Textbook of Dental Materials

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2nd Edition

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CHAPTER OUTLINE

"Innovation distinguishes between a leader and a follower."

—Steve Jobs

Key Terms

- **Dental implant**—is a prosthetic device made of alloplastic materials implanted into the oral tissues below the mucosal and/or periosteal layer and or within the bone to provide retention and support for a fixed or removable dental prosthesis
- **Subperiosteal implant**—a prosthetic device which is placed below the periosteum and overlies the cortical bone
- **Transosteal implant**—a prosthetic device that penetrates both the cortical plates and the thickness of the alveolar bone
- **Epithelial implant**—a device which is placed within the oral mucosa
- **Endosteal implant**—a prosthetic device which is placed into the alveolar and/or the basal bone of the mandible or the maxilla that transects only one cortical plate
- **Bioactive**—ability of the implant to simulate bone formation through ion exchange with the host tissues and forming chemical bonds
- **Bioinert**—are those materials which do not bond directly to the bone but are mechanically held in contact to the bone
- **Osseointegration**—process in which living bone tissue is integrated with an implant material without any intervening fibrous connective tissues
- **Fibrointegration**—here the implant attachment is through low differentiated fibrous tissues. It is also called as pseudo-periodontium
- **Ablative procedure**—it is surface treatment of implant which involves the removal of material from the surface of the material through acid etching, grit blasting or anodizing
- **Additive procedure**—it is surface treatment of implant which involves creating a layer by addition of material through plasma spray, porous sintering, sputter deposition and soluble gel coating
- **Osteogenesis**—process of formation of bone
- **Osteoinduction**—process to induce bone formation through differentiation and recruitment of osteoblasts
- **Osteoconduction**—process which provides scaffold or physical matrix for growth of new bone
- **Bioinert**—these materials do not bond directly to the bone but are mechanically held in contract with the host bone

ADA Specification No. 40; ISO 14801:2016

INTRODUCTION

Throughout history human beings have attempted replacement of teeth with artificial substitute. In the past, extracted teeth, wood, ivory, dry bone, gold, gold wires and other materials have been used as replacement. Biocompatibility was one of the major issues for failure of the treatment. Over past four or five decades, implants made of titanium and its alloys have gained wide popularity and acceptability as they have shown highly predictable results. The high rate of success and clinical longevity of dental implants have allowed larger number of patient the benefits of fixed restorations. Dental implant treatment has

become highly attractive treatment option because of its predictability, relative simplicity and minimal invasiveness. Multiple investigations have revealed more than 90% success rate of implants both in maxilla and mandible. It is important to have basic knowledge of implant materials and their applications as implant treatment is one of the most sought after treatment option for treating edentulous and partially edentulous patients.

Q *How did dental implants evolve to be used as one of the most widely used restorative technique?*

HISTORICAL CONSIDERATIONS

- *936–1013 AD: Albucasis de Condue* used ox bone to replace missing teeth
- *1800: Pierre Fauchard* and *John Hunter* advocated tooth transplantations
- *1809: Maggiolo* fixed gold roots to pivot teeth by using springs
- *1887:* Harris-shaped platinum post-coated with lead like tooth root and implanted into the socket
- *1895: Bonwell* used gold or iridium tubes implanted into bone to restore a single tooth or to support complete denture prosthesis
- *1898: Payne* implanted silver capsule as foundation to received porcelain crown which was cemented later
- *1905: Scholl* developed porcelain corrugated root implant
- *1913: Greenfield* advocated the use of hollow basket implant made from meshwork of 24-gauge iridium-platinum wires soldered with 24 karat gold. This helped in securing single implants as well as fixed prosthesis supported by as many as eight implants
- *1937: Venable, AE Strock* and *Beach* analyzed the effects of metals on bone. They advocated the use of inert, biocompatible metal called as "Vitallium". It was found to be relatively inert, compatible with the living tissues and was used in subperiosteal implants
- *1940: Dahl* first developed the subperiosteal implants
- *1947: Formiggini* developed single helix wire spiral implant made from tantalum or stainless steel
- *1948: Goldberg* and *Gershkoff* devised the first viable subperiosteal implant
- *1950: Berman* refined the subperiosteal implants by using direct bone impression technique
- *1952: Branemark* developed threaded implant design made of pure titanium. He extensively studied the physiological, mechanical, biological and functional aspect
- *1963: Linkow* designed and developed the hollow basket implants with vents and screw heads
- *1965: Branemark* first placed dental implant in human bone
- *1970's: Roberts* and *Roberts* developed the ramus blade endosseous implant
- *1975: Dr Small* first placed the transosteal implant called as the mandibular staple implant
- *1977: Branemark* coined the term osseointegration
- *1978: Dr Branemark* presented two stage threaded titanium root form implant. He called them as fixtures.
- *1980's: Dr Schroder* and *Dr Straumann* of Switzerland experimented with metals utilized in orthopedic surgery to fabricate dental implants
- *1980's: Dr Tatum* introduced the Omni R implants having horizontal titanium fins
- *1980's: Dr Niznick* introduced the core vent and screw vent implants with hydroxyapatite coating on it
- *1983: Bosker* modified the mandibular staple implants and used gold alloys for its fabrication
- *1985:* The ITI implant system introduced by Straumann company had plasma sprayed cylinders and screw which were designed to be placed in one stage surgical procedure
- *1998:* Concept of immediate loading implants was introduced
- *1999:* Zygoma concept was introduced
- *2003:* All on four concept was scientifically introduced by Paulo Malo.

