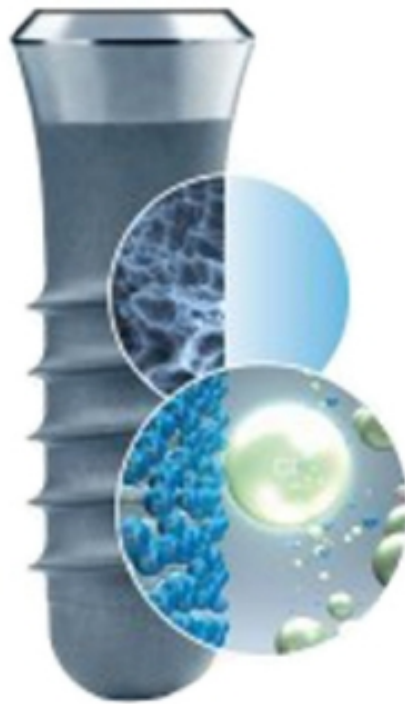


IMPLANTS

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The Biologic Fundamentals of Osseointegration

By Darin Dichter (/spear-review/author/darin-dichter/) on January 7, 2016 |  (/bookmarks/bookmark/38739)



The high-predictability of osseointegrated dental implants has altered the way modern dentistry is practiced. Teeth that may have been lost to disease or trauma or teeth that simply failed to form can be replaced in ways not possible before. In general, the goals for restorative dentistry are to restore form, function and appearance utilizing the most conservative approach available. Dental implants are often included in optimal treatment plans.

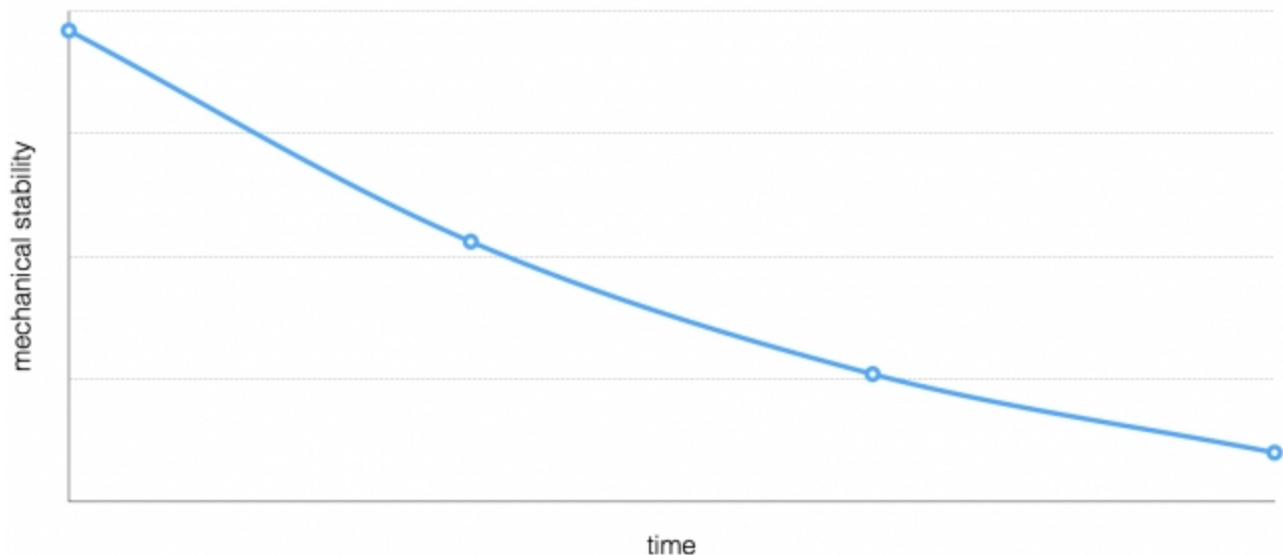
Certainly treatment outcomes are what our patients consider most important. Simplification of surgical and restorative protocols utilizing dental implants has, increasingly, allowed clinicians to focus on the procedural steps necessary to achieve desired clinical results. One, perhaps unintentional, consequence of the predictability with dental implants is that it has become easier for clinicians to lose sight of the biologic processes involved in osseointegration. This article briefly reviews the basic biology of osseointegration.

