REVIEW ARTICLE

From Digital Designs to Dazzling Similes: Unveiling The Potential of 3d Printing In Pediatric Dentistry

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Abstract:
Advances in dental technology have improved diagnostic accuracy, reduced treatment delivery and reduced seat time allowing dentist to provide more effective treatment. 3D printing allows the dentist to visualize, record hard and very soft tissue in a precise scale and print models. 3D printing can be helpful in a variety of treatments. The implications of 3D printing for pediatric dentists include implants for artificial insemination, small oriented endodontics, cutting and cutting machines, pre-operative treatment planning, cavities and restoration, crowns, veneers, bridges, space-regainers, operating equipment, oral protectors and other oral materials with great skill. In this article, we have also discussed and summarized various 3D imaging technologies and the latest developments in 3D digital imaging techniques in an attempt to provide a new perspective and greater understanding of the current construction of 3D dental printing technology. It is expected that this article will explore why 3D printing is important for pediatric dentists, and why dentistry promotes advances in 3D printing systems.

Keywords: 3D Printing, Rapid prototyping, Additive manufacturing, Stereolithography, Computer Aided Designing.

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INTRODUCTION:

Over the past few decades, there has been an increase in the utilization of 3D printing in the field of pediatric dentistry. This technology involves the creation of objects by systematically adding layers under the control of a computer. It is considered an additive manufacturing process, also known as rapid prototyping technology or stereolithography. The public has taken interest in 3D printing due to its precise automated procedures and the use of standardized materials to produce personalized 3D objects based on computer-aided designs

Charles Hull is credited with the invention of 3D printing back in 1983, originally referred to as 'stereolithography'. The technology quickly gained significant public attention for its exceptional precision and performance.The technology of 3D printing is characterized by its remarkable attributes of material efficiency, creative freedom, and the ability to personalize designs. It is a promising innovation that is rapidly gaining traction across a range of sectors including defense, art, design, aerospace, architecture, engineering, medicine, and dentistry[1]

During the early 2000s, 3D printing technology was initially utilized in the field of dentistry to fabricate dental implants, customized prosthetics, and anatomical models. The combination of 3D printing technology and 3D visual models has led to the development of a practical and user-friendly technique that benefits dentists in terms of diagnosis. The dental industry has greatly benefited from 3D printing and is currently embracing the latest trends in digital dentistry. This technology has proven to be valuable in creating precise and realistic models for educational, training, and research purposes, as well as treatment planning. Furthermore, 3D printing designed specifically for dental applications has the potential to provide dentists with more personalized service for patients, while significantly reducing costs. It also has the capability to simplify the complex workflows associated with the production of dental prostheses. The demand for 3D printing in dentistry continues to increase as technology advances, allowing dentists to perform dental procedures with greater efficiency and effectiveness.[2]

3DPrintingTechnology

Most restorations and equipment used to restore and protect your mouth are highly customizable. Traditionally, working hours in a dental laboratory have been invested in producing just one crown. With the adoption of more technology by the dentist, CAD / CAM continues to grow in value with unparalleled benefits to the dentist. 3D dental printing encompasses a combination of computer-assisted design and production (CAD/CAM), oral scanning, design, and 3D printing.

Technically, 3Dprintersarerobotic devices where their tools are nothing but computer-assisted software (design CID) that allows objects to be built in a visible environment. CAD incorporates the design and constructionof3Dmodels for services such as crowns, veneers, onlays, inlays, bridges, dentures, spacecraft, space-regainers, work equipment, mouth protector sand other oral materials with great craftsmanship.[3]

The advancement of computer technology and software applications plays a significant role in the ongoing technological revolution that has propelled 3D printing to its current state. In order for 3D printing to be truly valuable, it is imperative that we have the capability to create printable objects. CAD software enables us to build objects from scratch, while access to volumetric data, such as computed tomography (CT) data, cone beam computed tomography (CBCT) data, and intraoral or laboratory visual area scan data is essential for dentistry and prosthetics applications. Notably, recent advancements in CBCT technology and scanning techniques have brought about substantial changes to various aspects of dental restoration and replacement[4]

The utilization of Computer-Aided Design and Computer-Aided Manufacturing (CAD CAM) for the grinding of crown carriers and bridge structures has become comparable to contemporary dental technology. In the present day, dentists are well-acquainted with the construction materials employed in conjunction with CAD CAM systems, thereby replacing the conventional cast iron tools that have experienced a notable surge in prices in recent times. This technological implementation not only simplifies the handling of materials that would otherwise be troublesome, but also eliminates labor-intensive production techniques, affording the dentist the opportunity to concentrate their craftsmanship on various creative aspects of the production process, such as porcelain aesthetic design.[5]

