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Materials for Dentistry—Raising the Bar

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SCOPE

The grand challenge for Dental Materials in Frontiers of Dental Medicine is to create a platform where academics specialized in dental materials can share their research. This journal will be a nexus for all dentistry disciplines to interact and raise the bar thus achieving higher standards of quality care in clinical practice.

INTRODUCTION

An understanding of the materials used in dentistry is very important as this knowledge will to a great extent define the success of clinical procedures performed in the oral cavity. A dental material is any material or product used in the course of the provision of dentistry, not just those introduced in the host oral cavity to replace missing tissues. But, those materials used "permanently" in the mouth interact with various tissues, are exposed to a number of environments because they serve different purposes, and thus have a great range and variety of chemistries. All such materials need to be manufactured, processed, and tested to be safe to use clinically. By extension, this applies to all materials that ever come into contact with the patient, the dentist, or an assistant.

MANUFACTURING AND PROCESSING

The preparation and processing technology should be cost effective, sustainable, safe, fast, and precise. There are a number of methods that have been used for a several years to manufacture dental materials depending on their chemistry; 3D printing and computer-aided design and manufacturing has been available for a while now and it is appropriate to exploit it further (1, 2). Some materials, such as ceramics, develop flaws when processed (3) and processes need to be reviewed (4) and investigated further to enable a shift to higher-quality products for clinical use. The quality of the materials used in clinical practice needs to be monitored well by the manufacturer. One case in point is the use of industrial Portland cement in endodontics. While the idea to use a hydraulic cement in areas that are wet has resulted in better clinical outcomes for various procedures (5–8), the use of cement out of a sack should not be considered to be acceptable practice. The claimed heat treatment by a number of products (9) cannot eliminate the heavy metals present which originate in the source natural minerals and secondary fuels included during firing.

Speaking of heat treatment, this is nowadays promoted for the nickel-titanium alloys used in endodontics and orthodontic wires. Much advance has been made thereby, and with the use of shape-memory alloys. However, many instruments available for heat treatment promise much but have not been rigorously tested. Any advance here is in the branding rather than the manufacturing and processing.

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MATERIAL TESTING

It is therefore crucial to know more about the chemistry of a dental material, its use, the specific interactions in the oral environment and with the substrate, as well as the method of manufacturing and processing. All these factors need careful consideration when devising the testing that is to be undertaken. For all materials, test planning must be meticulous, and specific to the material type and use. Blanket or routine testing, with no insight as to why the testing is being performed, is not cost-effective and does not inform readers or the users of these materials in any useful way. Appropriate negative and positive controls and replication are needed for all such research. Likewise, simple comparisons of two or three products, and most especially without theoretical grounding—mere reportage, are of little value.

The Substrate

The substrate that the materials are placed against requires careful consideration. This can be soft or hard tissues, e.g., mucosa, tooth, bone. A note of how it has been prepared or treated is important, as is the background to the specific interaction of interest and the detail of how this interaction was investigated. This brings to mind the great deal of time and effort spent on the assessment of bond "strength," most of which is limited in value and in part useless. Careful consideration needs to be given to these tests (10) and the limitations taken into consideration when interpreting the results (11). The Academy of Dental Materials has issued guidance on bond strength testing (12) which is a step forward in maintaining adequate standards, but even that is tentative.

Interactions of the material with the functional environment have been termed "bioactivity," where a number of chemical reactions with components of tissue fluids and tooth tissue have been given an assumed and theoretical, but never clinically demonstrated, biological context. These are in fact simply changes to or on a material surface, often with apatitic deposits being formed (13), that in no way signify a biological interaction. Such interactions are difficult to simulate *in vitro* (14).

Laboratory Testing

The context of the material use, location, and exposure, is plainly important when designing experiments and this needs to be recognized and implemented through simulation for all tests, whether physical, chemical, mechanical, or biological. The test suite needs to be comprehensive and integrated, to cover all relevant aspects—single factor work, disregarding system complexity and interdependence, is rarely helpful, and may amount to "salami slicing" of the research. Surface testing may be part of this, separate from bulk (object) testing, because changes and effects may occur at the surface only. All materials, including prototypes, as well as those already in clinical use, need to be tested in these various senses.

Likewise, physico-chemical tests need to be conducted under conditions that simulate or represent in some substantive respect those of clinical use—wet and at body temperature is the very minimum. Material characterization, and reference to literature pertaining to the material's composition is important in every experimental plan, and covering theoretical expectations for the testing that follows. For biological testing, the choice of bacterial strains and cell lineages should be appropriate to the location of material placement and, whenever possible, both microbiological and biological testing is required to ensure that while the material may be antimicrobial it is not toxic to the host (15).

Laboratory testing is considered to be the very basic level for all work and is expected to be performed at least to existing norms that have been validated and previously published. While international standards may be helpful for quality control purposes and initial investigations, the methods they embody are often limited and further work based on them needs to go beyond this level of testing: they should always be checked against current understanding, best practice and sense, refined, and developed as required. Factors such as simulation of aging, and testing in quasi-clinical scenarios, are still challenging; such methods require further study to enable proper testing and advancement of understanding—which is the key test of any work. Research may then progress more expeditiously toward safe clinical use.

Clinical Investigation

For clinical studies, the level of expertise of the operators, the details of the center, and also whether multicenter, needs to be noted as even minutiae may affect the outcome. Prejudging relevance is inappropriate. Similarly, the precise clinical protocol employed with all the details of the materials used and how, how the substrate was treated, the clinical techniques, the recall and outcome variables used for follow up are essential. For newer materials, it is possible that otherwise established clinical protocols need updating or modification.

CONCLUSION

Both materials scientists and clinicians are facing exciting times. Let us embrace the future and change, but let us have a plan—rational, scientific, precise—on how to undertake the work for this change. Otherwise, the future will be bleak: inefficient, unsatisfying, and costly—for researchers, teachers, and patients alike.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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