(Click here to review possible risk factors of implant placement (<https://www.speareducation.com/spear-review/2015/04/possible-risk-factor-for-implant-placement>)).

Osseointegration is defined as the “direct structural and functional connection between ordered, living bone and the surface of a load carrying implant (<https://www.speareducation.com/spear-review/category/implants/>).” Clinically successful osseointegration allows the implant to be used for its intended restorative purpose, free from disease.

Commercially pure titanium or titanium alloys have been the material of choice for osseointegrated dental implants. Titanium is strong yet easily machined into desired shapes. Titanium is generally considered “resistant” to corrosion; though some emerging data indicates biocorrosion may be occurring over long periods of time. Titanium dental implants spontaneously form a coating of titanium dioxide, which is stable, biologically inert and promotes the deposition of a mineralized bone matrix on its surface.

At surgical placement, initial or primary stability of the implant is a function of bone quality and bone² quantity at the surgical site as well as the geometry of the implant body and threads. Initial stability comes from mechanical retention and is influenced by the amount of bone in contact with the implant and lateral compression of the walls of the osteotomy site. As the osteotomy heals there is an observed decrease in implant stability.

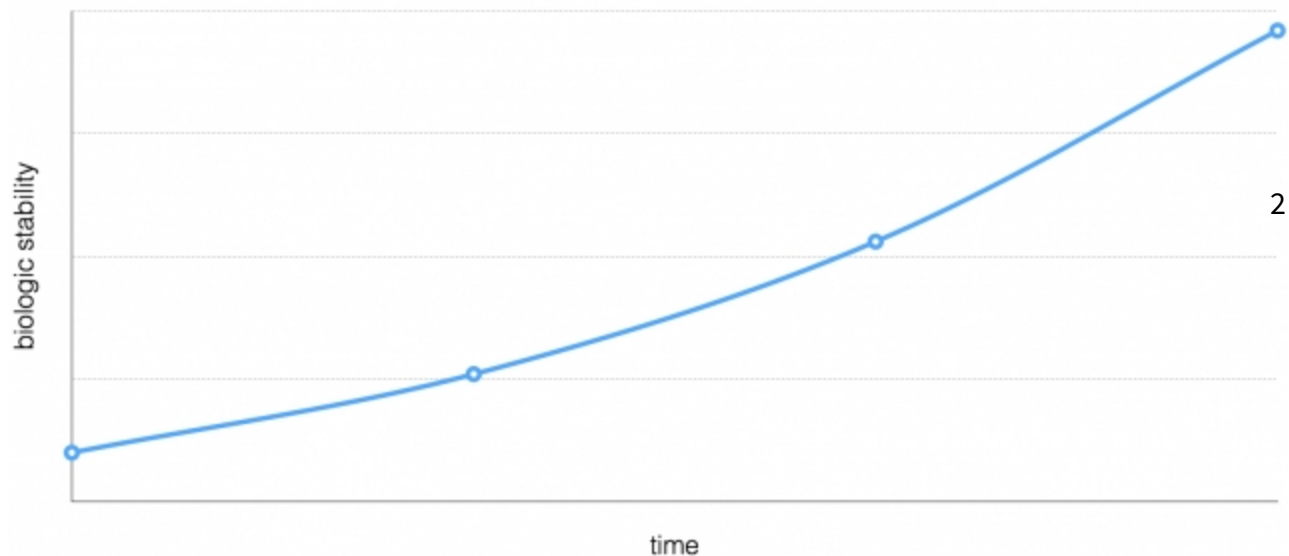


During surgical implant placement and in the time after implant placement, a complex biologic process is taking place. A passive film of complex phosphates of calcium and titanium forms on the surface of the titanium implant. A blood clot forms at the surgical site and results in the release of growth factors. These growth factors (VEGF, various bone morphogenic proteins and others) promote the formation of a fibrin scaffold and neovascularization. As new blood supply is established, osteoprogenitor cells migrate to the interface between the bone and implant, specifically migrating to and colonizing the fibrin scaffold.