Each time a dentist performs a rehabilitation or reconstruction procedure, it is customized based on the specific patient, jaw, tooth, or implant. The reconstruction or remodeling process requires accurately replicating the identified geometry, which can be quite complex. While CAD CAM axis grinding processes can achieve this, they are slower and result in waste as material is extracted from a solid block. Additionally, precision is influenced by factors such as the size of the tools used and the properties of the object. On the other hand, 3D printing offers the unique advantage of automating the production of complex structures with a range of desirable properties for dentistry and surgery[6]

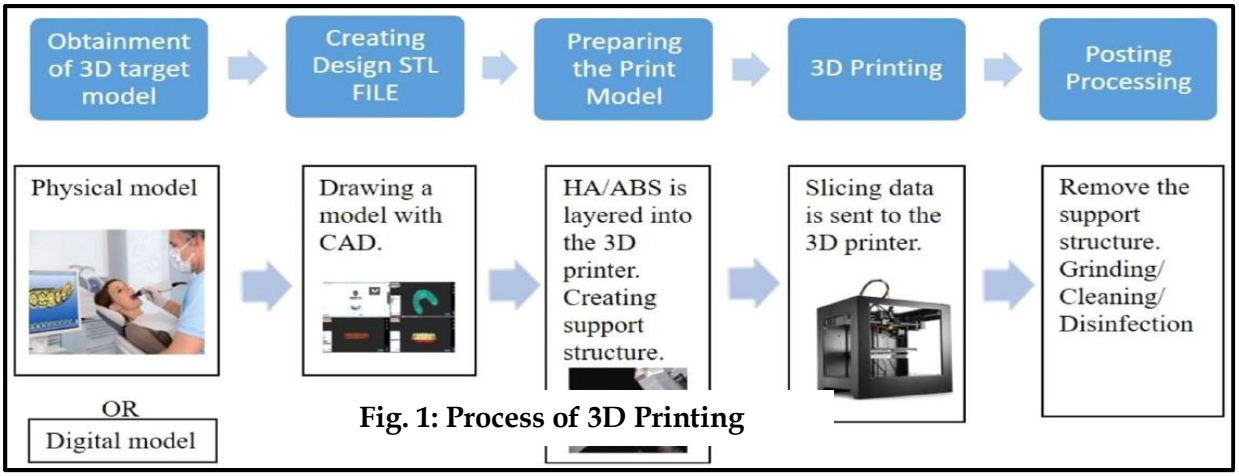

Fig. 1: Process of 3D Printing

UsesofDprintinginPediatricDentistry Oral surgery procedures:

Incorporating the utilization of 3D printing techniques enables the creation of anatomical models, which serve as a novel approach in the planning and simulation of surgical treatment. This innovative method grants dentists with a comprehensive understanding of intricate structures prior to the commencement of the operation. An illustration of the efficacy of this approach was provided by Anderl et al in the early 1990s, where they successfully employed CT-guided stereo lithography to produce an acrylic model. This model was instrumental in facilitating accurate pre-surgical planning and intra operative management for the surgical repair of a wide midline craniofacial fracture in an 8-month-old baby.[7]

In the context of reconstructing maxillofacial defects, it is crucial to not only prioritize anatomical similarity and appearance, but also the restoration of tissue functions. Autologous bone graft, known for its osteoconductive and osteo-inductive structures, remains the preferred method for reconstructing maxillofacial deformities. However, a major drawback of autologous bone graft is the requirement for manual facial manipulation.

Therefore, there is a need for a less aggressive treatment option for osteoporosis. One potential solution is the creation of an animated computer model and fast production, which involves designing a computer-generated 3-dimensional visual image that can be transformed into a solid model for clinical applications. 3D printing technology can be utilized to produce customized building plates and facilitate morphological reconstruction in cases of fractures and reconstructive surgery. Additionally, it can aid in the design and construction of a protective barrier that can absorb titanium mesh[8]

Markers were applied to the models, and CT scans were integrated into the software to produce a visual distortion of the model. Subsequently, a process of smoothing and distraction was carried out. An accurate debugging surgical method was developed to align with the preoperative system. To transfer information regarding pin position and alignment from the computer model to the patient, a 3D printing printer (stereolithographic) was utilized. A simulated surgery was conducted on the 3D printed models, and the outcomes were compared with the predictions made by the computer. The recorded data reveals the disparity between the current state and the anticipated state. The findings indicate that the integration of the surgical techniques with the planning process yielded highly precise results. If

implemented in clinical practice, this approach holds the potential to enhance clinical outcomes for patients undergoing traumatic osteogenesis treatment.

