Primary stability vs. viable constraint: A need to redefine

By Michael R. Norton, BDS, FDS, RCS(E)

A ny regular reader of the Journal of Oral & Maxillofacial Implants or indeed of any other publication on dental implants could not fail to have noticed how much attention has been focused on primary stability. The concept of primary stability is not new; indeed, as early as the 1970s, there were studies emphasizing the need to establish mechanical stability to ensure uninterrupted healing of the bone. This was most evident in the orthopedic literature as it pertains to hip prostheses. By the 1990s, numerous reports were being published on immediate loading of dental implants, and the groundbreaking work by Neil Meredith on the application of resonance frequency analysis (RFA) came to the fore with statements that achievement of implant stability was a prerequisite for long-term positive outcomes.

At the same time, Meredith recognized it was possible for clinically firm implants with poor axial stability to still be prone to failure. Of course, Brånemark recognized this in his early work, proposing as he did a period of submerged healing because of his concerns for any destabilization of the bone-to-implant interface during the early healing phase. However, today, we all recognize that such protective protocols are frequently unnecessary, with widespread acceptance of not only transmucosal healing but also immediate temporization and/or loading.

So how do we define primary stability? The most simple definition is one of mechanical friction between the implant and bone. Certainly, we can all appreciate that this contrasts with secondary implant stability where secondary stability is achieved by biological integration, i.e., osseointegration. The gradual shift from primary stability to secondary stability is critically poised at around three weeks. This is seen to be the least stable time point where viscoelastic stress relaxation of the bone along with remodeling results in a loss of primary mechanical stability but with an as yet poorly established degree of secondary stability or osseointegration.

This is also apparent in RFA curves, which, like a heartbeat, always register a certain pattern in healthy bone that reflects this loss of stability at the third or fourth week, regardless of bone density.

That said, we still need to define what constitutes primary stability, i.e., that which sets it apart from biological integration. As stated above, mechanical stability is one where a friction occurs between the implant and the surrounding bone, giving rise to a resisting torque at time of insertion.

This resisting torque is proportional to the effort required to seat the implant or peak insertion torque; they are in essence one and the same and depend largely on the characteristics of the implant, the density of the bone and the differential size of the osteotomy as it pertains to the diameter of the implant.

• STABILITY, Page D2

AAID: Digital implant dentistry isn’t the future

D igital implant dentistry is not the future. No, far from it. Digital implant dentistry is the here and now for dental implant practitioners.

From digital treatment planning and delivery to patient communication, new technologies are changing the way dentists practice implant dentistry. The American Academy of Implant Dentistry presents a course titled “Implant Dentistry in the Digital World” in Baltimore from April 24-25.

In addition to offering 12 hours of C.E., the AAID is honoring Dr. Leonard Linkow, one of the pioneers of the field of dental implants, with a dinner on Friday, April 24.

The conference, which is co-hosted by the AAID’s Northeast and Southern Districts, will be held at the Marriott Inner Harbor at Camden Yards in Baltimore.

More information and registration is available online at www.aaid.com. The following programs are among those to be included:

• “C-BIT Implant Planning: Digital Solutions from a Laboratory Perspective” (Joe “Ambrose” D’Ambrosio, CDT)
• “Reverse Engineering in Digital Smile Design” (Alain Methot, DMD)
• “Innovations in Digital Implantology” (Gilbert Tremblay, DMD, AAID, DABOI/ID)
• “Technology to Enhance Your Practice” (Marty Jablokow, DMD)
• “Fixed Implant Prosthetic Considerations” (Shankar Iyer, DDS, MDS, AAID, DABOI/ID)
• “Planning the Rehabilitation of an Edentulous Arch” (Lou Dipepe, DMD)
• “Soft Tissue Management in Implant Therapy” (Dr. F. Hamrick, DMD, AAID, DABOI/ID)
• “Protocols to Avoid Complications and Failures with the New Digital Workflow” (Scott Ganz, DMD) Estabished in 1953, the AAID is the only dental implant organization that offers credentials recognized by federal and state courts as bona fide. Its membership, which exceeds 5,000, includes general dentists, oral surgeons, periodontists and prosthodontists from across the United States and in 40 other countries. For more information, contact AAID at aaid@aaid.com or at (312) 335-1550 or (877) 335-AAID (2245).
Mathematically, it can be defined as follows:

\[ \text{Resisting torque} = \mu \cdot P \cdot H \cdot \pi \cdot D^2 \]