Osseous healing of the osteotomy occurs through both distance osteogenesis and contact osteogenesis. Distance osteogenesis is the ingrowth of bone from the lateral walls of the osteotomy. Contact osteogenesis is the process in which osteoprogenitor cells colonize on the implant surface and differentiate into mature, bone forming osteoblasts. As a result, the new bone that forms around dental implants following placement is developing from two distinct routes.

This new, rapidly formed and rapidly mineralized bone is referred to as woven bone. This type of bone is deposited in the early stages of osseointegration and is characterized by its high number of osteocytes and an irregular trabecular pattern.

Remodeling of the woven bone occurs next through what has been termed secondary osseointegration and results, clinically, in what is known as secondary stability. Osteoclasts remove the woven bone and any necrotic bone while osteoblasts lay down dense lamellar bone. Secondary stability is established as the woven bone remodels and increases over time.



The final phase of osseointegration actually occurs when the implant is “loaded” under physiologic forces. In ideal conditions the bone to implant contact will continue to increase to near its full potential.

(Click here to view the video course "Understanding the Biology of Implant Osseointegration (<https://www.speareducation.com/digital-learning/view/course/518/lesson/1316>).")

Assessing Osseointegration

Classic experimental approaches to assessing osseointegration commonly involve measuring removal torque or quantifying the amount of bone to implant contact. More recently gene expression studies are being utilized to better understand the influence of titanium surface modifications as well as systemic host conditions.

