Implantomania: Prosthodontics at a Crossroads

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Throughout the 1980s and '90s, a small core group of clinical scholars played a major and pivotal role in the combined surgical and prosthodontic dissemination of osseointegration scholarship. As professor of oromaxillofacial surgery at the University of Washington, Dr Philip Worthington was one such pioneering educator. His academic leadership was acknowledged via numerous academic honors and tributes, including his recent postretirement recognition as distinguished professor at his university. This invited paper is a personal assessment of the impact of clinical changes ushered in by the osseointegration technique and was recently presented at the University of Washington's unique celebratory tribute to Professor Worthington. *Int J Prosthodont 2012;25:180–185.*

Thirty years ago, the May 1982 Toronto conference on tissue-integrated prostheses launched Brånemark's technique of osseointegration (OI) into global use. The ensuing years have seen numerous clinical scientists coloring in novel additional details to the technique with a resultant expansion of its versatility and application. These initiatives also rapidly led to a quasi-panacea treatment status for partially and completely edentulous patients as a result of enlightened empiricism, a prevailing entrepreneurial spirit, and an aggressive marketing culture. A virtual "implantomania"* resulted from the ensuing clinical confidence in OI and perhaps inevitably led to four popular opinions:

1. Implants rarely fail to osseointegrate and are rarely accompanied by consequential surgical morbidity. Moreover, any failure is readily reversible through repeat surgical interventions.
2. Most targeted host bone implant locations can now be readily "site improved" to ensure favorable prognoses similar to those encountered in native bone.
3. Numerous implant systems appear to have similar microscopic and macroscopic design features. Surface feature improvements and correct clinical handling readily permit their routine immediate loading in most sites.
4. Recruiting implants into routine treatment plans provides a new standard of care for prosthodontic patients—a compelling objective for many dentists.

These convictions continue to provoke concern in clinical academic circles since they are regarded as articles of faith rather than science. Yet, it is important to keep in mind that significant breakthroughs in health sciences often result from unrelated but convergent occurrences in the laboratory or chairside. They occur as separate streams of thought from experimental and clinical application that gradually merge to catalyze new sources of creativity. It is therefore opportune for our discipline to take ongoing stock of the effectiveness of OI given the relatively sparse rigorous documentation to improve and expand its original applications to the entire area of orofacial rehabilitation. Prosthodontics is now at a crossroads in its long-standing claim to define and lead intraoral architectural initiatives, and it is prudent for surgeons, prosthodontists, and biomaterials experts to dwell on issues that impact their synergistic clinical roles as related to the implant, the healing response, the esthetic issue, the ecologic impact, and the research challenge.

The Implant

Implants continue to be introduced as variations on a theme of the original commercially pure titanium cylindric screw. Most currently marketed implants, irrespective of their variable published scientific pedigree, offer subtle and sometimes even profound design shifts that seek to optimize the induced interfacial healing response. Yet, in spite of the extraordinary documented success of OI, much remains imperfectly understood. For example, the inherent robustness of the human host's healing potential seems to encourage

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This paper was presented as a lecture given at the University of Washington's tribute to Prof Philip Worthington.

*The author coined the term "implantomania" after coming across Mike Dash's 1999 compulsive read *Tulipmania*. His is a fascinating study of human greed and self-delusion as opposed to prosthodontics' ongoing search for better ways to take care of patients.

an induction of interfacial osteogenesis irrespective of a patient's sex, age, race, behavioral habits, targeted host bone sites, or even traditional long-term intraoral ecologic concerns. This has expedited a treatment culture that may be vulnerable to the perception that numerous design variations that incorporate convergent themes of implant material, size, and macroscopic and microscopic features combined with the right design thread pattern will conquer all concerns, and that an instrument that measures initial stability in bone provides a reliable prognosis for the abutment's successful outcome. In the process, overall treatment-planning skills, specific surgical training principles, and scrupulous tissue-handling risk falling between the cracks of meticulously developed optimal patient management protocols. It is a given that the scientifically determined and tested biomechanical qualities of any final implant product are an integral and vital part of a successful outcome equation. However, the scrupulous imaging and selection of proposed bone sites together with surgical skill in manipulation of host tissues in the context of planned prosthetic loading remain the major determinants of long-term treatment success. The defining modus operandi in OI is that a quality implant per se is only as efficacious as the skill and judgment of the operator who places it.