Where: \( H \) = height of the implant cylinder, \( D \) = diameter of implant cylinder, \( \mu = \text{Coefficient of friction} \)

The important factor in this equation is \( P \), the critical pressure on the bone, as high pressure results in unfavorable bone strain, particularly within the cortical compartment. However, the formula indicates that the resisting torque is proportional to the diameter \( D \) raised to the power of 2. This means that if you double the diameter the resisting torque will be four times lower for the wider implant!

For example, an implant of 3 mm diameter inserted into 1 mm thick cortical bone with a torque of 20 Ncm will transmit the same pressure to the bone as an implant of 6 mm diameter inserted into 2 mm thick cortical bone with a torque of 60 Ncm. This assumes that 100 percent of the torque originates from the pressure on the cortical bone, and the contribution to torque from bone cutting, etc., is negligible. Yet manufacturers persist in providing a single target value of insertion torque across the range of implant diameters they offer.

It is therefore reasonable to discuss the virtues of insertion torque and ask the pivotal question: Is insertion torque an appropriate measure by which to quantify optimal primary stability? All bone is a living tissue, so any measure of primary stability must also reflect the future viability of the bone.

It is clear that higher insertion torques fulfill the desire to achieve a high degree of mechanical stability as interpreted through manual perception. Indeed, it is usual for manufacturers to provide some guidance on optimal insertion torque with some implant designs being specifically tailored to deliver higher insertion torques, in excess of 50 Ncm. This yields a sense of comfort for the clinician that the implant is initially “stable.” However, such a high torque has not been shown to be beneficial to the surrounding bone. Numerous studies have been published that clearly demonstrate that the critical pressure these high torques generate leads to microfracture of the bone,10,11 with a net resorption in the cortical bone12 and, indeed, an unfavorable delayed healing process with a reduced bone-to-implant contact.12

Such a response might well shift the onset for secondary stability and thereby delay or extend the period of potential vulnerability that may reduce the thickness of the bone to the goal we are trying to achieve with immediate or even early loading protocols, whereby we want to transfer from simple mechanical fixation to full osseointegration in the shortest possible time.

The most fascinating aspect of this debate is the lack of correlation between insertion torque and the implant stability quotient (ISQ) as measured by RFA, which appears to be counterintuitive. How is it possible for an implant that is driven in at 30 Ncm to have the same ISQ as one that required 100 Ncm of torque? Nonetheless, the weight of literature would seem to suggest this to be the case.

Because ISQ is measuring axial stiffness, it must be clear that frictional rotational resistance is a completely different parameter. After all, I don’t think we have all have experienced the “spinner” (an implant that exhibits little or no rotational stability) that went on to osseointegrate, and there are a number of studies published that report high success rates for immediately loaded implants that were inserted with low insertion torque.

By contrast, implants with an ISQ of less than 50 rarely go on to integrate successfully, and ISQ has been described as a good predictor of success.13,14 It is this dichotomy that has got me thinking and has led me to write this editorial piece. Could it be that axial stiffness is far more pertinent than rotational friction in ensuring an implant integrates? We already know from the literature that an implant can tolerate a degree of micro-motion, thought to be circa 0.1°,15,16 and this is in essence what ISQ measures.

Studies have also demonstrated that insertion torque correlates closely to the degree of micro-motion.17 However, it is not the aim to seek complete elimination of micro-motion, a valuable lesson learned in orthopedics. If it is possible to place an implant with lower insertion torque and still achieve axial stiffness with an ISQ >60, surely this provides us with a more optimal evaluation of primary stability.

