Who Drives This Train?

I recently was asked to participate in an interview for a new publication. One of the questions posed related to my perceptions regarding implant design and engineering. The experience made me think about the principles we apply to what we do and how others, especially those involved in engineering, perceive our efforts.

In the early days, implants were used to support prostheses in patients with mandibular edentulism. Back then 5 to 6 implants were used to provide rigid fixation for fixed prostheses. The implants were of modest dimensions and were made from the least robust grade of commercially pure titanium. These implants were arranged in a curvilinear pattern, and the prosthesis connected to the implants was rigid with a modest posterior cantilever. These prostheses were opposed by mucosal-borne polymethylmethacrylate-based complete dentures. Our colleague, the late Dr Richard Skalak, an engineer, told us this design would probably work fine given the loads that were anticipated on the dental prosthesis, and indeed these implants did perform well for the vast majority of patients.

With time, however, there was a transition from the management of complete edentulism to the management of partial edentulism. Curvilinear prosthetic frames were replaced by rectilinear prosthetic frames, and the opposing dentition was frequently made up of natural teeth. The original Skalak models were no longer applicable, as the number of implants, the distribution of implants, and the anticipated forces had all changed. These changes, especially in the earliest iterations, demonstrated the differences between a well-engineered restoration and an under-engineered restoration. With the under-engineered approach, clinicians began to discuss retaining-screw loosening and fracture along with the rare, but catastrophic, fracture of dental implants.

Perhaps the issues of design and engineering need to be addressed after a careful consideration of all potential adverse outcomes so that dental therapy is neither over- nor under-engineered. Clearly over-engineering carries the consequence of increased cost and diminished return on investment. Conversely, under-engineering could result in catastrophic failure from which recovery may be impossible. For example, in our design of patient treatment do we create sufficient redundancies to prevent any adverse effect toward our dental rehabilitative efforts, or do we devote our efforts to the establishment of restorations that are just a little stronger than what is necessary to accomplish the task at hand? The former approach is very appropriate if we consider the design of a new spacecraft because the consequences of failure are rather dramatic, while the latter approach may be totally appropriate if the consequences of failure are mild or limited.

In the interview I mentioned at the start, one of the questions alluded to the need to appropriately engineer care. My response was that it would be difficult to do so given that we clinicians have so little understanding of design and engineering principles. Surely we think about forces, but our depth of knowledge in this area pales in comparison to that of our colleagues in engineering. When considering design and engineering, the first question an engineer raises pertains to the anticipated load that must be resisted. The engineer will also ask whether loads are static or dynamic, whether materials will be subjected to fluctuation in temperature, and whether the environment is wet or dry. The engineer will talk about issues such as fatigue, corrosion, and distortion. Ultimately the engineer understands the different stresses and strains that occur in the implant and the prosthetic components. The engineer will likewise be able to identify the materials and make suggestions for designs that can withstand these forces.

As clinicians we do not think about engineering concepts on a daily basis. Certainly when we see a huge bodybuilder sitting in our chair we make the assumption that this patient will need something "stronger" than would the proverbial 98-pound weakling. The reality, however, is that function is rarely our enemy; parafunction is usually the culprit for adverse events and it may not equate with physical size. It would be nice to have some better predictors that help us avoid catastrophic events.

As I read the implant literature I'm always struck by the paucity of articles that provide comprehensive reviews of complications. I have to wonder if clinicians are embarrassed to share their failures, thereby preventing them from writing about complications. If there are no complications, the discussion of appropriately designing and engineering therapy is moot. But if, in fact, complications are not being documented, then the need for appropriate design and engineering is paramount.

I must make a confession: I have published a number of articles on complications. Each of these articles has helped me identify areas in which my practice could be improved. Many of these improvements were related to design and engineering.

Where will the future take us? Is it possible for industry to create devices that could be used over a short time period to monitor all aspects of function or parafunction? If we had such devices would this allow us to then appropriately engineer our patient treatment? Would the costs of such analytical equipment outweigh the benefits that could be accrued with such an analysis?

Design and engineering concerns beyond the scope of the dental clinician will continue to weigh in as implant dentistry moves into the future. So in answer to the question that titles this editorial, I think that the person who drives the train is the engineer and our charge for the future is to gain an improved appreciation of these engineering concepts.

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