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Polymerization mechanics of dental composites - Advantages and Disadvantages

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Abstract

Dental composite materials which are used as tooth fillings have numerous advantages and disadvantages in comparison to previously used alternative materials. Effects of polymerization shrinkage (light curing) of composite polymer materials which occur after illuminating with a LED lamp can cause problems in dental practice. Considered in this paper were the mechanical consequences which can occur due to light curing, along with strain fields for composites Z250, TetricEvoCeram and Silorane, as well as strain on a separate circular section that have occurred before and after light curing, by using the DIC method.

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1. Introduction

Resin based composite materials (hereinafter referred to as composites), due to their favourable physical and mechanical properties, including high resistance to compression and wear, relatively low costs and simple application, recently emerged as a substitute for amalgams. As for amalgams, despite their good properties, they have numerous disadvantages, such as: bioelectric potentials in the oral medium, potential risk of mercury poisoning, corrosion and impossibility of bonding with hard tooth tissues. Due to the aforementioned, radical cavity preparation is necessary, which involves sacrificing of a considerable amount of tooth tissue in order to ensure satisfying filling integrity, wherein a completely non-aesthetic form is obtained, which significantly reduces its overall value [1, 2].

Composites are essentially made of three basic components: resin based organic matrix, nonorganic filler particles or nonorganic dispersed phases and organic-nonorganic bonding agent, silane [3-5]. Organic matrix is made of monomers, that, due to polymerization, bond into polymers and form a three-dimensional network, which is

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filled with fillers, and in this way the physical and mechanical properties of the network are improved (Figure 1). In addition to the mentioned components, composites contain smaller amounts of additional materials which contribute to the overall material quality, such as: polymerization initiators, various additives, stabilizers, inhibitors, pigments etc. Filler materials typically include glass or quartz particles, or fused glass particles. Organic-nonorganic adhesive is typically added to filler particles themselves, and the nonorganic end of the molecule bonds with it, wherein the organic end of the molecule tends to bond with the resin matrix, thus unifying the organic and nonorganic phase of the composite.

The composite is non-metallic, contains no mercury, is thermally and electrically inert, possesses the ability to directly bond with hard tooth tissues, and ensures a satisfying aesthetic appearance of a natural tooth [3, 4].

The bond between tooth and composite has always been a sensitive issue in science, and the introduction of adhesive dentistry represents a huge step towards solving the issue of restoration conservation. One of the biggest disadvantages of restorative materials is their limited lifespan upon restoration, which may result as a consequence of occurrence of light curing and related stresses [6].

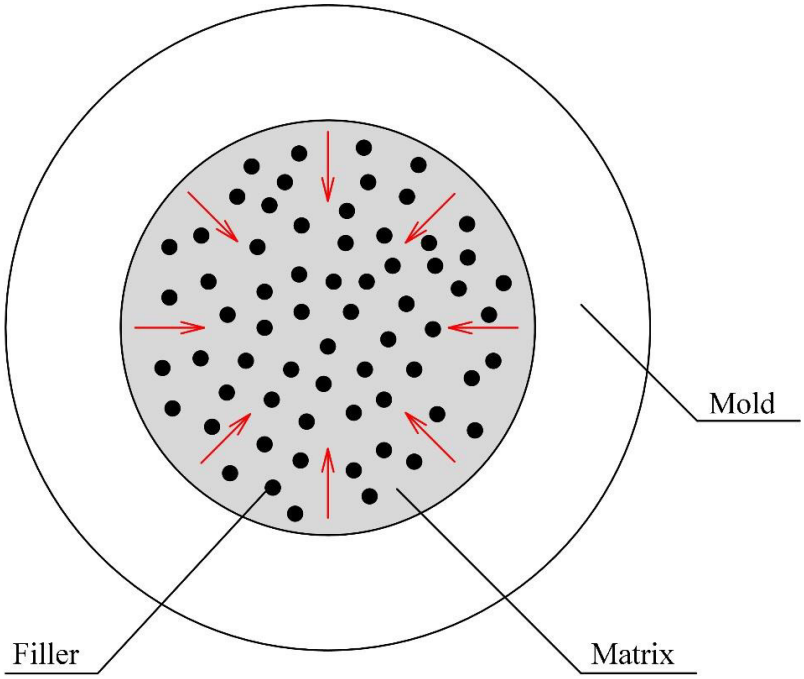

Figure 1. Light curing of a composite

2. Hardening mechanics and light curing

Displacement and spatial organisation of monomer molecules are responsible for volumetric changes during polymerization. At the beginning of the polymerization process, the resin enters the pre-gel stage, during which the organic matrix is in viscous plastic form, which allows it to “spill”, i.e. “flow”. In this stage the monomers can still move or “slip” into new positions within the organic matrix. The polymerization process continues, wherein larger molecules are formed, and the composite hardens and homogenizes into a solid body. The point at which any and all movement is no longer possible is referred to as the gel point, and denotes the transition from pre-gel to post-gel stage. Material is in a stiff elastic state, but is still contracting. This shrinkage causes stresses to occur. Gelation can be seen as the moment in which molecules within the material can no longer compensate the shrinkage. Total material shrinkage is determined by the pre-gel stage, during which the material can still be controlled and is