Our goal must be the rapid onset of secondary stability, with minimal critical pressure to the poorly vascularized cortical bone so unfavorable to restorative responses and delayed healing are avoided. At the same time, we need to employ an objective measure of constraint that reliably ensures the implant can tolerate early or immediate loading. As much was the case with the construction of the new bridge on the Thames. It was completed by Bawerds et al.17 I have labeled this objective measure viable constraint (VC), whose central purpose is to obtain a clinically relevant degree of stability while maintaining a low critical pressure on the vulnerable cortical tissue through which our implants are inserted.

Bone is not wood. It is not inanimate. It would behoove us all to remember this, and avoid the carpenter’s approach to implantology.

So I would take this opportunity to ask that we think in terms of viable constraint. It will, of course, take controlled prospective studies to determine the optimal conditions for VC, but if we were a gambling man (which I most certainly am!), I would guess for a 4.5 mm implant in bone with a cortex of 0.3 mm thickness that a maximum torque of 20 Ncm and an ISQ of 60 represent the optimal measures we are looking for to ensure immediate loading.

In the past, we used to think length was important with implants, whereas today there is increasing focus on short implants. However, I would point out that a strong correlation has been shown to exist between ISQ and implant length18-21 and, as such, for immediate loading. I also believe a longer implant with a higher ISQ, inserted at a lower insertion torque, will yield a more favorable outcome.

References available upon request from the publisher.

Note

This content originally appeared as an editorial in The International Journal of Oral & Maxillofacial Implants, published by Quintessence Publishing.

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Humberto Estrada, f.michmershuizen@dental-tribune.com

Christiane Ferret, c.ferret@dtstudyclub.com

Maria Kaiser, w.kenyon@dental-tribune.com

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The design philosophy of the Astra Tech Implant System EV is based on the natural dentition utilizing a site-specific, crown-down approach supported by an intuitive surgical protocol and a simple prosthetic workflow.

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Bone regeneration through tissue engineering offers new prospects for oral procedures

Regeneration of bone tissue could greatly benefit people with jaw-bone deficiencies due to tooth loss, infection or trauma. While an ideal method of bone tissue engineering is not yet available, research with a collagen-hydroxyapatite-Mesenchymal stem cell composite is showing promise. Hydroxyapatite is the main component of bone mineral and tooth enamel. A report in the Journal of Oral Implantology details researchers’ efforts to synthesize a collagen-hydroxyapatite composite through mineralization of collagen fibrils with nanometer-sized apatite crystals. Each of these methods has limitations that tissue engineering involving scaffolds and living cells can surpass.

The scaffold is an artificial structure that is combined with living Mesenchymal stem cells to form a tissue engineering construct that can repair or regenerate bone. Mesenchymal stem cells, which can differentiate into a variety of cell types, are used to precipitate bone growth.

The current study tested three ratios of collagen to hydroxyapatite: 80:20, 50:50, and 20:80. Both the 80:20 and 50:50 composites supported attachments and proliferation of mouse mesenchymal stem cells and human periodontal ligament stem cells in laboratory tests. The 50:50 ratio had the best mechanical properties suitable for bone grafting applications.

The authors report that these findings indicate a strong potential for collagen-hydroxyapatite composite complexes in bone tissue regeneration. The composites are porous and sponge-like, and show good biocompatibility and biomimetic properties.

Alveolar bone deficiency is a limiting factor for dental implant-supported prosthetic therapies. The effective formation of new bone offers a basis for further procedures to successfully repair teeth and jaws.


About Journal of Oral Implantology
The Journal of Oral Implantology is the official publication of the American Academy of Implant Dentistry. It is dedicated to providing valuable information to general dentists, oral surgeons, prosthodontists, periodontists, scientists, clinicians, laboratory owners and technicians, manufacturers and educators. The JOI distinguishes itself as the first and oldest journal in the world devoted exclusively to implant dentistry. For more information about the journal or society, visit www.joionline.org.

