The Integration of 3D along with Dental Technologies

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ABSTRACT: ***Three-dimensional (3D) printing is an additive manufacturing technique that involves putting down consecutive layers of material to create a three-dimensional object. 3D printers are devices that create models of things that have been designed using CAD software or scanned with a 3D scanner. Printing is a technique for reproducing text and images using ink on paper. Various techniques, including as selective laser sintering (SLS), stereolithography, fused deposition modelling, and laminated object manufacturing, may be utilized to print different dental parts. Individual imprint trays, orthodontic models, gingiva masks, and other prosthetic items may all be printed using the materials. The material's flexural strength is more than 80 MPa. Digital projects are now more effective in the manufacturing phase thanks to 3D printing. Using a combination of oral scanning, 3D printing, and CAD/CAM design, dental labs may create crowns, bridges, stone models, and other orthodontic equipment. For many years, modern 3D printing has been used to create prototypes, and it is now finding its way into the industrial sector. Using bespoke surgical guides and increasing the quality and precision of dental work, digital technology and 3D printing have greatly increased the percentage of success in dental implantology.***

KEYWORDS: ***3D printer, Cone Beam Computed Tomography (CAD), Three-dimensional, Laser Melting, Stereolithography.***

INTRODUCTION

3D printing and prototyping have grown in popularity in the medical community and among patients over the last 30 years. It has given dentists more comfort and improved the quality of their restorations. Furthermore, as compared to restorations made by dental professionals, rapid prototyping-produced dental restorations are more adaptable and quicker in manufacturing. This article examines the history of 3D printing as well as contemporary technology. Since the 1980s, 3D printing has been more popular. Charles Hull printed a three-dimensional item for the first time in 1983. He invented the first 3D printer that utilized the stereolithography technology, as well as the first virtualization software. They've gotten a lot of interest in areas like architecture because of the enhanced possibility in direct component building, aeronautics because of the simplicity of manufacturing different tiny parts for spacecraft construction, and technical subassemblies in the telecommunications domain. Their use in areas requiring millimetric accuracy has attracted the attention of general medicine experts, who have been using it since the 1990s [1].

Because 3D printers are becoming more widespread, 3D modelling technologies and methods are evolving. Dimensional printing is a relatively recent additive manufacturing method that allows for the creation of a range of geometrical objects utilizing different materials in the form of powder and binder.

Computerized scanning technologies and 3D printing systems have essentially replaced conventional ways for manufacturing prosthetic works in prosthetic treatments. The applications utilized in the creation of 3D printed components are mostly for producing different mechanical parts, and specific computer programmes with object libraries are required to accomplish design pieces. Scanning different prosthetic areas or utilizing digital imaging findings may be used to import dental work designs (cone beam computed tomography). The CAD/CAM technology is well-known in dentistry. The new methods for fabricating prosthetic restorations have almost eliminated the need for dental laboratories' assistance[2].

1.1 3D Printing Technologies in Dental Medicine:

Selective laser melting, stereolithography, fuse deposition modelling, and digital light processing are some of the 3D printing technologies utilized in dentistry.

1.1.1 Laser Melting:

One of the most promising approaches for addressing different issues faced while casting alloys is to create metallic frameworks using selective laser melting technology. Selected laser melting is a layer-by-layer addition method that produces three-dimensional objects by reinforcing selective and consecutive layers of powder material, one on top of the other, with heat produced by computer-controlled laser light[3]. Figure 1 shows schematic of selective laser melting.

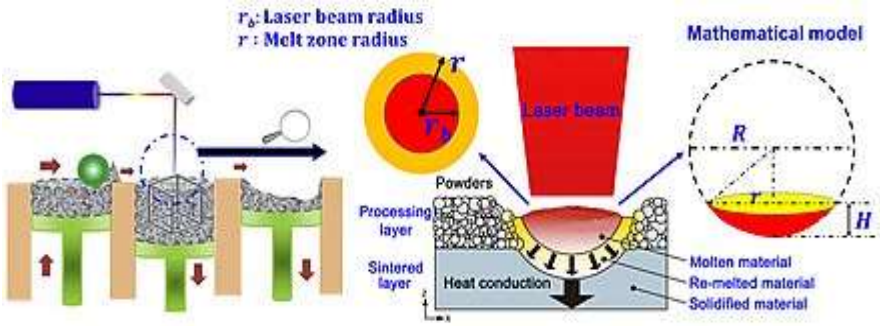

Figure 1: Schematic of selective laser melting and the heat transfer in molten pool [WIKIPEDIA].