Regrettably, the longevity of the biologic response's eventual clinical outcome is inadequately documented for several implant systems in common use. This reality makes for an exciting yet risky developmental climate by encouraging entertaining presentations at meetings in the category of progress and new developments. A typical example is the employment of visual advertising evidence of maximum bone-to-implant contact as the yardstick of optimal clinical long-term outcomes. This mindset leads to a race for a company with the highest bone-to-implant contact to claim to be the winner of the OI stakes, often in the absence of robust outcome evidence. Another example is the current enthusiasm for mini- and microimplants. Historically, differently sized implants were used for a variety of reasons, such as establishment of optimal ratios for bone support. The justification for routine employment of such abbreviated implants (other than in an adjunctive support capacity) is unclear, and evidence for their long-term favorable prognoses is far from compelling.

These observations may sound unduly harsh since a strong argument could be advanced that progress from an established baseline of proven clinical efficacy plus short-term effectiveness cannot be expected to undergo the identical long-term scientific scrutiny demanded of the pioneering work of early clinical scientists. Nonetheless, the success of implants should preferably continue to be measured by documented outcome evidence, not by unquestioned asseveration.

In the interim, ongoing research at a basic level remains full of promise. For example, it has already been shown that titanium implants with different surface topographies modulate the expression of a specific set of genes that are not involved in osteotomy-induced bone wound healing.[1] Furthermore, the induced gene products contribute to the establishment of OI and may offer additional scope for an increased understanding of the mechanisms of the healing response. Microroughened implant surfaces have also been shown to speed up the process of OI. They are reported to have advantages over the original machined and relatively smooth surfaces by providing better mechanical interlocking as well as promoting osteoblastic differentiation and faster bone formation. This well-supported observation rapidly led to earlier implant loading protocols, although hoped-for long-term outcomes and advantages of this approach for diverse host sites are not rigorous—the scientific jury is still out on this particular issue.

The current explosion of interest in nanotechnology for industrial and medical uses also suggests promise for yet another scientifically driven generation of implant designs. Nanotechnology-based surface modification processes may very well yield novel properties and functions that could profoundly influence cellular behavior. The possible outcome of such a development would then be an enhanced ability to control OI. While this additional design leap to incorporating more microroughness on a nanoscale may seem logical and desirable in both orthopedics and dentistry, clinical prudence demands more scientific evidence to justify a declaration of a new generation of implants that can lead to even better OI. It appears that dentists remain vulnerable to being carried away by the aura of novel scientific claims and beliefs that "success in a package" can be readily purchased. What must not be forgotten is that the quality of scientific evidence that characterizes the entire field of dental implants must undergo ongoing assessment. It is, after all, only one side of the coin of a therapeutic currency; the clinician's judgment, skill, and integrity are the other side.

The Healing Response

It has been repeatedly argued that successful long-term OI outcomes result from well-planned and scrupulous exploitation of any bone site's healing response. This clinical fact has now been robustly documented in patients of both sexes, from different races, and across the age spectrum—a reflection of the extraordinary efficacy of the applied clinical technique. It has

also proven to be successful in patients whose overall systemic health may be compromised but not in a brittle state, as well as in patients who have undergone oncologic therapy. Consequently, any treatment plan that includes a scrupulous preprosthetic imaging and surgical protocol would appear to be a valid consideration for an implant-supported/retained prosthesis. While cognizant of these truisms, numerous clinicians were initially frustrated whenever patients needing implant treatment lacked host site dimensions to accommodate implant sizes. Several oral and maxillofacial surgeons sought to compensate for these restrictions by employing autogenous bone grafts—an approach that was the recognized gold standard in orthopedic surgery and similarly provided the selected potential OI site with an osteoconductive matrix together with vital cellular and growth-stimulating features. Many patients benefited from such early ingenious and virtuoso surgical interventions, although the risk of attendant morbidity was always present, even in healthy patients. In fact, the disadvantages of using even limited host harvesting sites included increased postoperative pain, and the risk of infection militated against the procedure's routine use. Furthermore, patients with compromised health pictures also seemed to run an increased risk of ensuing morbidity, thereby limiting the protocol's application even further.

