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PRE-PROSTHETIC SURGICAL PHASE EMPLOYING THREE-DIMENSIONAL BIOPRINTING MATERIALS: a review

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ABSTRACT:-

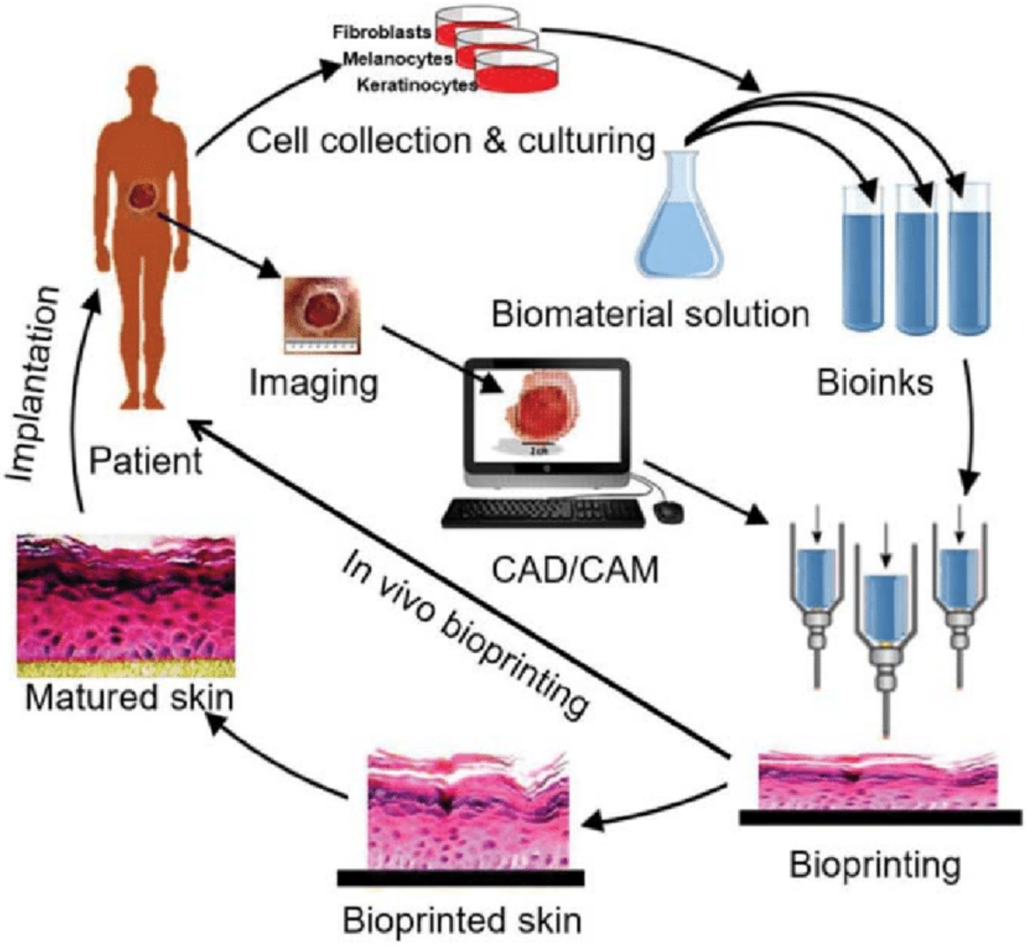
The dentistry field, with its complicated architecture and specialized tissues, poses unique problems that can benefit substantially from the accuracy and personalization provided by 3D bioprinting. The mouth is not only a functional element for mastication and speaking; it also has an important role in aesthetics and general health. It is critical to ensure that the repair or replacement of dental components satisfies both functional and cosmetic standards.The potential of 3D printing to generate extremely precise and individualized dental prostheses in a shorter period has fueled its growth in prosthodontics. Dental prostheses are currently made from a variety of materials, including resin-based materials, metal alloys, and ceramics, utilizing 3D printing technology. Prosthodontics can benefit greatly from the use of 3D printing materials because to their increased precision and customisation, increased time and cost efficiency, and better aesthetic results.This article presents an overview of the impact of some of 3D printing materials in surgical procedures prior to prosthetic rehabilitation.

Key Words: Preprosthetic Surgery, Bioprinting, Scaffolds

INTRODUCTION:-

The prototype machine was developed in the early 1980s by Dr. Hideo Kodama, an inventor who used the layering pattern from 3D topographical maps and the information from 3D scanning. Charles Hull created the Stereolithography Apparatus, or SLA, material in 1984. He went on to develop the first 3D printing business in 1986, which in turn created the first 3D printer in 1987 by employing stereolithography apparatus to print layers upon layers (SLA).
The industry term for 3D printing, also known as additive manufacturing (AM) or additive layer manufacturing (ALM), refers to the computer-controlled method of creating three-dimensional things by depositing materials, often in layers.
Additive manufacturing makes it possible to create products with exact geometric forms by using computer assisted design (CAD) or 3D object scanners.
Unlike traditional manufacturing, which frequently calls for milling or other methods to eliminate excess material, they are created layer by layer, much as using a 3D printing process.
Preprosthetic operations can be revolutionized by utilizing specially created 3D printed scaffolds that firmly and successfully repair the flaws through the application of tissue engineering and regenerative medicine techniques.

