Original Article

ROLE OF SURFACE GEOMETRY OF DENTAL IMPLANTS ON OSSEOINTEGRATION-REVISITED

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ABSTRACT

The success of a dental implant depends on the rate and quality of osseointegration. The surface geometry of dental implants is a very important factor for osseointegration, which means stimulation of osteoblast cells to form bone on implants of the dental surface. The morphology surface and chemistry are the two important factors that determine the osseointegration of dental implants. They are made of different materials like Titanium, PEEK, and Zirconia. There are many addition and subtraction technologies are available to modify the surface characteristic of dental implants like acid etching, blasting, fluoride treatment, anodic oxidation, and calcium phosphate coating to facilitate osseointegration. Each method has its advantages and disadvantages. There is no scientific evidence hence, a literature search of Pubmed, Scopus, and Google scholar was done from January 1965 to December 2020 using the keywords surface treatment of dental implants, dental implants, and osseointegration. In addition to that, a manual search was done on standard refereed dental journals like the Journal of Prosthetic Dentistry, International Journal Prosthodontics, Journal of prosthodontics, Indian Journal of Dental Research, Indian Journal of Prosthodontic Society, and International Journal of Implant Research from 2000 to 2020.

Key words: Fixed partial denture, Implant, Surface treatment, Titanium, Polymethyl Methacrylate resin.

Introduction

Implants are one of the most revolutionizing breakthroughs in the medical and dental field [1]. Dental implant is an alloplastic substance that is in part or placed inside the body for treatment, diagnostic, prosthetic, or investigational cause.

Implants are made from a variety of materials that undergo numerous surface treatments for better bone-implant interface [2]. For dental implants commercially pure (cp) Ti, Titanium-Aluminum-Vanadium (Ti6Al4V), and Titanium-Zirconium (TiZr), are used due to lightweight, strength, excellent biological performance, and more corrosion resistance in normal atmosphere [3]. The performance of Titanium implant is due to the formation passive oxide layer, which is similar to bone. Osseointegration [4] is the first and the foremost quality of an endosseous implant is to establish a straight union with the bone tissue. The second most desired quality out of an implant material is the rapidity with which this osseointegration takes place. Per-Ingvar Branemark, a physician from Sweden in, 1982 proposed the concept of osseointegration, which takes place roughly around 3-6 months.

Osseointegration is a cascade of events that involves stimulation and proliferation of osteoblasts and matrix-forming substances surrounding the surface of the implant [3]. There is continuous osteoinduction and osteoconduction, which progressively helps to bind the implant surface with the host tissue. Copper, Nickel, Cobalt, Silver dental implant materials showed low bio-compatibility, hence they showed no osteoconduction [4], bio-inert materials such as titanium, calcium phosphate are osteoconductive than osteoinductive and hydroxyapatite-coated, polylactic acid-coated, bio-glass implants show greater osteoinduction. A stronger bone-implant interface is influenced by several confounding factors, which include the type of implant material, morphology, topography, roughness, composition, hydrophilicity, and surface energy [5]. Factors like implant dimensions and shape, nature of bone, surgical techniques, and the loading protocol may disrupt the stability of the implants.

Implant topography is one such important factor that performs a key role in osseointegration for producing the osteophytic effects of rough titanium surfaces [6]. It comprises both the macro and micro-geometry on the implant surface. Different surface treatments are executed to accentuate this microtopography of the surface of the dental implant [7, 8]. Rough surfaces require less integration time which can further be enhanced by various surface treatments such as acid etching, blasting, anodization, hydroxyapatite, laser ablation, plasma spraying, etc. All these accentuates the surface topography and its likeliness towards the osteogenic cells. This article critically analyses the various surface treatment that facilitates osseointegration.

Materials and Methods

Revolution in surface topography of implants

Cooper LF *et al.* described that commercially pure Titanium implant with improved surface morphology showed improved osseointegration and mechanical properties [9].

Shibli JA *et al*. [10] mentioned that the oxidized surface of the dental implant had more contact with bone compared to machined surfaces after 2 months of the healing period. Also mentioned that oxidized surface had more dense bone formation surrounding the threaded area of the type IV bone.

Laranjeira MS *et al*. [11] concluded that the micro-structured surface bioactive coating had more potential to have the soft tissue increment attachment on the surface of the fixture.

Yeo IS [12] reviewed the surface of Titanium treated by acid etching, blasting, fluoride treatment, anodic oxidation, and calcium phosphate coating showed favourable osseointegration than pure Titanium surface.