There are now exciting reports and claims endorsing recombinant growth factor therapeutics for vertical bone augmentation—a welcome alternative to the onlay graft and its unpredictable risks. As a result, extensive sinus and alveolar ridge augmentation are frequently reported as readily feasible and accompanied by a new sense of optimism in this next site-improvement phase. Early evidence of postoperative de novo bone formation has also been rapidly translated into increased surgical application and endorsement of products that "finally bring osteogenesis under the control of surgeons." Furthermore, three-dimensional biomaterial scaffolds or matrices were introduced to support the regeneration of the lost tissues, and the method is now a routine one, especially in smaller host sites. Nonetheless, long-term clinical observation and a mixed quality of short-term documentation demonstrates that while such passive therapeutic matrices are useful in the provision of a framework and maintenance of space for tissue deposition, unpredictable results (eg, soft tissue dehiscence, infection) do occur, and the size of the targeted site is also a frequent treatment deterrent. All of this is heady and exciting stuff and offers very promising ongoing synergies for researchers in biomaterials, surgery, and prosthodontics.[2] It also reintroduces the need to address the essential question: Do the new techniques demonstrate the same predictable and reproducible results that underscored the introduction of OI in the first place? Clinical prudence continues to demand persuasive evidence-based information before such promising claims are readily incorporated into routine practice.

The Esthetic Issue

Dentists and dental specialists are health care providers who undertake the professional responsibility of ensuring continuing oral health and function in an esthetically satisfactory oral milieu. The disciplines of orthodontics, maxillofacial surgery, and prosthodontics in particular regard such objectives as integral parts of their mandate. The artistic roots of all three specialties remain inseparable from an overriding commitment to control and manage disease as well as traumatic and dyscrasia-related processes and their sequelae. However, in the consumer marketplace, the pursuit of "feeling better" is frequently measured in terms of self-esteem, leading to a blurring between cosmetic and dental health care. An esthetically pleasing natural or restored dentition remains an integral and important part of an individual's self-image; it simply cannot be ignored. In industrialized countries in particular, the middle class and wealthy regard straight, white teeth as a virtual birthright. Yet, an aggressive move into beautification techniques risks turning the patient into an object, an easel onto which the dentist can seek to be creative. The present cosmetization of dentistry risks a divide between patients and customers. The latter want and expect service, while the former perceive their dental management in the context of a far larger health picture. The challenge for the discipline is to reconcile a new narrative of prosthodontics as oral architecture as opposed to its expedient drift toward "interior decorating" without ignoring our patients' frequent need for both services.

Implant treatment is often marketed as offering a unique esthetic dimension to achieve the best results. This may be misleading because the role of implant treatment is not a guarantee of an esthetic solution but a useful adjunctive one. In fact, well-planned traditional prosthodontic treatment techniques can be successfully recruited to address the majority of dental esthetic challenges. The one big convenience that implants offer is their potential for ready incorporation of optimal retention and stability into a final treatment plan. Prosthetic teeth can then be placed in desired esthetic locations with minimal concern for neutral zone directives, which are often restrictive. This is particularly relevant to situations where

morphologic and specific biologic changes related to aging, namely advanced residual ridge reduction (circumoral collapse resulting from altered tissue tone or neurologic deficits), demand the sort of soft tissue support that would otherwise be unattainable. An obvious example here is the elderly edentulous patient with advanced residual ridge reduction for whom an implant–supported and retained prosthesis of the fixed or overdenture variety would readily address the attendant esthetic perceptions. Nonetheless, the risk of a fundamental treatment shift to cosmetic commodity status is not entirely without side benefits. For example, the decision to replace missing single or multiple teeth in visible anterior sites (so-called "esthetic zones") and where ridge bulk is depleted has already led to the introduction of numerous ingenious surgical reconstructive protocols—both with and without regenerative bone techniques—obviating the need for use of prosthetic materials to simulate missing soft tissues.

The Oral Ecologic Impact

OI catalyzed a new clinical mindset that seriously challenges dental education—prosthodontics in particular. The notion of oral ecologic responsibilities or "inconvenient truths" is already perceived as paralleling the much larger yet similar principals of global ecologic concerns. This perception is likely to evolve even more strongly when the profound differences between a tooth and an implant's attachment mechanism become even more increasingly self-evident. The mouth, like the extraoral environment of which it is an integral part, can be regarded as reacting to change with an intervention price that can either enhance or undermine eventual ecologic outcomes. This is no longer an exclusively academic hypothesis since modern prosthodontics regards clinical decision making as including a much broader-based concern for biologically tenable outcomes. Optimal treatment planning in the discipline is based on reconciling two key questions: *(1)* What is the biomechanical and esthetic price that has already resulted from the patient's current oral health status? and *(2)* What are the time-dependent biomechanical risks inherent in any required/proposed intervention?

