17. Sul YT, Johansson CB, Jeong Y, Albrektsson T. The electrochemical oxide growth behaviour on titanium in acid and alkaline electrolytes. Med Eng Phys 2001;23:329–346.
18. Massaro C, Rotolo P, De Riccardis F, et al. Comparative investigation of the surface properties of commercial titanium dental implants. Part I: Chemical composition. J Mater Sci Mater Med 2002;13:535–548.
19. Johansson CB. On Tissue Reactions to Metal Implants [thesis]. Göteborg, Sweden: University of Göteborg, 1991.
20. Donath K. Preparation of Histologic Sections by Cutting-Grinding Technique for Hard Tissue and Other Materials Not Suitable to be Sectioned by Routine Methods. Norderstedt: EXAKT-Kulzer,1993:1–16.
21. Larsson C, Thomsen P, Lausmaa J, Rodahl M, Kasemo B, Ericson LE. Bone response to surface-modified titanium implants: Studies on electropolished implants with different oxide thickness and morphology. Biomaterials 1994;15:1062–1074.
22. Ishizawa H, Fujino M, Ogino M. Mechanical and histological investigation of hydrothermally treated and untreated anodic titanium oxide films containing Ca and P. J Biomed Mater Res 1995;29:1459–1468.
23. Fini M, Cigada A, Rondelli G, et al. In vitro and in vivo behaviour of Ca- and P-enriched anodized titanium. Biomaterials 1999;20:1587–1594.
24. Sul YT, Johansson CB, Jeong Y, Röser K, Wennerberg A, Albrektsson T. Oxidised implants and their influence on the bone response. J Mater Sci Mater Med 2001;12:1025–1031.
25. Sul YT, Johansson CB, Röser K, Albrektsson T. Qualitative and quantitative observations of bone tissue reactions to anodised implants. A histologic, enzyme histochemical and histomorphometric analysis. Biomaterials 2002;23:1809–1817.
26. Sul YT, Johansson CB, Jeong Y, Wennerberg A, Albrektsson T. Resonance frequency- and removal torque analysis of implants with turned and anodized surface oxides. Clin Oral Implants Res 2002;13:252–259.
27. Sul YT, Johansson CB, Wennerberg A, Albrektsson T. Oxidized, bioactive implants are rapidly and strongly integrated in bone: Part 1—Experimental implants. Clin Oral Implants Res 2006 (in press).
28. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I). Success criteria and epidemiology. Eur J Oral Sci 1998;106: 527–551.

Commentary on the Role of Basic and Translational Research

Sreenivas Koka, DDS, MS, PhD
Consultant, Division of Prosthodontics
Associate Professor, Mayo School of Medicine
Mayo Clinic, Rochester, Minnesota, USA
Fax: 507-284-8082
Email: koka.sreenivas@mayo.edu

Advancing clinical therapies rely on systematic and rigorous scientific investigation prior to widespread use in the patient care setting. The research presented here by Sul et al offers both of these qualities in a well-designed and clearly written article. The challenge for the clinician, however, is to fit this basic research into the larger context, and to appreciate both its sophistication as science and its limitations as preliminary experimental evidence of an alternative strategy to manage edentulism.

At present, the literature on implants is dominated by 2 principal forms of science: *(1)* basic research at the cellular/molecular or the in vivo (animal) level, which offers relatively good control of many variables that may affect an important outcome; and *(2)* clinical research that reports on the success or survival of implants or their associated restorations, as well as improvements in the quality of life of patients. Often, the success/survival data generated for new systems and therapies are from relatively short–term studies, as revised therapies negate an investigator's interest in conducting long-term research with studies already initiated. The result of this environment is an intellectual and ethical chasm in which therapies that dare to challenge proven standards are not rigorously investigated with a sufficient number of patients (human subjects) over a meaningful period of time in a suitably controlled clinical research setting *before* marketing to the wider practitioner and patient audience. Today's thinking practitioner is immersed in a quandary where traditional osseointegration-based therapy is under constant modification, and translational research is not conducted to a degree sufficient to quell the healthy skepticism that one is trained to develop during graduate study. The influence of industry-conducted and industry-supported research on oral implant research, basic and clinical, is enormous, in part due to the limited resources assigned to this type of research by government and other non-industry parties, and in part due to implant manufacturers striving to improve their product to enhance both patient care and corporate success.

Sul et al state that "surface chemistry facilitated more rapid and stronger osseointegration of the Mg implants

despite their minimal roughness," and they propose potential clinical practice benefits for sites of "compromised bone" and instances of "immediate/early loading." However, from a broader perspective, some questions must be asked of any research that follows the format used in the present study. First, how relevant is a particular animal model to the human condition? For example, periodontic research with the beagle dog, although common, does not approximate the human healing response particularly well. In this study, the findings are suggested to offer new strategies for the compromised site. Clearly, an animal model offers convenience and practicality, but does this animal model and the site employed equate to a compromised site? Further, is research conducted with a sufficiently long time frame to be meaningful? Studies investigating responses at 6 weeks, or even 6 months, certainly suggest potential, but do not necessarily bestow promise. A practitioner cannot, in good conscience and with conviction, modify patient care without long-term translational research to support basic research findings. The effects of periods of function 5 years and longer must be considered; otherwise, clinicians risk treating patients as a series of individual experiments, rather than as long-term partners in care. The potential for traditional therapies to "catch up" and offer similar, if not better, outcomes to new therapies must be considered. Finally, are the conclusions aligned with the variables studied? Although *osseointegration* has many definitions in the scientific literature, the most clinically relevant definitions include the criteria of interfacial osteogenesis, which results in a durable host–implant relationship in diverse host sites and under clinical loading, thus ensuring pain-free and esthetic results.

Removal torque (RTQ) does not measure osseointegration. The value of the mechanical measurements such as RTQ and the histomorphometric measurements such as bone-implant contact required to define osseointegration ("osseosufficiency") are unknown. Furthermore, the methods required to gather mechanical measurements necessitate the use of instrumentation and the application of forces that hold little relevance to clinical function. However, we must recognize that these methods are all that is available to the basic researcher to identify new strategies that may be important. It is the translational research to bolster or undermine these preliminary findings that is lacking.

Basic research is a key first step to improve methods of patient care. The widespread promotion and application of basic science findings, however, occurs most convincingly after translational research has been thoroughly conducted to determine if the discrepancies between in vitro and in vivo model systems and the human condition are of minimal or major significance. It is no coincidence that the research model that works best in the long run is one of optimistic caution, rigorous in vivo experimentation, and enduring clinical evaluation, epitomized by the seminal work of Brånemark and Schroeder's research groups in the latter half of the last century. Although improvements in technology are rapid and seemingly constant, the human osseous healing response and the need for predictable clinical function demand that prudent scientific investigation be aimed toward horizons that can be reached, rather than toward those that may not exist.