Dental Implant, Materials, and Tissue Characterization

Versatility for Dental Research and Development

The oral environment experiences a variety of challenging conditions and encounters changing environments. Varying temperatures and textures, cavities, gum disease and tissue necrosis all affect the behavior and response of cells, soft tissues and bone in the mouth. Bose has developed versatile solutions to help dentists, researchers, and engineers better understand the behavior of dental materials and tissues. Applications include:

- Dental implant fatigue
- Mechanical properties of dental materials
- Characterization of tissues
- Tissue engineering of dentin, enamel, bone and soft tissue
- Simulation of anaerobic conditions
- Wear and abrasion studies

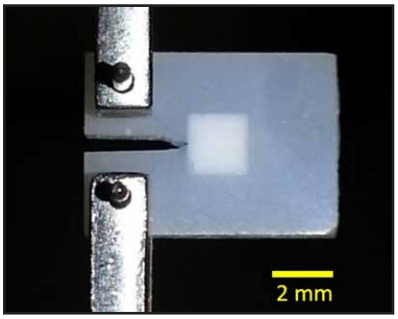
Bose® ISO 14801 Implant Fatigue Fixture

Dental Implant Fatigue

Endosseous dental implants are typically comprised of three components: the implant body, an abutment, and a connection mechanism that fixes the abutment to the implant body. Validation of the performance life of an implant can be done by performing monotonic (static) and fatigue tests.

The test setup and methodology to perform dental implant fatigue testing is defined within ISO 14801 - Dynamic fatigue tests for endosseous dental implants. The standard includes instruction for both straight and angled implants, and provides guidelines for testing in ambient or pshysiologically relevant conditions. Bose has designed a fixture that can be mounted to a number of our test frames to perform testing to ISO 14801. System configurations for dental implant fatigue testing include:

- The Bose® ElectroForce® 3200 Series III or the ElectroForce 3330 Series II test instruments which are both capable of meeting or exceeding the 15 Hz test frequency identified within ISO 14801
- A fixture that incorporates a unique, long-life bearing mechanism to allow unconstrained lateral motion during testing, a base that provides positioning of the implant at angles ranging from 0 to 45 degrees, and a zirconia loading surface
- A plate onto which a customer supplied implant holder can be mounted, or alternatively, Bose will customize a holder based upon customer requirements
- A saline bath to perform testing at physiologically relevant temperatures



Inset Compact Tension Specimen with a 2 mm x 2 mm Sample Used to Evalute Fracture Behavior of Human Enamel and Dental Ceramics[1]

Dental Materials and Tissues

When characterizing the mechanical properties of replacement materials, it is important to understand the behavior of the native materials being replaced and interactions between the two. The ElectroForce 3200 and ElectroForce 3330 test instruments have been used extensively for the mechanical characterization of dentin, enamel, composites and other restorative materials. Application examples include:

- Cantilever beam tests to understand the fatigue properties of dentin
- 4-point bend tests and fatigue crack growth to understand how the properties of dentin change as a result of aging and hydration
- Determination of bond strength of dental adhesives
- Delamination characteristics veneers of during cyclic loading

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Dental Tissue Engineering

Sealed Chamber to Allow Anaerobic Conditions During Mechanical Loading of Dental Tissues

Dental tissue engineering research aims to identify alternative therapies to treat dental tissue diseases or traumas which include caries, fractures, and periodontal disease. Stem cells for dental tissue engineering can be harvested from a number of sources including human exfoliated deciduous teeth, adult pulp, and the periodontal ligament. These stem cells have the potential to differentiate into dental tissue specific cells, such as odontoblasts, and ameloblasts which are instrumental in the formation of dentin and enamel, respectively.

Bose® BioDynamic® test instruments combine the sterile environment of a bioreactor with cell culture media perfusion and mechanical stimulation for dental tissue engineering applications. BioDynamic chambers can also be used to create anaerobic conditions which may be beneficial for dental tissue engineering and material characterization. Applications include:

- Tissue engineering of alveolar bone to enhance bone volume and quality in an effort to increase osseointegration potential of dental implants prior to implantation
- Whole-tooth tissue engineering
- Research to understand the biologic effects, such as biocompatibility and cytotoxicity, of dental composites and materials on surrounding tissues
- Studying of the effects of bacteria on dental restorative

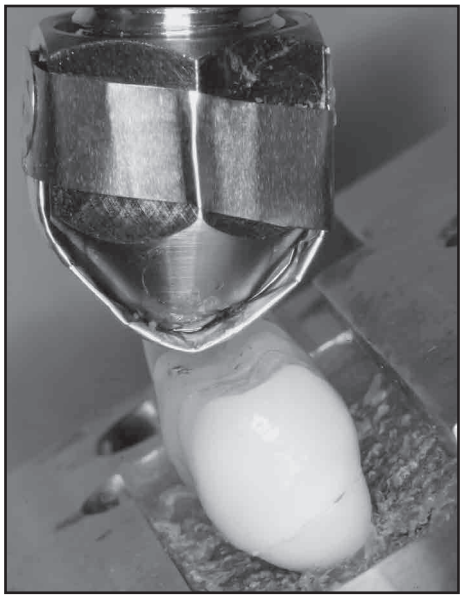
Dental Wear/Abrasion

The three phases of chewing (mastication) have been identified as the preparatory phase, the crushing phase, and the gliding (grinding) phase. The simulation of the masticatory cycle can be used to evaluate wear properties of dental biomaterials and/or restoration techniques. In addition, combined loading can be used to research the impact of accumulated damage on dental ceramics and assess the effectiveness of sealants or enamel replacements in the laboratory.

The Bose ElectroForce® dental wear simulator can be used to simulate two-body wear. Each of the identified phases operate under different system control modes. The preparatory and crushing phases (vertical motion) are accomplished with a combination of displacement and load control while the gliding phase (horizontal motion) is carried out in displacement control as defined by the tooth anatomy.

The dental wear simulator is well-suited for the evaluation of the fatigue and wear characteristics of inherently brittle materials, such as all-ceramic dental crowns. The wear simulator can effectively run hundreds of thousands of cycles and includes these key features:

- Multiaxial control, synchronization, and force measurement
- A user interface that allows easy setup of multi-axis masticatory cycle test conditions
- Bumpless mode switch to quickly and easily change from displacement to force control and back again
- Ramp-to-level control mode that allows the initial ramp to occur in displacement control up to an applied force value



Fatigue Failure Loading of a Zirconium-oxide Fixed-dental-prosthesis (FDP) on a Bose® ElectroForce® 3330 Dental Wear Simulator[2]

Photos courtesy of:
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