Effect of Dental Composite Type and Placement Technique on Polymerization Shrinkage Stress

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Strain gages from VPG's Micro-Measurements brand are used in a dental study that measures the amount of shrinkage stress new composite resin materials exert on the tooth structure. With their high precision and sensitivity, the strain gages enable accurate data to determine if the new restorative materials produce less stress than current materials, and therefore reduce clinical complications.

Company/Institute: University of North Carolina, School of Dentistry, Department of Operative Dentistry

Industry/Application Area: Dental materials/operative dentistry, stress measurement

Product Used:

- Strain gages, model EA-06-062AP-120/LE
- D4 data acquisition conditioner

The Challenge

Composite resin materials are popular dental restorative materials because of their esthetic nature and ability to be directly bonded to teeth. However, they have a volumetric shrinkage of 2.4% to 2.8% upon polymerization, which exerts stresses on the tooth structure via the bonding interface. This stress can lead to a host of clinical complications.

Recently, a new class of composite resin materials has been introduced to the market that claims to reduce the amount of polymerization shrinkage stress exerted on the tooth structure. If the restorative materials perform as indicated, dentists would be able to fill teeth with direct tooth-colored restorations much faster than with current materials, while patients would experience less sensitivity and complications.

The University of North Carolina's School of Dentistry put the new resin materials to the test by measuring the amount of shrinkage stress they exert on the tooth structure, using strain gages to measure tooth deformation as the materials polymerize.

The Solution

For the study, fifty extracted maxillary premolars were divided into five groups and mounted into phenolic rings. Micro-Measurements model EA-06-062AP-120/LE strain gages were bonded with a M-200 kit to the buccal and lingual (outer and inner) surfaces of the test teeth and connected to a Micro-Measurements D4 data acquisition conditioner. Another tooth was connected throughout the study, which served as a compensator for temperature and humidity fluctuation.

A self-etch adhesive (OptiBond XTR) was applied and the preparations were restored with materials placed and cured as follows:

- Positive control (n = 10): Filtek Supreme Ultra in 2 mm oblique increments
- Negative Control (n = 10): Filtek Supreme Ultra in bulk
- Experimental group 1 (n = 10): SonicFill in bulk
- Experimental group 2 (n = 10): Surefil SDR in bulk, covered with a 2 mm occlusal layer of Filtek Supreme Ultra
- Experimental group 3 (n = 10): Tetric EvoCeram Bulk Fill in bulk

While the teeth were being filled, the gage output was continuously recorded in με at 4 Hz. On average, the restorative sequences took 20 minutes. The maximum values from the buccal and lingual gages were identified and used for data analysis. In addition, values for both were combined to provide a maximum strain value per tooth.

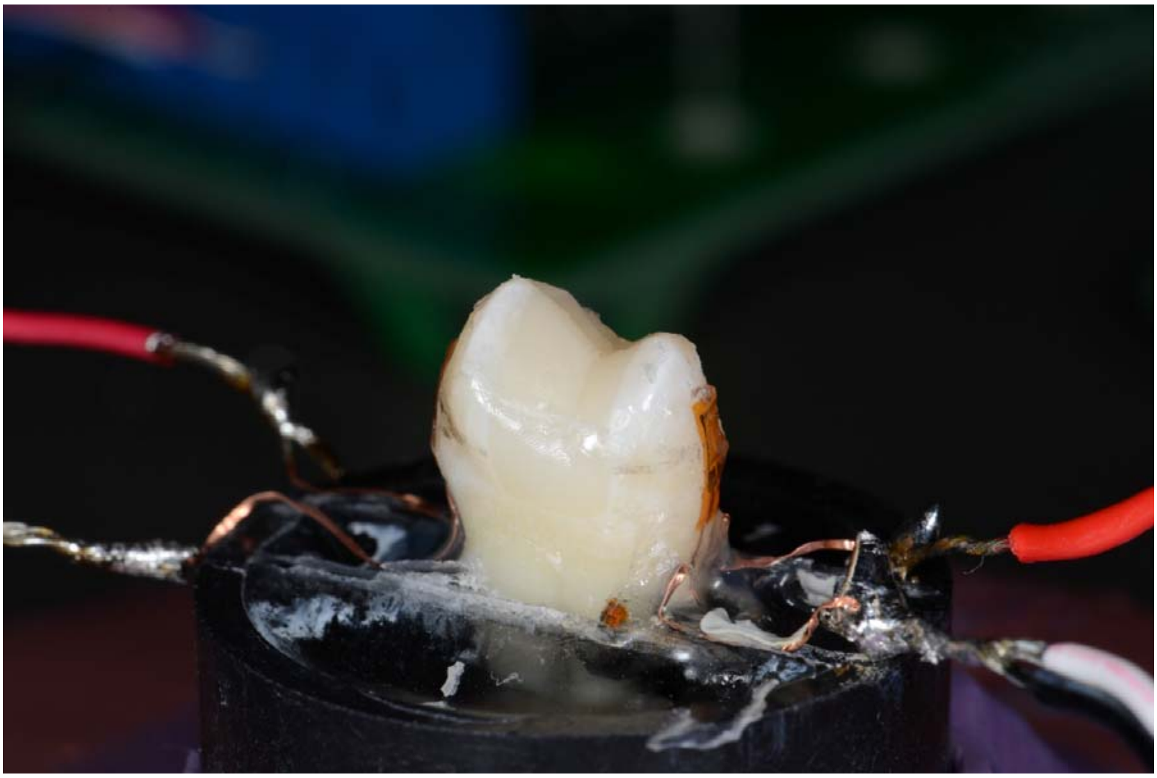

Figure 1: Micro-Measurements model EA-06-062AP-120/LE strain gages bonded to a maxillary premolar. The gages are connected to a D4 data acquisition conditioner.

Figure 2: Maxillary premolar mounted in a phenolic ring with Micro-Measurements model EA-06-062AP-120/LE strain gages bonded.

The User Explains

We chose Micro-Measurements strain gages for this study because extremely sensitive equipment was required; recorded linear tooth deformation would amount to just a few micrometers. In addition, Micro-Measurements strain gages have been used in numerous dentistry studies over the years, so their performance has been proven.

The mean maximum strain values and standard deviations for the study were:

- Positive control: 730.6 με, ±104.79 με
- Negative control 1264.2 με, ±1418.75 με
- Experimental group 1: 539 με, ±75.85 με
- Experimental group 2: 506.3 με, ±69.32 με
- Experimental group 3: 624.1 με, ±147.43 με

A significant difference ($p < 0.03$) was found between the positive control group and all experimental groups, as well as between groups 2 and 3 ($p < 0.02$). The negative control group was excluded from the statistical analysis due to the high mean and standard deviation of the group, both of which were the result of cuspal fractures due to shrinkage stress.

Through the study, we determined that bulk-fill composite resins exert less polymerization shrinkage stress when compared with conventional composites placed incrementally. The ability of bulk-fill materials to reduce shrinkage stress appear to be product-dependent. Bulk-filling with conventional composite resins proved to be unpredictable and contraindicated.

"With Micro-Measurements strain gages; we were able to determine that new bulk-fill composite resins exert less polymerization shrinkage stress when compared with conventional composites placed incrementally."

Acknowledgement:

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degree-granting and continuing education programs. A high standard of professional and personal ethics, as well as technical excellence, are integral to the learning experience.

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