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Original Research Paper

Dental Science

ENGINEERING AIDS IN MODERNIZING DENTAL RESEARCH

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ABSTRACT Engineering will have a considerable effect on dental practice during the coming years. The greatest effects will likely be related to the repair and replacement of mineralized tissues, the promotion of oral wound healing, correction of craniofacial abnormalities, integration of biocompatible prosthetic implant materials with the oral tissues, the regeneration of dental hard and soft tissues and the use of gene transfer. Being an ancient branch of medicine, dentistry largely needs a lot of technical instruments for its purpose to serve its patients.

KEYWORDS : Tissue engineering, Biomedical engineering, Dental biomechanics.

INTRODUCTION

Biomedical engineering is an interdisciplinary branch of engineering science that deals with the application of engineering principles in the field of biology and medicine for the betterment of health. It helps by development of newer tools and materials for diagnosis, treatment and preventive purposes. Personalized dental medicine, biomimetic, nanotechnology, genomic information, regenerative dentistry and stem cell studies are developed and integrated into dental practice.

Vaccine, cloning, DNA, drugs, tissue engineering, microbial bioinformatics and complex proteins are used in research on oral health to find out the best solutions for dental problems. Technological inventions in modern dentistry include computer assisted design, computer assisted manufactured technology, continuous liquid interphase printing laser dentistry, oral cancer screening device, dental implant, digital X-ray, intraoral camera, composite resins, various biomaterials. Amplifying and analyzing of nucleic acid through the polymerase chain reaction using specific DNA fragments to detect particular proteins. In biomedical sciences and engineering, it is used to identify various microorganisms, chromosomal disorders, tumor suppressor genes, tumor associated translocation and analysis of mutation in oncogenes. It is used to detect the periodontal carcinogenic pathogens, presence of viruses in host cells, microorganisms in endodontic infections, diagnosis and prognosis of oral cancer and the estimation of quantity of different microorganisms.[1]

Molecular biomimetics is an emerging field in which hybrid technologies are developed by using the tools of molecular biology and nanotechnology. Polypeptides can be genetically engineered to specifically bind to selected inorganic compounds for applications in nano and biotechnology. These genetically engineered proteins for inorganics can be used in the assembly of functional nanostructures.

Biomimetic tissue engineered prosthesis

The goal of tissue engineering of the synovial joint is to fabricate biologically derived analogues that can replace severely degenerated or traumatized synovial joint components. Cell seeding density in the synthesis of chondrogenic and osteogenic matrices from human mesenchymal stem cells has been explored.[2]

An image - based approach is used to the designing and manufacturing of biomimetic Tissue engineered temporomandibular condylar prosthesis. Tissue - engineered prosthesis utilizes a three dimensional designed and manufactured biodegradable scaffold shaped similar to a condylar head and neck, i.e. a condylar - ramus unit. The fabricated scaffold can be constructed with a specific intra-architectural design such that it will enhance the formation of tissue from implanted cells placed within its interstices.[3]

Clinically sized, anatomically shaped, viable human bone grafts can be engineered by using human mesenchymal stem cells and a "biomimetic" scaffold-bioreactor system. This approach has potential to overcome difficulty of in vitro cultivation of viable bone grafts of complex geometries to provide patient-specific bone grafts for craniofacial and orthopedic reconstructions.[4]

Bioreactors ,devices are designed to attain optimal conditions to grow cells In vitro to be utilized in tissue engineering. The design of a bioreactor primarily depend on the type of tissue that is being constructed. Its function is to provide a suitable, reproducible and easily controlled cell culture environment, in terms of temperature, mimicking physiological conditions. The bioreactor tries to respond to all the challenges : achieving adequate, uniform three-dimensional proliferation of mesenchymal stem cells on a biodegradable substrate and matrix synthesis. Bioreactors for bone engineering applications are classified into rotating wall vessels, spinner flasks, perfusion (direct and indirect) bioreactors, Compression Bioreactors and Combined Systems.[5]

Genetic Engineering -

Genetic engineering is the direct modification of an organism's genome, which is the list of specific traits (genes) stored in the DNA. By changing which proteins are produced, genetic engineers can affect the overall traits of the organism. Genetic modification can be completed by a number of different methods : Inserting new genetic material randomly or in targeted locations, Direct replacement of genes (recombination), Removal of genes, Mutation in genes. Through the biotechnology of gene therapy, scientists are making efforts at curing genetic diseases by attempting to replace defective genes with the correct version. The concept of gene therapy involves the introduction of exogenous genes into somatic cells that form the organs of the body to produce a desired therapeutic effect. The selected DNA fragment is first cleaved using restriction endonucleases. The vector or vehicle is prepared to transfer the genetic material. The vector is isolated purified and cleaved to allow insertion of the DNA fragment. The DNA fragments then must be joined to the cleaved end of the vectors, effectively closing the molecule. The second stage involves the introduction of the construct into a cell, allowing the production of a line of genetically identical cells containing the DNA sequence introduced by the vector. Gene transfer can be used both for gene therapy and gene therapeutics .The later modality is utilized for delivery of bioactive pharmaceutical drug through salivary glands into the body for management of local and systemic disease conditions.[6]

Tissue engineering is a multidisciplinary field which involves the 'application of the principles and methods of engineering