DEFINITION

Dental implant is defined as *a prosthetic device made of alloplastic materials implanted into the oral tissues beneath the mucosal and/or periosteal layer, and on/or within the bone to provide retention and support for a fixed or removable dental prosthesis.*

CLASSIFICATION OF DENTAL IMPLANTS

Based on the Type of Material Used

Metals and Alloys

- Stainless steel
- Cobalt-chromium-molybdenum based
- Titanium and its alloys
- Surface-coated titanium
- Other metals and alloys.

Ceramics

- Tricalcium phosphate
- Hydroxyapatite
- Aluminum oxide
- Calcium aluminates.

Polymers and Composite

- Polymethyl methacrylate
- Polytetrafluoroethylene
- Polyethylene
- Silicone rubber
- Polysulfone.

Carbons

- Polycrystalline glassy carbon (vitreous)
- Carbon silicon.

Q Which is the most preferred design of implant? What is the the reason for this choice?

Based on the Design of Implants

Subperiosteal Implants

This type of device first developed by Dahl (1940) and then modified by Berman (1951). It is a framework which derives its support by resting over the bony ridge without penetrating it. It is used for restoration of partially and completely edentulous jaws where there is insufficient bone support for endosseous implant placement. This type of design is obsolete and is very rarely used **(Fig. 32.1)**.

Disadvantages

- Retrievability of implant is difficult
- Excessive bone loss
- Rejection of implant is high
- Limited success rate.

Transosteal Implants

Also called as *Staple bone implant, transmandibular implant (TMI) and mandibular staple implants.* As the name suggests these implants penetrate both the superior and inferior cortical plates covering the entire thickness of the mandible. Transosteal implants were first developed in Germany in 1920s, popularized by Small (1968). *Bosker* in 1982 developed the TMI which were made of gold alloys **(Fig. 32.2)**.

Endosteal Implants

They are the most commonly used implants for restoring partially and completely edentulous jaws. These implants are most successful and frequently used because of high success rate. Endosseous implants only transect one cortical plate. These implants lie within the bone. They are of two types—(1) root form implants, (2) plate or blade form implants and ramus frame type implants **(Fig. 32.3)**.

Fig. 32.1: Subperiosteal implant.

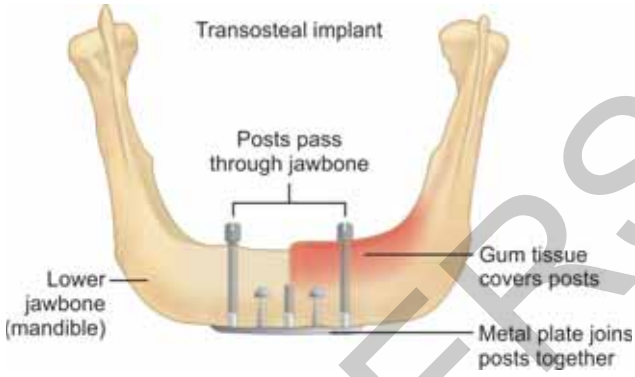


Fig. 32.2: Transosteal implant.

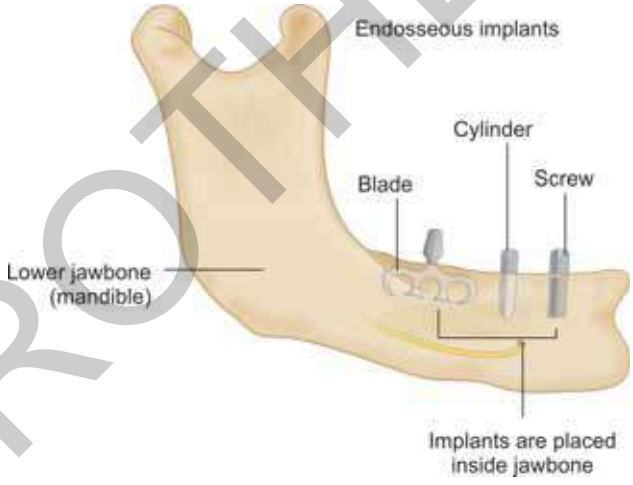


Fig. 32.3: Endosteal implants.

Blade implants were placed after cutting a groove into the bony ridge. Blade implants were independently developed by Roberts (1970) and Linkow (1968). These implants usually have holes in them so that bone could grow through it and hold the implant for extra stability. Such implants were not used for single tooth replacement because of its large size.

Clinical Significance

Root form implants are most successful and effective implants as they are surrounded by bone. After placement, the implants are allowed to heal so that new bone forms and implants are osseointegrated. Zygomatic and pterygoid implants are also endosteal implant designs which are of longer version.

Epithelial Implants

It is the type of implant which is placed in the oral mucosa. In this type, oral mucosa is used as the attachment site for the metal inserts.

Based on their Reaction to Bone

Bioactive

Ability of the implant to simulate bone formation, through ion exchange with host tissues they form chemical bonds

between the host tissues and bioactive material, e.g., hydroxyapatite and tricalcium phosphate.

Bioinert

These materials do not bond directly to the bone but are mechanically held in contact to the bone. Bone grows and fills in through this particular material and holds them in position, e.g., zirconium oxide and aluminum oxide.

