Surface Coating of Implants—A Review

Gururaju C.R., Raghu K.M., Thanuja R., Jayaparakash K.

Abstract

Different implant systems are produced by a wide range of manufacturers and each implant system manufacturer often offers several lines of different implants, and each line is considered a different system. The present article has made an effort to describe few of the implants system innovations. PubMed and “Google Scholar” were used to find out the various studies and the claims done by the various marketing implant systems up to 2011 to which further discretions are invited.

Key Words: Implants; Osseointegration; Surface Coatings

Introduction

Successful placement of implants through Osseo integration in both the mandible and maxilla has been achieved by various clinicians even in compromised clinical situations. The treatment outcome depends on biological and mechanical considerations which are intern dependent on the implant systems and their success in facilitating Osseointegration. Different implant systems are produced by a wide range of manufacturers and each implant system manufacturer often offers several lines of different implants, and each line is considered a different system. As the new products unveil in the market with a various combinations of the implant system lines enables a dental implant practitioner to offer a better and more predictable patient services. It’s the responsibility of the clinician to evaluate the products in the market before treating the patient in the planned treatment plan. The present article has made an effort to describe few of the implants system innovations: PubMed and “Google Scholar” were used to find out the various studies and the claims done by the various marketing implant systems up to 2011 to which further discretions are invited.

Various implant systems and their coatings

Nobel biocare implant system (TiUnite surface): TiUnite is titanium oxide rendered into an osseointegrative ceramic biomaterial through spark anodization. TiUnite™ is a highly crystalline and phosphate enriched titanium oxide characterized by a microstructured surface with open pores in the low micrometer range which has an enhanced bone response compared to machined implant surfaces resulting in faster and stronger osseointegration thereby, better maintenance of the implant stability. When anodized surfaces were compared for cell–materials interaction, it was noticed that each of the surfaces has different surface properties, which led to variations in cell–materials interactions. Colonization of the cells was noticed with a distinctive cell-to-cell attachment in the HF anodized surface. Good cellular adherence with extracellular matrix extensions in between the cells was noticed for samples anodized with H3PO4 electrolyte. Cell adhesions and differentiation were more pronounced with vinculin protein and alkaline phosphatase, respectively, on anodized surfaces.

SLA surface developed in 1994. This surface reduced the average healing time from 6-8 weeks to 3-4 weeks.

SLA active Straumann implant system: SLA surface developed in 1994. Shortly after its introduction, the macro and microstructured, osseoconductive SL surface became the gold standard in implant technology. This surface reduced the average healing time from 6-8 weeks to 3-4 weeks.

Two unique properties of SLActive surface are a. Hydrophilicity: Blood can move into deep cavities of surface, b. Chemical activity: Attract blood and proteins to the micropores of implant surface, initiating osteointegration process.

The new material, which is called Roxolid™, is an alloy of titanium and zirconium and is the first material to be designed specifically for dental implants. Roxolid™ is 50% stronger than pure titanium, integrates with bone better than pure titanium.

Bio-horizons Implant System: Key features of the system are the Laser-Lok Technology: This surface has been shown to elicit a biologic response that includes the inhibition of epithelial down growth and the attachment of connective tissue (unlike Sharpey fibers) producing a biologic seal around the implant that protects and maintains crestal bone health.

Collagen fibers functionally oriented toward the grooves on the implant surface, remodeling of new bone in the coronal...
direction was observed. Sulcular epithelium with the desquamating activity of the cells and the junctional epithelium were also observed.14

Laser-Lok micro channels is a series of cell-sized circumferential channels of 0.7 microns that are precisely created using laser ablation technology which produces extremely consistent micro channels that are optimally sized to attach and organize both osteoblasts and fibroblasts. Also includes a repeating nanostructure that maximizes surface area and enables cell pseudopodia and collagen micro fibrils to inter digitate with the Laser-Lok surface. Laser-Lok surface has been shown using light microscopy, polarized light microscopy and scanning electron microscopy to also be effective for soft tissue attachment.

Zimmer implant system: MTX TM – Micro textured Titanium: Zimmer Dental’s MTX surface is a non-coated, micro textured surface created by grit-blasting the machined titanium implant surface with hydroxyl apatite (HA) particles, followed by washing in non-etching acid and distilled water baths to remove residual blasting material. Implant threads are not rounded by the MTX process, and cutting grooves remain intact for efficient self-tapping. MTX treatment results in a relatively uniform surface of closely spaced micropits. MP-1® HA Coating: Zimmer Dental’s MP-1 HA process increases HA crystalline content for greater coating stability increasing the average crystalline content of the HA from 77% to >90%, contributing to greater coating stability than lower crystalline HA coatings.15

Astra Tech Implant System: Osseospeed: Osseospeed is a chemically modified titanium surface with unique nano scale topography.16 MicroThread™, was introduced on the Astra Tech Implant System™ as early as 1992 and is one of the important key features of the Astra Tech Bio Management Complex.17 Bone tissue reactions of implants with and without a micro thread configuration showed that the degree of bone-implant contact within the marginal portion of the implants was significantly higher with micro thread implants (81.8%) than at the control implants (72.8%). It was suggested that the micro thread configuration offered improved conditions for osseointegration.18

Conical Seal Design: The connection between the implant and abutment is located below the marginal bone crest, thus transferring the load deeper down in the bone and reducing the peak stresses in the bone.

