

## Latest Implant Materials and Implant Coating Materials- A Narrative Review

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### Abstract:

Dental implant fittings are often made of a variety of materials. Titanium alloys, zirconium, PEEK, composite materials, 3D-printed materials, and biodegradable materials are a few of the most recent implant materials. A great deal of research is being done on implant surface coating materials, such as nanostructured materials and bioactive coatings, to improve the osseointegration of the implant with the bone.

### Introduction:

Although the use of conventional titanium implants is still common, advances in titanium alloys have improved the material's mechanical characteristics, osseointegration, and durability over time. More recent titanium alloys might be stronger, more resistant to corrosion, and more biocompatible.[1]Titanium and its alloys are extensively utilised in dental implantology due to their exceptional biocompatibility and resistance to corrosion. In clinical trials, titanium implants have shown excellent success rates and long-term durability. [2,3] Though the titanium is highly successful materials with maximum clinical usage by the clinicians worldwide, still having some disadvantages such as sensitivity seen in few patients and stress-shielding at bone-implant interface and aesthetic problems. To overcome these problems researchers continuously trying for invention of better material. This narrative review aimed on different newer implant materials and implant surface coating materials.

### I.Newer Implant materials:

**Zirconia:** Because of their biocompatibility, cosmetic qualities, and capacity to inhibit plaque buildup, zirconia implants have become more and more well-liked. They are a less aesthetically pleasing option to conventional titanium implants and are especially good for those who are allergic to metals. [4]Zirconia implants' translucency

and tooth-like colour make them a good choice for aesthetic purposes. **Biocompatibility:** Patients with metal sensitivity can benefit from zirconia due to its high biocompatibility and low allergenic potential. [5,6]

**Poly Ether Ether Ketone (PEEK):** is a high-temperature, semi-crystalline thermoplastic that is a member of the PAEK (polyaryletherketone) family. Due to the ether and ketone functional groups that join its aromatic rings, it has exceptional stability and chemical resistance. PEEK is appropriate for human body implantation since it is biocompatible and has little inflammatory reaction in vivo. PEEK is like human cortical bone in that it has remarkable mechanical qualities such as high tensile strength, stiffness, and fatigue resistance. PEEK is radiolucent, which means that, in contrast to metallic implants, which may create interference, it can be clearly seen on imaging methods like X-rays. It can tolerate sterilisation procedures like autoclaving thanks to its high melting point and lack of noticeable deterioration. PEEK is appropriate for long-term implantation in corrosive settings within the body because of its broad chemical resistance. [7]

PEEK implants' radiolucency makes precise postoperative assessment easier to do without interference from metallic artefacts. Because of its nearly identical mechanical characteristics to those of real bone, it reduces stress shielding and encourages bone ingrowth. PEEK is easily machined into intricate shapes, enabling the creation of implants that are anatomically matched to patients. PEEK implants have demonstrated good integration with surrounding tissues and long-term durability. [8-10]

**Composite Materials:** Researchers are looking into the possibility of using composite implants, which are composed of a blend of polymers and ceramics, to emulate the mechanical characteristics of natural bone and encourage the formation of new bone. The advantages of these materials are their radiolucent properties and light weight.[11]

**3D Printed Implants:** Using additive manufacturing methods like 3D printing, implants with intricate geometries and patient-specific features can be made to order. For the best possible fit and functionality, 3D-printed implants provide accuracy, flexibility, and personalisation. Implant geometry, porosity, and material qualities can all be precisely controlled during the production process of 3D printed implants, sometimes referred to as additive produced implants. These implants can be tailored to meet the specific demands of each patient since they are constructed using anatomical data unique to that patient. This is a summary of dental implants made using 3D printing. [12]

**Biodegradable Implants:** Made of materials like polymers or magnesium alloys, biodegradable implants progressively break down inside the body over time. These implants may avoid the need for implant removal surgeries by offering temporary support during the healing phase.[13]