Q *What is the most accepted mechanism of attachment of implant to the bone?*

Based on the Mechanism of Attachment

- *Osseointegration:* It is the process in which living bony tissue is integrated with an implant material without any intervening fibrous connective tissues **(Fig. 32.4)**. It is a direct contact between the bone and the surface of functional implant. Some authors refer this direct contact similar to tooth ankylosis.
- *Fibrointegration:* In this implant attachment was through the low differentiated fibrous tissues. This process is also called as *pseudo-periodontium* **(Fig. 32.5)**. These pseudo periodontium fibers orient parallel to the implant surface. This is similar to suspending the implant rather than making any direct contact with the bone. Clinical research indicate that this type of interaction is susceptible to greater amount of progressive loosening and infection resulting in failure of implant.

Based on the Surface Treatments

- Hydroxyapatite coated
- Plasma sprayed
- Blasted or etched with other biomaterials
- Electropolished
- Machined.

Based on the Macroscopic Design

- Hollow design
- Cylindrical or conical design
- Threaded design.

Q *What are indications and contraindications of dental implants? What are benefits and drawbacks of this type of treatment modality?*

INDICATIONS AND CONTRAINDICATIONS

Indications

- Patient unable to wear removable partial or complete dentures
- Free end distal extension without any posterior abutment

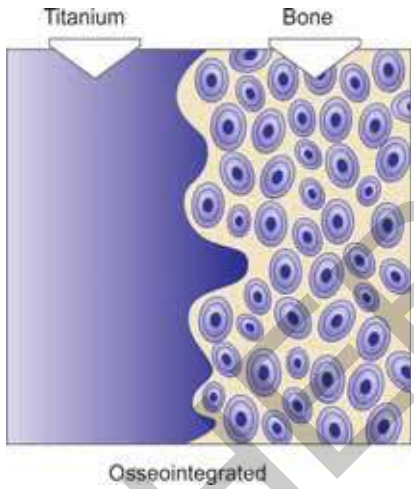


Fig. 32.4: Osseointegration.

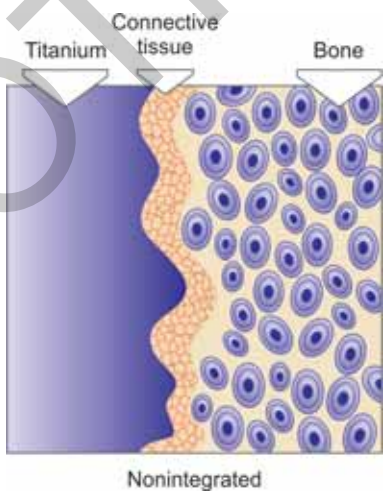


Fig. 32.5: Fibrointegration.

- Number and location of the natural abutment is unfavorable
- To avoid preparation of sound or minimally restored teeth to receive fixed partial denture in single edentulous space
- Presence of adequate bone height, width, length, contour and density.

Contraindications

Absolute Contraindications

- Acute and terminal illness
- Pregnancy
- Uncontrolled metabolic disorders
- Bone and soft tissue infection.

Relative Contraindications

- Patient on radiotherapy
- Uncontrolled diabetic
- Parafunctional habits
- HIV

- Bisphosphonate usage either orally or intravenous
- Patient with unrealistic expectation
- Poor patient motivation and oral hygiene
- Inadequately trained clinician
- Poor patient compliance.

Advantages

- Aids in preserving bone
- Enhances masticatory efficiency
- Helps in maintaining proper vertical dimension
- Immune to dental caries
- High level of predictability
- Improves esthetics and phonetics
- Increases retention and stability of the prosthetic restoration.

Disadvantages

- Initial treatment cost is high
- Patient to undergo a surgical procedure
- Procedure depends on availability of bone and clinicians skills
- Limited scope in placement in medically compromised patient.

Uses

- Dental implants are used to replace missing tooth or teeth by anchoring prosthesis to the jawbone
- Can be used to anchor extraoral prosthesis.

Q *How has concept of osseointegration influenced the evolution of dental implants?*

CONCEPT OF OSSEOINTEGRATION

PI Branemark coined the term "osseointegration" in 1977. According to him, osseointegration can be defined as the direct structural and functional connection between organized, living bone and the surface of a load bearing implant without intervening soft tissue between the implant and the bone.

Definition: Osseointegration** is defined as **the** apparent **direct attachment or connection of osseous tissue to an inert, alloplastic** material **without intervening** connective **tissues.

Rationale: To achieve direct contact between the bone and the implant without any fibrous tissues between the two interfaces.

Mechanism of Attachment

- During placement of the implant there should be good contact between the bone and the implant surface to ensure good primary stability
- Blood clot forms at the osteotomy site, which is replaced by bone over a period of time
- Initial clot formation is followed by proliferation and differentiation of numerous phagocytes and undifferentiated mesenchymal cells from adjacent periosteum
- Initial bone trauma leads to resorption of the bone which will decrease the primary stability which was initially achieved
- This necrotic bone is replaced by initial woven bone formation
- Quality of bone and its volume that contacts the implant determines its initial stability. This stability should be maintained for the bone to form over a period of time
- After the critical period of 2 weeks, the bone formation takes place and the level of bone contact and implant stability is enhanced
- Depending on the initial stability and the quality of bone, single stage or two stage surgery is done
- In single stage implant procedure, the primary stability is good and the implants can be loaded immediately whereas in the two stage procedure implants are submerged till it attains adequate stability. After 3–4 months, the implants are uncovered and then loaded.
- Greater osseointegration is observed in cortical bone with good blood supply than in the cancellous bone
- The degree of osseointegration increases with time and function.
- Greater forces applied to the implant may lead to apical movement of the bone margins resulting in some loss of osseointegration.

