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The effectiveness of different polymerization protocols for class II composite resin restorations

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ABSTRACT

Objectives: To investigate the effect of reduced light exposure times on Vickers hardness (VH) of class II composite resin restorations.

Methods: Class II restorations were made *in vitro* in three 2 mm thick increments in a human molar. Two composite resins (Clearfil AP-X; Esthet-X) were polymerized with four light-curing units (Halogen; Astralis 10, LED; The Cure, L.E.Demetron I, Smartlite) following four curing protocols. Three protocols with exposure times of 10 s, 20 s or 40 s (control) per layer. In the fourth protocol, 10 s irradiation per layer was combined with additional lateral curing for 10 s from buccal and palatal after removal of the metal matrix. VH of the axial surface was determined at top and bottom layers directly after light-curing and after 7 days storage. Linear regression analysis was performed to analyze the effect of protocol variables.

Results: Directly after light-curing VH of both composite resins was significantly influenced by curing protocols. After 7 days, curing protocols had no significant effect on VH of Clearfil AP-X, except for the Smartlite. VH of Esthet-X was still influenced by curing protocol, but differences were smaller than directly after light-curing.

Conclusions: With high intensity light-curing units, exposure times of 10 s/2 mm increment can be sufficient to obtain under *in vitro* conditions a high degree of conversion, depending on materials and curing protocols. With additional lateral curing of a class II composite resin restoration a higher degree of cure can be obtained in less time.

1. Introduction

An adequate polymerization process is crucial for good physical properties of a composite resin restoration. Previous studies have shown that light polymerization is influenced by various factors such as composition and shade of the composite resin, quality of light-curing unit, exposure time, curing protocol and composite layer thickness.[1–7] Traditionally, exposure times of 60 s for increments, not exceeding 2 mm in thickness, are recommended when a halogen-curing unit with a minimum light intensity of 400 mW/cm^2 is used.[8] Nowadays, halogen-curing units and light emitting diode (LED)-curing units are available with outputs exceeding 800 mW/cm^2. This resulted in recommendations by manufacturers that shorter exposure times, down to 10 s, are sufficient for polymerization of their composite resins, which

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would be favorable for dentists as well as for patients. However, these shorter exposure times may lead to an insufficient degree of conversion of the composite resin. Especially at the bottom of the restoration, this may lead to reduced physical properties and poor biocompability[9–11] as the composite layer adjacent to the cervical cavity floor of a class II composite resin is difficult to cure well from the standard occlusal light source position for several regions. The increased distance between the cavity floor and the light source coupled with light attenuation caused by reflection, scattering and absorption of light through the thickness of the initial gingival increment combine to make adequate radiation time a more critical factor here in comparison to curing composite adjacent to the light source.

The effectiveness of polymerization can be established in several ways. Measuring microhardness of the composite resin restoration to evaluate polymerization is a frequently used technique. Because of its accuracy and relative simplicity this is the most favorable indirect method for investigating the degree of conversion.[12] Like other indirect methods, hardness measurements are not suitable for a direct comparison of different composite resins.[12,13] Direct methods like infrared spectroscopy and laser Raman spectroscopy are more complex, expensive and time-consuming.[3,12] In case of hardness testing, the norm for an acceptable degree of conversion at a certain depth from the surface is often set by demanding a hardness of 80–90% of the hardness at the top surface.[1,3,14,15]

In vitro hardness measurements are often performed on standard disks of composite resin made in Teflon or metal molds.[1,3,5,12,14,16–18] The disadvantage of using only these molds is the possibility of a changed reflection, transmission and absorption of light compared to the clinical situation in which composite resin is also surrounded by natural tooth structure.[3,19]

The aim of this study was to investigate the effect of a reduction of light exposure times on the degree of conversion of two composite resins placed in a class II preparation, when curing with high intensity halogen- and LED-curing units.

2. Materials and methods

For this study a standardized *in vitro* set-up was developed. One freshly extracted third molar was selected with the same mesio distal size as the artificial first molar in a typodont (KaVo Dental, Biberach, Germany). In this molar a class II preparation was ground with a diamond bur. The height from the top of the cusps to the bottom of the box was 7 mm but due to the anatomy of the central fissure the height of the restoration was set at 6 mm. The bucco palatal width was 5 mm and the depth to the axial wall was 2 mm (Fig. 1). The internal buccolingual width of the box was made slightly narrower than the proximal cavo-surface margins to allow removal of the restoration after polymerization. The molar was mounted on the position of the first molar with acrylic resin in the typodont so that it could be removed and stored in water to prevent dehydration. In the typodont adjacent artificial teeth were in situ to simulate clinical conditions. A stainless steel Tofflemire matrix in a universal Tofflemire retainer (Kerr Hawe, Bioggio, Switzerland) was placed around the molar and secured with a wooden wedge. Silicone separation liquid (CFS Products, Goes, the Netherlands) was applied into the cavity to prevent adhesion of the composite resin to the cavity wall. As a result, it was possible to make identical restorations in the sample tooth, which could be removed for testing.

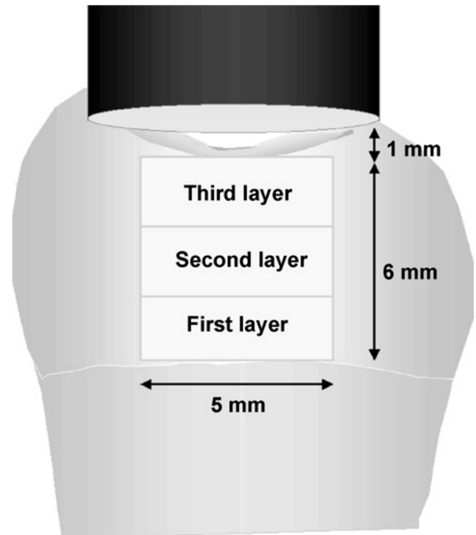

Fig. 1 – Class II restoration in sample tooth with layer technique and dimensions.

Two light-curing hybrid composite resins, Clearfil AP-X (Kuraray) and Esthet-X (Dentsply) were selected as well as four light-curing units, one halogen-curing unit (Astralis 10, Ivoclar Vivadent) and three blue LED-curing units (The Cure, Spring Health Products; L.E.Demetron I, Kerr; Smartlite, Dentsply). Details of the selected composite resins and light-curing units are shown in Table 1. Before starting the experiment and each time before changing to another composite resin, light intensities of the light-curing units were checked during 10 s with a radiometer (model 100, Demetron Kerr, Orange, USA) to ensure the same initial light intensity level for each material. To ensure a standardized output for the L.E.Demetron I and Smartlite, the rechargeable battery of the L.E.Demetron I was reloaded after 10 restorations and the battery of the Smartlite was reloaded after each restoration.

The restorations were placed following one of four standardized curing protocols. The composite resin was injected into the cavity from a preloaded tip and placed and cured in three 2 mm thick horizontal increments (Fig. 1). Each increment was polymerized from the occlusal surface. Light exposure time of the increments varied between 10 s and 40 s as shown in Table 2. The groups cured with the halogen-curing unit Astralis 10 with an exposure time of 40 s for each increment were considered as positive control groups. During light-curing, the distance between the light tip and the composite was standardized by positioning the light tip each time on the cusps of the molar. The occlusal surface of the restoration was hand shaped flattened on the same level as the central fissure. As a result distances between the light source and the upper surface of the final composite increment or the upper surface of the initial cervical composite increment were 1 and 5 mm, respectively. Moreover, the light beam was kept parallel to the axial wall of the cavity. After