The Effect of Light Curing Distance on the Micro-hardness of Bulk Fill Resin Composite

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Dedication

I would like to dedicate this work to

My small family, my dear husband and my little hero Abd Al Rahman

My big family, my great mother, my dear father, my lovely sisters and my dear brother

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Introduction

Recently, a new category of resin based composites was introduced as a bulk fill material and as a liner in class I and II restorations. The particularity of the new so-called bulk fill composite resin is stated to be the option to place it in 4 mm thick bulks instead of the current incremental placement technique, without negatively affecting material's properties. Moreover, manufacturers stated that the polymerization shrinkage of those materials is even lower when compared to commonly usedflowable and conventional resin based composites [(1)].

However, some concerns exist, regarding bulk-fill composites. Energy of the light emitted from a light-curing unit decreases drastically when transmitted through resin composite, leading to a gradual decrease in degree of conversion of the resin composite material at increasing distance from the irradiated surfacedue to the absorption and scattering of light by filler particles and resin matrix [(2)]. This decrease results in a gradation of cure such that it decreases from top surface inward. This then accounted for the difference between top surface hardness and bottom surface hardness. [(3)]

Decrease in degree of conversion compromises physical properties and increase elution of monomer and thus may lead to premature failure of a restoration due to inadequate polymerization especially at the critical gingival area or may negatively affect the pulp tissue. When restoring cavities with light-curing resin composites, it has therefore been regarded as the gold standard to apply and cure the resin composite in increments of limited thickness. The maximal increment thickness has been generally defined as 2 mm. However, restoring cavities, especially deep ones, with resin composite increments of 2 mm thickness is time consuming andimplies a risk of incorporating air bubbles or contaminations between the increments [3].

There are direct and indirect methods for investigating the depth of cure. Infrared spectroscopy and Raman spectroscopy are direct methods. Microhardness, scratching and visual inspection are some of the indirect methods. Direct methods are complex, expensive and time consuming; however, microhardness testing appears to be the most popular method because the other indirect methods tend to overestimate the curing depth. Surface microhardness has been shown to be an indicator of the degree of conversion and correlates well with the infrared spectroscopy [4].

It was therefore found to be beneficial to compare the top to bottom hardness of different bulk fill materials when cured at different thicknesses and curing distances.

Review of Literature

I. Importance of composite resin micro-hardness and contributing factors:

Micro-hardness evaluation has been used widely in literature for assessment of the mechanical and physical properties of composite resin. It has been shown to be a good indicator of the depth of cure [(5)].Inadequate depth of cure directly affects mechanical properties, solubility, dimensional stability, color stability, and biocompatibility of resin composites. The residual unreacted monomer acts as a plasticizer and alters the mechanical properties of the material. Consequently, composite resins should be polymerized as completely as possible to achieve increased restorations durability [(6)].

The effect of different parameters on the depth of cure was studied by many investigators [(7)]**.** While the composite resin composition and shade influence polymerization, light intensity and wavelength are also contributing factors. Consequently, light-activated composite should receive sufficient total energy at the correct wavelength from the light curing unit[(8)].The depth of cure of resin-composites depends on three factors: material factors such as resin chemistry, filler fraction, filler particle size; optical properties such as shade, translucency and refractive index; and the control of the clinician such as the layer thickness, duration of light exposure and intensity of light source. The efficiency of resin-composite polymerization may also depend on the light intensity and spectral distribution of the curing unit and the concentration of the photoinitiator in the resin [(9)].

II. Depth of cureof composite resin and light cure type:

Light-activated composite materials polymerize by free radical polymerization when exposed to light at wavelengths in the 400 to 500 nm range. The photoinitiator absorbs light energy emitted from the light-curing unit (LCU), and directly or indirectly initiates polymerization. Camphorquinone (CQ) is a commonly used photoinitiator that absorbs energy and reacts with a photo reducer to begin the polymerization process [8].

Currently, a wide variety of curinglights and methods is available. These newer units offer remarkablyhigher output intensity levels. Also, many featuresrelated to output control duringexposure have been provided[10]**.**The most popular method of delivering bluelight has been with halogen-based light curing units (QTH) [11]. Their bulb is filled with iodine orbromine gas and contains a tungsten filament. Whenconnected to an electric current, the tungsten filament glowsand produces a very powerful light [16].QTH LCUs produce a broad wavelength spectrum and need a filter to reduce output of undesired wavelengths, delivering light in the 410 to 500 nm region of the visible spectrum[8].

Photo-activation techniques have been proposed, such as the programmed use of low and high intensities that have claimed to be more effective in decreasing the stress generated by polymerization shrinkage while maintaining a high degree of conversion and satisfactory mechanical properties. Since the introduction of this method, other