Q *What factors influence osseointegration of dental implants?*

Factors influencing osseointegration are (Fig. 32.6):

- *Biocompatibility and implant design:* Commercially pure titanium (cp Ti) implants are the most commonly used material to establish osseointegration. The implant design influences greatly the initial stability and its function. The design parameters are:
  - *Implant length:* Commonly used implant lengths are between 8 and 15 mm which correspond closely to the natural root length
  - *Implant diameter:* For adequate implant strength at least 3.25 mm diameter implants are used. Most

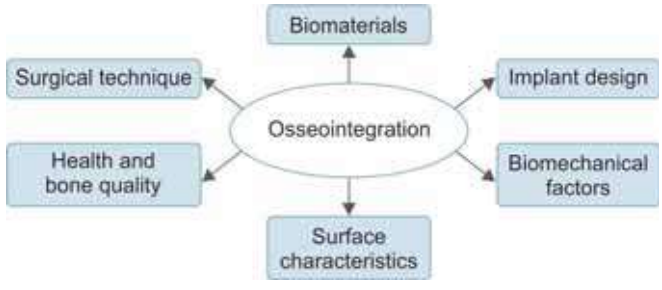


Fig. 32.6: Factors affecting osseointegration of dental implants.

commonly used diameter is 4 mm. Implant diameter rather length influences the amount of force distributed to the surrounding bone
- *Implant shape:* Implant shapes such as hollow cylinders, hollow screws, solid cylinders or solid screws influence the amount of osseointegration and this provides initial stability. Alteration in the size or pitch of the threads can influence the initial stability of implants
- *Surface characteristics:* Degree of roughness influences the osseointegration. Surface treatment like grit blasting, etching, plasma sprayed or hydroxyapatite coating improves osseointegration by increasing the bone to implant contact.

❖ *Bone factors:* Quality and quantity of bone greatly influences the stability of implant during placement. Well-formed cortical and dense trabecular bone with good blood supply is most desirable for implant placement. Quality of bone is influenced by factors such as infection, smoking or irradiation which reduces blood supply to the bone

❖ *Loading factors:* Sufficient time for healing should be given to the implant before loading. Ideally 6 months for maxilla and 4 months for mandible is recommended

❖ *Prosthetic considerations:* Properly planned occlusal loading will help in increased bone to implant contact and long-term osseointegration. The functional loading conditions depend on the following:
- *Type of occlusal factors:* Shallow cuspal inclines and reduced loading during lateral excursion results in lesser load transfer to the surrounding bone
- *Type of prosthetic reconstruction:* It may vary from a single tooth replacement to full arch reconstruction or implant supported overdentures
- *Number, location and design of implants:* The greater number of implants will distribute the functional forces over the larger surface area, thereby reducing the amount of load per area
- Similarly, location and design of implants influences osseointegration of dental implants
- *Patient habits:* Any parafunctional habits will drastically influence the prognosis of the treatment
- *Design and properties of implant connectors:* Rigid connectors which are having passive fit help in distributing load between the multiple implants and also provide good splinting
- *Elastic modulus of the implant:* The elastic modulus of implant is inversely proportional to the strain transferred to the implant-bone interface during functional loading. If the implant has greater elastic modulus than the bone, there will be greater stress on the implant and very less stress will be transferred to the bone which eventually will result in bone loss. This phenomenon is called as **'Stress shielding effect'**. For this reason the elastic modulus of implant should be comparable to that of the bone
- *Strength and ductility:* The metal framework and components possess greater strength and ductility when compared to ceramics and carbon which are brittle in nature. In areas of high tensile stress metal abutments or fixtures are better because they have greater ductility and can sustain permanent deformation.

Q *What is the rationale behind pretreating the implant surface? Which are commonly used methods for surface treatment of implants?*

Surface Treatment of Implants

As mentioned earlier surface characteristics of implants is critical for osseointegration. The surface characteristics can be classified as subtraction type (acid etching) or addition type (coatings). These surface treatment increases surface area and enhances bone integration. There are various methods of surface treatment of implants **(Fig. 32.7)**.

Methods of surface treatments:

❖ *Ablative procedures:* It involves the removal of material from the surface of a material through:
- Acid etching
- Grit blasting
- Anodizing
- Sandblasted and acid-etched (SLA) surface.

❖ *Additive procedure:* It involves creating a layer by addition of material through:
- Plasma spray
- Porous sintering
- Sputter deposition
- Electrophoretic deposition
- Biomimetic precipitation
- Soluble gel coating.

Acid Etching

The surface of implant is pitted by means of acid etching process. Strong acids, such as hydrochloric acid (HCl), nitric acid (HNO_3) and sulfuric acid (H_2SO_4) are used for this purpose. The roughness achieved by acid etching depends on the type of acid, immersion time of implant, bulk, and surface topography. Minimum roughness achieved from this process is in the range of 0.3–1 μm (Sa value). The *Sa value refers to the mean height of peaks and pits on the surface.* Roughness on the surface of implant by acid etching is believed to improve osseointegration **(Figs. 32.8A and B)**.

Clinical Significance

Etched surface increases the surface area which aids in improving the mechanical interlocking of bone with implant.

