## COMMENTARY

EFFECTS OF GLASS FIBER LAYERING ON THE FLEXURAL STRENGTH OF MICROFILL AND HYBRID COMPOSITES

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The present research article is sound and has logically approached investigating the potential advantages for new applications of fiber reinforcement in composites. The authors recognized potential limitations for the practical use in clinical applications of this technique and pointed out the need for more careful consideration of other environmental factors that could mitigate actual clinical results. Yet their work also begs some other interesting questions.

What is most fascinating is that, in the Introduction, the authors offer justification for doing the work. The authors argue that dentistry needs better strength for composites in stress-bearing areas. Although this may seem obvious and a fundamental clinical principle, a closer look at the obvious raises a number of questions. What are the core clinical references that prove that we need stiffer or stronger composites in stress-bearing areas? How many medium- to long-term clinical research articles do we have that document fracture as a major mechanism of failure of such restorations? What are the advantages of fiber reinforcement over other approaches? What are the other considerations for composite design that might argue for other priorities for newer composites? For the moment, consider each of these.

The authors justify their argument for increased fracture resistance on the basis of comments from published laboratory studies. Using in vitro arguments to support this premise has become common because of the paucity of clinical trials. Fracture could be the final demise for all posterior composites, but it may be much more informative to examine fracture rate. Fracture rate might, in fact, be very low. If all posterior composites provided, on average, 10 to 20 years of service without fracture, one might deem them as providing adequate service, and any subsequent fracture would be viewed in a quite different light. Simply stating that posterior composites fail because of fracture does not mean they have a problem. To date, there is no published clinical evidence to elucidate this situation.

If fracture were the problem of the highest importance, then which approach would seem to be the better solution—increasing modulus and strength, increasing strength only, or increasing strength and decreasing modulus? Is there truly a need for improved strength at all? So many times, a research team works on a problem because of the team's interest and not because of clinical justification. Increasing the strength could inadvertently make the material more brittle and potentially even more fracture prone. Materials with more deformation could provide greater fracture resistance. That would be a much simpler solution.

Does the approach of adding fiber reinforcement seem to be the best strategy to improve fracture strength? Dentistry has been intrigued with fiber reinforcement for many years. One of the key early research articles was published in 1976.[1] Fiber reinforcement has been a topic in discussion forums for dental research for well over 30 years.[1–3] There are currently 383 US patents (http://www.uspto.gov/ search by—fiber AND dental AND composite AND restoration). There has been intensified interest in aluminosilicate fiber use in dental materials since the developmental period of packable composites.[4–6] Remember that the addition of fibers as well as other reinforcement or by itself still means that the combination is a dental composite and follows all the normal rules. (Remember, adding fiber reinforcement either alone or in addition to existing particulate reinforcement results in a composition that follows the "rule-of-mixtures" based on volume contributions of phases for predicting mechanical behavior.)

Are there reasons that one might be hesitant to use fibers to improve dental compositions? Fibers are difficult to incorporate into most dental compositions. Many, if not most, of the fiber reinforcement options are not very esthetic and could only be of practical value in situations that do not demand good esthetics. There are several technical problems as well. Fiber reinforcement tends to provide the greatest mechanical advantage along the direction of the fiber


DOI 10.1111/j.1708-8240.2009.00252.x

and not perpendicular to individual fibers. For this to be partially overcome, fibers are generally supplied in preformed mats and woven in two dimensions. The authors used this approach in the current experimental evaluation.

Fibers can be added during manufacturing or during the design of a restoration. There are a tremendous number of choices for fiber types. They can be incorporated as short (chopped fibers) or as long (pseudo-continuous fibers). They can be woven, bundled, or layered. In any case, fiber-reinforced compositions are subject to the same problems as simpler composites. All composites, including fiber-reinforced composites, are defect limited. Water can migrate to fiber interfaces, and fatigue can propagate cracks from those points. This article elegantly establishes the initial advantages for fiber reinforcement of a hybrid composite sandwich and points out potential advantages. However, the authors caution that their experiment is a static one and did not take into account the variety of environmental variables, including fatigue, which will likely contribute to failure via defects in a real clinical situation. Until a more dynamic testing is conducted, any real advantage is very limited in value.

As with any composite, interfaces present challenges and must be managed by trying to chemically bond the phases together. In dentistry, the only strategy that seems to work consistently is to use silica-based compositions that are amenable to silane coupling. This is the case in the authors' experiment. Any problems arising from coupling or from other defects may quickly cancel out any proposed advantages. There are even more intriguing fibers than silica-based ones such as carbon fibers,[7] SiC whiskers,[8,9] alumina fibers,[6] and calcium phosphate fibers.[10] All promise special mechanical properties if they can be coupled into current dental matrices. Silica-based fibers work well when they can be oriented properly for the application and when defects are minimized during fabricating steps. These processes have been much more challenging over the years than originally anticipated.

Fiber reinforcement faces additional challenges if the fiber dimensions are small. Asbestos fibers are avoided as a result of not only their chemical composition but also their relatively small size (<1 µm). The latter has been one of the reasons why most tests of fiber experiments generally have involved relatively large fiber diameters (>5–10 µm). This is an area of science that needs much more elaboration.

So where are we? Fiber reinforcement has been an area of interest in dentistry for a long time. We need to make sure that we really need it in specific applications. We also need to find ways to create very different and new types of fibers that will work for dentistry. These all deserve the attention of people making new ceramics and exploring new ways to build structural dental composites. The present study is a small part that again points down to this long-considered path.

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