**Roxolid Implants:** The titanium-zirconium alloy (Roxolid) is the most recent addition to the implant material inventory. A unique alloy called Roxolid was created by Straumann, a maker of dental implants. It is an alloy of

titanium and zirconium made especially for dental implants. According to marketing, zirconium implants are stronger and more durable than conventional titanium implants due to their improved mechanical qualities. Zirconium's composition is primarily made of titanium, with trace amounts of zirconium and other metals. In comparison to pure titanium, the alloy's mechanical qualities, such as tensile strength and fatigue resistance, are meant to be enhanced by the inclusion of zirconium. [14]

When compared to traditional titanium implants, Zirconium implants are said to offer a better tensile strength and fatigue resistance. This enhanced strength might make it possible to employ implants with smaller diameters, which would eliminate the requirement for bone augmentation operations. Because Zirconium keeps titanium biocompatible, there is less chance of tissue irritation or unfavourable reactions when it is used for dental implantation. High success rates similar to conventional titanium implants have been found in clinical investigations evaluating Zirconium implants. These investigations usually evaluate variables throughout time, including peri-implant bone levels, osseointegration, and implant stability. Studies indicate that both short- and long-term clinical results for Zirconium implants appear favourable, with high implant survival rates and low complications. [15-17]

**II. The implant coating materials includes:** Proper osseointegration is the key factor for the success of implant dentistry. Implant surface coatings playing major role in osseointegration. Many surface coating methods are practicing by the manufacturers. The researchers are thriving to introduce newer surface coating materials for the better osseointegration, which includes:

**Nanostructured Surfaces:** To encourage quicker osseointegration and increase implant stability, surface alterations at the nanoscale level have been devised. Improved clinical results could result from implants and surrounding bone tissue interacting more effectively thanks to nanostructured surfaces. Implant stability and osseointegration are increased by nanoscale surface changes in nanostructured surface implants. In order to encourage interactions with bone cells and tissues, these changes entail adding nanoscale characteristics to the implant surface, such as nanotubes, nanoparticles, or nano roughness. [18]

**Nanotubes:** By treating titanium implants to produce nanotube structures on their surface, a large surface area is made available for improved cellular adherence and proliferation. **Nanoparticles:** By adding nanoparticles to implant surfaces, such as growth factors or hydroxyapatite, osteogenic activity can be stimulated, and bone production accelerated. **Nano roughness:** Protein adsorption, cell adhesion, and tissue integration can all be enhanced by carefully arranging the implant surface to have a predetermined amount of nanoscale roughness. Better bone-to-implant contact and quicker bone healing are made possible by nanostructured surface implants, which improve osseointegration, prolong implant stability, and shorten healing times. **Improved Biocompatibility:** Nanostructured surfaces minimise inflammatory responses and foreign body responses in the surrounding tissues by having enhanced biocompatibility and bioactivity. [19,20]

**Biodegradable Implants:** Made of materials like polymers or magnesium alloys, biodegradable implants progressively break down inside the body over time. These implants may avoid the need for implant removal surgeries by offering temporary support during the healing phase. Biodegradable implants have attracted a lot of attention in the medical community, especially in dentistry, because they can be used to stimulate tissue regeneration and healing temporarily while the implant eventually breaks down naturally. An overview of biodegradable dental implants is provided here. While implant fixation and bone regeneration are two dental applications where biodegradable implants show potential.[21]

#### Biodegradable materials covers:

Polymers are covered with biodegradable materials. Dental implants frequently employ biodegradable polymers including poly(lactic acid) (PLA), poly(glycolic acid) (PGA), and their copolymers (PLGA). These substances hydrolyze to produce harmless byproducts that the body metabolises and excretes.[22]

**Magnesium Alloys:** Magnesium alloys are another class of biodegradable materials investigated for dental implants. These alloys offer mechanical properties similar to bone and degrade over time into magnesium ions, which are essential for cellular metabolism. [23,24]