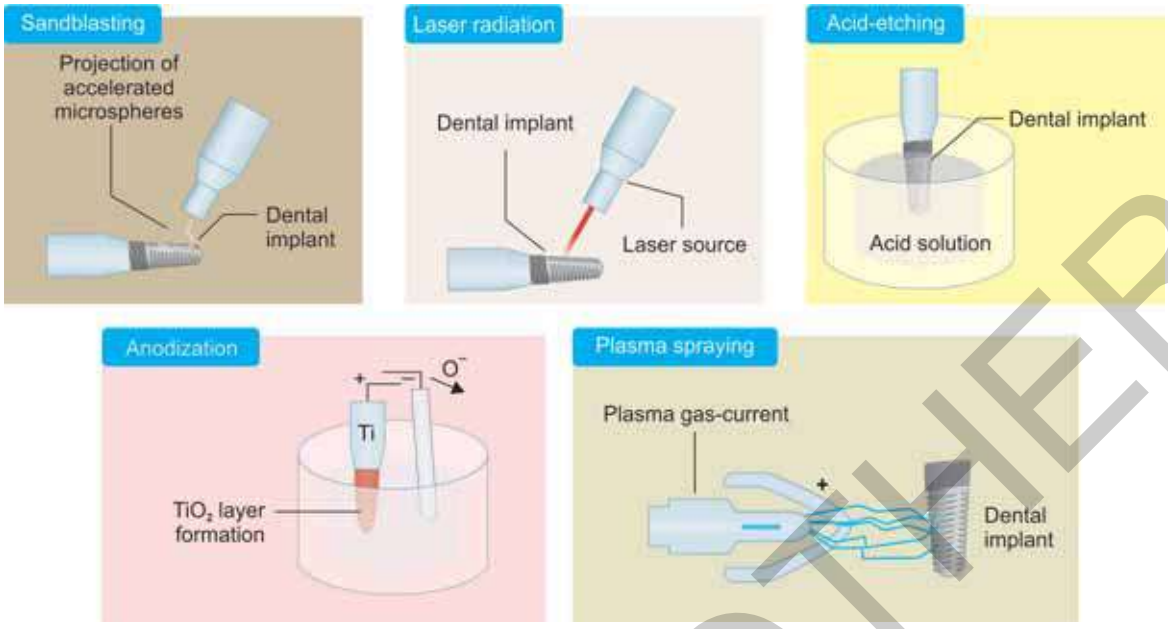
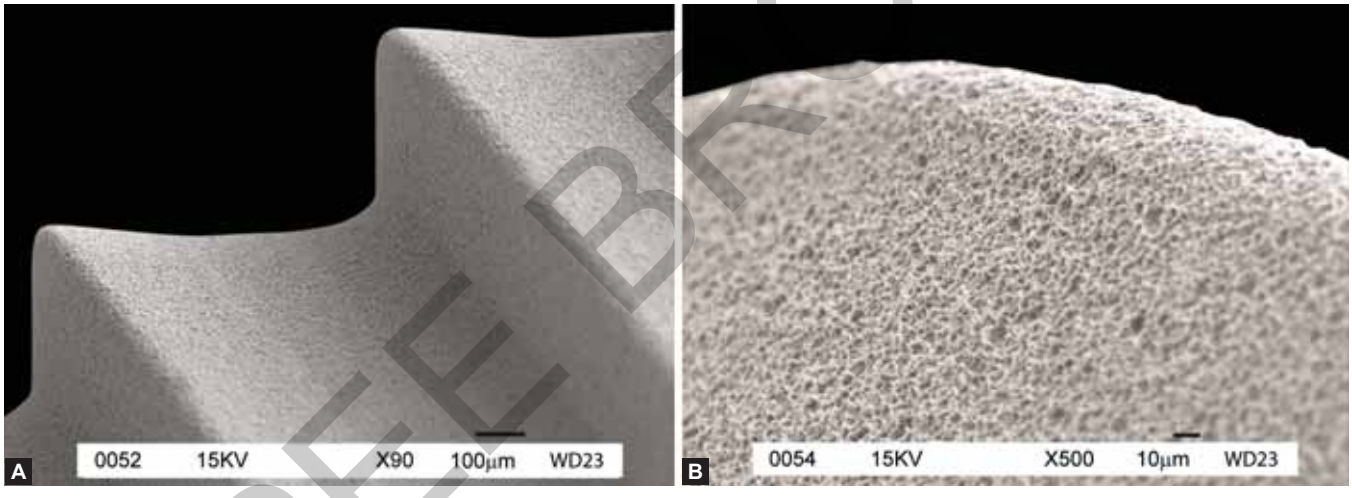


Fig. 32.7: Various surface treatments of dental implants.



Figs. 32.8A and B: Acid-etched surface of implants.

Grit Blasting/Sandblasting

This process is done by blasting the surface of implants with small particles of aluminum trioxide and titanium dioxide. As grit blast hits the surface of implants, it forms craters which cause roughness.

Clinical Significance

The roughened implant surface promotes adhesion, proliferation and differentiation of osteoblasts, and therefore increases osseointegration. The Sa value is in the range of 0.5–2.0 µm.

Anodization

Anodization of titanium implant surface results in partial crystalline and phosphate enriched microstructural topography. The roughness achieved helps in improving bone growth due to mechanical interlocking thereby increasing osseointegration. This method shows greater bone implant contact ratio, higher removal torque value and greater overall clinical success rate.

Sandblasted and Acid-etched Surfaces (SLA)

Currently available dental implants are both sandblasted and acid etched (SLA) to increase the surface roughness. SLA surface shows increased hydrophilicity of the implant surface because of minimal carbon contamination. SLA active implants show greater healing, increased osseointegration and stability. Sa value for blasted and acid etched implants are 1–2 µm.

