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Academy of Dental Materials guidance—Resin composites: Part II—Technique sensitivity (handling, polymerization, dimensional changes)

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ABSTRACT

Objective. The objective of this work, commissioned by the Academy of Dental Materials, was to review and critically appraise test methods to characterize properties related to critical issues for dental resin composites, including technique sensitivity and handling, polymerization, and dimensional stability, in order to provide specific guidance to investigators planning studies of these properties.

Methods. The properties that relate to each of the main clinical issues identified were ranked in terms of their priority for testing, and the specific test methods within each property were ranked. An attempt was made to focus on the tests and methods likely to be the most useful, applicable, and supported by the literature, and where possible, those showing a correlation with clinical outcomes. Certain methods are only briefly mentioned to be all-inclusive. When a standard test method exists, whether from dentistry or another field, this test has been identified. Specific examples from the literature are included for each test method.

Results. The properties for evaluating resin composites were ranked in the priority of measurement as follows: (1) porosity, radiopacity, sensitivity to ambient light, degree of conversion, polymerization kinetics, depth of cure, polymerization shrinkage and rate, polymerization stress, and hygroscopic expansion; (2) stickiness, slump resistance, and viscosity; and (3) thermal expansion.

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Significance. The following guidance is meant to aid the researcher in choosing the most appropriate test methods when planning studies designed to assess certain key properties and characteristics of dental resin composites, specifically technique sensitivity and handling during placement, polymerization, and dimensional stability.

1. Introduction

Much of the testing of dental resin composites is designed to ascertain various universal or standardized properties such as strength, hardness, and resistance to wear or deformation. Appropriate test methods for these important properties have recently been reviewed [1]. However, it is well recognized that obtaining the maximum level of these properties is dependent on the clinician and how well they manipulate the materials [2,3]. Therefore, characteristics that may affect the manipulation of the material, or the so called "technique sensitivity", may have a profound impact on the ultimate properties obtained, and the clinical success of a resin composite restoration. Characteristics such as the stickiness and slump resistance, are very important for clinical handling, but are less amenable to being analyzed by typical standardized tests. Other properties, such as porosity and viscosity, are more likely to have standard tests, but can only be considered as imperfect surrogate measures for assessing the handling characteristic in question. Congruently, some handling characteristics, such as stickiness, can have an impact on other, more well-defined properties, such as porosity.

Extent of polymerization can be well characterized using methods such as Infrared or Raman spectroscopy. But the property itself is affected by a myriad of factors, some of which are inherent in the material (photoinitiator type and amount, resin monomer type), others of which are under the influence of the curing light (irradiance, beam profile, spectral output), and others yet that are under the control of the clinician (exposure time, exposure distance, light guide position) and therefore subject to technique sensitivity. Polymerization likewise results in dimensional changes that are readily measured with tests such as dilatometry, Archimedes principle, or the bonded disk, but the clinical results of such dimensional changes, which may include marginal leakage, interfacial gap formation and tooth fractures, are more difficult to accurately assess. While there might not be true "standard test methods" for properties related to technique sensitivity, there are specific recommended test methods for many of the pertinent properties. The purpose of this paper is to review various tests available for assessing properties associated with the placement technique sensitivity of resin composite, including handling, for characterizing the polymerization reaction of resin composites, and for assessing dimensional change during and after the curing process and its associated outcomes. These properties are summarized in Table 1, and are accompanied by a value representing their relative importance for measurement and study.

2. Technique sensitivity: handling, placement

2.1. *Stickiness*

Stickiness refers to the propensity of a resin composite to be retained on an instrument while the material is being placed into the cavity preparation. There is an ideal, yet poorly defined level of stickiness whereby the resin composite will be retained in the cavity and not pulled out or deformed as the placement instrument is removed. A number of tests have been devised to assess stickiness, most of which follow a similar scheme. A set volume of composite is placed in a mold, and then a steel rod or instrument is inserted into the unset material at a constant rate or until a predetermined force or depth is reached; then the motion is reversed until the composite separates from the instrument (Fig. 1). Immediately upon separation, the composite is irradiated with a curing light to harden the material, leaving the surface in the shape of a peak. This peak of composite, sometimes called a "composite flag" can be measured for height and/or area and used as a measure of stickiness [2–5]. Depending on the instrumentation and measurement capability, the unplugging force and work (the force and work required for the composite to detach from the instrument in withdrawal direction) [2] can also be measured and calculated (Fig. 1). All of these methods have been found to be reliable measures of composite stickiness that allow for good differentiation among current materials. In addition, one study correlated the unplugging work and force of various resin composites to the subjective handling characteristics as assessed by dentists and found a good association between the two, indicating that these tests are a good proxy by which to evaluate resin composite stickiness [2]. Resin composite temperature, speed of the instrument/rod insertion and removal, and the surface area and roughness that the composite is in contact with have all been shown to be important factors influencing the results of these tests, and therefore should be well described whenever publishing results in this area.

2.2. *Slump resistance*

Slump resistance is the ability of a resin composite to maintain its shape after placement and prior to curing. This is important in a clinical situation when a clinician desires to sculpt the anatomy of a restoration in the unset paste prior to light curing, in part to reduce the amount of finishing required. This is particularly the case in class III or class V restorations, in large anterior restorations, e.g. a direct composite veneer or a class IV restoration, and when reconstructing the cuspal or crestal anatomy in posterior restorations (class I and II), especially