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and life sciences towards the fundamental understanding of structure - function relationships in normal and pathological mammalian tissues and the development of biological substitutes that restore , maintain or improve tissue function' (Shalak and Fox, 1988). This field builds on the interface between materials science and biocompatibility, and integrates cells , natural or synthetic scaffolds , and specific signals to create new tissues . Tissue engineering is viewed as synonymous to "regenerative dentistry" because the goal of tissue engineering is to restore tissue function through the delivery of stem cells , bioactive molecules , or synthetic tissue constructs engineered in the laboratory . Tissue engineering in dentistry takes several forms from gene transfer to osteoinduction .[7]

Nano Tissue Engineering by utilizing cellular and mineral components can generated new tooth . Chen et al by using nanorods like calcium hydroxyapatite crystals which were aligned roughly parallel to each other , created hardest tissue in human body , i.e., dental enamel and pretend the natural biomineralization process. 8 It is also useful in the field of medicine, electronics, biomaterials and energy production. It plays a major role in various biomedical applications ranging from drug delivery and gene therapy to molecular imaging , biomarkers and biosensors.[9]

Determining forces

Dental biomechanics represents a field in which Finite Element analysis is used to improving the design of materials , structures and manufacturing procedures, thus improving clinical results in implantology . Finite Element analysis was first proposed in 1943 by R. Courant to obtain approximate solutions for vibrating systems . It analyzes the effect of load and how to modify load transfer by improving implant design . In a combined finite element model of an implant in bone , stress and strain under conditions of tension , compression , and shear can be calculated based on mechanical properties of each of the materials being modeled . Design improvements will reduce areas of stress concentration , more nearly achieve stress transfer homogenization across the interface , affecting long term bone maintenance favorably at each point on the implant interface .[10]

Impact of a mass on osseointegrated fixtures . (Figure-1)

In case of an unprotected metallic fixed partial denture , the entire construction acts like a stiff unit , and it will therefore produce larger forces. Acrylic resin covering provides internal damping. The duration of force becomes longer and peak force is comparatively less . This is shock absorbing action . Impact loads are lowest with acrylic resin & increases with composite resin metal occlusals & porcelain. Acrylic prosthesis provides progressive bone loading, it may also reduce the impact force on the early implant to bone interface . Forces on implants increase rapidly as the inter implant spacing decreases and the cantilever length increases , affecting the interfacial bone. Forces acting on every abutment in a group of say four or six implants supporting a prosthesis can be analysed by method proposed by Skalak and Brooke-Smith .

Fibre Bragg grating sensors are biomechanical sensor that are used to measure strains at a mandible surface that are caused by static or impact loads on a dental implant . The measuring apparatus uses a fixed optical filter reference scheme and is able to detect dynamic signals with frequency components .[11]

An engineering approach to resolve biomechanical problems involves determining the nature of complications and then designing an approach to eliminate their underlying causes . Treatment planning should incorporate methods to reduce stress and minimize its initial and long-term effects .

Rapid prototyping

Three dimensional printing is very often used rapid prototyping . It printing has the ability to fabricate geometrically complex shapes in a range of materials across different scales . It has various applications in medicine , art ,manufacturing and engineering .Three dimensional scanning is a process of collecting digital data on the shape and appearance of a real object , creating a digital model based on it .Stereolithography is a Rapid prototyping system designed to create solid and detailed , three-dimensional physical models that can accurately replicate complex anatomical structures directly from computer data . Combining the scanned information of reconstructed Computed tomography images with an ultraviolet laser beam sequentially passed over a photosensitive resin , it is possible to produce, from a two-dimensional image , a dimensionally accurate three-dimensiona anatomical model , as a complete replica of the external surface and internal structures (including soft tissues) in a layer-by-layer fashion .[12]

Summary

Engineering is the process of designing , manufacturing , assembling, and maintaining products and systems . Currently, molecular biosciences and technologies are appearing fields in dentistry. Probiotics play a major role in preventing issues with overuse of antibiotics and antimicrobial resistance. Genetic engineering, nanotechnology and ozone therapy will change dentistry , healthcare , and human life more extremely than other developments of the past . Using machine tools to make smaller machine tools, which, would be used to make still smaller machine tools, and so on all the way down to the molecular level, such nanomachines, nanorobots and nanodevices could be used to spread an extensive range of atomically precise microscopic instrumentation and manufacturing tools .

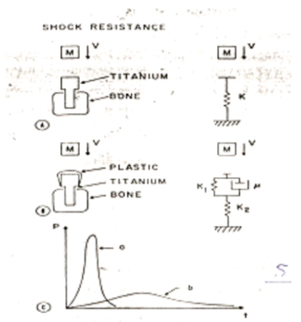

Figure 1 : A - impact of a mass M , at a velocity V onto a metallic fixed partial denture on fixtures that are osseointegrated with bone , System behaves like a spring with modulus K . B - Acrylic resin sheath is placed over metallic fixed partial denture . Softer spring K 2 and dashpot representing acrylic resin . C-Qualitative sketch of force versuses time resulting from impact in cases A & B above .

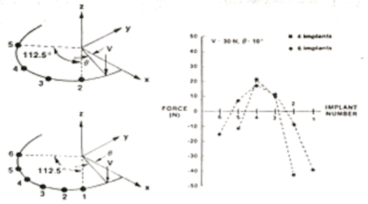

Figure- 2 Skalak model 10

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