The first question is relatively easy to answer because most evidence of oral damage encountered by the clinician can be readily seen, imaged, and often tested. Disease processes and their sequelae, at their diverse levels of presentation, can be studied, and the resultant information synthesized into a comprehensive diagnosis. Above all, resultant intraoral ecologic changes can be reconciled with the patient's age, systemic health, and behavioral considerations, with the net result leading to a decision on what an optimally prudent intervention should comprise.

The answer to the second question is more difficult since patients are consumers and expect to pay for both correct and ethical guidance as well as the treatment itself. They often want a say in the treatment plan, and their subjective concerns and wishes as well as their commitment to optimal oral health maintenance must also be viewed in the context of what professionals have to offer. That choice also includes a strong awareness of the inherent biologic price of any proposed prosthodontic intervention. A knee-jerk response to treatment ("let's replace the missing teeth with dentures") is no longer valid in today's OI era. The relative ecologic implications of implant-supported prostheses as compared to tooth- or soft tissue–supported ones now demands a complex yet more balanced approach to guiding patients' decisions that may very well be a similar sentence, but ending "with an implant-supported/retained fixed prosthesis."

The biotechnology of OI and its applications has been successfully harnessed to manage and treat the consequences of dental diseases. Hopefully, new biotechnologies will also soon become available to curtail and perhaps even cure caries and periodontal diseases. In the interim, implant preprosthetic surgery and prosthodontics are likely to continue to dominate the needs of all those patients who have already lost their teeth or of those with remaining dentitions with poor prognoses. Additional concerns still exist though regarding the apparent ease with which implant solutions continue to be promoted. For example, recently promoted technologies link computed tomographic scans to surgical guides and prosthetic delivery, assuring accuracy of implant placement and prosthetic fit within a short time frame. These systems appear to be the ultimate in technologic brilliance and patient convenience. In fact, the protocol is likely to prove to be a boon in the hands of experienced specialists, even if the associated price tag may be perceived as a high one. On the other hand, the questions about the repeatability of the approach, the real need for such accelerated treatment, and the dangers of its being used by inexperienced dentists without the necessary special training suggest cause for concern. The OI technique has become so attractive that the mantra of "teeth in an hour or a day" runs the risk of distracting the practitioner from the true worth of this bioengineering breakthrough.

The proven promises of OI included predictable and virtually morbidity-free recruitment of prosthetic implant abutments for diverse prosthetic designs—a

welcome if belated departure from heroic and often unpredictable reliance on adjunctive efforts to prolong the useful life of tooth abutments. It also introduced an ecologically viable alternative since risks of pulpal and periodontal disease were automatically precluded as early edentulous patient management protocols rapidly morphed in entirely new directions. It has now led to broad acceptance of implant prosthodontics as the modern choice for treating virtually all forms of tooth loss. Furthermore, numerous and long-term multicenter outcome studies with best-researched implant brands record very small numbers of OI failure. This is probably the result of the extreme variant of osseoseparation (failure to achieve optimal OI), which results from a compromised time-dependent healing response in the first place. It appears that the success and promise of successful OI, together with its invulnerability to caries and pulpal and periodontal diseases, remains underappreciated.[3]

Michael MacEntee quoted the French philosopher Foucault (1926–1984), who observed that "Medical certainty is based not on the completely observed individuality but on the completely scanned multiplicity of individual facts."[4] Unfortunately, the profession's collective scanning gaze remains imprecise in many areas and at times blind to the wants and needs of the community. It is therefore understandable that many clinical educators, especially prosthodontic ones, are restless about the slow pace of curricular development and acceptance of the technique's educational impact. They are confronted with crossroad decisions as a result of the profound and exciting treatment implications of OI. Others continue to demand evidence-based approaches that systematically evaluate existing research in the field while risking being perceived as slowing down progress and remaining overtly committed to a passé world of handicraft techniques. It must be conceded that we are clearly no longer being asked to make leaps of faith in what clinical teaching and patient care is all about in our discipline. Leaps of science have already taken place, and the speed of ongoing change and development demands new decisions that will significantly alter traditional educational protocols at both undergraduate and graduate levels.