Clinical Significance

SLA active implants are found to achieve osseointegration and stability in 6 weeks in comparison to 12 weeks in conventional implants.

Plasma Spraying

Hydroxyapatite crystals are most commonly used material to plasma spray the implant surface to increase the bioactivity of the implants. Through this method calcium phosphate layer is deposited on the surface of the implant. Thickness of the coating is in the range of 100–300 μm. There is about six times increase in the surface area using this method. The average roughness is in the range of 5 ± 1 μm. Hydroxyapatite coated surface shows greater bone implant surface contact. However, there is possibility of microbial infection, thickness of coating is nonuniform and the long-term adhesion of the hydroxyapatite coating is questionable.

Porous Sintering

It is the method of incorporating porosity on the surface of implant by sintering metal powder. The porous layer on the surface aids in increased retention due to improved ingrowth of bone into these porous layer. Currently, greater roughness is sought by laser sintering method which helps in improving long-term performance.

Sputter Deposition

It is one of the methods of depositing bioceramic thin films of calcium phosphate on the implant surface. It helps in improving adhesion of the substrate and bioceramic material. It shows higher removal torque as compared to untreated implants. This method is time consuming.

Biomimetic Precipitation

The implant surface is biomimetically precipitated with calcium phosphate to promote early bone growth on the porous surface. Through this technique thick layer of hydroxyapatite coating is formed which is 20–25 μm thick.

Clinical Significance

Coatings of these materials greatly improves osseointegration and have higher torque value for removal compared to uncoated titanium implants. They facilitate early bone growth and failure due to debris coating, macrophage infiltration and fibrous tissue encapsulation do not occur.

Laser Ablation

Lasers are also used for surface treatment of implants for creating micro and nanostructured surfaces. Laser ablation uses the laser sources to produce on site melting of the metal. This produces microchannels which facilitate faster healing of bone. These surfaces improves strength and adhesion with bone. They increase hydrophilicity in the performance of the biological response and cell recruiting and aids in faster healing of bone. They show greater removal torque values, e.g., SLActive (Straumann Institute, Basel, Switzerland), Laser-Lok (BioHorizons, AL, USA).

Recent development in surface treatment of implants:

- *Bioactive glass coating*—bioactive silicate glass particles are sprayed over the implants by enameling process.
- *Protein coated*—the implant surface is coated with protein such as recombinant human bone morphogenic protein (rhBMP).
- *ZiUnite*—the surface of implants are coated with zirconia particles
- *Corundum blasting*—the implant surface are blasted by corundum particles to create deep pits which acts as retentive pockets for growth of new bone
- *PVD coating*—physical vapor deposition coatings of materials such as titanium nitride or zirconium nitride are coated on implant collars for esthetic purpose.

IMPLANT SURGICAL PLACEMENT

Dental implants are placed in bone either in single stage or as two stage procedure. Implants can also be placed immediately after extraction or conventionally after healing of bone post extraction.

Single Stage Implants

- Preoperative planning of the selected surgical site is done using radiographs
- After adequate anesthesia the crestal incision is given and flap is raised in the edentulous area or the tooth is extracted
- If planning an immediate implant the extraction socket is thoroughly currettaged
- Sequential osteotomy is done using cortical drills of different diameter
- Planned length and diameter of the implant is inserted after final osteotomy with the appropriate cortical drill
- The implants are closed with healing abutment and the implant remains exposed through the healing stage
- The flaps are sutured in place around the abutment.

Two Stage Implants

- In conventional stage 1 the implants are buried within the tissues for 2–3 months
- On complete healing the implants are uncovered and healing abutments are placed
- After one week impressions are made for the final prosthesis.

Q *How does healing process around dental implants occur? Is it different than healing after tooth extraction?*

HEALING PROCESS IN IMPLANTS

The healing process around the dental implant is similar to the process that occurs for primary bone. The healing process in implants occurs in three phases namely:

1. Osteophyllic phase
2. Osteoconductive phase
3. Osteoadaptive phase

Osteophyllic Phase

- After osteotomy procedure when the rough surface implant is placed, blood is present between the surface and the bone which subsequently forms a clot
- At this time only small portion of implant is in contact with bone and the rest of the surface is exposed to extracellular fluid and cells
- During the initial implant-bone interaction, cytokines are released which increases collagen synthesis and regulate bone metabolism
- While inflammatory phase is active, there is vascular ingrowth from the surrounding vital bone starting from the third day
- Vascular network matures in the first 3 weeks after implant placement
- There is cellular differentiation, proliferation and activation which occurs during this phase
- Ossification occurs from the first week itself when the osteoblasts cells migrate from the endosteal surface of the trabecular bone and inner surface of buccal and lingual cortical bone
- This phase lasts for 1 month.

Osteoconductive Phase

- During this phase as the osteoblasts spreads along the metal surface to deposit the osteoid
- Initially, immature connective tissue matrix in the form of thin woven bone is laid down which is called the *footplate*
- Fibrocartilaginous callus matures into the bone callus similar to the endochondral ossification of bone
- This phase occurs for the next 3 months
- After 4 months of implant placement, maximum surface area of implant is covered by bone
- At the end of this phase, a steady state is reached and there is no more formation of bone.

Osteoadaptive Phase

- This final phase occurs after 4 months of implant placement
- In this phase, remodeling of bone occurs even after the implants are exposed and loaded
- After loading, the bone surrounding the implant thickens in response to the load transmitted to the implant
- Reorganization of the vascular pattern is observed during this phase
- About 4–8 months of healing period is recommended for adequate osseointegration depending on the quality of the bone.

