JOURNAL OF THE MECHANICAL BEHAVIOR OF BIOMEDICAL MATERIALS 37 (2014) 42–47

Available online at www.sciencedirect.com
ScienceDirect
www.elsevier.com/locate/jmbbm

Research Paper

Effect of thickness of bonded composite resin on compressive strength

Jorien T. Hamburger[a,*], Niek J.M. Opdam[a], Ewald M. Bronkhorst[a], Joost J.M. Roeters[b], Marie-Charlotte D.N.J.M. Huysmans[a]

[a]Department of Preventive and Restorative Dentistry, Radboud University Nijmegen Medical Centre, Philips van Leydenlaan 25, P.O. Box 9101, 6500 HB Nijmegen, The Netherlands
[b]Dental Material Sciences, ACTA, Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 29 April 2014
Accepted 3 May 2014
Available online 11 May 2014

Keywords:
Dental materials
Composite resin
Compressive strength
Adhesion
Thickness

ABSTRACT

Objective: The aim of this study was to investigate the compressive strength of composites with different physical properties bonded as a restoration to dentin in layers of varying thicknesses.
Methods: Four types of direct composite materials: a midway-filled (Tetric EvoCeram); a compact-filled (Clearfil AP-X); a nano-filled (Filtek Supreme); and a micro-filled material (Heliomolar) were bonded in 0.5–3.0 mm thick layers onto bovine dentin. Each material group contained 25 samples, which were loaded until fracture.
Results: The nano-filled and the compact filled material showed a significant association between layer thickness and compressive strength. The midway-filled composite was the most consistent material showing similar failure load over the complete thickness range.
Conclusion: A clear influence of layer thickness on compressive strength was found in some composite resin materials. When restorations are placed that are heavily loaded, such as in patients with severe wear due to bruxism it may be advisable to choose a material that is adequately strong in all thicknesses.

1. Introduction

A number of patients that suffer from severe tooth wear need restorative treatment to maintain a functioning dentition during their lifetime. In order to have sufficient space to restore the occlusal surfaces of posterior teeth and palatal surfaces of anterior teeth, the vertical dimension of occlusion often needs to be increased. This involves a new occlusion that has to be constructed by the dentist, which is a complicated treatment that can be achieved in several ways (Alonso and Caserio, 2012; Hamburger et al., 2011; Schmidlin et al., 2009). Severe tooth wear may be caused by erosion, bruxism or a combination of these factors (Smith et al., 1997). Therefore, as bruxism may be present and the support of natural tooth substance to occlusal forces is absent in restorations made in increased vertical dimension, these restorations are likely to be subjected to heavy loading resulting in an increased risk of fracture and wear. From

*Corresponding author. Tel.: +31 24 3616410; fax: +31 24 3540265.
E-mail address: jorien.hamburger@radboudumc.nl (J.T. Hamburger).

http://dx.doi.org/10.1016/j.jmbbm.2014.05.008
1751-6161/

the limited number of clinical studies on treatment of tooth wear it indeed appears that fractures are the most common type of failures (Hamburger et al., 2011; Schmidlin et al., 2009).

Therefore, a restorative material to be used in these heavily loaded restorations should have a sufficiently high strength and wear resistance. Clinical studies performed in a general practice environment have shown that composite resin performs well in normal and large sized restorations in all kinds of patients (Alonso and Caserio, 2012; Da Rosa Rodolpho et al., 2011; Opdam et al., 2010; Pallesen et al., 2013; van de Sande et al., 2013). Apparently, current dental composites have adequate mechanical properties for use in all areas of the mouth. However concern still exists when direct composites are placed in high stress situations, especially in patients with bruxing or other parafunctional habits (Ferracane, 2011), although a recent review paper recommends these materials for severe tooth wear (Lynch et al., 2014). A clinical study found that bruxism as a patient risk factor increased the failure rates of posterior composite resin restorations (van de Sande et al., 2013). In one study reporting on the use of micro-filled composites to restore tooth wear in increased vertical dimension a high failure rate was found, which may indicate that the material was not strong enough although from the paper reasons for failure are not clear (Bartlett and Sundaram, 2006). Recent developments in dental composites include nano-composites with smooth surfaces and higher fracture strength than micro-filled materials, but clinical results for these materials are scarce (Ilie and Hickel, 2009; Palaniappan et al., 2009) and limited to case reports where the special category of patients with severe tooth wear and bruxism is concerned (Reston et al., 2012).

The minimally invasive restorative treatment of severe wear patients includes direct or indirect uplays on the occlusal surface that are commonly bonded to the tooth without previous preparation. The thickness of a restoration mainly depends on the interocclusal space, and it may vary within the restoration due to the required anatomy but also because teeth are not worn down in a flat surface and may be subject to further eruption limiting the available space. This may result in localized thin layers of resin composite in some teeth, possibly compromising the strength of the restoration. Thickness of the restoration can be influenced either by increase of vertical dimension of occlusion (VDO), or by creating space by grinding. The latter invasive option is undesirable, as these patients have already suffered inordinate loss of tooth substance.

It is assumed that the fracture strength of a bonded layer of composite depends both on physical properties of the material and its thickness. Studies on the relation between layer thickness and strength of the material are scarce. A recent study comparing direct composites, indirect composites and ceramic materials showed a clear influence of layer thickness on compressive strength of the materials and showed that direct hybrid composites produced better than indirect materials (Hamburger et al., 2013).

In a recent in-vitro study ultra-thin (0.6 mm) occlusal uplay-restorations, CAD/CAM manufactured from composite and ceramic, were cemented onto teeth and subjected to loading until fracture occurred (Schlichting et al., 2011). In this study too authors concluded that restorative material thickness influenced the fatigue resistance of composite and ceramic. The effect of material composition is less clear. Filler volume of a composite was shown to have an important influence on physical properties of composite resin restorations (Ilie and Hickel, 2009; Schlichting et al., 2011). Other researchers found the influence of the type of material on the mechanical properties to be significant, but low (Palaniappan et al., 2009).

As no data on the influence of different types of composite on compressive strength are available, the aim of this study was to investigate the compressive strength of direct composites of different composition and physical properties, applied in layers of varying thicknesses to dentin.

2. Materials and methods

For this study, four materials were chosen: a compact-filled resin composite, Clearfil AP-X (Kuraray, Osaka, Japan); a midway-filled resin composite, Tetric EvoCeram (Ivoclar Vivadent, Schaan, Lichtenstein); a nano-filled resin composite Filtek Supreme (3M, St. Paul MN, USA); and a micro-filled resin composite, Heliomolar (Ivoclar Vivadent, Schaan, Lichtenstein).

Results for APX and Tetric Evoceram have been used previously (Hamburger et al., 2013). These materials vary in physical properties as shown in Table 1. The division of dental composites is chosen according to their morphological and mechanical characteristics (Willems et al., 1992). Using

Table 1 – Specifications and properties of the materials used.

Composite	Type	Manufacturer	Filler particle size (μm)	Content (w/v)	FS (Mpa)	FM (Gpa)	E (Gpa)
Clearfil AP-X	Compact filled	Kuraray	0.2–17	86/70	204	15.3	15.3
Filtek Supreme XTE	Nanofilled	3M ESPE	0.6–10	87.5/59.5	108.6	6.1	6.1
Tetric Evo Ceram	Midway filled	Ivoclar-Vivadent	~550 nm	76/55	120	10	10
Heliomolar	Microfilled	Ivoclar-Vivadent	<1	66.7/46	100	4.1	4.1

FS: flexural strength.
FM: flexural modulus.
E: E-modulus.