DENTAL MATERIALS XXX (2018) XXX–XXX

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.intl.elsevierhealth.com/journals/dema

Investigating the limits of resin-based luting composite photopolymerization through various thicknesses of indirect restorative materials

C.M.F. Hardy[a,b,c,*], S. Bebelman[c], G. Leloup[a,b,c,d], M.A. Hadis[e], W.M. Palin[e], J.G. Leprince[a,b,c,d]

[a] School of Dental Medicine and Stomatology, at Cliniques Universitaires Saint-Luc, Universite catholique de Louvain, Belgium

[b] Advanced Drug Delivery and Biomaterials (ADDB), Louvain Drug Research Institute (LDRI), Université catholique de Louvain, Brussels, Belgium

[c] Bio- and Soft- Matter (BSMA), Institute of Condensed Matter and Nanoscience (IMCN), Université catholique de Louvain, Louvain-la-Neuve, Belgium

[d] CRIBIO (Center for Research and Engineering on Biomaterials), Brussels, Belgium

[e] Biomaterials Unit, University of Birmingham, College of Medical and Dental Sciences, Institute of Clinical Sciences, School of Dentistry, 5 Mill Pool Way, Birmingham B5 7EG, UK

ARTICLE INFO

Article history:
Received 27 December 2017
Received in revised form
16 April 2018
Accepted 9 May 2018
Available online xxx

Keywords:
Degree of cure
Degree of conversion
Light transmittance
Light transmission
Polymerisation kinetics
Resin based luting composite
Indirect restorative materials
Lucirin-TPO
Irradiation time
Camphorquinone

ABSTRACT

Objective. To determine the limitations of using light-curable resin-based luting composites (RBLCs) to bond indirect ceramic/resin-composite restorations by measuring light transmittance through indirect restorative materials and the resulting degree of conversion (DC) of the luting-composites placed underneath.

Methods. Various thicknesses (0–4 mm) and shades of LAVA Zirconia and LAVA Ultimate were prepared and used as light curing filters. A commercial, light curable RBLC, RelyX Veneer (control) was compared with four experimental RBLCs of the following composition: TEGDMA/BisGMA (50/50 or 30/70 wt%, respectively); camphorquinone/amine (0.2/0.8 wt%) or Lucirin-TPO (0.42 wt%); microfillers (55 wt%) and nanofillers (10 wt%). RBLCs covered with the LAVA filter were light-cured for 40 s, either with the dual-peak BluephaseG2 or an experimental device emitting either in the blue or violet visible band. The samples were analyzed by Raman spectroscopy to determine DC. Light transmittance through the filters was measured using a common spectroscopy technique.

Results. All the factors studied significantly influenced DC ($p < 0.05$). RBLCs with increased TEGDMA content exhibited higher DC. Only small differences were observed comparing DC without filters and filters ≤ 1 mm ($p > 0.05$). For thicknesses ≥ 2 mm, significant reductions in DC were observed ($p < 0.05$). Transmittance values revealed higher filter absorption at 400 nm than 470 nm. A minimal threshold of irradiance measured through the filters that maintained optimal DC following 40 s irradiation was identified for each RBLC formulation, and ranged between 250–500 mW/cm^2.

* *Corresponding author at*: School of Dental Medicine and Stomatology, Universiteí catholique de Louvain, Belgium.
E-mail address: chloe.hardy@uclouvain.be (C.M.F. Hardy).

https://doi.org/10.1016/j.dental.2018.05.009

Significance. This work confirmed that optimal photopolymerization of RBLCs through indirect restorative materials (≤4 mm) and irradiation time of 40 s is possible, but only in some specific conditions. The determination of such conditions is likely to be key to clinical success, and all the factors need to be optimized accordingly.

1. Introduction

Clinical studies describe high performance of bonded ceramic restorations (esthetics, good survival rate), not only to restore anterior teeth [1–4], but also for extensive posterior restorations [5–7]. For both indications, the bonding quality is essential to provide clinical effectiveness, especially for partial restorations. Weaknesses in the bonding interface may lead to early clinical failures; mainly loss or fracture of the restoration, but also possibly favor the occurrence of other issues such as secondary caries, post-operative sensitivity or marginal discolouration due to marginal leakage [8].

