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Research paper

Contraction behaviors of dental composite restorations — Finite element investigation with DIC validation

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ABSTRACT

The objective of this study was to examine the effects of cavity configuration on the polymerization shrinkage and stress of light-cured composite restorations by combining local strain measurement and a finite element analysis (FEA). Dental mesio-occluso-distal cavities of various widths and depths (each for 2 *vs.* 4 mm), representing different configuration factors, were prepared on extracted molars. The displacements of the bonded tooth cusps and cavity floors, caused by polymerization shrinkage of composite restorations, were assessed utilizing a digital-image-correlation (DIC) technique. The cervical marginal microleakage was investigated by examining the resin replicas of these restorations under SEM. The local material properties of the polymerized composite along the curing depth were defined by the nanoindentation test and applied in the subsequent FEA. In the FEA, four models were generated to correspond with the experimental restorations. In the DIC measurement results, the $4_{(w)} \times 4_{(D)}$ mm cavity presented the greatest values of inward displacements at the cusp and floor. The cavity depth, rather than the cavity width, was found to significantly correlate to the floor deformation, the location of shrinkage centers, and also the cervical microleakage ratio. The FEA simulation results showed that the $2_{(w)} \times 4_{(D)}$ mm cavity presented the maximal von Mises and principal stress located respectively on the cervical margins and cavity floor. Additional safety factor analysis showed a high risk of bond failure over the cavity floor in the 4-mm deep cavity. With the experimental validation, the simulation revealed that the cavity depth was significant to the formation of contraction stress and the incidence of interfacial debonding.

1. Introduction

The resin composites have been the most popular dental restorative materials. With modified compositions, dental composites are widely adapted for various applications such as preventive fissure sealants, restorative materials for anterior and posterior teeth, or luting cements for dental prostheses and orthodontic appliances. Resin composite materials are heterogeneous blends of organic resin and inorganic fillers. The resin matrix accounts for 30%–40% of dental

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