduced. There are several techniques in performing composite resin fillings, including bulk and incremental techniques. These techniques have their respective advantages and disadvantages. The aim of this literature review was to compare the physical properties of composite resin restorations with bulk filling and incremental techniques. Physical properties that being studied include polymerization shrinkage, stress shrinkage, degree of conversion, bonding strength, water resorption, color stability, and temperature increase. Comparing the two techniques, composite resin with incremental filling technique has superior physical properties compared to bulk technique. From the comparison of the two techniques, the composite resin with incremental filling technique has superior physical properties compared to the bulk technique, especially in higher conversion which causes lower shrinkage stress. This situation makes the incremental technique provide better bond strength, water resorption, color stability, and lower temperature rise.

**Keywords:** Bulk, Composite Resin, Incremental, Physical Properties, Restoration, Restoration Technique

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**INTRODUCTION**

Nowadays, composites have undeniably become the first choice among the filling materials in direct techniques. Their aesthetic potentials suit a variety of therapeutic indications and also have a better ability to conserve the tooth structure because they are using adhesive methods rather than depending on cavity design.<sup>1</sup> The abrasion resistance of dental composites has continued to increase since its introduction as a dental restoration, allowing extended use in posterior restorations with good longevity.<sup>2</sup> However, like all dental materials, composites have their drawbacks, for example, the gap formation caused by polymerization contraction during setting, leading to marginal discoloration and leakage.<sup>2,3</sup>

Polymerization shrinkage is a significant concern among dental practitioners and researchers.

It may lead to clinical problems, such as marginal fading, restoration or tooth fractures, the solubility of the bonding system and marginal leakage. Microleakage is characterized by the invasion of acids, enzymes, ions, bacteria, and bacterial products into the margins of the restoration, causing post-operative sensitivity, recurrent caries, inflammation or even pulp necrosis.<sup>4</sup> This phenomenon also may cause residual stresses in the tooth, even when not in function.<sup>4,5</sup>

Polymerization shrinkage causes stress at the interface between a tooth and a restoration as the elastic modulus of the composite increases during curing. This stress manifests as a bond failure, cuspal flexure, enamel microcracking, pulpal irritation and secondary caries due to bacterial infiltration, and post-operative sensitivity, which in

turn can lead to restoration failure requiring re-restoration.<sup>4,6</sup>

Efforts have been made to reduce polymerization shrinkage of composites such as increase inorganic filler loading, decreasing reactive sites per unit volume, and filling techniques.<sup>3,7,8</sup> Restoration placement techniques are commonly known as a major factor of shrinkage stress. By using specific filling techniques, stress resulting from polymerization shrinkage may be reduced. Several filling techniques have been anticipated in an alternative way to reduce stress caused by polymerization shrinkage. However, it is still not sure which restorative technique should be effective to reduce shrinkage stress.<sup>9,10</sup>

Applying the composites in layers instead of using a bulk technique is suggested to reduce shrinkage stress. The incremental layering of composites has been proposed to counteract shrinkage and its stress on the bonded interface.<sup>10</sup> Although incremental placement techniques may have the advantage of maximizing polymerization of each increment due to less light attenuation through smaller increments of material and increased adaptation of the composite to cavity walls, the value of incremental placement in reducing shrinkage stress has been questioned.<sup>10,11</sup>

Many studies have compared the results of bulk-fill and incremental techniques with respect of some physical properties. In this research paper, the writer will conclude about several comparisons between the bulk filling and incremental filling techniques in physical properties factors.

## METHODS

The data were collected from data source search using PubMed, Google Scholar, and Science Direct. Articles were selected based on keywords: Incremental-fill composites, bulk-fill composites, polymerization shrinkage, degree of conversion, bond strength, water sorption, color stability, and temperature rise from year 2011-2021. Paper was written in English and the discussion were focused on physical properties comparison of resin-based composites between incremental-fill and bulk-fill techniques. From the data search, 25 articles and systematic reviews were collected.

## POLYMERIZATION SHRINKAGE AND SHRINKAGE STRESS

One way to determine polymerization shrinkage and shrinkage stress is by assessing cuspal deformation. It can be a valuable method of assessing the effects of polymerization shrinkage

stress where stress in a tooth cannot be measured directly.<sup>10,12</sup> Several studies have conducted the comparison between the bulk filling and incremental filling techniques in polymerization shrinkage.<sup>2,13,14</sup> Kim et al. performed research using linear variable differential transformers (LVDT) to compare the effect of incremental techniques and bulk filling on polymerization shrinkage stress.<sup>13</sup> In this study, the bulk filling group showed more cuspal deformation and higher C factor rather than the horizontal incremental and oblique incremental filling group. The C factor is the ratio of bonded surface to unbonded free surface and it is well known that polymerization shrinkage stress is influenced by the C-factor of the cavity. An increase in the C-factor restricts the flow of the shrinking composite material because more of the material is constrained at the interface between the cavity walls and the composite.