Three-dimensional (3D) printing technology enables the creation of a personalized 3D object using a preferred material, a specified computer-aided design, and precision manufacturing. Digital technological advancements, smart biomaterials, and enhanced cell culture, when coupled with 3D printing, offer promising foundations for patient-tailored therapy. In dentistry, the "digital workflow" of intraoral scanning for data collecting, object design, and 3D printing is already in use for the production of surgical guides, dental models, and reconstructions.



Binder Jetting-

Binder jetting use powder materials such as metals, composites, sand, and ceramics that are distributed to form a thin powder bed in a manner similar to selective laser sintering (SLS). Unlike SLS, which utilizes a laser to connect successive layers of powder, binder jetting employs an industrial printer to selectively deposit a liquid binding agent onto the powder. Layers of material are built up based on a CAD file until the required layer thickness is achieved and the final 3D product is completed. Once produced, the components must be cured (if plastic) or sintered (if metal) to complete. Binder jetting, sometimes known as 'inkjet,' is a low-energy and cost-effective method of producing objects.

Directed Energy deposition-

Depending on the specific application or technique employed, the DED process is sometimes referred to as Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Additive Manufacturing (EBAM), Directed Light Fabrication, and 3D Laser Cladding. In order to fuse materials together to form a structure, Directed Energy Deposition involves depositing molten material onto a predetermined area and waiting for it to solidify. Typically, DED machines employ a nozzle positioned on a multi-axis arm that may move in different directions to provide varied deposition. Usually, a regulated chamber with lowered oxygen levels is used for the procedure.

Powder bed fusion-

The same fundamental idea underlies the additive manufacturing technique known as powder bed fusion (PBF), which forms components by adding material instead of deleting it as in traditional forming processes like milling. Creating a 3D CAD model and mathematically "slicing" it into several distinct layers is the first step in the PBF process. A heat source scan route is computed for every layer, defining the border contour as well as a fill sequence (usually a raster pattern as the heat source is usually an energy beam, such as a laser).

Sheet lamination-

There are two methods that fall under the category of sheet lamination: ultrasonic additive manufacturing (UAM) and laminated object manufacturing (LOM). Using alternating layers of paper and glue, laminated object production is well-suited for producing objects with visual or aesthetic appeal. Ultrasonic arc welding (UAM) is a low-energy, low-temperature method of joining thin metal sheets. It is applicable to a variety of metals, including titanium, stainless steel, and aluminum.

Material extrusion-

By depositing a continuous filament of thermoplastic or composite material, material extrusion is an additive manufacturing (AM) technology that builds three-dimensional (3D) items layer by layer. A heated extrusion nozzle is used to feed filament from a spool onto a build platform, where it deposits the heated material.
Extrusion technique and materials are cheap, which makes it the most often used 3D printing method for home hobby usage, even if it is not as precise or quick as other additive manufacturing processes. Material extrusion is utilized in industry to create fast prototypes.

Vat polymerisation-

This method layers an item together using a vat of liquid resin photopolymer. Mirrors are used to direct ultraviolet light, which cures the successive layers of resin via photopolymerisation.