The Research Question

The inherent promise of the OI technique has also been challenged by risky commercial and professional initiatives that have not been research-driven. Moreover, disputed territories of professional skills also complicated OI's growth engine research status and permitted numerous industries to build on and relentlessly diversify Brånemark's original scientific landmark. A flurry of exciting assertions also followed—opportunistic claims regarding the introduction of new standards of care, individual disciplines and organizations claiming that they were specialists in implant placement, equipment and product manufacturers asserting that special instruments would provide better OI plus diagnostic and prognostic information about its longevity, together with accompanying premature claims that routine and reliable bone regeneration is readily available. The resultant confusion underscores even further the expectation that research rigor continues to direct not only dentist-mediated outcomes but also patient-mediated ones. As a profession, we simply cannot risk having biotech developments and their spin-off techniques usurp the very basis of what the dental profession is all about.

In a provocative commentary,[5] the authors observe that, "while the duty of universities is to seek the truth, the duty of pharmaceutical companies is to make money for their shareholders; the companies that fail to do so go out of business." These authors also assert that universities that subordinate the search for truth to other ends lose credibility and their claim to a privileged place in society. If either institution abandons its fundamental mission, operational imperatives are bound to conflict and failure becomes a risk. While the commentary specifically addresses the relationship between pharmaceutical companies and universities, its implicit message regarding a health profession's safeguarding of the public interest applies to the dental implant field as well. The authors go on to explicitly sum up their case by stating that: "Research can either serve or subvert public interest. Its findings may advance knowledge and support useful innovation, or be filtered and twisted to support prejudices or gain commercial advantage. The capacities and integrity of researchers, and their universities, can be enhanced or corrupted in the process. Some partnerships are united by an open-minded quest for discovery; others are unholy alliances whereby researchers and universities become handmaidens of industry. Whatever ethical bed we make, we lie in."[5]

It is essential that we do not exclusively approach the subject of tooth loss and their replacements without considering humanitarian concerns such as poverty, distributive justice, and the social contract in health care.[6] After all, loss of teeth is both a socioeconomic phenomenon as well as a biologic consequence of disease. Any advance in oral health care must also look carefully at the accessibility of service to people with limited financial resources or who live in remote regions without easy access to dentists. This is a very

challenging and civilized concern given the absence of robust evidence to support the comprehensive effectiveness of OI vs relative benefits and risks of the traditional alternatives available to patients, third party providers, and governments.[7] The emerging western attitude of never "doing pink"—given the choice of the gray titanium breakthrough—usurps the entire notion of a humanitarian professionalism in the context of fiscal and global concerns.

Nonetheless, clinical educators in particular need to readily concede that the clinical efficacy of the OI technique for specific undertakings is today beyond dispute. It is necessary and opportune for our discipline to modify and replace traditional curricular content to absorb the reality of OI. The challenge of "not throwing out the baby with the bath water" should not elicit a stronger determination to cling to old clinical and laboratory teaching models. It should instead catalyze a willingness to reconcile the discipline's new biologic direction with a stronger commitment to think outside the rigid limits of narrow technique determinants. Above all, the profession's most important commodity, intellectual integrity, must be protected by the sorts of commitment, or even rules, that ensure due diligence. Universities, professional organizations, and scientific journals must continue to be major sources of clinical education by promoting research involving human subjects that includes definition, disclosure, and management of conflicts of interest. This is inarguably the best way to ensure that OI fulfills its catalyzing and ongoing role in redefining much of the profession's therapeutic remit.

Conclusion

The technique of OI as a seminal clinical application for edentulous patients was conceived by Per-Ingvar Brånemark prior to its 1982 Toronto debut. Its subsequent worldwide trajectory ushered in a prosthodontic management revolution in rehabilitative dentistry and ensured exciting and continuing synergies between clinical disciplines and the world of biomaterials. The introduction of OI was an extraordinary example of empirically tested convictions and observations—a far cry from the currently described, albeit rarely achieved, standard of randomized controlled clinical trials. Yet it succeeded in changing traditional convictions about the feasibility and desirability of prescribing dental implants. It also created discord regarding its impact on cultural and technologic changes in global patient management. It is hoped that ongoing research will continue to establish better and more humanitarian guidelines regarding comparable outcome merits of past protocols as well as alternative ones. Such an approach is then bound to lead to the development of realistic standards of care.

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