The similar result comes from the study by Young-chul Kwon et al. that investigated the effect of layering methods on the polymerization shrinkage stress of light-cured composites. In this study, the cuspal deformation in the incremental filling group was significantly lower than that in the bulk filling group. Incremental layering can present additional free surface areas between layers that allow the composite of each layer to have compensatory flow during curing with the same bonded surface area as in bulk filling. It means that the polymerization stress can be reduced.<sup>2</sup>

The different result comes from the study from Campodonico et al. They tested the effect of bulk versus an incremental technique on shrinkage stresses by recording cuspal deflection with a custom-developed software called CuspFlex. They found no significant difference in cuspal deflection between the bulk and incremental methods. With fact that the conditions and cure were similar between the bulk and incrementally filled restorations and the cuspal deflections were not significantly different, they conclude that differences in shrinkage stresses between the bulk and two-layer incremental placement methods could not have been substantial.<sup>14</sup>

## DEGREE OF CONVERSION

The degree of conversion is defined by the monomer composition and ratio, filler content, and photo initiator type and concentration. Because light-causing activation of the photo initiator is reduced by composite absorption and scattering, depth of composite cure relies on the material's capacity to transfer light into its depths.<sup>14,15,16</sup> Bucuta

et al. performed the study that assessed the degree of conversion of resin-based composites by using Confocal Raman Spectroscopy. This study found that degree of conversion in 4 mm depth bulk-fill techniques restoration had a lower degree of conversion than at shallower depth. When placed incrementally, the composites had a higher degree of conversion because each increment received the same irradiance and a longer light exposure that increased composites degree of conversion. A higher filler loading, leading to a greater number of particle/resin matrix interfaces, which may result in increased light scattering. Therefore, fewer photons would reach deeper layers of composites when placed using the bulk-fill technique, and consequently, a lower degree of conversion value would be found at the deepest depths of the restoration.<sup>16</sup>

The similar finding comes from the study from Campodonico et al. which measured microhardness of the composite restorations by using a hardness tester (MicroMet). They concluded that the degree of conversion was affected by different filling techniques. For the conventional bulk technique, they found a continuous drop in the hardness values as the depth and were significantly lower than those of the same material placed with the incremental techniques. This confirms that a bulk technique compromises depth of cure. In the incremental techniques, the hardness values of material placed with the incremental technique followed the same continuous drop as found in material placed with the bulk technique, except that there was a step increase at a depth of 2.0 mm which was the beginning of another increment that received more light energy and higher cure than the deeper composite of bulk techniques. Incremental techniques, therefore, improved the overall cure within a restoration.<sup>14</sup>

### **BOND STRENGTH**

Several studies compare the bulk-fill techniques and incremental techniques on bond strength to the cavity floor.<sup>17,18,19</sup> According to Bakhsh et al., the incremental filling techniques had more effective adhesion to cavity floor comparing to bulk-fill techniques.<sup>17</sup> Similar result with Han et al. findings, in high C-factor cavities, the incremental technique showed higher bond strength than the bulk-fill technique on the cavity floor.<sup>18</sup>

Different findings came from Flury et al, which found the increasing of increment thickness had no significant effect on bond strength. However, increasing increment thickness led to a few adhesive failures at the resin composite interface and some

cohesive failures in resin composite, indicating that light-curing at the bottom of the resin composite increments was less effective.

### **WATER RESORPTION**

The absorption of moisture by the resin-composites leads to the degradation of both strength and stiffness of composites. Water sorption also could lead to dimensional changes, loss of retention, staining and breaking in margin contours.<sup>19,20</sup> El-Safty et al conducted the research that compared bulk-fill and incremental filled composites in a stored dry condition and stored in distilled water. The bulk-fill resin-composites showed more influence of water storage over the creep strain and permanent set than the incremental filled resin composites. All the investigated resin-composites exhibited higher creep strain, higher permanent set and lower creep recovery in the wet group than in the dry group. The presence of water and other fluids has the potential to induce swelling and peeling stress in the structure, in addition to a plasticizing effect on the polymer matrix as well as debonding of the filler from the matrix, all of which can lead to increased creep formation.<sup>20</sup>

A different result came from a study by Tiba et al. that evaluated water sorption by weighing the volume of the restoration before and after placed in a water bath for 30 days. They concluded that the incremental filled composites restoration had a higher volume of water resorption than the bulk-fill restoration.<sup>19</sup>

### **COLOR STABILITY**

Color stability of composite resin is an important property influencing its clinical longevity.<sup>21,22,23</sup> In the oral environment, composite resin restorations are exposed to different dietary which might result in absorption of colorants in food into the resin and consequently color change.<sup>21,22</sup> Shamszadeh et al. performed the study of comparing bulk-fill and incremental filled composites restoration by placed them in 2 group of stored in distilled water and coffee solution to see how the color changes. Their results demonstrated that the bulk-fill composite resin had greater color susceptibility after involvement in coffee than incremental filled composites. It can be concluded that the discoloration is increased with greater increment thickness and it might be due to their lower depth of cure when placing bulk-fill materials.<sup>23</sup>

### INCREASE OF TEMPERATURE

Another disadvantage of composite material usage is the heat production during polymerization. Exothermic reactions of the composite resin and radiant heat from the light-curing unit contribute to this heat production. Excessive heat during dental procedures may contribute to pulp inflammation.<sup>24,25</sup> Kim et al. conducted a study about temperature increases during the polymerization of composite resin that was measured with thermocouples on bulk-filled and incremental filling techniques in composites restorations. In this study, the bulk-fill group exhibited higher temperature increases compared with the incremental group. In the incremental group, the temperature increases were greater during polymerization of the 1st increment than the 2nd increment. In both groups, the temperature increases were greater at the centre than at the corner and the top surface than at the bottom surface. By this study, they suggested that the incremental filling is recommended over bulk filling to minimize the potentially harmful thermal effects on pulpal health.<sup>25</sup>

In general, the incremental technique showed better performance on several physical properties rather than bulk-fill technique in composites restoration. Many studies believed that by placing the composite incrementally, composites would have a higher degree of conversion that will lead to a maximum amount of polymerization. The incremental technique also believes to have lower C-factor which potentially generate lower shrinkage stress to the restoration. These situations make incremental technique provides better performance on bond strength, water resorption, color stability, and lower temperature rise. However, bulk-fill technique serves a shorter time of restoration which satisfies the patient demand for faster and easier procedures. Hopefully, the future bulk-fill materials could provide better physical performance as well as the incremental technique in conventional composites.

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