Lee HJ *et al*. [13] evaluated soft tissue adhesion on titanium implants with microgrooves on machined-surfaces, sandblasted, acid-etched (SLA), and SLA made of commercially pure titanium. The coronal portion showed a firm union of osteoblast and gingival fibroblasts which is in favour of good peri-implant soft tissue sealing. To peri-implant soft tissue, lowest water contact angle, highest surface roughness, and prominent expression of adhesion molecules along with better peri-implant soft tissue seal.

Tuna T *et al*. [14] concluded that the surface of the implant changed with the concentration of carbon, oxygen, and zirconia which made a change in hydrophobic to hydrophilic state in acid-etched zirconia-based dental implant by UV light.

Sezin M *et al*. [15] compared different surface treatments that modify the surface microtopography showed dissimilar but unique and distinct features based on the type of chemical treatment.

Halldin A *et al*. [16] suggested that the nano and microstructural alterations created by a roughened implant surface treated with hydrofluoric acid enhanced the initial biomechanical performance of dental implants.

Novaes Jr AB *et al*. [17] mentioned that incorporation of bone morphogenic protein and peptides on the surface of the dental implant showed a positive effect on bone formation.

Govindharajulu JP *et al*. [18] concluded that the performance of dental implant's after surface coating with chitosan/P-HAP bi-layers showed positive biomineralization, osteoblastic activity, and antibacterial activity against Streptococcus Gordonii.

Ryden L *et al*. [19] mentioned that Titanium implants with amorphous and crystalline thin HA coating didn't show any inflammation in crystalline hydroxyapatite and exhibited less inflammatory response in the amorphous hydroxyapatite.

Roy M *et al*. [20] confirmed that ZrO_2 implant after UVC irradiation showed 3-fold carbonless on the surface which may improve soft tissue seal around the implants.

He J *et al*. [21] found out that plasma electrolyte oxidation (PEO) on implants with Zn might facilitate bone remodelling and formation which will shorten the duration for bonding of dental implant with the bone.

The dental implants can be classified based on

1. *Depending on the position*
   - Fixture of Endosteal
   - Fixture of Subperiosteal
   - Fixture of Transosteal
   - Fixture of Epithelial
   - Special category-Basal implants

2. *Based on the implant materials*
   - Non-metallic (polymers, ceramics, zircon)
   - Metals and alloys (Ti, Co-Cr-Mo, Iron-Chromium-Nickel alloys)

3. *Based on tissue response*
   - Bioactive: Glass-ceramic and Bioglass
   - Bioresorbable: (Ca^{2+})
   - Bioinert: (Al), (Zr) and carbon
   - (Al), (Ti), and (ZrO_2)
   - Calcium Phosphate upon Bioactive and Biodegradable Ceramics
   - Carbon and Carbon Silicon Compounds
   - Polymers and Composites: $(C_2F_4)_n$, $(C_{10}H_8O_4)_n$, $(C_5O_2H_8)_n$, High ultra-molecular weight $(C_2H_4)_n$, $(C_3H_6)_n$, $(C_{27}H_{26}O_2S)$, and (C_2H_6OSi) or Elastomer (rubber-like material).

4. *Based on the stages of implant placement:* One Piece (usually the two-piece implant is supplied in two parts, a fixture and an abutment which are interconnected through a screw) and two-piece (abutment attached directly to the fixture without the provision to remove these parts separately).

5. *Based on the microscopic design of the body of implant:* Cylinder, thread, plateau, perforated, solid, hollow, and machine taper.

Endosteal implants: The most commonly used dental implants traverse only one cortical bone. Due to its improved stability and proven success rates. They are also called root-form implants.

Subperiosteal implants: They are custom-made implants with a large framework that is placed below the periosteum of the bone. They make use of larger bone surface area rather than the bulk of the bone to support the dental prosthesis. The major drawback was its size and more prone to failure.

Transosteal implants/ transmandibular or staple implants: They are longer and pierce the cortical plates on both sides of the anterior region of the mandible. They are projecting above the gingiva for anchoring the prosthesis. They are seldom used in dentistry nowadays.

Basal implants: In 1972, Dr. Jean-Marc Julliet formulated a separate category of single-piece endosteal implants into (BCS) Basal Cortical Screw and (BOI) Basal Osseo Integrated that are designed to engage the basal bone areas.