$1.5 million gift establishes first endowed professorship at UMSOD
The University of Maryland School of Dentistry (UMSOD) has received the largest one-time gift in the school’s 175-year history, a $1.5 million donation from alumni Frederick G. Smith, MS, DDS ’78, and Venice K. Paterakis, DDS ’81, that will establish the institution’s first endowed professorship.

This donation will provide resources to fund the work of the school’s distinguished faculty.

“As the world’s first college of dentistry, established in 1840, we celebrate our 175th anniversary this year. This historic gift pays tribute to the school’s illustrious past as a leader in dental and dental hygiene education while ensuring that the UMSOD will remain among the premier dental schools in the world,” said Dean Mark A. Reynolds, DDS ’86, PhD. “I speak for all of us here at the School of Dentistry when I express my heartfelt gratitude to Dr. Smith and Dr. Paterakis for their generosity.”
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Nobel introduces a ‘complete posterior solution’

By Nobel Biocare Staff

Large extraction sockets, limited accessibility, tough-to-remove excess cement and high occlusal forces. These are just some of the challenges a clinician faces when restoring a single tooth in the posterior. And, with molar replacement being among the most common indications, these challenges are encountered repeatedly.

A solution that addresses all these problems in an efficient and predictable way will make life easier for dental professionals and patients. That’s precisely why Nobel Biocare is bringing innovation back to the posterior region with its new complete posterior solution – an original combination of new wide-platform implants and restorative options, all specially designed for molar sites.

An implant like no other

Multiple Nobel Biocare innovations combine to make this solution complete, but the foundation for treatment success is the implant itself. Here Nobel Biocare offers several options, each engineered for the specific demands of the posterior. All are intended to shorten time to teeth for the patient by enabling immediate loading whenever possible.

One option is NobelActive. Many clinicians are already familiar with this award-winning* implant. Its distinctive design and the surgical protocol form a unique combination that can enable immediate function in cases where it might otherwise not be achievable.1-3

To condense bone gradually, its tapered body features threads that narrow towards the apex, while the apex itself features drilling blades to preserve bone by allowing a smaller osteotomy. These features are all designed for high primary stability, even in soft bone and extraction sockets.

Now, a new variant offers the benefits of the NobelActive family but with dimensions ideal for the molar region. NobelActive wide platform (WP) possesses a wider diameter implant body (5.5 mm) to better fit the large extraction sites in the molar region and a wider implant platform for an optimal emergence profile. NobelActive WP also comes in an option with a shorter body (7 mm) to avoid critical anatomical structures such as nerves.

Stability and flexibility in parallel

Alternatively, clinicians can opt for NobelParallel Conical Connection (CC). Combining a parallel-walled implant body that is well documented with an advanced internal conical connection, NobelParallel CC offers extraordinary flexibility. It is engineered for use in all bone qualities and for a wide range of indications. The 5.5 mm Wide Platform option is designed for an optimized emergence profile for large molar sites.

Both experienced clinicians and those early in their implant careers will appreciate NobelParallel CC’s straightforward surgical protocol. It offers flexibility and shortens treatment time, benefiting the patient too. Together, the surgical protocol and implant design form a unique combination that’s intended to allow immediate function in more cases by providing high primary stability. The thread design and tapered apex of NobelParallel CC are designed for underpreparation of the surgical site and bicortical anchorage – techniques that support immediate loading.4-5

High stability during the initial healing phase is then maintained by Nobel Biocare’s unique TiUnite surface.6 In addition, patented grooves enhance osseointegration4 for a predictable end result.

Connecting strength and flexibility

Both new implants benefit from Nobel Biocare’s internal conical connection. This advanced connection’s conical seal and hexagonal interlocking mechanism provide high mechanical strength.7 It offers restorative flexibility too, being compatible with Nobel Biocare’s most innovative restorative solutions, including those designed specifically for the posterior.

These include the new PEEK Healing and PEEK Temporary Abutments, which are anatomically shaped to match the molar contours. As the PEEK Abutments come ready-shaped for an optimized emergence profile, fewer adjustments are needed. This can simplify treatment and reduce costly chair time.