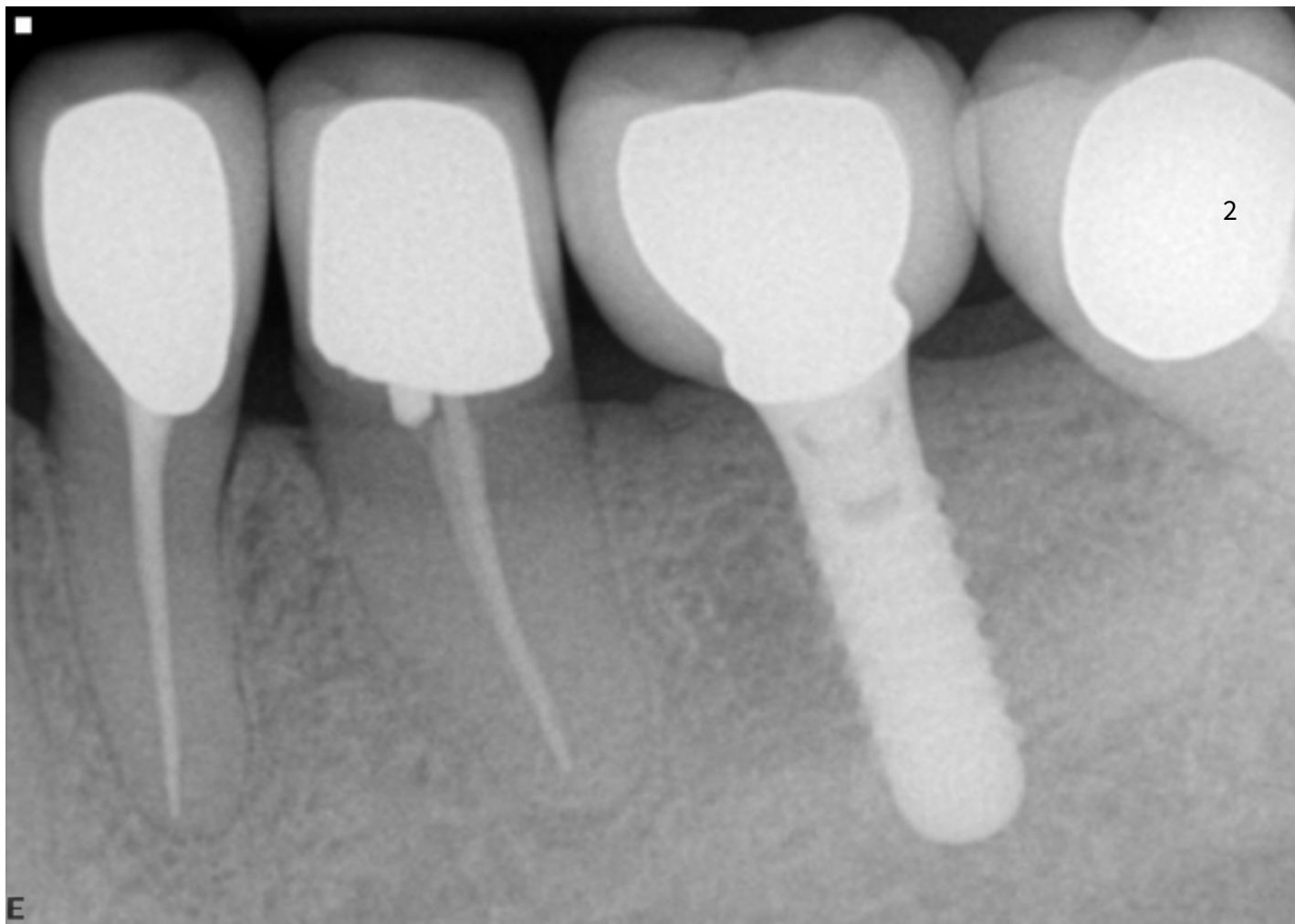
These studies are certainly beneficial for increasing our understanding of the underlying biologic processes that are occurring in osseointegration, yet these experiments are conducted under controlled, laboratory environments and it remains unclear where exactly the threshold for clinical success lies.

Resonance frequency analysis (RFA) has been used to assess the level and stability of osseointegration clinically. The Ostell ISQ System (Ostell AB, Gotenborg, Sweden) uses RFA to quantify bone stiffness at the bone to implant interface through a transducer that is connected to the implant. Measurements are reported as an implant stability quotient (ISQ) value ranging from 1 to 100.

Primary stability is important to the developing secondary stability. Macro- or micro-movements of the implant fixture is thought to disrupt bone healing and may result in the formation of a connective tissue interface rather than a bone to implant interface. Clinically this phenomenon is often described as failure to integrate and may be discovered following second stage surgery (if the implant was submerged for healing) or as various restorative components are connected to the fixture.

Advocates for resonance frequency analysis praise the objectivity and reliability of the reported values and assert any decrease in the ISQ value indicates a problem with osseointegration with respect to a particular implant. Clinicians would love to know that an implant is healthy or at least free from problems at the bone to implant interface before committing to costly definitive restorative procedures. Critics of RFA suggest waiting for further scientific validation of the technique.

Creating a clinically successful outcome with dental implants requires achieving successful osseointegration. Understanding the biologic process allows researchers to manipulate it in ways that may speed up the process, enhance the connection between the implant and bone or both. Clinicians with a



good working knowledge of the biology are better able to critically evaluate manufacturer claims and new techniques. As a result, our patients benefit from shorter treatment times and more predictable outcomes.

Ultimately, achieving healthy osseointegration is just the beginning. For long-term success it is important that osseointegration can be maintained. This article examined the bone to implant interface, future articles will address the interface between the mucosa and implant.

(If you enjoyed this article, click here for more by Dr. Darin Dichter (<https://www.speareducation.com/spear-review/author/darin-dichter/>)).

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