1.1.2 Stereolithography:

Stereolithography, a device developed by Charles Hull in the 1980s, is the most widely used fast prototyping technique. This was the first commercially available rapid prototyping printer. The concept is based on a photosensitive monomer resin that hardens and forms a polymer when exposed to UV light. UV radiation produces a reaction that occurs exclusively on the material's surface[4]. Figure 2 shows diagrammatical demonstration of the functioning of stereolithography.

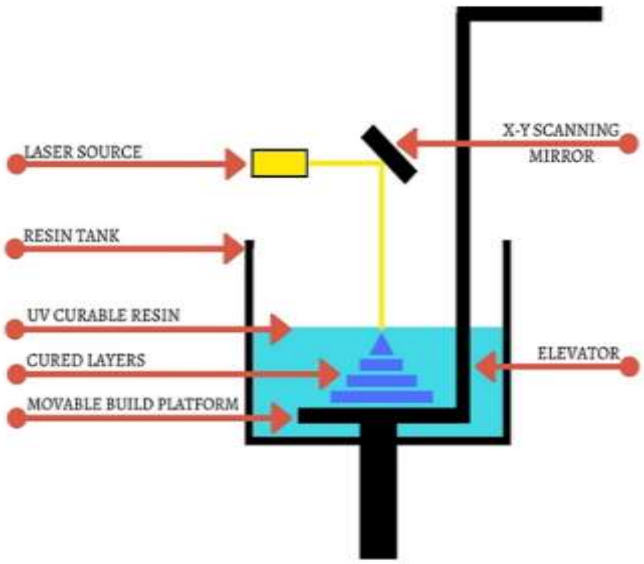

Figure 2: A Diagrammatical Demonstration of the functioning of Stereolithography [MANUFACTUR3DMAG].

1.1.3 Modeling of Fuse Deposition:

The 3D printer builds things from bottom to top by extruding and depositing molten thermoplastic polycarbonate in a layered manner from a computer-aided model or scan in- forming. The layers of molten plastic immediately fuse together, resulting in very complex components that are simple to manufacture[5]. The final object's appearance may be combined using a variety of materials, such as acrylic or wax. Figure 3 shows the fused deposition modeling.

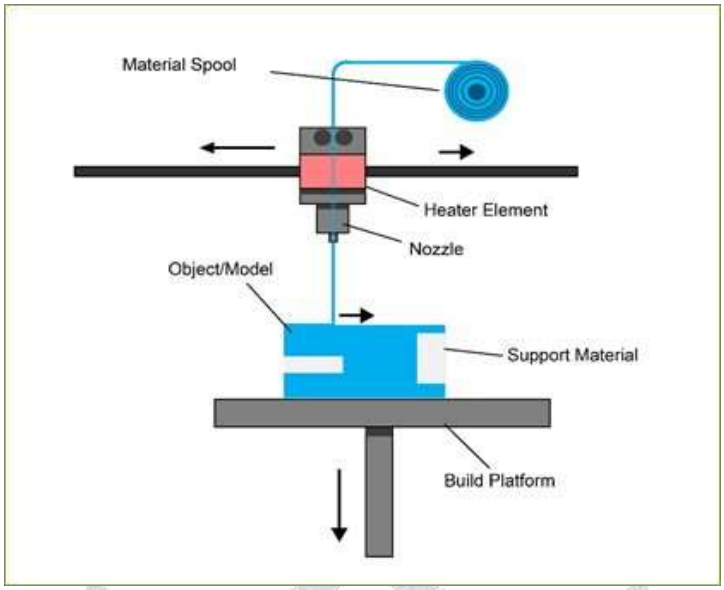

Figure 3: Illustrates the Fused Deposition Modeling [3DPARTSUNLIMITED].

1.1.4 Processing of Digital Light:

Layer by layer, a projector light source cures the liquid resin. The item is built on a platform that may be raised and lowered. The layer is generated backwards. The liquid polymer is drained off and the polymer is layered as the item is being built.

