In Vitro Testing of Restorative Materials—What's the Value?

Dental professionals regularly make decisions on the selection of restorative materials for patients. These decisions are often based on the clinician's clinical experience of using a material with successful results. When faced with the decision to use a new material or to justify the continued use of a familiar material, the clinician looks for data to support the decision. Sources of data might include: recommendations from colleagues (study club, continuing education program) or manufacturer representatives, in vitro studies, reports from product evaluation groups (The Dental Advisor, Reality, Clinicians Report), and clinical studies.

Some questions arise regarding the value of in vitro testing of materials. Are there different types of in vitro testing? What is the purpose of in vitro testing of restorative materials? Do in vitro data predict clinical success?

In vitro testing of restorative materials involves the measurement of physical, mechanical, and even biological properties using standardized tests. Physical tests might include: solubility, water sorption, and color stability. Mechanical tests might include: flexural strength and modulus, bond strength to tooth structure, and wear resistance. The methodology for these tests is often described by American National Standards Institute/American Dental Association (ANSI/ADA) and International Organization for Standardization (ISO) specifications so that any testing laboratory in the world can perform equivalent tests and hopefully get comparable results. These specifications were developed from measurements of the properties of clinically successful restorative materials. It is assumed that a new material with properties that are equivalent or better than a currently successful material will also be successful.

Another model for in vitro testing is the simulated clinical test. For example, simulated chewing machines have been developed for studies of wear resistance of materials. Instead of measuring the bond strength of a cylinder of cement bonded to a slab of extracted dentin, a simulated clinical test would measure the retention of a crown cemented to an extracted tooth. Results from simulated clinical tests are often more difficult to reproduce in different testing facilities because there are often confounding variables.

Is an in vitro measurement of bond strength useful? Would a restorative dentist more likely choose a bonding agent for a bonded veneer that had bond strength to enamel of 25 MPa or 8 MPa? Would an orthodontist more likely choose a resin cement for bonding a metal bracket that had a bond strength to enamel of 25 MPa or 8 MPa?

Does the degradation of a resin composite by salivary enzymes produce degradation products (such as bisphenol A [BPA]) that are biologically active? In vitro testing under standardized conditions can identify degradation products and determine the amount (ppm) of that product. Such data can provide useful guidance for subsequent measurements clinically.

The big question is: do in vitro tests predict clinical success? The simple answer is no. An in vitro test of color stability of resin cement might predict that the cement will change color over time. The in vitro test cannot predict when that color change will occur in the mouth or whether it will result in a clinical failure that requires replacement of the restoration.

In vitro test data from manufacturers, university research laboratories, and product evaluation services are critical to assisting dental practitioners in making evidence-based decisions on the use of restorative materials. In vitro test data also provide foundational information that can assist clinical research investigators with an appropriate design for a clinical

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study. However, ultimately, the "proof is in the proverbial pudding." In vitro studies are great indicators of possible clinical outcomes, but in many cases should not be viewed as absolute predictors of what will happen clinically.

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