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COMPARATIVE EVALUATION OF DEPTH OF CURE OF THREE BULK-FILL COMPOSITES- AN INVITRO STUDY

Dental Science

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ABSTRACT

Introduction: Composite is one of the widely used aesthetic restorative material since 1960's. For decades, conventional composites were placed in maximum increments of 2 millimetres, because of the limited depth of cure. Bulk-fill composites are introduced as an alternative to the incremental layering technique which claims to enable restoration in thick layers up to 4 – 6 mm .So the aim of the study is to evaluate and compare the depth of cure of three bulk-fill composite restorative materials.

Material and methodology: Nanofilled bulk-fill material (Filtek Bulk Fill Posterior Restorative), nanohybrid bulk-fill material (Tetric N-Ceram Bulk Fill) and posterior bulk-fill flowable resin material (SureFil SDR flow).The depth of cure was assessed according to International Organization of Standard ISO 4049: 2009 and the data collected was statistically analyzed Results : The mean depth of cure values for SureFil SDR flow were 4.37±0.16 mm, followed by Filtek Bulk fill Posterior 3.84±0.15 mm and Tetric N Ceram Bulk Fill 3.64±0.22 mm. Conclusion: Within the limitation of the study posterior bulk-fill flowable resin material (SureFil SDR flow) showed the highest depth of cure than nanohybrid bulk fill composite (Filtek Bulk Fill Posterior Restorative and Tetric N Ceram Bulk Fill).

KEYWORDS

Bulk-fill, depth of cure, increments.

INTRODUCTION

Composite is one of the widely used restorative materials in dentistry. For decades, conventional composites have been used to provide patients with minimally invasive and esthetic restorations. It is placed in maximum increments of 2 millimeters (mm)[1]. Incremental build-up of multiple thin layers are required because of the limited curing depth[2].

For placement of dental composites, incremental layering technique has been accepted as a standard protocol, to ensure adequate light curing and reduce polymerization shrinkage. However, this technique has several drawbacks such as the possibility of incorporating voids or contamination between layers of dental composites. Also it is difficult to place the increment because of limited access to the cavity[3,4,5].

The multiple curing regimens and layering techniques of conventional composites are time consuming[2]. As a consequence, the composite market is often driven by consumer demand for easier and faster procedures by reducing the curing time and/or multiple composite layers[2]. In order to minimize the undesired effects, composite resin should be cured to a high degree and appropriate depth[2].

Bulk-fill composites have been launched as an alternative to the incremental layering technique. It claims to enable the restoration in thicker layers up to 4 – 6 mm[1] instead of incremental placement technique of conventional composite. Manufacturer's claim that bulk-fill composites have greater depth of cure[1]. The use of thicker increments in bulk-fill is due to both developments in photoinitiator dynamics and its increased translucency which allows additional light penetration and a deeper cure. It is achieved by means of novel resins, special modulators and unique fillers[3].

The particularity of this material category is the option to place in bulks, without negatively affecting the degree of conversion, polymerization shrinkage, or cavity adaptation[6]. According to the manufacturers, polymerization shrinkage of bulk fill composites are lower than commonly used flowable and conventional composites[7]. So it could minimize various problems related to polymerization shrinkage. These include gap formation which leads to secondary caries (due to bacteria colonization), irritation of pulp and post-operative sensitivity. Also, the idea of placing a self-adapting material as bulk, improving material handling and saving time, is of great interest[6].

However the extent of cure at the bottom of the restoration should be examined. Inadequate curing depth can affect both chemical and physical properties of resin composite. The test for depth of cure provides an indication of the total depth to which the composite will cure when composite is irradiated by a curing light for the amount of time recommended by the manufacturer[1]. This study investigated the depth of cure of three different types of bulk fill composite resin materials by using ISO 4049 : 2009 method[8]. So the aim of the study is to evaluate and compare the depth of cure of three bulk-fill composite restorative materials.

MATERIALS

The materials used for the study are

- Nanofilled bulk-fill material (Filtek Bulk-Fill Posterior Restorative, 3M ESPE)
- Nanohybrid bulk-fill material (Tetric N-Ceram Bulk Fill, Ivoclar Vivadent)
- Posterior bulk-fill flowable resin material (SureFil SDR flow, Densply)
- Digital micrometer accurate to 0.001 mm.

METHODOLOGY

This study was conducted in the Department of Conservative Dentistry and Endodontics, A.B.Shetty Memorial Institute of Dental Sciences, Deralakatte, Mangaluru. The depth of cure was analyzed according to International Organization for Standardization, ISO 4049:2009.

SAMPLE PREPARATION

Ten samples of each group were prepared in a metallic mold with an orifice of 4mm in diameter and 12 mm in depth. The mould was placed onto a strip of the transparent film on a glass microscope slide and filled with the test material. The mould and strips of film was pressed between the glass slides to displace excess material. The microscope slide covering the upper strip of film was removed and the exit window of the light curing unit (Demi ultra, Kerr Corporation) was gently placed against the strip of film. The material was irradiated for the time recommended by the manufacturer to achieve a depth of cure. Immediately after curing, specimen was removed from the mould, followed by removal of uncured material with the help of plastic spatula.

