DENTAL MATERIALS 32 (2016) 499–509

Available online at www.sciencedirect.com

ScienceDirect

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

Fatigue resistance of CAD/CAM resin composite molar crowns

Fatma A. Shembish[a], Hui Tong[a,b], Marina Kaizer[a,c], Malvin N. Janal[d], Van P. Thompson[e], Niek J. Opdam[f], Yu Zhang[a,*]

[a] Department of Biomaterials and Biomimetics, New York University College of Dentistry, 433 First Avenue, New York, NY 10010, USA
[b] School of Metallurgy and Environment, Central South University, Changsha, Hunan 410083, PR China
[c] Graduate Program in Dentistry, Federal University of Pelotas, Pelotas, Brazil
[d] Department of Epidemiology and Health Promotion, New York University College of Dentistry, 380 Second Avenue Suite 301, New York, NY 10010, USA
[e] Tissue Engineering and Biophotonics, King's College London Dental Institute, United Kingdom
[f] Radboud University Nijmegen Medical Centre, College of Dental Sciences, Preventive and Restorative Dentistry, Ph van Leydenlaan 25, PO Box 9101, 6500HB Nijmegen, The Netherlands

ARTICLE INFO

Article history:
Received 27 June 2015
Received in revised form
3 November 2015
Accepted 7 December 2015

Keywords:
Fatigue
Fracture
Resin composite
Glass-ceramic
CAD/CAM crowns
Weibull analysis

ABSTRACT

Objective. To demonstrate the fatigue behavior of CAD/CAM resin composite molar crowns using a mouth-motion step-stress fatigue test. Monolithic leucite-reinforced glass-ceramic crowns were used as a reference.

Methods. Fully anatomically shaped monolithic resin composite molar crowns (Lava Ultimate, $n = 24$) and leucite reinforced glass-ceramic crowns (IPS Empress CAD, $n = 24$) were fabricated using CAD/CAM systems. Crowns were cemented on aged dentin-like resin composite tooth replicas (Filtek Z100) with resin-based cements (RelyX Ultimate for Lava Ultimate or Multilink Automix for IPS Empress). Three step-stress profiles (aggressive, moderate and mild) were employed for the accelerated sliding-contact mouth-motion fatigue test. Twenty one crowns from each group were randomly distributed among these three profiles (1:2:4). Failure was designated as chip-off or bulk fracture. Optical and electron microscopes were used to examine the occlusal surface and subsurface damages, as well as the material microstructures.

Results. The resin composite crowns showed only minor occlusal damage during mouth-motion step-stress fatigue loading up to 1700 N. Cross-sectional views revealed contact-induced cone cracks in all specimens, and flexural radial cracks in 2 crowns. Both cone and radial cracks were relatively small compared to the crown thickness. Extending these cracks to the threshold for catastrophic failure would require much higher indentation loads or more loading cycles. In contrast, all of the glass-ceramic crowns fractured, starting at loads of approximately 450 N.

* *Corresponding author*. Tel.: +1 212 998 9637; fax: +1 212 995 4244.
E-mail address: yz21@nyu.edu (Y. Zhang).

http://dx.doi.org/10.1016/j.dental.2015.12.005
0109-5641/© 2015 Academy of Dental Materials. Published by Elsevier Ltd. All rights reserved.

Significance. Monolithic CAD/CAM resin composite crowns endure, with only superficial damage, fatigue loads 3–4 times higher than those causing catastrophic failure in glass-ceramic CAD crowns.
© 2015 Academy of Dental Materials. Published by Elsevier Ltd. All rights reserved.

1. Introduction

In clinical dentistry, there is a shift toward placing metal-free restorations. For direct restorations, resin composite has become the standard material that, depending on risk factors of tooth and patient, provides restorations with good longevity [1–3]. Indirect restorations allow the dentist to have greater control of the form and function of a restoration, especially for teeth with considerable amount of tooth substance loss. For indirect restorations, several types of ceramic restorative materials have shown good survival rates when applied as full coverage crowns or inlays, although chipping of the ceramic remains a common problem [4,5]. Indirect resin composite restorations have shown acceptable survivability [6,7], but their performance is not better than direct restorations [8]. The increased use of resin composite materials for indirect restorations is a result of several recent trends: significant improvements in their mechanical properties, increased demands for highly esthetic, metal-free, biocompatible restorations [9,10], and rapid advances in computer-aided design/computer-assisted manufacturing (CAD/CAM) technology. Recently, resin composite blocks have been introduced for use with CAD/CAM systems as an alternative for machinable ceramics [11]. CAD/CAM resin composite restorations have several advantages over their ceramic counterparts: (1) Resin composite blocks are milling damage tolerant, which allows for a faster milling speed and provides better marginal quality [12]; a full contour crown takes only 6 min to mill [13]! (2) No post-milling firing is needed. (3) Indirect resin composite restorations can be easily polished and adjusted for proper occlusion. These properties permit the fabrication and placement of a complete restoration within a single dental office visit [13,14], benefiting both the patient and practitioner.

