

Abstract

Objective: The level of stress generated by the polymerization of dental composite restorative in a confined setting was observed through measurements of force. Method: Twelve commercial restoratives, including three brands labeled as "flowable" composites (Flowline, Revolution and Tetric Flow), were evaluated in a custom mechanical testing machine. In the test, two 6mm diameter acrylic posts were arranged coaxially with a 1.0mm gap between the flat ends. One post was attached to a load cell, and one to a compliance-correcting actuator. The gap between the posts was filled with composite, which was polymerized by directing the light from two halogen curing units through the acrylic posts for 20s. The force registered by the load cell was monitored for five minutes, and the maximum was recorded for three runs of each material. Results were compared using ANOVA/Tukey's test ($p < 0.05$). Superscript letters denote materials that did not differ significantly.

Results:

Material	Force (N) ave, s.d.	Material	Force (N) ave, s.d.
Charisma	40.0, 1.0 ^{ef}	Hytec	31.0, 1.0 ^{ab}
Definite	33.0, 1.0 ^{bc}	Prodigy	41.7, 1.5 ^f
Esthet-X	35.2, 2.0 ^{cd}	Prodigy Con.	37.0, 1.0 ^{de}
Filtek Z250	28.0, 1.7 ^a	Revolution	61.0, 2.0
Flowline	56.7, 0.6	Tetric Ceram	35.3, 1.5 ^{cd}
Heliomolar	36.7, 0.6 ^{cd}	Tetric Flow	42.3, 0.6 ^f

Conclusions: Flowable composites demonstrated higher levels of polymerization stress than conventional composites, probably due to the higher levels of polymerization conversion and shrinkage that flowables typically exhibit. Supported by NIH/NIDCR Grant DE014124. Email: jcondon@oralwear.net.

Introduction

Measurements of polymerization stress are an important indicator of a composite's tendency to de-bond from surrounding tooth structure after placement. A successful testing method would offer:

- Realistic test geometry and illumination scheme
- Easy and repeatable specimen preparation
- Meaningful results with low variance

The Pro-test Polymerization Stress Tester by Proto-tech offers all of these features in one compact testing platform. The goal of this study was to compare the polymerization stress of a dozen commercial composites having a variety of flow characteristics.

Materials and Methods

Tests are performed in the Pro-test Polymerization Stress Tester as follows:

1. The faces of two 6mm diameter acrylic posts are primed by brushing on a mixture of MMA (methyl methacrylate) in DCM (dichloromethane)
2. The posts are mounted in the fixtures of the testing machine (Figure 1 and 2)
3. A 1mm thick layer of the composite is applied between the acrylic posts
4. Two light-curing guns are directed through the acrylic posts to cure the composite.

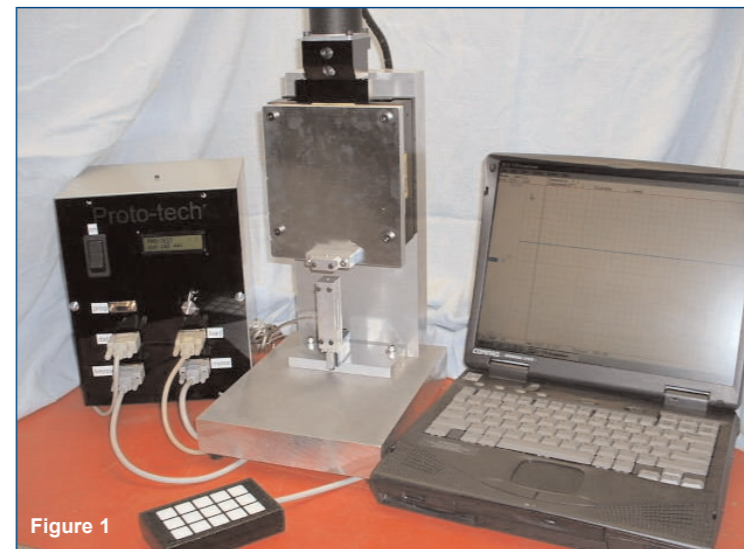


Figure 1

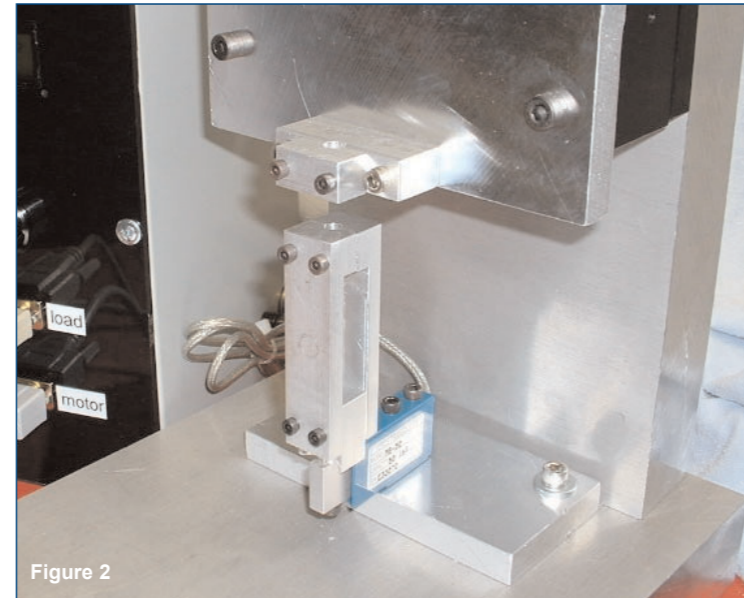


Figure 2

Figures 1 and 2: The Pro-test Polymerization Stress Tester, with special fixturing for composite light curing.