Connective Contour: The Connective Contour is the unique contour that is created when the abutment is connected to the implant, described as a waist profile starting at the implant bevel, continuing coronally on the abutment surface. It allows for an increased soft tissue volume and contact zone (compared to a straight design) in this area. Located within the Connective Contour is the implant-abutment junction.19

Biocon Implant System: Bicon’s unique plateau design follows bioengineering principles which allow for the use of SHORT® Implants offering at least 30% more surface area than a screw implant of the same dimensions and allows for the callus formation of mature haversian bone between the fins of the implant. Bicon implant has been grit blasted with alumina and passivated in a nitric acid solution called as Integra – Ti. Low-speed drilling at 50 RPM without irrigation has been the surgical protocol of Bicon, since 1985 allows the clinician to harvest the patient’s own bone.

Bicon Integrated Abutment crown: The IAC is cement less and screw less restoration. It is possible only with the Bicon System, because the seating of an abutment is not dependent upon the timing of a screw or faceted anti-rotational designs and Bicon’s 360° of universal abutment positioning.20

Intra lock dental implants: OSSEAN Surface: Ossean is a calcium phosphate molecular impregnated surface. When magnified it reveals a facetal surface structure that is the same pattern repeats itself from the macro scale all the way to the atomic level. This assures that biologic activity remains constant at all levels of the healing cascade, even at higher magnifications at nano texture the surface is free of any discrete particles. In ossean s surface calcium phosphate is incorporated by elemental modifications of the titanium oxide layer at the molecular level. This feature can be evaluated by XPS-ESCA or Auger spectroscopy. Calcium phosphate molecules more than a thousand times smaller than nano particles can be revealed. They are present in the titanium oxide layer as molecules well beyond the nanometric level. At this level these molecules have a greater binding energy than larger particles of calcium phosphate. In addition to extreme stability the calcium phosphate retains its bioactive properties. The Ossean™ surface dramatically increases the rate of osteoblastic synthesis of type I collagen, thus promoting osseointegration and reducing the chances of early failure of immediately loaded implant. Even distribution of the calcium phosphate surface is critical to control the physiology of osteoblasts.21,22

3I DENTAL IMPLANTS: NanoTite™: The NanoTite implant incorporates the complex architecture at the nano-scale allowing a bone bonding surface. Bone bonding is achieved by increasing the complexity of the surface topography by addition of nano scale calcium phosphate crystals by discrete crystalline deposition process on the osseotite dual acid etched surface which is established at sub micron scale. The crystal deposits are around 20-100 nanometers, the shear strength of crystals attachments to the osseotite surface exceeds the minimum shear strength value of 34.5 MPa. The nano scale discrete crystalline deposition process increases by 200%.

The CaP is not applied via a plasma sprayed process but rather a solution based form of self-assembly. It is not a continuous coating but consists of actual deposits of discrete crystals that occupy approximately 50% of the OSEOTITE® Surface.23 The total amount of CaP material on a NanoTite Implant is so small
that it weighs less than 20 micrograms. This is in contrast to the 20,000 micrograms of CaP on the typical plasma sprayed surface – a one thousand fold difference.2,24,25

Conclusion
Current HA surfaces have limited biologic interaction when compared to newer acid-etched titanium surfaces and no longer offer any significant clinical advantage. There is a continuous evolution in regard to enhance the osseointegration and Implant surfaces are evolving to keep up with the pace of research in the field of osseointegration to know the mechanism better at the molecular levels. No one surface can be credited to be the most suitable for the integration with the tissues. It is the duty of a clinician to know his best knowledge about the various implant systems their pro and cons so that the knowledge can be implemented cautiously to select the implant suitable for the case and mode of treatment planned as it is said “no two patients are alike”.

Authors affiliations
1. Gururaju C.R. MDS, Senior Lecturer, Department of Oral and Maxillofacial Surgery, Sharavathi Dental College and Hospital, Shivamogga, Karnataka, 2. Raghu K.M. MDS, Prosthodontist, #139, 9th Cross, DVG Road, Canara Bank Layout, Kodegihalli, Bangalore, 3. Thanuja R. MDS, Reader, Department of Oral pathology, 4. Jayaprakash K. MDS, Professor and Head, Department of Public Health Dentistry, I.T.S Dental College, hospital and research centre, Greater NOIDA, UP, India.

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Address for Correspondence

Dr. Gururaju C.R. MDS, Senior Lecturer, Department of Oral and Maxillofacial Surgery, Sharavathi Dental College and Hospital, Shivamogga, Karnataka, India. E mail: drgururajucr@yahoo.co.in

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