Much effort has been made to improve the mechanical properties of resin composite restorative materials, such as increased filler content, changes in filler particle size and shape, changes in matrix composition, and improvements of polymerization methods [15–19]. Recently, nanotechnology has been introduced to the dental resin composite manufacturing field. One recently developed nanohybrid resin composite material is Lava Ultimate CAD/CAM Restorative (3 M ESPE, St. Paul, MI, USA); it is heat-cured through a proprietary manufacturing process, which eliminates the need for any further polymerization after milling.

Several *in vitro* studies have evaluated indirect resin composites. Magne and colleagues conducted a number of studies on Paradigm MZ100 (3 M ESPE) [20–22]. They compared the fatigue resistance of resin composite and ceramic occlusal veneers and onlays with various thicknesses on posterior teeth (some with endodontic treatments). They reported that posterior occlusal veneers and onlays made of MZ100 had significantly higher fatigue resistance compared to IPS Empress CAD (Ivoclar Vivadent, Schaan, Liechtenstein), IPS e.max CAD (Ivoclar Vivadent), and Vitablocks Mark II (VITA Zahnfabrik, Bad Säckingen, Germany). Kassem et al. [23] examined the effect of cyclic loading using a hardened steel ball (r = 3 mm) on fatigue resistance and microleakage of monolithic CAD/CAM molar ceramic and resin composite crowns. Their results revealed that MZ100 resin composite molar crowns were more fatigue resistant than Vitablocks Mark II ceramic crowns, after 1,000,000 cycles of cyclic loading at 600 N. However, ceramic crowns exhibited significantly less microleakage relative to resin composite crowns, irrespective of the type of the cement used. Belli et al. [24] compared the fatigue resistance of modern dental ceramic bar specimens *versus* resin composites using the 4-point bending method. Their results revealed that while resin composite and dental ceramics exhibit similar fatigue degradation, resin composite materials used for direct restorations are more resistant to cyclic flexural loading than glass-rich ceramics used for indirect restorations. Johnson et al. [25] showed superior fracture strength of posterior occlusal veneers made from Lava Ultimate resin composites than Paradigm MZ100 and concluded that Lava Ultimate were able to survive higher occlusal loads than MZ100.

By introducing the new and improved indirect nanohybrid resin composite material, the clinical indications of CAD/CAM resin composite restoration have been extended to full coverage posterior crowns, which require greater mechanical integrity than inlays and onlays. However, to our knowledge, no *in vitro* fatigue study has been conducted on full-coverage posterior nanohybrid resin composite crowns. The purpose of this *in vitro* study is, therefore, to investigate the sliding contact mouth-motion fatigue behavior and reliability of a newly developed indirect nanohybrid resin composite (Lava Ultimate) for posterior crown applications.

2. Materials and methods

2.1. Crown fabrication

Anatomically correct mandibular first molar crowns (n = 24, resin composite Lava Ultimate crowns; n = 24, glass-ceramic IPS Empress CAD crowns) were designed and milled from CAD/CAM blocks using the following systems: Lava Milling System (3M ESPE) in a 3M certified dental lab (Jensen Dental, North Haven, CT) and CEREC System (Sirona, Charlotte, NC, USA). A standard die of a mandibular first molar preparation was scanned into the system adjusted to compensate for the cement layer thickness (50 μm). Tooth preparation was modeled by reducing the proximal walls by 1.5 mm and the occlusal surface by 2.0 mm. After milling the crowns were

Download English Version:

https://daneshyari.com/en/article/1420495

Download Persian Version:

https://daneshyari.com/article/1420495

Daneshyari.com