



EFFECT OF EXPOSURE DURATION ON FLEXURAL STRENGTH AT COMPOSITE DEPTHS

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INTRODUCTION

The adequacy/effectiveness of a photocuring light to polymerize a thickness of composite has been of interest ever since the introduction of this technology to clinical dentistry. On the one hand, the dentist seeks a restorative treatment that can be performed using minimal chair-side time, while also providing quality, long-lasting restorations.

With light curing units being marketed with ever increasing power density values, manufacturers advocate use of exposure durations much shorter than those delivered using lights from previous technologies. The effectiveness of these less than "standard" exposure duration values needs to be examined with respect to parameters that have clinical significance.

The standard quartz-tungsten-halogen unit (QTH) exposure for composites ranges from 20, to 40, to 60 seconds for a 2 mm-thick increment, depending on the specific brand and shade. It is unstated, but assumed that this duration provides equivalence of polymerization, and thus performance of the material from the top, irradiated surface, to the bottom depth of the increment placed.

Tests used to evaluate the thoroughness of the polymerization reaction (the "Depth of Cure") usually evolve around some sort of easily measured physical parameter. Thus, scraping depth has been advocated, and is now an ISO standard technique. Other tests utilize surface microhardness measurement of a sectioned composite specimen throughout its depths, attempting to determine when a hardness value drops to less than 80% of that seen at the top, irradiated surface. Still other types of testing evaluate monomer conversion of composite at specific composite thicknesses. However, no test has yet to determine the effect of exposure duration on a property having clinical significance: the flexural strength of composite as a function of depth.

MATERIALS AND METHODS

OVERALL TESTING SCHEME

Methodology was developed to measure the biaxial flexural strength of composite disc taken from a theoretical cylinder of composite that was irradiated from the top surface. Specifically, half mm-thick discs were retrieved at every 0.5 mm increment up to 3.0 mm depth. The duration of light exposure was varied and statistical measurements compared flexural strength of discs to that of the top-surface disc. The strength value at the deepest composite location that was still not statistically different to that at the top surface was considered the "Depth of Cure" for that exposure duration.



SPECIFICS

Composite
Prodigy A3 Body, lot # 2760779, Unidose, Kerr Corporation, Orange, CA
Manufacturer-recommended exposure duration (MRED): 5 seconds for a 2.5 mm-thick increment (directions)

Light curing unit
DEMI, sn P4, Kerr Corporation, Orange, CA
Tip-to-Target distance: 2 mm
Exposures - 5, 10, 15, 20 seconds



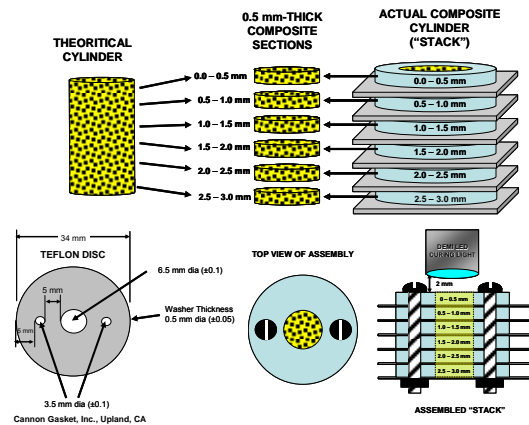
Replications
10 "stacks" per exposure duration – total of 40 stacks, six 0.5 mm-thick discs in each, separated by Mylar

Universal Testing Machine – to obtain flexural strength
Model 8844, Instron Corp., Canton, MA
Crosshead speed: 0.5 mm/min

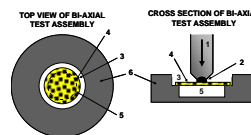
Infrared Spectrometer – to obtain monomer conversion
FTS-40, Digilab-Bio-Rad, Cambridge, MA
Settings: 16 scans at 2 cm⁻¹ resolution
Horizontal Attenuated Total Reflectance unit: Diamond element, Golden Gate, SPECAC, Cranston, RI

METHODS

THEORETICAL AND ACTUAL CYLINDERS OF COMPOSITE FABRICATED IN 0.5 mm-THICK STACKED DISCS



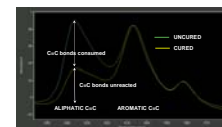
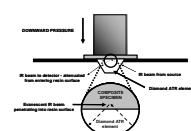
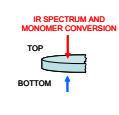
BIAXIAL FLEXURAL STRENGTH



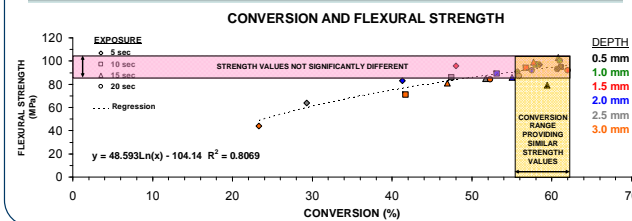
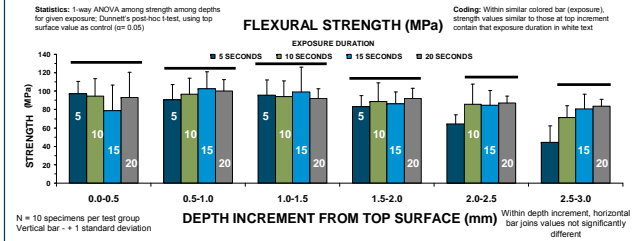
- 1. Downward moving rod
- 2. Self-leveling hemispherical ball
- 3. Recess to contain specimen
- 4. Composite specimen
- 5. Recess to allow for flexure
- 6. Stainless steel fixture

FTIR – MONOMER CONVERSION

IR Spectra of fractured Post bi-axial specimen



RESULTS



CONCLUSIONS

- Manufacturer-recommended exposure (5 seconds) for 2.5 mm increment does not provide similar strength values when compared 10, 15, or 20 seconds, but this finding may be the result of the holding tip 2 mm away (a more clinically relevant distance than 0 mm).
- At 2 mm tip distance, a 5-s exposure provides equivalent strength up to a 2 mm increment depth as a 10, 15, or 20-second exposure – proving 5-s optimizes properties at this depth
- Strength values seem to plateau at conversion values of 45% and greater, indicating maximal strength is not correlated with maximum conversion (maximal flexural strength does not require maximal monomer conversion)

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