

Dental Implants and Nanotechnology

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Abstract

Dental implants' early Osseo integration is associated to their long-term clinical success. This study examines the various processes through which biological fluids, cells, tissues, and implant surfaces interact. Implants come into contact with blood proteins and platelets right after implantation. The healing of the peri-implant tissue will thereafter depend on the development of Mesenchymal stem cells. Instead of fibrous tissue encapsulation, direct bone-to-implant contact is preferred for a biomechanical anchoring of implants to bone. An important factor in these biological interactions is the surface's chemistry and roughness. Protein adsorption, cell adhesion, and differentiation may eventually be regulated by physicochemical properties in the nanometer range. Dental implants' surfaces are increasingly being modified using nanotechnologies. Using thin calcium phosphate (CaP) coatings is another method to improve Osseo incorporation. On titanium implants, bioactive CaP Nano crystals are deposited, and they promote bone apposition and healing. The type of peri-implant tissues may eventually be directed by future nanometre-controlled surfaces, increasing their clinical success rate.

Keywords: Dental implant; Microbial resistance; Nanomaterial; Antimicrobial nanotechnology; Stem cells

Introduction

The most common human diseases, caries and periodontitis, are both of bacterial origin and, according to the World Health Organization, are both linked to frequent surgical treatments. The main causes of edentulism are these infectious diseases and various noninfectious conditions including dentoalveolar trauma and congenital absences. To minimise or lessen the contribution of these infectious diseases to the early loss of teeth, a number of preventative measures and educational initiatives are used. However, human activities like intense and contact sports have increased dentoalveolar trauma. In dental surgery, implants are frequently used to restore teeth. Obtaining and maintaining Osseo integration and the epithelial connection of the gingival with implants is one of the issues in implantology. Direct bone bonding may assure a biomechanical anchoring of the artificial dental root, while an intimate interface between the gingival tissue and the neck of dental implants may avoid bacterial colonizations that cause peri-implantitis [1].

Primary stability, the first stage of the Osseo integration of implants, deals with mechanical anchorage, implant design, and bone structure. The secondary anchorage, which is defined by a biological bonding at the interface between bone tissues and the implant surface, benefits from the main interlock's gradual decline over time. Implant stability could be reduced between the primary mechanical and secondary biological anchoring. Numerous researches have tried to improve the Osseo integration of implants by altering their surfaces. Biological surface qualities for protein adsorption, cell adhesion and differentiation, and tissue integration are intended to be added to metal implants [2]. These biological characteristics are connected to the surface roughness, wettability, and chemical makeup of metal implants. For researchers and dental implant makers, controlling these surface features at the protein and cellular levels-and thus in the nanometre range-remains a difficult task. These biological characteristics are connected to the surface roughness, wettability, and chemical makeup of metal implants. For researchers and dental implant makers, controlling these surface features at the protein and cellular levels-and thus in the nanometre range-remains a difficult task [3].

With the help of nanotechnologies, innovative implant surfaces with predictable tissue-integrative qualities might be created. These

surfaces would have controlled topography and chemistry, which would aid in understanding biological interactions. Dental implants can be processed using a variety of techniques from the electronic industry, including lithography, ionic implantation, anodization, and radio frequency plasma treatments, to create controlled features at the Nano scale. Then, these surfaces might be examined in vitro employing high throughput biological experiments. For instance, it is important to investigate how the surface features affect certain protein adsorption, cell adhesion, and stem cell development. This strategy might specify the optimum surface for a particular biological reaction. Nanostructured surfaces may be investigated in animal models after in vitro screening to confirm the idea in a challenging in vitro environment [4].

For the purpose of coating implants with the bone mineral hydroxyapatite and related calcium phosphates (CaP), new coating technologies have also been developed. Numerous investigations have shown that these CaP coatings gave titanium implants a surface that was osteoconductive. Following insertion, the peri-implant region's CaP coatings dissolving enhanced the blood's ionic strength and saturation, which precipitated biological apatite Nano crystals onto the implants' surface [5]. The extracellular matrix of bone tissue is produced by osteoprogenitor cells adhering to this biological apatite layer, which contains proteins. Additionally, it has been demonstrated that the bone-resorbing cells known as osteoclasts are capable of enzymatically degrading the CaP coatings and producing resorption pits on the coated surface. Finally, compared to surfaces without coatings, the presence of CaP coatings on metals encourages an early osseointegration of implants with direct bone bonding. To achieve direct bone contact on implant surfaces, the issue is to create CaP coatings that would degrade at a similar pace as bone apposition [6].

