

Size-Dependent Strength and Reliability of Resin Composite Blocks and Nanoceramics for Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) Restorations

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Abstract-

Background: Mechanical reliability and size-dependent strength behavior remain critical concerns for CAD/CAM restorative materials. This study evaluated resin-based CAD/CAM materials, including resin composite blocks (RCBs) and nanoceramics. The influence of specimen size on flexural strength and the applicability of Weibull-based strength predictions were assessed by comparing experimental and Weibull-predicted values.

Methods: Twelve CAD/CAM materials were investigated, including ten resin-based materials and two controls (lithium disilicate ceramic and polymethyl methacrylate). Rectangular specimens (1 × 4 × 14 mm and 1 × 12 × 14 mm) were tested using a three-point bending test. Flexural strength, modulus, and resilience were calculated. Reliability and size dependence were assessed using two-parameter Weibull statistics and effective-volume-based predictions. Data were analyzed using statistical tests selected according to data distribution characteristics ($\alpha = 0.05$).

Results: RCBs exhibited higher flexural strength, modulus, and resilience than nanoceramics ($p < 0.05$). Weibull analysis indicated higher reliability and limited size dependence for RCBs, whereas nanoceramics showed greater variability. The ceramic control exhibited the expected reduction in strength with increasing specimen size. In contrast, resin-based materials showed inconsistent responses to changes in specimen size. Prediction error analysis revealed variable agreement between predicted and experimental values, indicating that agreement with classical Weibull assumptions was material-dependent.

Conclusions: Resin-based CAD/CAM materials demonstrated limited size-dependent behavior compared with brittle ceramics. The reduced agreement between experimental and Weibull-predicted values suggests that effective-volume scaling may have limited applicability for these contemporary materials and should be interpreted cautiously on a material-specific basis.

Index Terms- dental materials; ceramics; composite resins; computer-aided design; flexural strength

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