Pros of basal fixtures: They reduce the possibilities of treatment failure of the dental implant due to interface issues between abutment and implant. Because they take more support from the basal bone, hence more resistant to resorption and have faster-repairing capacity. In addition, they function well in compromised bone in which the augmentation procedures helped fruitfully and the masticatory forces are transmitted in a better way in basal implants. Basal implants function well in people with controlled diabetics, smokers, and chronic periodontitis.

Cons of the basal fixtures: The technique requires substantial challenges; hence, it necessitates expertise in the discipline of bone physiology and biomechanics.

Terminologies

Osseointegration: Bone to implant bonding is called osseointegration [21-24]. The word osteon is derived from Greek and the integrated word from Latin. It was formulated by Dr. Per-Ingvar Branemark, according to him it is “the living bone and the surface of the fixture amongst the direct functional and structural interlink”. The American Academy of Implant Dentistry (AAID) defined osseointegration as "a communication recognized without the intercession of non-bone tissue amongst regular remodelled bone and a fixture involving a continuous transmission and issuing of consignment from the fixture plant to the bone" [22]. Osseointegration depends on a wide range of factors, like the systemic status of the patient, bone quality and quantity, intraoperative sterility, and trauma, antibiotic coverage post-implant placement, etc. The features of the dental implant play a major role in boosting osseointegration. Surface modifications are done to enhance surface topography for desired bone integration around the implant.

Osseointegration can be divided into 3 phases according to Branemark [21-24] Osteophytic, Osteoconductive, and Osteoadaptive.

Osseodensification: Osseodensification does not remove bone cells but it preserves the bone bulkiness by simultaneously compacting and auto-grafted in an outward manner with the compacted dense layer of bone. It is also used for alveolar ridge expansion and crestal sinus floor elevation.

Surface alteration of titanium implants

Surface topography is an imperative factor for the fixation of dental fixtures into the bone [25]. Surface modification may promote the potential of dental implants for osseointegration [25]. In 2014, Albrektsson & Wennerberg classified the dental implants commercially into Flat (Sa < 0.5 μm), slightly coarse (Sa = 0.5-1.0 μm), relatively coarse (Sa = 1.0-2.0 μm) and coarse (Sa > 2.0 μm).

Classification one: Established surface therapy process

1. *Processes of Subtractive /Ablative:* Acid Etching, Anodization, Sandblasting, and Laser shock peening
2. *Processes of Additive:* Biomimetic precipitation, Thermal spray coating, sol-gel coating process, and electrophoretic deposition.

Classification two: Established on surface texture

1. *Concave texture:* the hydroxyapatite coating and titanium plasma spraying like additive procedures.
2. *Convex texture:* Due to subtractive procedures like engraving and blasting

Classification three: Established on the distribution of indiscretions on the surface

1. *Isotropic surfaces:* Dental implants have the same morphology that is not depending on the measurement direction.
2. *Anisotropic surfaces:* They have different surface roughness values in a different direction

Classification four: Established on the adjustment of surface

1. *Physicochemical:* To enhance the bone-fixture intersect surface strength, surface charge, and surface configuration modification is done.
2. *Morphological:* Alteration of surface morphology and roughness of dental implants had a positive effect on cell and tissue response.
3. *Biochemical:* Biochemical modifications laid viable cells on the dental implant.

Classification: five Based on the size of the surface geometry

1. *Macro surface modification:* The surface roughness is inside the series of mm to tens of microns [25-27]. Threaded screws and macro-porous surface treatments create a surface roughness greater than 10m. A major issue with macro surface roughness is ionic leakage that

may be the cause for peri-implantitis [28]. They are strand shapes (V-form, rectangular, buttress, reversal buttress, and spiral). The thread shapes determine the face angle, thread intensity, thread width, thread pitch, and thread helix angle (0.8 mm pitch).

2. *Micro surface modifications:* The coarseness of the surface lies between 1-10m.The micro surface roughness increases the interlocking of the dental implant with the bone. There are many methods of micro surface modification

    1. Abrasive blasting, sandblasting, shot peening, acid etching, dual-acid etching, sandblasting and acid etching SLA, and different substance remedies as liquid cleansing, alkaline etching, and metalization.
    2. Electrochemical treatments (Anodic oxidation, biocoat, biodize, bio-bright), electrophoresis, and cathodic HA depositions.)
    3. Laser therapy
    4. Vacuum therapy
    5. Plasma therapies like plasma accumulation and surface amendment
    6. Implantation ion technique
    7. Treatments of Thermal
    8. Thermal plasma spray (TPS)
    9. (RF) Sputtering, Sputtering deposition
    10. Electrophoretic Deposition
    11. Biomimetic precipitation
    12. Electrolytic deposition
    13. Sol-gel coated implants
    14. Ultrasonic spray pyrolysis

Sandblasting: Blasting with Alumina ($Al2O_3$) or silica (SiO_2) of various sizes and shapes is directed towards the surface under compressed air usually blasted with 25 µm particles. Distinctive Sa values lie within 0.5-2.0 µm are used for cleaning the surface of the dental implant to improve the bioactivity, roughness of the functional surface which accelerate osteoblasts' adhesion and proliferation.