SAMPLE EVALUATION

The height of the cylinder of cured material was measured with the

digital micrometer to an accuracy of 0.001 mm. This value was divided by two and recorded as the depth of cure. The test was repeated twice.

FIGURES

Fig 1: A) Stainless steel split mold

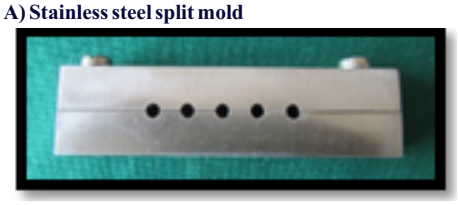


Fig 1:B) Curing of the samples

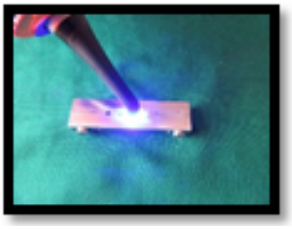
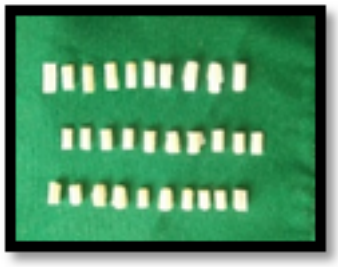


Fig 1:C) Samples prepared as per ISO specification



STATISTICALANALYSIS

The data collected was statistically analyzed using one-way analysis of variance test and Tukey's post hoc test. Significance level was set at P-value <0.05. IBM SPSS Software version 22 was used for the analysis.

RESULTS

The depth of cure values from all the three study materials was analysed to identify if there is any significant difference among the values. One-way analysis of variance (ANOVA) was applied to find the differences between the means among materials. P< 0.05 is considered to be significant.

Mean depth of cure values for SureFil SDR flow were highest at 4.37±0.16, followed by Filtek Bulk-fill Posterior 3.84±0.15 and Tetric N Ceram bulk-fill 3.64±0.22 (Table 1). One way ANOVA showed significant difference between the three materials. The post-hoc Tukey's HSD test was used for pair-wise comparison between the means when ANOVA test is significant.

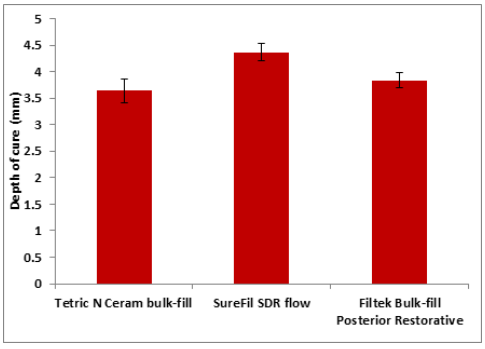
Depth of cure between Tetric N Ceram bulk-fill and SureFil SDR flow differed significantly (P<0.001) and depth of cure between SureFil SDR flow and Filtek Bulk-fill Posterior Restorative differed significantly while there was no significant difference between depth of cure between Tetric N Ceram bulk-fill and Filtek Bulk-fill Posterior Restorative (P=0.052) (Table 2).

Table 1 – Mean and Standard deviation of depth of cure values in all groups

DEPTH OF CURE (mm) between three groups (Mean ±SD)					
Material	N	Mean	Std. Deviation	Minimum	Maximum
Tetric N Ceram bulk-fill	10	3.64	0.22	3.31	3.93
SureFil SDR flow	10	4.37	0.16	4.19	4.68
Filtek Bulk-fill Posterior Restorative	10	3.84	0.15	3.54	4.00
Total	30				

Table 2 –Multiple Intergroup Comparisons for depth of cure using Tukey HSD test

Material 1	Material 2	Mean Difference	P	95% Confidence Interval	
				Lower Bound	Upper Bound
Tetric N Ceram bulk Fill	SureFil SDR flow	-0.73	<0.001	-0.931	-0.529
Tetric N Ceram bulk Fill	Filtek Bulk Fill Posterior Restorative	-0.2	0.052	-0.400	0.002
SureFil SDR flow	Filtek Bulk Fill Posterior Restorative	0.53	<0.001	0.331	0.732



Graph 1: Mean and Standard deviation of depth of cure values of three groups

DISCUSSION

Composite resins are considered material of choice in restorative dentistry because of the increasing demand for high-quality esthetic results in everyday practice[9]. In spite of the numerous advantages of composites used in restorative dentistry, high polymerization shrinkage and low depth of cure have always caused restrictions in the field of application of these materials[9]. Depth of cure has significant effect on biological as well as physical properties of restorations[10]. The presence of partially and fully unpolymerized monomers can result in the release of possible irritating, allergic, or toxic components into the surrounding tissues[10]. Bulk fill composites are specifically designed for large posterior restorations. This paradigm shift away from the traditional 2 mm increment system represent a new era in direct-filling-technology.