The crown that ‘rules them all’

When it comes to the final restoration, the FCZ (full-contour zirconia) Implant Crown is designed for strength and predictability even under the high occlusal forces of the posterior. There’s no worrying about chipping either, as the full-contour nature of the NobelProcera FCZ Implant Crown removes the need for veneering.

The biocompatibility of the materials used contributes to biological stability in the areas it matters most. Plus, being screw retained, the FCZ Implant Crown is completely cement free, avoiding the risks associated with cement excess entirely. Even the titanium adapter is mechanically retained.

The ability to use an angulated screw channel (ASC) allows the screw access hole on the FCZ Implant Crown to be placed anywhere between 0 and 25 degrees in a 360-degree radius. This means it can be angled towards the front of the mouth for easy access, even in the posterior. It also helps avoid placing the access channel on the cusp of a tooth, where it could affect occlusion. The associated Omnigrip Screwdriver further simplifies work on the restoration. Its effective pick-up function and secure grip on the screw help the clinician to work safely and efficiently.

Natural-looking tooth color is another benefit offered by the FCZ Implant Crown. Whichever of the eight available shades is used, the color is applied throughout the material. This means discoloration isn’t a concern when making adjustments. Cutbacks and staining can also be used to achieve the desired esthetic effect.

Several components, one complete solution

While each product within Nobel Biocare’s complete posterior solution stands out on its own, they stand stronger together. Like all Nobel Biocare innovations, they are tested together as one system, as they exist in the patient’s mouth.

Combining Nobel Biocare components means all elements are designed to work in synergy for the optimal treatment outcome. Restoring single molars represents a clinical challenge for many reasons, but now, by uniting new and proven innovations, Nobel Biocare has the answer.

Find out more at nobelbiocare.com/bringinginnovationback.

References are available upon request from the publisher.
Straumann introduces a flexible collagen membrane that’s easy to handle and place

By Straumann Staff

Straumann is once again expanding its portfolio of regenerative solutions to better meet customer needs. Now, Straumann® Membrane Flex™ joins Straumann® Membrane Plus™, Straumann® XenoGraft, Straumann® AlloGraft, BoneCeramic™ and Emdogain™ to provide a single trusted source for dental implant and regeneration needs, according to the company.

A quick look at Membrane Flex

- Desirable handling characteristics.
- Because it’s not side specific, it’s easy to handle and to place.
- With outstanding flexibility, it easily drapes over defects and naturally conforms to contours.
- Flexibility with placement as it can be easily repositioned for precise placement.
- Can be placed dry or hydrated.
- Even when hydrated, does not adhere to gloves or instruments.
- Takes sutures or tacks with ease, for simple yet secure fixation.
- Dependable strength.
- Proven biomechanical strength enhances fixation assurance.*
- In pre-clinical testing, the suture pull out strength was three times higher than a similar product.*
- Because of its significantly higher suture pullout strength, can be firmly anchored to surrounding tissue with minimal risk of tearing or detachment.*

Supports wound healing

- Biocompatible because it’s meticulously manufactured from highly purified intact porcine collagen and minimally cross-linked for predictable resorption.
- Reduced degree of inflammation and foreign body response as compared to other similar products in pre-clinical testing.
- In pre-clinical testing to exceed many of the performance characteristics of other similar products.*
- Available sizes: 15 x 20 mm, 20 x 30 mm, 30 x 40 mm

This new offering — along with other recent additions to the Straumann portfolio — is one of the latest products the company provides customers with for a total solution that yields patient satisfaction and practice success.

To learn more about the new Straumann Membrane Flex, visit www.straumann.us/bone/

* Data on file with manufacturer

About Straumann

Headquartered in Basel, Switzerland, Straumann (SIX: STMN) is a global leader in implant, restorative and regenerative dentistry. In collaboration with leading clinics, research institutes and universities, Straumann researches, develops and manufactures dental implants, instruments, prosthetics and tissue regeneration products for use in tooth replacement and restoration solutions or to prevent tooth loss.
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