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Can CAD/CAM resin blocks be considered as substitute for conventional resins?

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ABSTRACT

Objective. Dentists are facing a myriad of new CAD/CAM product for dental filling therapies. Are the new materials any worthwhile using? Are they succeeding the standard filling materials? Here we compare for the first time the new resin-composite blocks (RCBs) with conventional materials (Filtek Z250 and Tetric EvoCeram).

Methods. The material were tested for residual monomer elution by HPLC, thermogravimetric analysis (TG) was used to determine the percentage of fillers by weight, hardness was evaluated by Vickers method, morphology of fillers and distribution in the matrix were examined by scanning electron microscopy (SEM), elemental analysis for elemental determination of the filler particles was performed by energy-dispersive X-ray spectroscopy (EDX) cytotoxicity using human gingival fibroblasts and an epithelial cell line.

Results. The RBC outperformed conventional composite regarding mechanical characteristics (hardness) and monomer eluation, but showed some worrisome results regarding cytotoxicity.

Significance. The cost benefit is not in favour of RBCs in comparison to conventional composites, as the cytotoxicity was found higher for RBCs.

1. Introduction

The research and development of materials appropriate for CAD/CAM applications are one of the most active fields in dental materials [1]. The saltation evolution of CAD/CAM technology has led to a revolution in the forms of materials now used for many dental applications [2,3]. There are in two categories of materials available to the dentist (chairside): glass-ceramics/ceramic blocks and resin-composite blocks (RCBs) [1].

Conventional resin composite material (CRCM) consists of a polymeric matrix reinforced by fillers that are usually inorganic (oxide ceramic, glass ceramic or glasses), organic, or composite [1]. The filler particles are silane-treated to facilitate filler-matrix bonding. CRCMs are also made of other components such as polymerization initiators, stabilizers and colour pigments [4]. The material is usually in a paste form that allows adaptation to the cavity to be filled after a bonding procedure, and is commonly cured with a high-intensity light source.

The curing part is not required for CAD/CAM RCBs as they are pre-polymerized into ready-to-mill blocks. This controlled

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and optimized curing may lead to a superiority of RCBs over CRCMs due to more homogeneity, no operator related variables, and mechanical characteristics [5,6]. Nguyen et al. [7] tested commercial conventional resin composites by curing them under high-temperature and high-pressure (HT/HP) conditions and compared their mechanical properties. The results suggested that HT/HP polymerization could be used to obtain dental RCBs with superior mechanical properties, suitable for CAD/CAM processing [7].

Studies evaluating mechanical properties have reported inconclusive results when comparing CAD/CAM ceramic materials to RCBs. RCBs are expected to be more fracture resistant than glass ceramics, especially when the thickness of the restoration is limited [8], and the fatigue resistant have been reported to be better [9,10]. Contradictory to this, conventional resin composite materials have been reported to be more fatigue resistant than these glass-rich ceramics [11]. Polymer-based materials have been found to perform better than ceramics in flexural testing, with high flexural strength and low flexural modulus [12] and with higher modulus of resilience [12]. Whereas other studies have described the flexural properties for RCBs as comparable to ceramic blocks, but far inferior to lithium disilicate glass ceramic and densely sintered yttrium-stabilized zirconia for CAD/CAM [13]. However, some experimental studies have shown superior mechanical properties of RCBs compared to conventional composites [6,14]. Consequently, the mechanical properties of RCBs are expected to be between that of ceramic and conventional composites.

The composite materials are placed into a harsh and hostile environment where they are exposed to relatively large mechanical loads (cyclical loading), as well as major changes in both temperature (temperature cycling), pH-values from the very acidic to the very basic, and even individual changes in saliva flow and buffering capacity over time [15,16]. In addition to the mechanical requirements and physical properties, dental resin composites must not be detrimental to the patient or clinicianís health and safety. These factors obviously place great demands on the physical and chemical properties of the materials to fulfil the clinical expectations of both performance and longevity [17]. Will this new era of commercial CAD/CAM blocks lead to superior clinical success against these challenges?

Most of the studies on commercial CAD/CAM resin blocks are done with the aim of comparing these to ceramic materials for CAD/CAM application. However, there are few studies comparing composition and mechanical properties to the conventional composite materials, the material of choice for many dentist in restorative dentistry. Many of the new materials are described by the producer's based on in-house laboratory testing. Objective research and clinical evidences are insufficient, partly due to their short time on the market. Recently (12/06/2015), the producer changed the specification for Lava Ultimate due to debonding at a higher rate than anticipated. The product is no longer indicated for crown restorations; however, the indication for onlays, inlays (with retentive internal design) and veneer consists. This demonstrates the there is a need for independent in vitro and clinical research for identification of these products potential strengths and limitations.

The production methods of all three of the commercial resin CAD/CAM blocks in our study are differently described. Thus it is interesting to compare the properties of resin CAD/CAM blocks, and compare these to the given production methods.

The aim of the study was to evaluate if commercially available RCBs outperform conventional composites, and as such, represent a cost-benefit for dental patients and practitioners. Furthermore, to evaluate how the resin blocks for CAD/CAM differ from one another in composition and mechanical properties. Is the composition of the materials in agreement with the producer's description of the material? We evaluated and compared the monomer elution, cytotoxicity, morphology of filler particles, filler volume, filler content and hardness of three RCBs for CAD/CAM with two of the most used conventional composites in Norway. The null hypothesis was that there is no difference between resin blocks for CAD/CAM and conventional composites in regards to material safety (cytotoxicity), material (mechanical) properties and cost-benefit. Furthermore, there are no differences between the CAD/CAM materials for the *in vitro* parameters tested.

2. Experiment

2.1. Materials

CAD/CAM materials were selected based on the producer's characterization of their material. The conventional composite selection was based on the most frequently used conventional composite materials in the public dental health in Akershus County, Norway. **Materials**: Lava Ultimate (LAVA), Vita Enamic (VITA), Paradigm MZ100 (MZ100), Filtek Z250 (Z250) and Tetric EvoCeram (TEC). Batch number and information regarding the product was taken from the companies technical datasheet and presented in Table 1. The conventional composites were cured with the same LED curing light, LEDemetron II Light (Kerr Corporation, Orange, CA, USA), selected on the basis of recommended light intensities for the different material manufacturers. Filtek Z250 and Tetric EvoCeram were cured for 20 s from top and bottom.

2.1.1. Monomer elution

Cured material (sample size: 2.0 ± 0.1 mm, weight 76.6 ± 3.6 mg) was stored in acetone for seven days prior to liquid chromatographic analysis in an Agilent 1100 HPLC (Agilent Technologies, Santa Clara, CA, USA). The chromatographic conditions were done at ambient temperature using a Symmetry C18 column (150×150 mm, 5 μm particle size, 100 Å pore size) with an injection volume of 50 μL, eluent A:acetonitrile:water mix (50:50), eluent B:acetonitrile. Gradient was set as following: 0–5 min 100% A, 5–10 min 20% A, 10–20 min 20% A, 20–22 min, and UV detector at wavelength. Bisphenol A glycerolate dimethacrylate (BisGMA, CAS no. 1565-94-2, Mw: 512), triethylene glycol dimethacrylate (TEGDMA CAS no. 109-16-0, Mw: 286) and diurethane dimethacrylate (UDMACAS no. 72869-86-4, Mw: 471) (Sigma Aldrich Oslo Norway) was used as reference materials and linear calibrated ($r > 0.99$) at concentrations of 0.1, 0.25, 0.5, 1, 1.5, 2, 10, 30, 60, 100 ug/mL. The amount of residual monomer is

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