Short Communication

The Effect of Preparation Design on the Marginal Stress of Resin-Bonded Metal-Free Crowns: A Finite Element Study

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The aim of this study was to evaluate the stress distribution at the marginal edge of metal-free crowns using 2 different materials (ceramic and hybrid composite) and 4 different preparation designs (knife edge, chamfer, heavy chamfer, rounded shoulder). All marginal preparation designs for hybrid composite crowns showed lower compression and tensile stress than the ceramic crowns. The rounded shoulder preparation provided more even stress distribution than the knife-edge preparation. Heavy chamfer was an acceptable preparation design for ceramic crowns. The chamfer preparation was preferred for hybrid composite crown. *Int J Prosthodont 2008;21:445–447.*

The success of crown treatment relies in part on the preparation.[1] The marginal preparation is the region at which the artificial crown material meets the natural dentin, leading to a situation in which materials of different mechanical properties are loaded in contact to one another. An adhesive interface can bind the materials together. The volume ratio of artificial crown material to dentin varies according to the preparation design. This may influence stress distribution and long-term survival of the crowns. The aim of this study was to evaluate the stress distribution at the marginal edge of 2 different materials (dental ceramic and hybrid composite) and 4 different marginal designs (knife edge, chamfer, heavy chamfer, rounded shoulder) using 3-dimensional (3D) finite element analysis.

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Materials and Methods

Figure 1 shows the schematic preparation design of margin and boundary conditions used in this study. A 3D finite element model of a molar crown contour was constructed. The geometry of the 3D crown model was described by Wheeler.[2] The preparation design of abutment teeth was prepared for an assumed jacket crown with an occlusal clearance of 1.5 mm and a cervical clearance of 2.5 mm from the external shape to the level of the occlusal surface of the abutment teeth. Four different marginal preparation designs—knife edge, chamfer, heavy chamfer, and rounded shoulder—were used in this study. Marginal clearance was 0 mm for knife edge, 0.9 mm for chamfer, 1.2 mm for heavy chamfer, and 1.5 mm for rounded shoulder. To avoid quantitative differences in the stress values of the models, all solid models were derived from a single mapping mesh pattern that generated 34,897 twenty-node brick elements and 52,204 nodes. Load conditions consisted of 75 N[3] to the medial cusp, vertically applied to the crown element. The final element in all directions of the finite element model base was fixed and defined as a boundary condition. Total bonding between dentin and the crown material was assumed. The materials used were ceramic (IPS Empress 2, Ivoclar Vivadent) and hybrid composite (ESTENIA C&B, Kuraray). Most of these materials' properties, which are presented in Table 1, were determined according to a literature survey.[4,5] Finite element analysis was presumed to be

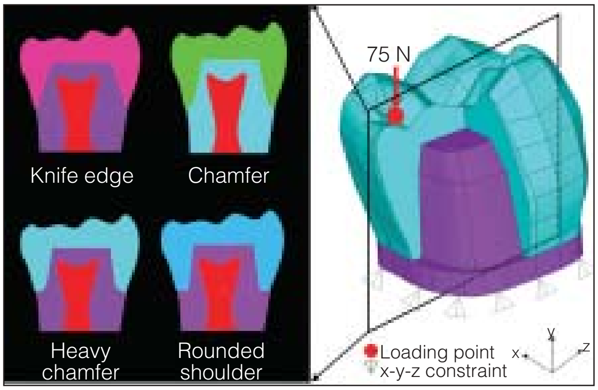

Fig 1 Schematic preparation design of the margin and boundary conditions used in this study.

Table 1 Properties of the Oral Structures and Materials Used in This Study

	Young's modulus (GPa)	Poisson ratio
Dentin	18.6	0.31
Pulp	2.1×10^{-3}	0.45
Ceramic	96	0.24
Hybrid composite	22	0.27

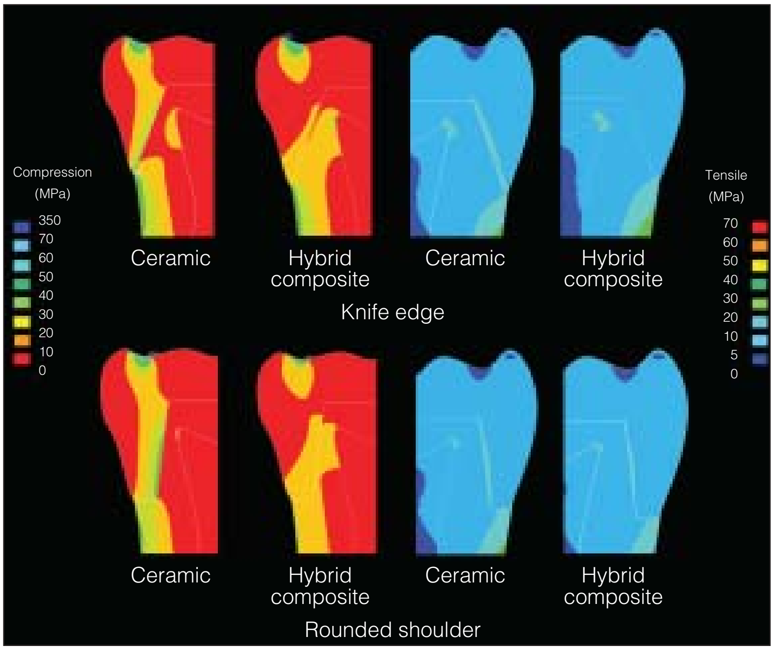

Fig 2 Stress distribution of the hybrid and ceramic crowns.

linear static. Finite element model construction and finite element analysis were performed on a personal computer (Precision Work Station 670, Dell) using a finite element analysis program (ANSYS 10 Sp, ANSYS). A finite element analysis was used to calculate the compression stress, tensile stress of the marginal edge, and displacement of the crown.