1.2 Dentistry Applications of 3d Printing:

1.2.1 Orthodontia:

Rapid prototyping-based anatomical models are a new technique to surgical planning and simulation (Figure 4). Anatomical objects, such as three-dimensional physical representations of the skull or other structures, may be replicated using these techniques, allowing surgeons to have a better understanding of complicated anatomy before surgery. When moving from a visual environment to one that enables both visual and touch interactions, a new code known as "touch to understand" is introduced[6].

Chemical evidence suggests that fast prototyping may assist to reduce the dangers associated with surgery. Oral surgery may utilize 3D printing methods to make surgical guides and perform different blocks to augment bone abnormalities, and learning modules can use 3D printing to produce mandibles and jaws that can be readily shown to students.

Figure 4: Rapid prototyping-based anatomical Orthodontia models [ALPHAMOM].

1.2.2 Implantology:

In the past 20 years, the use of dental implants has advanced significantly. Oral implantology research has resulted in predictable restorative solutions for individuals who are partly or completely edentulous. The implant-supported prosthesis' predictability is reduced when the implant is placed in the wrong position[7]. Due to the advent of guide-lines for the surgical process to place a dental implant, 3D printing technology has gained favor in dental implantology (figure 5). Rapid prototyping methods allow for the mass production or customization of 3D objects utilizing data from a computer.

Figure 5: Illustrates 3D printing technology in dental implantology [GMS-DENTAL].

3D printers can produce bone tissue that is customized to the patient's needs, as well as biomimetic scaffolds for bone cell augmentation, tissular growth, and differentiation. Novel 3D printed alginate-peptide hybrid scaffolds may also be utilized in bone regeneration techniques. According to research, alginate-based scaffolds offer a stable environment for stem cell development. We can make scaffolds out of composite powders that can be printed. Calcium phosphate (CaP) powders may be mixed with a calcium sulphate ($CaSO_4$)-based 3D printing (3DP) powder, and the scaffolds can be utilized as bone augmentation material[8].

1.2.3 Prosthetics for The Maxillofacial Region:

Congenital or acquired diseases may cause the absence of portions of the external ear. When using prosthetic materials to replace these missing components, the prosthesis should be tailored to better understand its role in the complex. When faults are unilateral, scanning the other side and duplicating the afflicted side is the best option. In addition to ears, scientists have printed cartilage and blood cells[9].

1.2.4 Prosthodontics:

Custom trays may be produced using locally accessible materials or with digital scanning of impressions/models and printing. For the creation of study models for working in a virtual environment, there are two approaches. Scanning the imprint and putting it into a computer is the first approach. The second technique is taking an imprint on a stock or semi-custom tray and then pouring the model into stone. The stone prototype may be scanned or directly utilized in the production process. The research prototype may be duplicated using duplicating hydrocolloid or printed if necessary, as long as a high quality scan is available[10].

1.3 3D Printing Benefits and Disadvantages:

When the benefits of 3D printed restorations are weighed against the benefits of traditional or CAD/CAM restorations, 3D printing restorations will undoubtedly come out on top. They allow for the creation of high-quality repairs in a short amount of time. Several investigations have shown the high quality of these restorations, but cost remains a significant concern. Stereolithography and digital light processing have the drawback of being limited to light-curable liquid polymers and requiring the removal of support materials. Resin is also filthy and may irritate the skin, as well as causing inflammation when inhaled or touched. They also have a short shelf and vat life and cannot be heat-sterilized, despite the fact that they are a high-cost technology. The downside of selective laser melting is that it is a very expensive and time-consuming technique.

