Primary stability vs. viable constraint: A need to redefine

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By Michael R. Norton, UK

Any 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 un-interrupted healing of the bone interface was evident in the orthodox literature as it pertains to prosthesis.

By the 1990s, numerous reports were being published on immediately loading of dental implants and the ground-breaking work by Nadler 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, Mehregan recognized this could be possible for clinical firm implants with poor axial stability to still be prone to failure. Of course, Buser 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-implant interface during the early healing phase. However, today we all recognize that such an approach is 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 period 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.

**Primary stability**

Primary stability is defined as follows:

$$R = \mu T \times D^2$$

Where: \( R \) = Resisting Torque \( \mu \) = Coefficient of friction \( T \) = Torque \( D \) = Diameter of implant

The important factor in this equation is \( R \), the critical pressure on the bone, as high pressure results in unfavorable bone formation, particularly within the cortical compartment. However, the formula indicates that the resisting torque is proportional to the diameter of the implant raised to the power of 2. This means that if you double the diameter of the implant, the resisting torque becomes four times higher. Put another way, if we use the same insertion torque for a 2 mm wide implant and a 6 mm wide implant, then the critical pressure will be four times higher for the larger 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 neglected.) 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 criterion by which to quantify primary stability? After all, bone is a living tissue, so any measure of primary stability must also reflect the 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 percutaneous measurement. 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 75 Ncm. This would be a source of comfort for the clinician that the implant is initially “stable.”

However, such a high torque has not been shown to be propitious to the surrounding bone. Numerous studies have been published that clearly demonstrate that insertion torque these high torques create leads to micro-fracture of the bone, with a net resorption in the cortical zone and, indeed, an unfavorable delayed healing process with a reduced bone-to-implant contact. Such a response might well shift the onset for secondary stability and thereby delay or extend the period of potential vulnerability. This is clearly counter 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 consensus 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 90 Ncm to have the same ISQ as one that required 100 Ncm of torque? Nevertheless, the weight of literature would seem to suggest this to be the case.

**Viable constraint**

Many have noticed how much attention has been focused on Primary Stability. As stated above, mechanical stability, with minimal critical pressure to ensure an implant integrates? We already know from the literature that an implant can tolerate a degree of mobility, thought to be around 100-190µm and this is in essence what ISQ measures.

Studies have also demonstrated that insertion torque correlates closely to the degree of micro-motion. However, it is not the aim to seek complete elimination of micro-motions, which often has got me thinking and has led me to write this editorial piece. Could it be that we need to employ an objective measure of constraint that reliably ensures the implant can tolerate early or immediate loading. As much was recently proposed by Barone et al.

I have labeled this objective measure Viable Constraint (VC), whose central purpose is to define a time-limited degree of relative stability while maintaining a low critical pressure on the surrounding bone 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 “plug and play” approach to implant dentistry. So I would take this opportunity to ask us to think in terms of the Constraint. It will, of course, take controlled prospective studies to determine the optimum degree of micro-motion, but if we were a gambling man (which I most certainly am!) I would guess that for a 4.5 mm implant inserted into a cortex of <1.0 mm thickness that a maximum torque of 20 Ncm and an ISQ of 60 represent the optimal measures we are looking for to ensure safe immediate loading.

In the past, we used to think length was important with implants, where as 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 length with wide variability, with a longer implant being a higher ISQ, inserted at a lower insertion torque, will yield a more favorable outcome.

**Note**

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**References**


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