The testing machine has a 200N load cell that senses the force generated by the composite (Figure 3). The testing machine is programmed to correct for load-cell compliance by making 1 micron steps during the testing, which can be seen in the slight "staircase" shape during stress build-up (Figure 4). The force is monitored and recorded by the data acquisition computer.

The composites tested are listed in Table 1. They include three low-viscosity composites marketed as "flowable" and two nanofilled composites. Three specimens of each composite were tested and the stress after five minutes was recorded. The results were compared by ANOVA/Tukey's test ($p < 0.05$).

Table 1

Composite	Type	Manufacturer
Charisma	Hybrid	Hereaus Kulzer, Wehrheim, Germany
Definite	Hybrid	Degussa, Hanau, Germany
Esthet-X	Nanofilled	Caulk, Milford, DE, U.S.A.
Filtek Z250	Hybrid	3M, St Paul, MN, U.S.A.
Flowline	Flowable	Hereaus Kulzer, Wehrheim, Germany
Heliomolar	Nanofilled	Vivadent, Schaan, Leichtenstein
Hytac	Hybrid	Espe, Seefeld, Germany
Prodigy	Hybrid	Kerr, Orange, CA, U.S.A.
Prodigy Cond.	Hybrid	Kerr, Orange, CA, U.S.A.
Revolution	Flowable	Kerr, Orange, CA, U.S.A.
Tetric Ceram	Hybrid	Vivadent, Schaan, Leichtenstein
Tetric Flow	Flowable	Vivadent, Schaan, Leichtenstein

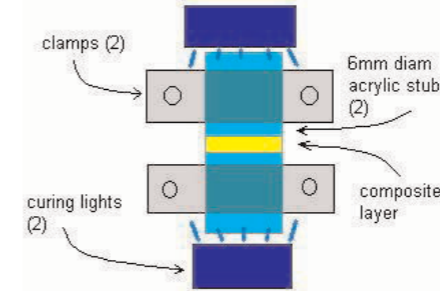


Figure 3: The composite is cured as a layer between acrylic posts which conduct the curing light.

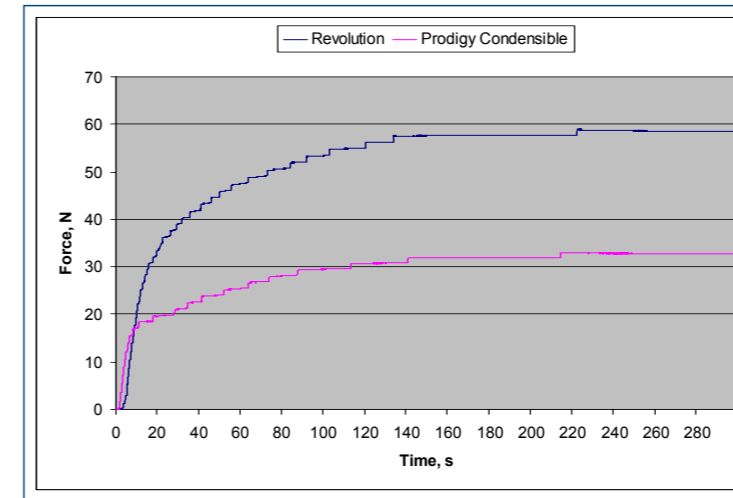


Figure 4: The production of polymerization stress is accompanied by compliance correction steps, which cause the slight "staircase" shape of the graph.

Results

The polymerization stress levels as indicated by the maximum force are shown in Figure 5. Bars connected by a line were not significantly different. The flowable composites had the highest stress levels. The variance in the measurements was less than 5% for almost all materials.

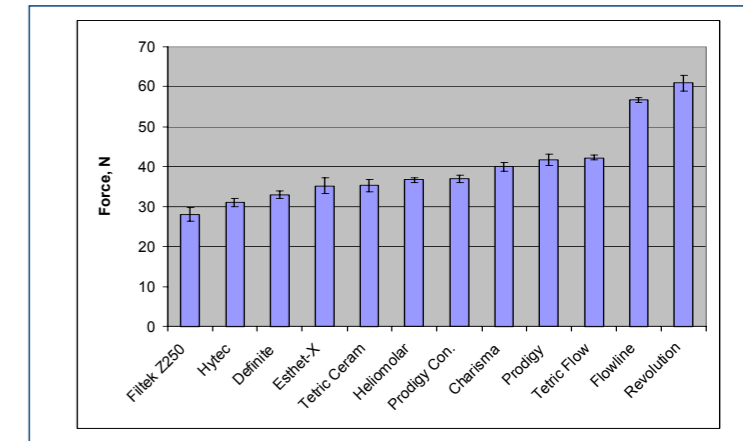


Figure 5: Final force values for the twelve commercial composites.

Discussion

Polymerization stress tests reflect how much stress is exerted by the composite on the interface after curing. Adhesive bond strength measurements predict how much stress can be applied to a bonded interface without failure. Materials that demonstrate high polymerization stress are more likely to cause adhesive interfaces to fail.

This testing mode evaluates uni-axial stresses in a thin layer geometry that might resemble a luting situation, though the results are applicable to the more complex geometry of a direct restoration. It provides a repeatable and easily prepared testing method. By directing the curing lights through the transparent substrates, the composite forms a strong bond earlier in the curing process, reducing specimen de-bonds.

The flowable composites tested in this study demonstrated the highest polymerization stress levels. It is likely that the lower inorganic filler levels of these composites led to higher polymerization shrinkage, which resulted in higher stress. Composites with lower filler levels also attain higher levels of conversion, which would also contribute to higher polymerization stress. The more heavily-filled hybrid composites such as Filtek Z250, Hytac and Definite produced the lowest stress levels.

Conclusions

The Pro-test Polymerization Stress Tester found significant differences in polymerization stress among a dozen commercial composites.