2 DISCUSSION

Digital dentistry refers to the use of dental technology or equipment that use digital or computer-controlled components rather than mechanical or electrical instruments to perform dental operations. Both for restorative and diagnostic reasons, digital dentistry may make dental operations more efficient than utilizing mechanical equipment. Used to make dental procedures easier and to suggest innovative methods to satisfy increasing patient expectations. For many years, X-rays have been very useful in assessing dental health. However, since it is just a 2D picture, the image generated may only reveal a limited amount of information at times. Intra-oral cameras (IOCs) provide a good picture of the interior of the mouth to the operator. IOCs feature a small camera around the size of a dental mirror that can detect more on the 3D surface of a tooth than a 2D x-ray picture can reveal. Cavities in particular places and sizes, fractured teeth, severe erosion, abrasion, and other issues are examples. Placing an imprint substance put on an impression tray over the dental arches is how traditional dental impressions are produced. Because it leaves a bad impression on the mouth's soft and hard tissues. Digital intra-oral impressions taken using intra-oral cameras may nearly immediately convert a patient's favorable image of their dentition and other structures into a digital format on a computer.

At the past, dentists would utilize a physical shade guide in the dental office to compare the patient's teeth to the hues in the guide while the patient was in the chair. Newer computer matching algorithms provide a higher level of accuracy than existing matching approaches. When it comes to the human eye and observation, there are always variations in perception. This was shown in a research that discovered a strong statistical connection between a spectrophotometer and the digital camera in use. It is now being utilized in certain dental operations to help enhance communication between the dentist and the laboratory. The accuracy of both direct and indirect digitized impressions used to produce clinically acceptable zirconia crowns was evaluated in two trials. When compared to conventional casting techniques, a considerably lower marginal fit was found, as well as a more precise marginal and internal fit. A double-blinded randomized clinical study was used to assess the efficiency and fit of completely ceramic restorations produced using CAD/CAM. Direct digital impressions were obtained directly from the lips of the patients, whereas indirect digitized impressions were taken from previously produced impressions. The digital imprints were then utilized to mill all-ceramic crowns using CAD/CAM technology. The direct digital impression method was statistically more accurate than the indirect digital impression technique, with substantially better inter-proximal contact. In compared to traditional techniques such as taking imprints using silicone impressions and shipping them to a lab, the whole process proved to be more time efficient for both the dentist and the patient.

The dental hard tissue undergoes structural changes as a consequence of the caries disease process. The loss of mineral content is caused by the passage of ions out of the tooth, which is known as the demineralization process. Bacteria and water will mostly fill the resultant area. This area will have more porosity than the surrounding tissue, resulting in a noticeable change in the optical characteristics of the afflicted dental tissue, indicating that caries has caused the alteration. Caries is detected via optical techniques based on changes in certain optical characteristics. Fluorescence generated by light in a quantitative manner – When a tooth is irradiated with violet-blue light from a camera hand piece, changes in enamel fluorescence may be observed and quantified. The picture is processed and stored. The final result is an image that depicts the size and severity of the lesion. Virtual Reality (VR) is a computer-generated simulation that enables for an interactive experience by completely recreating the environment in which the simulation is run. Augmented Reality (AR) is a kind of virtual reality that allows users to interact with the actual environment via simulation. Because the things and people are computer-generated, they are enhanced, yet they are seen in the actual world via a camera onto a screen.

By using digitally synthesized elements that may replicate real-life circumstances, augmented reality simulations can serve as the basis for training exercises. These may be utilized at any point in a professional's career, from undergraduate students through specialized and training days. In dentistry education, virtual reality and augmented reality technologies are becoming increasingly prevalent. They'll keep changing clinical education to promote more responsive approaches to processing individual learning requirements and self-directed learning. These pedagogical techniques are claimed to reduce educational expenses while improving quality.

3 CONCLUSION

Rapid prototyping will become a commonly utilized technique for 3D reconstructions in the dental laboratory as more research and technical advancements are made. Nonetheless, despite all of the technical advancements in

3D printing, these technologies will never be able to replace the existing dental production processes. As a result, the data provided in this book begs for participation to match the dental technician's invaluable ability, experience, and knowledge. Cost, a lack of willingness to adapt to new dental equipment, and a misunderstanding of new technologies are all barriers to digital dentistry. As digital dentistry evolves and becomes more widely used, the method to integrating the subject into learning objectives throughout dental school must evolve as well. Future dentists must be exposed to new digital processes in the curriculum and instruction as we approach the "digital era of dentistry education." Faculty and ministries should be the ones to encourage integration of digital teaching into the education of future physicians and students, as well as the learning of up-to-date and relevant digital technologies, according to an article titled "Digital Teaching and Digital Medicine: A National Initiative is Needed."

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