In this study, Filtek Bulk Fill Posterior Restorative, SureFil SDR flow and Tetric N-Ceram are compared and evaluated. According to the study, mean depth of cure values for SureFil SDR flow was highest, 4.37±0.16, followed by Filtek Bulk-fill Posterior Restorative (3.84±0.15) and Tetric N Ceram (3.64±0.22) (Graph:1). This study showed curing depth of SureFil SDR flow differed significantly from the other two materials tested. But Tetric N Ceram bulk-fill and Filtek Bulk-fill Posterior Restorative showed no significant difference between each other.

Various parameters influence depth of cure of dental composites. These are composition, filler contents, initiator types, viscosity, translucency, concentration and light intensity. To achieve a high depth of cure, all these factors have to be considered. Manufacturers have claimed that bulk fill composites have reduced polymerization shrinkage and it can be placed in bulks of 4-6 mm. All these have led to further interest about the composition of the bulk fill composites[6].

A new type of RBCs named bulk fill has been introduced to the market, which contains lower amount of filler with larger size. Presence of large sized filler (up to 2µm) in the structure of this composite will increase the level of connectivity between matrix and filler and improve the transmission of curing blue light into the deeper point of composite restoration[7].

Bulk-fill composites are more translucent than other restorations, which allow the light to get to much deeper layers[11]. The bulk-fill flowable composite resin possess a lower modulus of elasticity, as well as lower levels of polymerization stress in comparison to traditional flowable composite, without compromising on depth of cure[11]. Various factors like light reflection from the surface of material, scattering by filler particles and its absorption by photoinitiators limits the depth of

cure in conventional composite[12]. Of these the most important factors are filler content and particle size. Majority of the light scattering occurs at the resin and filler interface. Larger the filler particle, smaller will be the surface area of the filler. So the resin-filler interface will be less and light scattering will be less[12]. So larger filler particle in macrofiller range are included rather than smaller filler particle. Manufacturers of some low viscosity bulk-fill have also used reduced filler content[13].

One of the best methods to improve the depth of cure of RBCs is to increase the material translucency by matching the refractive indices of matrix and fillers. Differences in the refractive indices of filler and the composite matrix may increase light scattering, which consequently reduces the depth of cure of the composite restorations[14]. Tetric N-Ceram Bulk Fill utilizes advanced composite-filler technology, patented dibenzoyl germanium derivative Ivocerin (polymerization booster), camphorquinone, an acyl phosphine oxide. It allows the composite to be placed in bulk without deteriorating the optical properties of the composite such as translucency or colour[15]. The absorption coefficient, quantum efficiency and light reactivity of Ivocerin is much higher than camphorquinone and acyl phosphine oxide. Also Ivocerin is far more light-reactive than camphorquinone or acyl phosphine oxide.

SureFil SDR showed good values for depth of cure, these results might be related to the lower viscosity of these types of bulk fill composites. The manufacturers of Surefil SDR flow renounced the use of bisphenol-A dimethacrylate. They formed the organic matrix using other dimethacrylates6. Hence the RBCs are less viscous because TEGDMA, UDMA, and ethoxylated EBPDMA constitute more flexible polymers as compared to Bis-GMA[6]. The composition of SureFil SDR flow is based on a modification of triethylene glycol dimethacrylate, which is found to have more flexible side groups, reducing and forming a more homogeneous polymer network[10]. Typically the resin had a refractive index that's lower than that of the filler but Filtek Bulk Fill Posterior Restorative was formulated with aromatic resins which allowed the refractive index to more closely match the filler so the light would not be significantly bent and successfully transmitted through the material which increased the material's depth of cure. UDMA is a high molecular weight, low viscous monomer present in Filtek Bulk Fill Posterior Restorative. The proportion of the various monomers are adjusted to produce a bulkfill which is sculptable, fast curing, low polymerization shrinkage and with greater depth of cure. Tetric N Ceram bulk fill utilized, in addition to standard photo initiators camphorquinone, newly patented initiator Ivocerin which play an important role in increasing depth of cure[16,17,18].

It is important to highlight that the measurements were done by placing modern high-intensity LED at the upper surface of the mold. In clinical situations, often the curing unit is placed at a distance from the restoration/composite surface. Hence the clinical depth of cure value could be lower than the study results[6].

It must be considered that all experiments were done in an ideal laboratory condition. So the effect of various environmental factors like moisture, saliva and temperature were excluded. Hence the results have to be accepted with caution[19].

CONCLUSION

Within the limitations of this in vitro study, it can be concluded that Posterior bulk fill flowable composite (SureFil SDR flow) has the highest depth of cure than nanofilled bulk fill composites (Filtek Bulk Fill Posterior Restorative) and nanohybrid bulk fill composites (Tetric N-Ceram Bulk Fill). Depth of cure of SureFil SDR flow differed significantly from both Filtek Bulk Fill Posterior Restorative and Tetric N-Ceram Bulk Fill. Depth of cure of Tetric N-Ceram Bulk Fill and Filtek Bulk-fill Posterior Restorative had no significant difference. Curing depth is a material specific property; which is influenced by factors such as composition, filler, viscosity, and translucency of these materials. Further studies such as measurement of depth of cure using FTIR and other laboratory and clinical studies on bulk-filled materials are needed to confirm these findings.

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