COMPONENTS OF DENTAL IMPLANTS (FIGS. 32.9 AND 32.10)

Parts of all the implant systems are usually similar.

Implant body or fixture: It is a component that actually engages the bone. Usually, the fixture is made of titanium or alloys. They can be having different implant surface such as threaded, perforated, nonthreaded, plasma sprayed or coated. Plasma sprayed or coated implants are used to increase attachment of bone.

Cover screw: It is a screw that is placed in the implant during healing.

Healing cap or gingival former: It is a dome-shaped screw which is placed after the stage II surgery. It projects from the soft tissues into the oral cavity. They help in enhancing soft tissue esthetics by developing papilla and marginal gingiva.

Transmucosal abutment: It provides a connection between the implant fixture and the prosthesis that will be fabricated. It can be straight or angled and it eventually supports

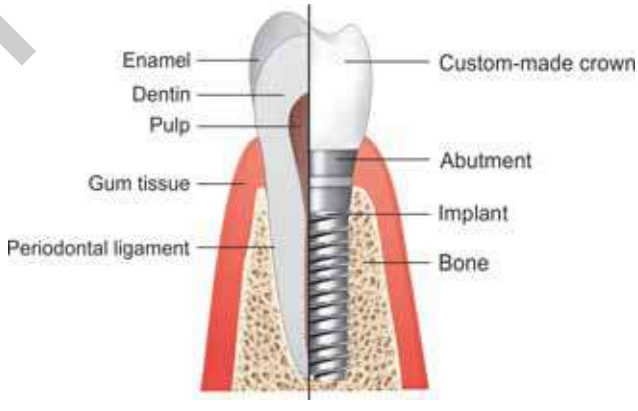


Fig. 32.9: Parts of dental implant.

Fig. 32.10: Components of dental implants.

- Metallic implant materials are more susceptible to electrochemical degradation than ceramics
- Implant materials can corrode and wear resulting in formation of submicron sized debris which may elicit local or systemic biologic response. Local accumulation of debris around the implants can result in metallosis or tissue discoloration
- Implant material should not affect the local tissues and organ function
- Principal factor in selection of implant material is its response to bone
- Therefore, success of dental implants is influenced by surface characteristics of implant, site of placement and implant-bone interface.

Q What factors should be considered before designing an implant prosthesis?

BIOMECHANICS IN DENTAL IMPLANTS

Dental implants are subjected to wide range of complex forces in multiple directions. Complete osseointegration of implant ensures transfer of stresses with minimal relative movement between bone and the implant. Stresses generated are greatly influenced by following factors:

- Masticatory factors—frequency of mastication, amount of bite force, mandibular movements
- Type of support to the prosthesis—implant supported, implant—tissue supported or implant tooth supported
- Properties of the materials—ductility, fracture strength, fatigue, modulus of elasticity, etc.

Biomechanical Considerations

Implant Design

- **Smooth sided, cylindrical implants results** in greater shear stress at the bone implant interface. Shear stress can be reduced by coating the surface with hydroxyapatite or plasma spray
- Whereas tapered implants with a taper not more than 30° provides greater component of compressive load at the bone-implant interface and provides ease of surgical placement
- Threaded implants have unique ability to convert the type of load imposed at the bone implant surface by controlling the thread geometry
- Thread geometry parameters which are of importance are—thread depth, pitch and its shape
- Greater the depth of the thread, greater will the functional surface area of the implant. Similarly if the thread pitch is greater, then lesser the number of threads per unit length and thus lesser the functional surface area
- Shape of the thread can be square, V shaped or buttress shaped
- Square threads experiences least amount of shear stress as compared to V-shaped or buttress-shaped threads
- Thread design of implant can influence the bone turnover rate, i.e., the remodeling of bone during occlusal load conditions.

Length of Implant

- Greater the length of the implant, greater will be the surface area available for function
- Longer implants provide greater stability to lateral loading conditions
- Longer implants are recommended in poor quality bone.

Diameter of Implant

- Wider diameter implants has greater bone to implant contact with greater surface area. This aids in better stress distribution
- Larger the width of the implant, more closely it is able to match the emergence profile of the natural tooth.

Number of Implants

- Greater the number of implants, greater will be the distribution of occlusal load and lesser will the stress at the bone implant interface
- More number of implants reduces the cantilever length which reduces the overall stress to the bone.

Occlusal Loading

- For effective stress distribution, occlusal table should be small and there should be no posterior offset loads. As much as possible forces should be directed along the long axis of the implant bodies
- Bone is ideally suited to bear axially directed compressive force rather than shear or tensile forces. If implant is placed at an angle, there will be greater angled load which will result in greater crestal bone loss
- Premature contact should always be eliminated because it increases the duration and magnitude of occlusal load to the implant body and the surrounding bone
- For a patient with parafunctional habit, occlusal scheme should be selected which will minimize occlusal trauma to the bone
- Occlusal overloading will result in failure of implants because of crestal bone loss, prosthetic failure or peri-implantitis.

