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POLYMERIZATION SHRINKAGE AND VOID INCIDENCE IN BULK FILL COMPOSITE RESINS RESTORATIONS: THE EFFECT OF SUBSURFACE DEFECT, MATERIAL VISCOSITY AND RESTORATIVE TECHNIQUE

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ABSTRACT

Bulk-fill composite resins (BFCR) have gained popularity among clinicians due to the simplicity of the technique, which makes it cost and time effective. Placing BFCR greater than 2 mm has raised concerns regarding the adaptation of the material causing debond restorations from its internal walls and trapped voids. **Objectives:** This study aimed to identify subsurface debond immediately after curing by understanding the dynamic of BFCR polymerization shrinkage, and to investigate the occurrence of voids in relation to different manipulation techniques utilizing different types of BFCR. **Methodology:** Study was conducted in 2 parts; Part A investigated the linear (LD) and volumetric (VD) polymerization shrinkage displacement in presence of debond, and Part B investigated the incidence of voids. For Part A in-vitro studies, Class-I cavities of 4 x 4 x 4 mm^3 were prepared in 25 extracted molars and divided into 5 groups (n:5): G1 - bonded at all surfaces, G2 – debonded at floor, G3 – debonded at mesial wall, G4 - debonded at two adjacent walls and G5 – debonded at two opposing walls. LD and VD were measured from the experiment utilizing microCT, theoretically calculated from a new equation and FEA simulation. Agreement between the microCT-measured and theoretical-calculated and FE-predicted methods were analysed. The difference between the 5 groups were also investigated for any statistical difference ($p<0.05$). In Part B, four different types of CR were investigated with five restoration techniques in 25 class-I cavities (n:5) of $4 \times 4 \times 5$ mm^3: GI - conventional incremental oblique, GII - bulk-fill single placement, GIII - bulk-fill incremental cuspal build-up, GIV - incremental placement with different viscosities and GV - sonicated bulk-fill single placement. These restorations were scanned using microCT, and voids percentages were calculated at two locations: (1) within the restoration (closed voids) and (2) between the cavity wall and restoration (open voids). Data were analyzed using Kruskal-Wallis and Mann-Whitney post-hoc tests ($p<0.05$). **Result:** In Part A, the micro-CT images and FEA showed displacements did occur at all free and debonded surfaces, with the largest displacement at the middle of occlusal surface restoration. MicroCT-measured LD were G1:62.4±5.2µ, G2:32.8±4.0µ, G3:34.5±4.1µ, G4:30.8±4.8µ and G5:29.4±6.1µ. The FEA-oredicted values were G1:46.8µ, G2:34.6µ, G3:37.7µ, G4:32.3µ and G5:30.5µ. Theoretical-calculated was G1:60.2±7.4µ, G2:31.3±7.5µ, G3:33.2±6.9µ, G4:29.7±7.1µ and G5:27.1±6.5µ. G1 exhibited the highest value and G5 the lowest in all measurement methods. One-way ANOVA showed significant difference ($p<0.05$) between G1 to G2, G3, G4 and G5, but no significant difference ($p>0.05$) noted between G2, G3, G4 and G5 in all measurement methods. In part B, the findings were ranked according to occurrence of voids, as GII<GI<GIV<GIII<GV and GII<GIV<GI<GIII<GV for closed and open voids, respectively. Single bulk-fill placement (GII) produced the fewest closed and open voids, while single bulk-fill sonicated placement (GV) produced the most voids. All groups had significantly ($p<0.05$) fewer open voids than GV. GV also had significantly more closed voids than GI, GII, and GIV ($p<0.05$). **Conclusion:** Debond walls or floor in restorations gave an immediate specific characteristic on the LD and VD polymerization shrinkage. The in-vitro experiment and FEA confirmed that subsurface debond significantly reduces the surface displacement of composite resins restoration from a fully bonded restoration. It was also concluded that restoration techniques with different material viscosities did influence void occurrence.

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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The advancement of composite resins materials has helped increase the success and longevity of aesthetic dental restorations. These materials are nowadays the materials of choice for restoring damaged or decayed teeth due to their aesthetic values, minimal cavity preparation, good handling characteristics and improved physical and mechanical properties (Hervás-García et al., 2006; Fugolin and Pfeifer, 2017). In Malaysia, it was reported that almost 1.4 million tooth-colored restorations were provided in the government sector dental health division in 2020, fully demonstrating their popularity among dentists and patients (Oral Health Programme MOH 2021 Annual Report).

Time effectiveness and simplified treatment procedures are the focus of developments in the dental field. Bulk-fill composite resins have gained popularity among clinicians due to the simplicity of the technique, which makes it cost- and time-effective. The added photo initiator and greater translucency of bulk-fill material enhances the light curing efficacy by allowing sufficient material cure to the depth of 4-5 mm (Bucuta and Ilie, 2014; Zorzin et al., 2015; Rizzante et al., 2019) even when an undermined cavity is prepared to preserve the surrounding tooth structure (Ghani et al., 2019). Bulk-fill composite resins are available in low viscosity (flowable), normal viscosity, or high viscosity, which provides different rheological properties. The viscosity of these composites can be altered by varying the filler compositions and inorganic matrices, heating the material, and applying sonic vibration (Baroudi and Mahmoud, 2015).

However, rising as a concern, a practice-based study has demonstrated that only 62% of composite resins restorations survived after 4.6 years of service (Hurst, 2014; Kopperud et al., 2012) and a recent review reported a mean survival rate for resin composite of 86.2% as opposed to 92.8% for amalgam over a mean period of 55 months (Moraschini et al., 2015). It has been widely reported that, together with tooth or restoration fracture, recurrent caries is the most common reason for restoration replacement by clinicians, resulting in high treatment costs and dissatisfaction for