Grit blasting: The dental implant surface is intermixed in a liquid, throughout a whole at an elevated speed of velocity targeted with alumina, silica, titanium oxide, calcium phosphate particles, and compressed air. The residues in the pre-implant area may disrupt osseointegration.

Shot peening: Small surface area is targeted with small spherical media called shot that introduces essentially compressive stresses on the material´s surface. Al_2O_3 particles with 25-75 µm produce surface roughness of 0.5-1.5 µm, 200-600 µm size particles produce roughness of 2-6 µm and glass particles of 150-230 µm produce a surface with a roughness of 1.36 µm.

Acid etching: Acid-etched Titanium implant surface with HCl, HNO_3, and $H2SO_4$ for a particular duration makes a micro-coarseness of 0.5-3 µm.

Dual acid-etched technique: Several minutes immersion in combined concentrated Hydrochloric acid and sulphuric acid consequently heating it more than 100°C produces a micro surface roughness.

Large grit, Acid-etched, Sandblasted - (SLA-Buser): Titanium fix surface is initially sandblasted with 250 - 500 µm grits, then acid-etched with HCL/H_2SO_4.

Other chemical treatments

Solvent cleaning: They are used to remove oils, greases, and fatty surface contaminants. Organic solvents like alcohols, aliphatic hydrocarbons, ketones, surface-active soaps chlorinated hydrocarbons, and alkaline cleaning solutions are recently applied for this purpose.

Alkaline etching: Titanium surface treatment with four-five M NaOH at 600°C for twenty-four hours produce an asymmetric surface landscape and a more open type of porosity. Heating with 0.2 M NaOH at 1400°C for 5hrs produces condensed nanoscale pits on the surface of the titanium.

Metallization therapies: Titanium dipping at room temperature for thirty mins in 20-40 vol percentage solution of HNO_3, which should be then neutralized, rinsed, and dried. In addition, passivation with HNO_3 and 400- 600 °C boiling in air or aging in deionized heated H_2O for numerous hours is another method of passivation.

2. Electrochemical treatments

Anodic oxidation: The anodic oxide has interconnected pores of 0.5-2 µm in Ø and intermediary coarseness of 0.60-1.00 µm. Titanium can be thermionically dissolved in (H_2SO_4), (Na_3PO_4), and ($C_3H_7O_4P$-2) in ($C_2H_6O_2$), ammonium pentaborate, and ($C_4H_6O_2$), and ($C_3H_7CaO_6P$). Ca and P are accumulated on the TiO_2 amid electroplating which is beneficial for the materialization of HA.

Biocoat: Titanium is connected to an anode and immersed into an electrolyte which leads to forming an oxide film at the surface.

Biodize: In this method, thicker TiO_2 layers formed on the surface.

Biobright: Titanium is connected as an anode and immersed into an electrolyte that leads to dissolving the titanium.

Innosurf: The detached layer of titanium lies within five to thirty micrometers.

Electrophoretic deposition (EPD): Application of the order of 20- 200V voltages is when the HA coatings are obtained. The density coat is enhanced by fritting at above or 600°C. This technique outlined all sizes of particles that will be deposited. It is a simple process with low cost with constant thickness and complex shapes.

Electrochemical cathodic deposition: The titanium cathode from an immersion encompassing concentrations of phosphorus and calcium in the electrolyte made by calcium-phosphate coatings.

Pulsed electrochemical deposition: Post therapy with fritting underneath void at extreme heat amongst 300 and 800°C was necessary because it produces CaP coatings on absorbent Titanium substrates underneath serious circumstances (pH 4.4, 25°C).

3. Laser treatments: Laser produces micrometer and nanometer 3-D structure. It is appropriate for the discerning adjustment of surfaces and it is quick and very clean. It produces complex microstructures with high resolution. Laser is used to treating only the vale and flank parts of the dental fixture. In LASER peening, there is no contact and is free from contamination. Laser light beams produce high intensity (5-15 GW/cm2) nanosecond pulses of (10-30ns) which generate (3- 5mm width) short-lived plasma that causes a shockwave. The compressive creates shock wave lingering stress that pierces the superficial and makes the fixture stronger. The laser-treated acid-etched fixture regular surface coarseness is 2.28 µm.