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This study examines the various processes through which biological fluids, cells, tissues, and implant surfaces interact. Dental implants' most recent Nano scale surface alterations and calcium phosphate coating technologies are reviewed. There is a connection between the order of biological processes and surface characteristics. On the surface of implants, mechanisms of contact with blood, platelets, hematopoietic, and Mesenchymal stem cells are outlined. These early occurrences have been demonstrated to influence implant osseointegration as well as cell adhesion, proliferation, and differentiation. The tissue-integrative capabilities and long-term clinical effectiveness of future implant surfaces may be enhanced for the benefit of patients [7].

Material and Methods

Three fundamental scenarios depicting various anchoring scenarios for dental implants were taken into consideration. In case 1, the implant is supported by an apically positioned permanent surface but is not in contact with the cortical or trabecular bone at its vertical walls. Maximum implant deformation under vertical loading in this instance occurs in the coronal section and gradually decreases toward the apex [8]. As a result, there is less micro motion between the implant and the vertical walls of the socket as it approaches its apex. A layer of elastic trabecular bone was added apically to the implant, changing its fixed apical rest. Here, the elastic material that the implant is sitting on is primarily compressed by an axial force pressing on the implant. Since trabecular bone has a far lower elastic modulus than titanium, it is possible to ignore the implant's deformation and consider only the relative movement between the implant and bone [9].

Discussion

Within the constraints of this experiment, it was possible to show how friction phenomena and implant design-threaded versus cylindrical-affect stress distribution and implant displacement. The reduction of implant displacement under a 200 N axial load was achieved by adding threads to a cylindrical implant as well as increasing friction between the implant and bone. Changing the contact type between implant and bone to force fit caused load transfer to occur primarily in the cervical region of the implant, which is surrounded by stronger cortical bone? [10] This resulted in a more uniformly distributed loading condition at the implant bone interface. Contrast this with a scenario in which there is no friction predicted which results in the highest loading of bone around the periapical region of the implant. According to these results, screw-shaped implants are beneficial from a clinical standpoint, but bone quality is likely the most crucial factor in establishing sufficient primary implant stability for rapid loading. When selecting a certain loading process, all of these aspects should be taken into consideration [11].

It may be demonstrated that the healing condition affects the incidence of micro motion phenomena along the implant bone interface based on a comparison of recently implanted and Osseo integrated implants. Regardless of the location taken into consideration, micro motion remained consistent for a soft implant-bone contact, which represents early phases of osseointegration [12]. The distribution of micro motion at the implant bone interface was drastically altered by the addition of a friction coefficient between the implant and bone in a simulation of mature bone reflecting an Osseo integrated implant. A decrease in micro motion was seen in addition to generally lower levels of micro motion compared to a newly implanted implant. As you got closer to the implant's apex, there was less micro motion [13].

The fact that only one particular value for the axial loading of

the implants was selected may be considered as a drawback of this investigation. According to research by Brunski and colleagues, the axial components of biting forces can have values between 100 and 2400 N, albeit the precise figures depend on the type of food being consumed as well as the position within the mouth. Axial closure forces for patients with implant-supported dentures have been observed to range from 45 to 255 N. Thus, it seems that the selected number accurately captures clinical loading magnitudes [14].

Additionally, biological elements, in addition to the purely mechanical issues covered in this study, are crucial to the process of osseointegration of dental implants. After the implant has been placed, the healing process begins with serum proteins adhering, then Mesenchymal cells attaching and proliferating. As a result, osteoid develops in the mineralized material. As a result of the implants' surroundings, bone remodelling starts to take place after that. The combination of both mechanical and biologic elements seems to be crucial to the integration of the implant since these processes happen concurrently with mechanical loading in an immediate loading environment [15].

Conclusion

Numerous studies have demonstrated that nanometer-controlled surfaces have a significant impact on early dental implant implantation processes like protein adsorption, blood clot formation, and cell behaviour. The migration, adhesion, and differentiation of MSCs are significantly impacted by these early occurrences. The character of the peri-implant tissues may ultimately be controlled by nanostructured surfaces by controlling the differentiation routes into particular lineages. Despite on-going research in dental implants, finding the best surface for anticipatory tissue integration is still difficult.

Conflict of Interest

None

Acknowledgement

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