Results

Stress concentrations were located at the marginal edge of the crown in all models (Fig 2). Every preparation design for hybrid composite crowns showed lower compression and tensile stress than those of ceramic crowns. Compression stress, tensile stress, and maximum displacement of the crown are shown in Fig 3. Compression and tensile stress values of hybrid composite crowns with a knife-edge preparation were 64% lower than with ceramic crowns. However, in cases of a rounded shoulder, no differences in the stress between ceramic and hybrid composite were found. At the margin, the stress value was highest with the knife-edge ceramic crown (compression stress: 322 MPa, tensile stress: 25.5 MPa). As the marginal reduction increased, the stress at the marginal edge was decreased. Displacement of knife-edge ceramic crown was the highest of the tested designs and materials. By increasing the marginal reduction, the maximum displacement was decreased. The lowest displacement was found with rounded shoulder hybrid composite crowns.

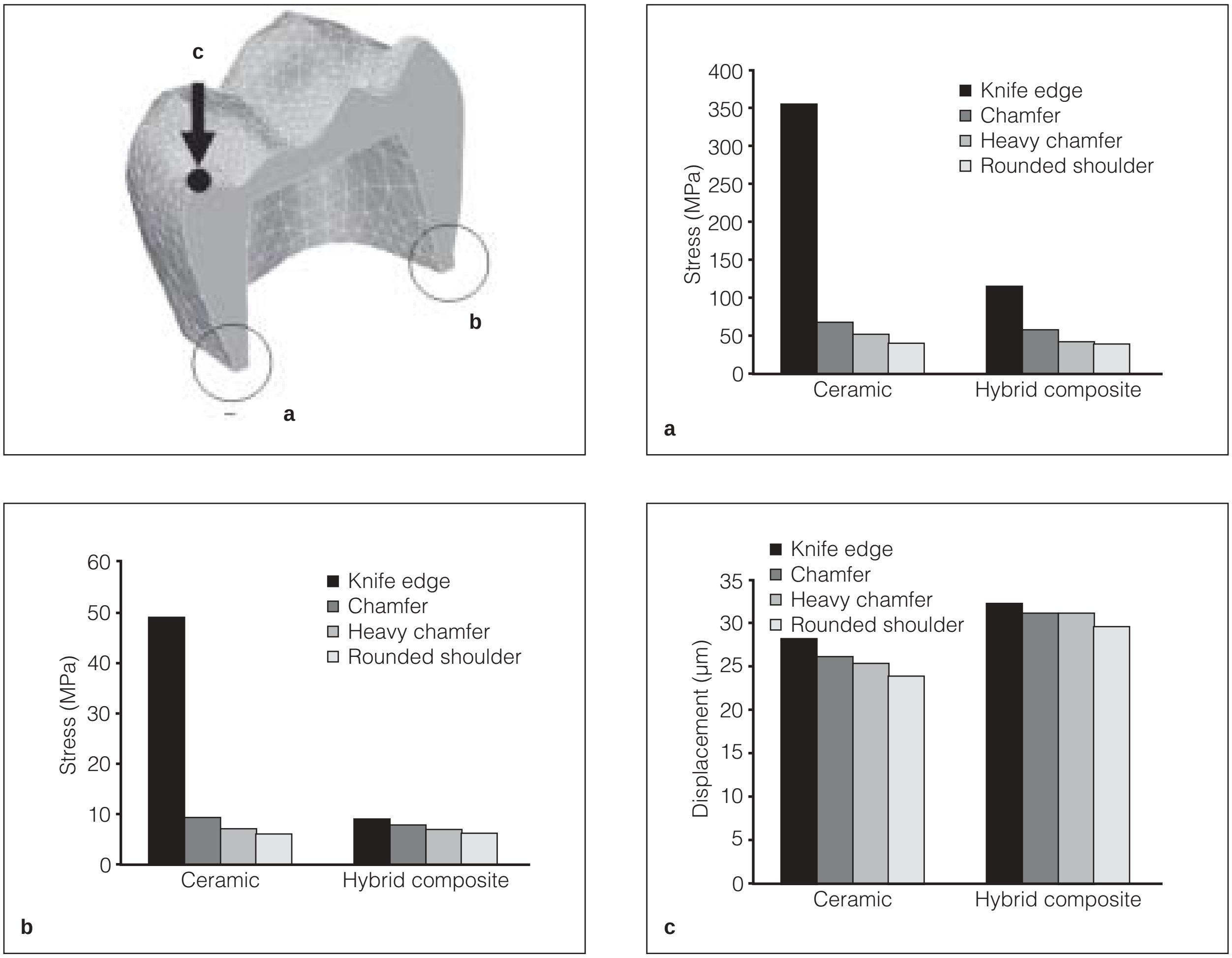

Fig 3 Compression stress **(a)**, tensile stress **(b)**, and maximum displacement **(c)** of the crown.

Conclusions

The finite element model revealed differences in displacement and stress between different marginal designs and materials. In general, rounded shoulder preparations provided more even stress distribution at the margin than knife-edge preparations. Heavy chamfer preparations with 1.2 mm of marginal reduction were acceptable for ceramic crowns. For hybrid composite crowns, a chamfer preparation with 0.9 mm of marginal reduction was preferred.

References

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