Editorial

Material Science Research and Dentistry

Materials science remains likely the most important basic science and didactic subject in all of dentistry. Most real advances in dental practice have involved advances in materials, the development of new materials, or the adoption of materials just appearing in industries outside of dentistry. Imagine prosthodontics without ceramics, poly(methyl methacrylate), irreversible hydrocolloid, or silicone impression materials; endodontics without gutta percha, sealants or MTA; operative without enamel and dentin bonding; orthodontics without beta titanium, stainless steel, or shape memory alloys; oral surgery without resorbable sutures, stainless steel, or bone substitutes; all of implantology without titanium alloys.

Whenever possible, I enjoy including in my lectures the history of the introduction of ceramics into dentistry. At the beginning of these lectures I ask the audience whether at any stage in the introduction of various ceramics into dental practice, were these examples of (1) craft art or (2) high technology? Before asking for a showing of hands I provide a definition of each category. Craft art would mean borrowing from artisans, jewelers, craftsmen and etc. High technology would mean: an invention made for dentistry; new knowledge recently published in journals outside of dentistry; incorporating a new material just introduced into an industry outside of dentistry. Most hands go up for "craft art" – so the rest of the lecture becomes all the more fun! Let's go back and deconstruct the opening paragraph with this analysis regarding material-based practice improvements and their being state-of-the-art.

Porcelain dentures were introduced in Paris within decades of the development of high technology porcelain manufacturers in France. The first porcelain prosthesis was made from porcelain formulations obtained from the Guehard Porcelain Factory and fired on very high technology kilns at the factory[1]. The first porcelain denture teeth with embedded platinum pins, allowing fabrication of prostheses using metal-working technology, happened in 1808, again in Paris. The platinum pins were not obtained from jewelers but from houses supplying alchemy researchers (platinum was not used in jewelry until about 1915). Porcelain formulations that could be reliably fired onto metal casting was developed by following a paper then recently published in the Journal of the American Ceramics Society and by hiring the PhD thesis advisor of the first author. Our first high-strength core ceramic (alumina filler in feldspathic glass) came on the heels of GE switching from sand to alumina as a filler in their massive insulators for high-tension power lines. The use of fillers for the dispersion strengthening of glasses was also just being published in the Journal of the American Ceramics Society. Poly(methyl methacrylate) was incorporated into dentures rapidly following its invention after World War II. Same timing for the appearance of irreversible alginates. Silicone impression materials became available shortly after their development for NASA as high temperature polymers for space craft. Stainless steel was a serendipity invention during trial-and-error research into high strength alloys for rifle barrels ahead of World War I – and almost immediately used in dentistry. Nickel-titanium shape memory alloys were invented at the Naval Ordinance Laboratory (hence nitinol – nickel titanium NOL) and literally introduced into dentistry by the inventor giving his wife's orthodontist a sample. Mineral trioxide aggregate (MTA) was invented by a dentist whose father was a heavy user of Portland cement in the construction industry. Implantology became possible due to the discovery of titanium-bone integration. The first gutta percha patents were issued starting in 1820. By 1847 "Hill's stopping" was on the market as a filing material consisting of bleached gutta percha, calcium carbonate and silica. By 1867 it was being used to obturate root canals.

In each of these examples, and many, many more, dentistry was at the forefront of incorporating high technology materials. In a related fashion dentistry is also at the forefront of "infinitely flexible manufacturing" with the development of CAD/CAM and automated systems into clinics and laboratories. As was pointed out to the incoming director of the U.S. National Institute for Dental and Craniofacial

http://dx.doi.org/10.5335/rfo.v20i3.5973

Research (NIDCR), during a question portion of her presentation at a meeting of the Academy of Prosthodontics, beyond the introduction of fluoride into drinking water little to no advances in dental practice have resulted from research sponsored by the NIDCR in many decades. Examine as an example the literature in periodontics. While rich scientifically there is still no understanding of the disease process or even its diagnosis.

Sadly, this decades-long de-emphasis of funding for basic materials science research by the NIDCR has created a huge hole in the training of future faculty for dental schools. Rich PhD programs, such as at the University of Florida and the University of Michigan, have dried-up or diminished. Graduate students could only be funded if research was related to tissue engineering or tissue-material interactions. Students interested in PhD-level training in materials science must enroll in schools of engineering. Many deans appear to lack an understanding of the importance of materials science in their curricula. Schools loosing materials science faculty have trouble replacing them and many simply do not bother to do so. For years now I have taught part-time at Tufts University, along with others from around the country, to make-up for the loss of their materials faculty. In many schools operative or prosthodontics faculty substitute for professors trained beyond the dental textbook level. Another impact is on the availability of qualified research mentors – critical to developing and maintaining influential programs. Brazil has addressed this in part by funding PhD students to work for a research abroad year in recognized laboratories. It has also sent students to PhD programs oversees who have then returned to serve as excellent mentors (e.g. Prof. Della Bona).

World-wide experts from the Academy of Dental Materials are developing a set of guidance documents for young researchers without strong mentors, to establish best practices for research in ceramics, resin-based composites and adhesives. Besides recommending specific tests over others, these guidelines will provide background information on why certain tests are preferred or not, on what is being measured, on how to analyze the data and its potential clinical meaning. These guidance documents should start becoming available in the journal Dental Materials and eventually compiled into a book.

It is high time that the dental materials community wake-up to our diminishing stature and effectiveness within academic dentistry. Research is what sets a “profession” apart from a “trade”. The contributions of our community have been crucial to the development of modern practice and this engine cannot be allowed to sputter much longer!

Obrigado.

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Reference

1. Kelly JR, (2016): Ceramics in Dentistry: Principles and Practices, Chicago: Quintessence Publishing Co., Ch. 1.