**Bioactive Coatings:** By encouraging interactions with surrounding bone tissue, bioactive coatings on dental implants seek to improve long-term implant success rates, accelerate osseointegration, and shorten healing times. Usually, the materials used in these coatings have bioactive qualities to promote bone integration and production, or they are composed of materials that closely resemble the makeup of actual bone. Although bioactive coatings have the potential to enhance implant outcomes, successful clinical translation will require addressing issues with coating adherence, stability, and long-term durability. Bioactive coatings promote osseointegration and the long-term stability of dental implants by promoting a stronger and faster interaction between the implant and the surrounding bone. Reduced healing time: The bioactive qualities of coatings encourage speedy bone healing and regeneration around the implant site, which cuts down on treatment times and expedites the return of function to the mouth. Better Clinical Outcomes: Compared to uncoated implants, bioactively coated implants have shown increased success rates, decreased implant failure rates, and enhanced peri-implant bone density in clinical trials.[25,26]

#### Types of Bioactive Coatings:

**Hydroxyapatite (HA):** HA is a calcium phosphate compound that closely resembles the mineral component of natural bone. HA coatings on implants provide a bioactive surface for bone attachment and growth, facilitating osseointegration.[25] Hydroxyapatite coatings promote osseointegration by providing a bioactive surface that enhances bone bonding.[26]

**Calcium Phosphate (CaP):** CaP coatings, including tricalcium phosphate (TCP) and biphasic calcium phosphate (BCP), enhance bone regeneration and implant stability by releasing calcium and phosphate ions that promote osteogenic activity. [27]

**Bioactive Glasses:** Bioactive glasses contain elements such as silicon, calcium, and phosphorus, which react with bodily fluids to form a hydroxycarbonate apatite (HCA) layer on the implant surface. This layer promotes bone bonding and stimulates new bone formation. [28]

### **III.The future implant materials:**

Researchers are continually exploring and developing new materials for dental implants to improve their performance, biocompatibility, and clinical outcomes. Some of the material may be used in the future which includes:

**Graphene:** Graphene, a two-dimensional carbon material, has gained attention for its exceptional mechanical, electrical, and biological properties. Researchers are exploring its potential application in dental implants to enhance osseointegration, antibacterial properties, and implant longevity. [29]

**Nanocomposites:** Nanocomposite materials, such as polymer-ceramic hybrids or metal-polymer blends reinforced with nanoparticles, offer improved mechanical strength, wear resistance, and biological activity compared to traditional materials. These materials may enhance the performance and longevity of dental implants. [30]

#### **Bioresorbable Metals:**

Bioresorbable metals, including magnesium and iron alloys, degrade gradually in the body and are being investigated for temporary implant applications, such as bone fixation or guided bone regeneration. These materials eliminate the need for implant removal surgeries and offer potential advantages for tissue healing and remodelling. [31]

#### **Stem Cell-Derived Materials:**

Biomaterials derived from stem cells or extracellular matrix components show promise for promoting tissue regeneration and integration with host tissues. Researchers are exploring the use of stem cell-derived scaffolds or bioinks for 3D printing patient-specific implants with enhanced biocompatibility and regenerative potential. [32]

#### **Antibacterial Coatings:**

Novel antibacterial coatings incorporating nanoparticles, antimicrobial peptides, or bioactive molecules are being developed to reduce the risk of peri-implant infections and implant-related complications. These coatings may inhibit bacterial colonization and biofilm formation while promoting tissue integration and wound healing. [33]

**Smart Materials:**

Smart materials, such as shape memory alloys or stimuli-responsive polymers, offer unique properties that respond to environmental cues or mechanical forces. These materials may enable dynamic adjustments in implant function or morphology, enhancing adaptability and performance in changing physiological conditions. [34]

**Conclusion:**

Technology advancing day by day in all the fields of dentistry including implantology. The researchers are coming with latest inventions for the service of mankind. The clinicians should update their knowledge regularly to provide better clinical services.

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