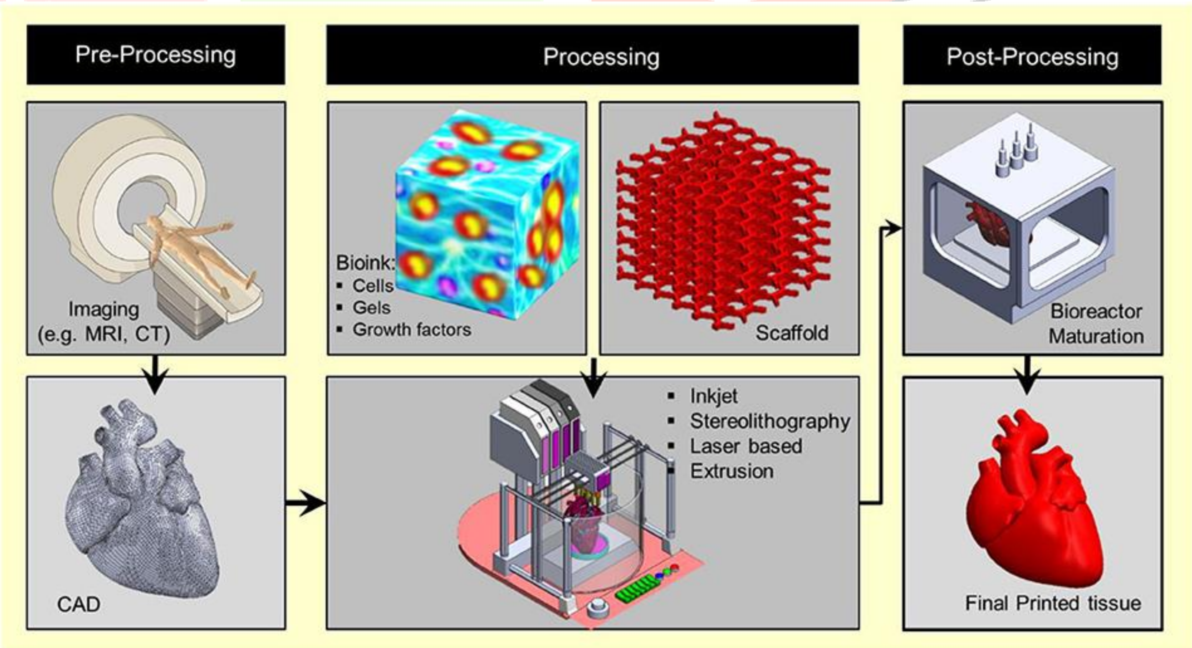
Wire arc additive manufacturing-

Wire arc additive manufacturing employs arc welding power sources and manipulators to construct 3D forms using arc deposition. This procedure often use wire as a material source and follows a preset path to produce the required form. This kind of additive manufacturing is often accomplished with robotic welding equipment.

CLINICAL APPLICATIONS:-

Reagents and biological ingredients are precisely layered cross-sectionally from the bottom during 3D bioprinting. A computer-aided design (CAD) program generates a 3D model, which is the first step in the process. After that, cross-sectional slices of the model are transferred to the AM device, which deposits each layer to create the item. In 3D bioprinting, the complete product may be manufactured in a single step, saving time and money compared to conventional approaches that require many pieces to be assembled.

Artificial grafts that may be more adaptable, safe, and minimally invasive than both autografts and allografts can be created thanks to three-dimensional bioprinting technology. The properties of osteoconductivity and biocompatibility are desired in 3D printed biomaterials. Additionally crucial for vascular development, tissue ingrowth, and the delivery of nutrients to the newly formed tissues is porosity.



Various materials, such as bioceramics, biopolymers, and composites, can be employed to create tailored 3D scaffolds for repairing dentoalveolar defects.

Hydroxyapatite:

Stereolithography (SLS) was employed to create HA scaffolds using the lost-mold technique. Direct-write assembly with viscoelastic inks was employed to create 3D HA scaffolds.Michna et al. customized the design and sintering conditions of HA scaffolds to achieve desired properties for direct-write assembly. Chumnanklang et al described two approaches for incorporating adhesive binder into HA powder: combining as separate grains or coating the powder.According to Irsen et al., HA granulates may not be suitable for 3D printing due to their high cost and poor interaction with binder liquid.

Cell hydrogel :-

For the purpose of producing four-layer constructions, the cell-hydrogel composites were put into a syringe and inserted into the Bioplotter, which was equipped with a pneumatic dispensing mechanism. The findings demonstrated that the implanted cells were evenly distributed throughout the hydrogel scaffolds that had been produced and that the cells had not broken down throughout the deposition process.

Calcium phosphate/collagen:-

Inzana et al.83 investigated utilizing low-temperature 3D bioprinting to create collagen-calcium phosphate composites by dissolving collagen in phosphoric acid as a binder. The use of high-resolution inkjet printing of collagen in 3D printing of calcium phosphates is new. This study examined the impact of high-resolution inkjet printing of collagen on the mechanical and biological properties of calcium phosphate inclusions in vitro. Adding collagen to the phosphoric acid binder solution significantly increased the strength of the 3D printed calcium phosphate, which increased linearly with collagen content.

Biogenic polyphosphate:-

Bioprinted bio-polyP scaffolds offer high resolution and require no further processing, unlike traditional approaches. Bio-polyP promotes bone mineralization by increasing the production of bone morphogenetic protein 2 and inhibiting osteoclastic precursor development into osteoclasts. This preserves bone integrity and prevents resorption. Additionally, the expression of osteocalcin and osterix, which are important in osteoblast development, is elevated. Bio-polyP stimulates the inductive role of the healthy extracellular matrix before sickness or damage.

Titanium:-

Pure titanium may be made to have a modulus similar to bone. Engineers may modify the mechanical characteristics of bulk Ti scaffolds by adding porosity to them. Furthermore, the implant's porosity allows for cell growth.However, traditional approaches have not enabled the creation of porous materials.Ryan et al110 utilized a commercial 3D printer (Thermojet) to create a porous Ti scaffold using a wax template. Porous Ti was created via powder metallurgy by pouring a Ti slurry around a wax pattern.

CONCLUSION:-

3D bioprinting has the ability to translate sophisticated tissue engineering into therapeutic applications by producing regenerative scaffolds customized to patient-specific needs. It is envisaged that ongoing research and improvement in 3D bioprinting, particularly in the processes and materials utilized in dental applications, would lead to a degree of refinement and standardization that may be completely incorporated into the management and practice of resolving oral healthcare issues.

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