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Fractographic failure analysis of a Procera[®] AllCeram crown using stereo and scanning electron microscopy

Susanne S. Scherrer^a ... Janet B. Quinn^c

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Abstract

Objectives

Presentation of a methodological approach using stereo and scanning electron microscope examination for the failure analysis of an alumina all-ceramic premolar crown (Procera[®] AllCeram).

Methods

The recovered part of a fractured Procera alumina crown was examined utilizing first a stereomicroscope and second a scanning electron microscope (SEM). The stereomicroscope analysis was performed at low magnifications with oblique lighting in order to enhance spatial relationships and gross detection of crack features. A preliminary fracture surface map of the stereo observations was drawn and used as a

guide for the SEM analysis that followed. Specific sites of interest identified under the stereo microscope were analyzed using the SEM at high magnifications searching for small fracture features such as wake hackle and twist hackle within the veneering ceramic in order to confirm the direction of crack propagation.

Results

At low magnifications and oblique illumination, the stereomicroscope analysis provided an excellent overview of the fractured topography, showing sites of major interest such as a primary edge chip at a margin, a compression curl indicating the end of the fracture event as well as larger hackle lines distributed over the cracked surface. The greater magnifications with the SEM analysis of the sites of interest showed the presence of wake and twist hackle, indicators of the crack propagation direction. A general map of the fracture events could be reconstructed starting with a primary veneer edge chip at the mesial margin. Hackle and wake hackle of the crack front emanating from this margin arose from hoop stresses and propagated through the full crown thickness towards the distal end of the restoration where the compression curl was located. Additional occlusal surface damage in the form of veneer chipping containing arrest lines and twist hackle running in the opposite direction as the main crack path were observed, but occurred as a secondary event without penetrating the alumina core material.

Significance

Stereo and scanning electron microscopy are complementary analysis techniques useful for the mapping and interpretation of the fracture surface. This case examination is intended to guide the clinical researcher in using qualitative (descriptive) fractography as a tool for understanding the failure process in brittle restorative materials, as well as for assessing possible design inadequacies.



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Keywords

Fractography; Ceramic; Failure analysis

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