4. Cold plasma therapy / Vacuum/ Glow-discharge: There are three methods of low-pressure electrical discharge is targeted on the dental implant surface.

1. *Plasma deposition:* The solid target from the coating is deposited using glow discharge in the gas phase.
2. *Plasma surface modification:* The dental implant surface is modified using glow discharge which tends to alter the surface properties of implants.
3. *Plasma spraying:* The titanium condenses and fuse and the projected particles are onto the surface of the fixture using Titanium Plasma Spray (TPS), forming a film about 30µm thick with an average roughness of approximately 7µm.

5. Ion implantation method: The fixture surface is attacked with an average of 100 KcV to 1 McV energy ions. The superficial of the fixture is penetrated to a depth of 0.1-1 µm.

6. Therapies of Thermal: Titanium implants can be strengthened up to 1000°C to form a TiO_2 layer with average coarseness between 0.90 and 1.30 µm and the coarseness of the unprocessed 0.08 µm was a sample. Therapy of caloric amongst 600°C and 650°C for 48hrs opted for dental fixtures.

9. Sputter deposition: Vacuum chambers are ejected in atoms or molecules of material through (RF) sputtering of magnetron and sputtering of radiofrequency.

10. Biomimetic precipitation: Both other calcium phosphate and hydroxyapatite substrates are accumulated on the surfaces of the fixture between 2 weeks to 4 weeks with the replacement of SBF solution. The ratio of Ca/P was 1.51 for HA biomimetic coating and the width of the HA coatings was 20 to 25µm.

11. Electrophoretic accumulation: Hydroxyapatite Nano precipitates in a liquid medium are deposited in the range of <1 to >500µm thick which is a cost-effective and simple method producing variable thicknesses coating which increases at 1200˚C.

12. Sol-gel coated implants: Homogenous coating with large dimensions and complex design. This advantage of the system has the attraction to HA and metallic substrate. It is comprehensible and cost-effective which gives more mechanical strength and toughness.

13. Electrolytic deposition: Uniform coating of 1µm thickness on the porous surface. The nanoparticles HA are organized through blending H_3PO_4 and $Ca(NO_3)_2$ in a ratio of 1.67. The liquid crystalline segment controls the particle size approx. 5nm. The debris is accumulated onto the surface of the Ti fixture via a dip-coating method. The detergents are burned away at 55°C for 5mins inside the atmosphere of nitrogen.

14. Ultrasonic spray pyrolysis: Particles with the size of 1-100µm produced which can be based on progenitor atomization, aerosol conveyance by heat and aerosphere modulated reactor that is utilized in the manufacturing of nanopowders.

Surface coatings of bioactive [29]

1. Glass coatings bioactive
2. Hydroxyapatite Coating (HA)
3. Coating of Calcium-Phosphate
4. Coatings of Titanium Nitride
5. Treatment of Fluoride
6. Active Biological Drugs
7. Bisphosphonates
8. Zocor
9. Antibiotic coating- Gentamycin Tetracycline-HCl

1. *Coatings glass of bioactive* [30]: Silica-based bioactive glasses could bond with bone chemically, which will tolerate 47Mpa.
2. *Double glass coating:* This procedure is performed to settle the issues due to coefficients of thermal expansion. Coating of an inert glass layer with a coefficient of thermal expansion similar to Ti_6Al_4V gave a better bond with the substrate. Silica coating was derived by the combination of coating of hydroxyapatite and/or bioactive glass particles or a sol-gel.
3. *Hydroxyapatite (HA)* [30-33]: HA composite coating provides better bioactivity and biocompatibility to dental implants. Plasma spraying or ion beam-assisted

deposition is usually done by HA. HA coating has rapid osseointegration which is prone to immediate fixation of dental implant which is due to a stronger bond amongst fixture and bone that prolongs the clinical outcome of the prosthesis. The major problem is this coating needs sophisticated and costly equipment and is done at higher temperatures.