SUMMARY

- Dental implants are prosthetic devices which are implanted into the oral tissues beneath the mucosa or periosteal layer or within the bone to provide retention and support to the fixed or removable dental prosthesis
- Dental implants can be of four types—subperiosteal implants, transosteal implants, endosteal implants and epithelial implants

- Root form endosteal implants are most commonly used
- Osseointegration is direct attachment of implant to the bone tissue without any intervening connective tissues
- Implant surface can be treated by—ablative or additive procedure
- Ablative procedure involves removal of material from the surface of the material such as acid etching, grit blasting or anodization
- Additive procedure involves creating a layer by adding material through plasma spray, porous sintering or sputter deposition
- Healing in dental implants occurs in three phases–osteophyllic phase, osteoconductive phase and osteoadaptive phase
- Component of dental implants—implant body, healing abutment and transmucosal abutment
- Different implant materials are stainless steel, cobalt chromium-molybdenum alloy, titanium and its alloy vitreous carbon implant, polymers such as PEEK
- Mini implants are used for orthodontic anchorage and in providing retention in overdentures
- Mechanism of bone augmentation are—osteogenesis, osteoinduction and osteoconduction
- Bone grafts can be autogenous bone grafts, allografts and alloplasts
- Bioactive ceramics exhibit chemical contact with the host bone
- Bioinert ceramics do not bond directly to the bone but are mechanically held in contact with the host bone
- ADA provisions for accepting dental implant materials are—adequate strength, ease of fabrication and sterilization without degradation of the material

CLINIC-BASED QUESTIONS

1. A 48-year-old Banker came to your dental clinic with broken crown in left lower first molar tooth with mild pain. On examination you find the crown is fractured till the root. There is fracture line which goes deep towards the furcation. You decide to extract the tooth.
   What treatment option you give to the patient for replacement of the tooth after extraction. Give reasons for your choice of treatment.
2. A 65-year-old retired woman came for replacement of missing lower posterior on right and left side. On examination you find both lower molars on both sides to be missing with highly resorbed knife edge ridge. CBCT report indicates 6 mm height and 3.7 mm width of available bone. Interarch space is adequate.
   What will be your plan to treat such patient. Give reasons for your choice of treatment?

TEST YOURSELF

Essay Questions

1. Classify dental implants. Discuss biocompatibility and biofunctionality of dental implants.
2. Describe various methods of surface treatments of implants.
3. Discuss various ceramic-based materials used in implants.
4. Classify various graft materials. Write in detail autogenous graft materials.
5. Describe the mechanism of bone augmentation.
6. Classify various materials used in implants. Write in detail about titanium and its alloys used in implant.
7. Enumerate parts of implant. Write in detail about abutments.
8. Discuss biocompatibility and biomechanics of dental implants?

Short Notes

1. Osseointegration.
2. Healing in implants.
3. Success criteria of implants.
4. Endosseous implants.
5. Biomechanics of implants.
6. Mini implants.
7. Immediate implants.
8. PEEK in dental implant.

Multiple Choice Questions

1. Which of the material is not used as implant material?
   A. Stainless steel
   B. Pure titanium
   C. Nickel-chromium
   D. Cobalt-chromium
2. Which of the following is an acceptable definition of osseointegration?
   A. Bone growth through the hole in the implant by the formation of new bone in intimate contact
   B. Placement of implant directly within a bony structure
   C. Stabilization of an implant by the formation of new bone in intimate contact
   D. Intimate contact between connective tissue and implant resulting in bonding
3. All is true about bioactive implant material, except:
   A. Ceramic
   B. Stronger than steel
   C. Chemically bonds to bone
   D. Similar stiffness as bone
4. Hydroxyapatite is coated on the surface of implants to:
   A. To ensure strong union between the implant and the bone
   B. To improve bone growth at the surface of implant
   C. To improve esthetic of metallic implant
   D. To increase biocompatibility of the metal implant
5. The most common metal used in implants is:
   A. Titanium
   B. Stainless steel
   C. Gold
   D. Silver

Textbook of Dental Materials

The second edition of *Textbook of Dental Materials* is a comprehensive book that covers various materials used in dentistry in an easy-to-understand format. The book extensively covers the topics with the current and latest updates in material science, technology and manipulation techniques in a pointwise manner for easy recapitulation.

Salient Features

- The book is divided into eight sections with 33 chapters based on general properties, auxiliary materials, impression materials, denture base materials, direct and indirect restorative materials, preventive and endodontic materials and recent trends in dental materials.
- Includes the chapter on digitization in dentistry, implant dentistry and the latest trends in material science covering nanotechnology, laser, 4D printing, tissue engineering, robotics, artificial intelligence, virtual and augmented reality, etc.
- Each chapter is compiled with multiple-colored photographs, illustrations, schematic diagrams and flowcharts. Reasoning questions, classification and clinical significance are highlighted in color-coded boxes for better understanding.
- Each chapter contains test yourself (multiple-choice questions) to assist students to prepare for entrance examinations.
- For self-assessment, essay questions and short notes are given that will help students to prepare for various university examinations.
- Contains appendix and glossary at the end of the book.
- Includes reference charts for quick revision of the materials before the examination.
- Covers the entire syllabus prescribed by the Dental Council of India (DCI).
- Useful for dental graduates, dental hygienists, dental technicians, postgraduates and clinical practitioners.

New additions in this edition:

- Chapter on Digitization in Dentistry
- Clinical-based questions
- Key Terms at the start of each chapter and summary in the end
- Reasoning questions to test understanding of the topic in all chapters
- Special emphasis on important topics with highlighted text and color-coded boxes

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Printed in India

Available at all medical bookstores
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JAYPEE BROTHERS
Medical Publishers (P) Ltd.
EMCA House, 23/23-B, Ansari Road,
Daryaganj, New Delhi - 110 002, INDIA
www.jaypeebrothers.com

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ISBN 978-93-5696-367-2