Traditionally, a dual-cure resin-based luting composite (RBLC) is preferred for the placement of indirect restorations, to ensure effective polymerization even through thick and/or opaque restorations. The dual-cure chemistry supposedly combines the assurance of 'dark' chemical curing with some of the numerous advantages provided by purely light-curable systems. The latter notably include improved handling aspects, such as a single paste without the need for mixing, better control of working time, faster setting, easier excess removal or improvement of the interface colour stability [9]. Despite these advantages, very few works investigated the use of purely light-curable composites to lute indirect restorations [10,11]. One reported the possibility to reach an "adequate" polymerization of a conventional resin composite (described as 80% of the maximum material microhardness) when light cured through 7.5 mm thick 'endocrowns' [11]. Another revealed higher bond strength values when light curable resin composites were used to lute 4 mm thick inlays compared with the use of a dual-cure resin composite [10]. Such observations may be explained by two major elements: firstly, light curable resin composites usually contain more fillers than dual cure resin cements [12], hence higher intrinsic mechanical properties [10]. Secondly, photopolymerization processes probably generate a higher concentration of free radicals, which can be profitable during the autoacceleration step in dimethacrylate resins. During such step, any new growth centre created indeed leads to efficient chain propagation since the low mobility of the building polymer chains reduces the likelihood of bimolecular termination [13]. This reinforces the potential interest of utilizing solely light-curable chemistries not only to lute veneers [14] or thin inlays, but also thicker posterior restorations, such as endocrowns [10,11]. The importance of effective photopolymerization in light-curable RBLCs, and even those systems that include autopolymerization chemistries, is highlighted in numerous works [15–18]. For example, a previous study has reported a three-fold decrease in microhardness of dual-cure RBLCs when light cured through thick (4 mm), compared with thinner (2 mm or less), or no use of indirect ceramic filters [15]. A similar observation was made when measuring the degree of conversion of a dual-cure RBLC, with a two- to four-fold decrease of conversion through opaque 2 mm ceramic filters [17]. The autopolymerization step in a dual-cured system seems therefore insufficient to ensure optimal polymerization of luting composites. Hence, undercuring of dual-cure materials beneath thick indirect restorations remains a risk, which is potentially worsened with systems that use light-curable chemistries alone. Effective polymerization of the latter, is indeed necessary to ensure optimal physico-mechanical properties [13,19] and colour stability [20,21], thereby reducing the risk of interfacial failure.

Light transmittance through a tooth-coloured indirect restoration is significantly affected by material type. Veneers are commonly fabricated with feldspathic glass (porcelain), which exhibit relatively high translucency, however, more opaque materials exist, especially those fabricated using more modern CAD/CAM processes, including resin-based composites, particle reinforced ceramic composites (e.g. lithium disilicates and leucite-based ceramics) and polycrystalline ceramics (e.g. alumina and zirconia), the latter of which are expected to be the least translucent (notwithstanding modern attempts to increase translucency of monolithic polycrystalline crowns by adjusting the phase stabilisation dopant, grain size, and so forth). Therefore, if light transport is limited by the opacity of the indirect material, other inherent material chemistries that circumvent the need for effective polymerization using higher irradiance is certainly worthy of consideration.

The interest of using alternative photoinitiator systems to the classical combination of camphorquinone/amine (CQ), such as Type 1 acylphosphine oxides, has been extensively described for direct restorative resin composites. Notably, higher final DC and higher mechanical properties have been reported using curing times shorter than 3 s [22–26]. This was explained by higher molar absorptivity and quantum yield efficiency [27,28], which are potentially key aspects as regards light-curing through indirect materials. Indeed, low transmittance is iexpected through thick indirect material layers, which explains the relatively long irradiation times that were used when luting with light-activated (non-dual cure) resin-composites (from 40 s [10] to several cycles of 90 s [11]).

Consequently, the aim of this work was to determine the limits of RBLC photopolymerization by measuring light transmittance through various thicknesses of indirect restorative materials and the resulting degree of conversion (DC) of the resin cements placed underneath. Experimental RBLCs of various monomer ratios and photoinitiator content, as well as filters of different materials and shades were considered.

Please cite this article in press as: Hardy CMF, et al. Investigating the limits of resin-based luting composite photopolymerization through various thicknesses of indirect restorative materials. Dent Mater (2018), https://doi.org/10.1016/j.dental.2018.05.009