4. *Calcium-phosphate coating* [29-33]: It facilitates bone formation around the implant which is needed for effective osseointegration.
5. *Coatings of titanium nitride:* It is also called Plasma nitriding or PVD coating with TiN. Mechanical strength is more than making the fixture more corrosion-resistant because the surface hardness is high. The various methods of titanium nitride coatings are gas nitriding, plasma nitriding by plasma diffusion management, plasma-supported chemical vapor accumulation, closed field unbalanced ion plating magnetron sputter, and pulsed DC reactive magnetron sputtering.
6. *Fluoride treatment:* Titanium react with fluoride ions and forms soluble TiF_4 that improves dental osseointegration fixture.
7. *Biologically active drugs:* Bisphosphate enhances osseointegration fixture. Example Simvastatin produces a morphogenetic bone protein (BMP) that facilitates bone materialization.
8. *Coatings of antibacterial:* Their action to the fixture provides better antibacterial.
   a. Local prophylactic agent-Gentamycin
   b. Sanitization and reclamation of tainted fixture surfaces-*Tetracycline-HCl.*

Nano-Surface modifications: Nanotechnology provides particle sizes of 1 and 100 nm. And the nanometre coarseness facilitates adsorption and osteoblastic activity.

Organic nanoscale self-assembled monolayers [24-28]: Titanium oxide and Aluminium oxide are the combinations of alkane phosphate SAMs on metal oxides. The hydrophilicity of these alkane phosphate SAMs promotes the growth of fibroblasts.

Hydrogels on titanium surface [24-28]: Hydrogels swell by absorbing the aqueous solvent. The swollen hydrogels are highly biocompatible, biodegradable, and capable of incorporating biomolecular cues.

Titanium nanotubes: The size of the nanotube is 10-9 nm inner diameter, with 3-30 nm in outer diameter in multiple layers. The synthesis of (TiO_2) nanotubes was done through the anodization method. When electrolytes encompassing fluoride ions and the higher surface energy and wettability hold in the nanotube-like pores compared the nano-porous structures of TiO_2 were obtained.

Evaluation methods of coarseness surface

1. Mechanical Contact Profilometers
2. Scanning Probe Microscopes
3. Optical Profiling Instruments Focus Detection Systems Confocal Laser Scanning Microscopy White Light Interferometer

Sterilization of surface coated implant

Regularly, then comes cleaning at the beginning, then sterilization followed. frequently utilizing sterilization methods such as moist heat, dry heat, (autoclaving), (EtO) Ethylene Oxide, Chlorine dioxide, (O_3), vapor phase Hydrogen Peroxide (H_2O_2), low-temperature gas plasma, Glutaraldehyde solution, Formaldehyde, Peracetic acid, and Radiation (Machine-generated X rays, Gamma rays, Universal homogeneous ultraviolet (UHUV) rays, Accelerated electron beam).

Lead is equal and single to pitch in a screw-threaded but is also considered to double the duration of the pitch in a double-threaded screw vice versa. Double threaded implants can be inserted more readily quicker than single-threaded ones. However, the triple threaded implants need 1/3 of the duration needed for a single thread. In implants with equal length, there are more threads when the pitch is smaller [34]. Commercially available conventional implant designs have to balance compression and tension strength with minimal shear force [34]. A mild load stimulates bone formation and woven bone formation. Nevertheless, the higher load leads to microfractures that may cause osteoclastogenesis.

Practical occlusal loading on dental fixture induces formation in surrounding bone [15]. When the smooth area of the dental implant encounters the crestal bone, which produces more shear forces that leads to marginal bone loss and finally more pocket formation. The micro threads at the neck of the implants will distribute some forces which maintain the height of the crestal bone.

Lathing, milling, threading of machined implants based on the design of cutting tool used, applied pressure, bulkiness of the material and the lubricant, and the machine speed. The machined surface had a roughness of 0.3-1.0 μm. The 2-10 nm thick TiO_2 surface oxide stimulates osteoblast that forms bone alongside the canals not on the surface. Therefore, a prolonged period of 3-6 months is required for cell adhesion to a machined implant surface. Purification and sterilization affect the roughness and hydrophobicity of dental implants which thereby affect the osteogenic potential of individual osteoblast-like cells (MG63). Explicitly, autoclaved SLA surfaces of dental implants vanished the osteoblast variation, hence recleaned and re-sterilized Ti fixture surfaces cannot be taken into account for osseointegration due to altered cell responses and surface properties.

Conclusion

The widely accepted and prevailing philosophy for osseointegration is that these morphological deformations may significantly influence the biological environment around an implant and promote bone cell maturation for anchoring implant surfaces into the bone tissue. This ultimately improves the accomplishment of the dental fixture and their prompt reappearance to withstand the functional loading. Thus, the undeniable fact is that surface treatment techniques more affect the standard protocol of clinical outcomes of dental implants in rehabilitative prosthodontic dentistry.

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