A novel dentin bond strength measurement technique using a composite disk in diametral compression

Shih-Hao Huang\textsuperscript{a}, Lian-Shan Lin\textsuperscript{b}, Joel Rudney\textsuperscript{c}, Rob Jones\textsuperscript{d}, Conrado Aparicio\textsuperscript{b}, Chun-Pin Lin\textsuperscript{c,*}, Alex Fok\textsuperscript{b,*}

\textsuperscript{a} Graduate Institute of Clinical Dentistry, School of Dentistry, National Taiwan University, Taiwan
\textsuperscript{b} Division of Pediatric Dentistry, School of Dentistry, University of Minnesota, Minneapolis, MN, USA
\textsuperscript{c} Department of Diagnostic and Biological Sciences, School of Dentistry, University of Minnesota, Minneapolis, MN, USA
\textsuperscript{d} Minnesota Dental Research Center for Biomaterials and Biomechanics, School of Dentistry, University of Minnesota, Minneapolis, MN, USA
\textsuperscript{e} Department of Pediatric Dentistry, School of Dentistry, University of Minnesota, Minneapolis, MN, USA
\textsuperscript{f} Department of Dentistry, School of Dentistry, National Taiwan University and National Taiwan University Hospital, Taiwan

\textbf{A R T I C L E I N F O}

\textit{Article history:}
Received 4 October 2011
Received in revised form 30 November 2011
Accepted 29 December 2011
Available online 15 January 2012

\textbf{Keywords:}
Dental post
Bond strength
Brazilian disk
Image correlation
Acoustic emission

\textbf{A B S T R A C T}

New methods are needed that can predict the clinical failure of dental restorations that primarily rely on dentin bonding. Existing methods have shortcomings, e.g. severe deviation in the actual stress distribution from theory and a large standard deviation in the measured bond strength. We introduce here a novel test specimen by examining an endodontic model for dentin bonding. Specifically, we evaluated the feasibility of using the modified Brazilian disk test to measure the post–dentin interfacial bond strength. Four groups of resin composite disks which contained a slice of dentin with or without an intracanal post in the center were tested under diametral compression until fracture. Advanced nondestructive examination and imaging techniques in the form of acoustic emission (AE) and digital image correlation (DIC) were used innovatively to capture the fracture process in real time. DIC showed strain concentration first appearing at one of the lateral sides of the post–dentin interface. The appearance of the interfacial strain concentration also coincided with the first AE signal detected. Utilizing both the experimental data and finite-element analysis, the bond/tensile strengths were calculated to be: 11.2 MPa (fiber posts), 12.9 MPa (metal posts), 8.9 MPa (direct resin fillings) and 82.6 MPa for dentin. We have thus established the feasibility of using the composite disk in diametral compression to measure the bond strength between intracanal posts and dentin. The new method has the advantages of simpler specimen preparation, no premature failure, more consistent failure mode and smaller variations in the calculated bond strength.

\textcopyright 2012 Acta Materialia Inc. Published by Elsevier Ltd. All rights reserved.

\textbf{1. Introduction}

Many factors affect the prognosis of endodontically treated teeth. Among them, post loosening and root fracture are the most common reasons for failure [1]. Both events are caused by excessive forces, either at the tooth–restoration interface or in the tooth tissue itself. In fact, the two are related, with loosening of the restoration being one of the main factors causing root fracture. This has been confirmed by finite-element analysis, which shows that interfacial failure between the post and tooth will significantly increase the stress in the tooth and, hence, the risk of root fracture [2]. Following post loosening, the post–core–crown–tooth structure will no longer be able to function as a single unit in sustaining the occlusal load [3]. Therefore, ensuring adequate bond strength between the post and dentin is paramount for endodontic treatments to be successful. Interfacial debonding is also responsible for the failure of other forms of restoration, e.g. secondary caries in composite restorations due to colonization of acid-producing bacteria within the compromised interface.

Many different mechanical test methods are available for measuring the bond strength between intracanal filling materials and dentin, e.g. the microtensile bond test, the pull-out test and the push-out test [4]. The main disadvantages of the microtensile bond test, which uses extensively machined specimens with a complex shape, include a high percentage of premature specimen failure and non-uniform stress patterns. These lead to a large variability in the test results [5]. In contrast, the push-out test is reported to have a more homogeneous stress distribution and less variability in the measured data. With this method, the bond strength can be calculated by simply dividing the maximum recorded force by...