Maxillofacial prosthesis:

Maxillofacial prostheses are commonly used to replace missing parts of the outer ear, which can be attributed to both congenital anomalies and acquired conditions. To ensure optimal functionality and aesthetic appearance, the design of the prosthesis should take into consideration the intricate nature of the surrounding anatomy. In cases where the missing part cannot be accurately replicated, a technique of scanning the opposite side and replicating it on the affected side has proven to be effective. In addition to ear prostheses, advancements in tissue engineering have enabled the printing of cartilage and blood cells.[9]

Dental Implants:

The utilization of dental implants has undergone significant advancements in the last two decades. Researchers in the domain of oral implantology have made great strides in providing dependable solutions for patients who are partially or completely missing teeth. Incorrect placement of implants can lead to decreased stability of the prosthetic structure supported by the implant. The adoption of 3D printing technology has become increasingly popular in the field of dental implants, primarily due to the development of precise surgical guidelines for implant placement. Rapid design techniques enable efficient mass production or personalized fabrication of 3D objects using computer-generated data[10]

According to research findings, 3D printers have the capability to produce bone tissue tailored to a patient's requirements. These printed tissues can be utilized as screws that mimic the properties of natural bone, facilitating the development of bone cells and promoting tissue growth and differentiation. Moreover, in bone rehabilitation procedures, novel alginate-peptide hybrid scaffolds can be created using 3D printing technology. Scientific studies have indicated that scaffolds made from alginate offer a stable environment for the growth of stem cells. Additionally, composite powders can be formulated to create printable scaffolding. By combining calcium phosphate (CaP) powders with 3D printing powder based on calcium sulphate (CaSO4), scaffolding materials that enhance bone formation can be produced.[11]

Restorative Procedures:

As photo-polymerization has been utilized in long-term dental treatments, methods involving UV or light in 3D printing have emerged as the initial options. Frames, therefore, have become the most commonly utilized materials in 3D printing; however, they have displayed some limitations in terms of their structured and simplistic editing properties. Consequently, further testing is required for printed 3D frames. In a conducted study, the availability of temporary resin crowns produced through photopolymer jetting, grinding, and compression methods was assessed (in three groups). Twelve study models were created using the image of the mandibular 1st molar mandibular model. Additionally, a visible crown with a cementation space of 60 micrometers was incorporated in all three groups. The design files were subsequently converted into a Poly-jet 3D printer, and the biocompatible photopolymer was printed with a setting size of 5 micrometers.The study's findings indicate that both Poly-jet and Milling techniques yield more precise temporary crowns in the adjacent and lateral regions compared to the molding group. There were no significant differences observed between Milling and Poly-jet ($p < 0.001$). Further research has concluded that 3D printing offers the potential for producing temporary crowns with greater accuracy than traditional methods. However, it should be noted that despite being deemed clinically acceptable in the literature, 3D printed frames for restoration purposes still encounter issues related to shrinkage.[12]

Advantages and disadvantages of 3D printing

Comparing the advantages and disadvantages of 3D printing, it can be said that 3D print restoration is more advanced when compared to standard restoration or CAD/CAM. It offers high-quality recovery opportunities with fast and easy craftsmanship. The quality of this restoration has been proven in various studies, although cost remains a significant concern. On the downside, stereo lithography and digital light processing are limited to light polymers that need to be stretched,

and supporting materials must be removed. Moreover, the resin used can cause skin irritation and inflammation upon contact with odors. Additionally, the technology has a limited shelf life and vat life, and it cannot withstand high temperatures. Furthermore, it is an expensive technology. Similarly, opting for laser melt also has the disadvantage of being a more expensive technology with a slower process.

DISCUSSION

This work has already integrated digital production technology, resulting in a shift from traditional art processes to digital production for laboratory work. Only the final stages of restoration require manual intervention. The utilization of CAD CAM technology has become prevalent in dental laboratories and is particularly evident in dental surgery. The process of initiating digital scanning and production varies based on the availability of scanning and production facilities. However, numerous laboratories now possess their own scanners and processing units. In the dental practice field, intraoral scanners and CBCT are progressively becoming more commonplace.

All of this indicates that dentists possess extensive knowledge and proficiency in handling substantial amounts of digital data. Additionally, 3D Printing serves as a valuable tool in CAD dental software, allowing for the integration of intricate objects and various materials. This proves advantageous in situations where the structures are distinct, customized; possess intricate geometries, and when 3D scanning data is readily accessible.

In the field of dentistry, the utilization of 3D printing is already prevalent and holds significant potential for the advancement of various innovative treatments and techniques for dental restoration. However, it is worth noting that national regulatory authorities have not yet established specific guidelines pertaining to the application of 3D printing in surgical procedures or dental practices. Nonetheless, there may arise a need for regulatory bodies to direct their attention towards this technology in order to establish suitable standards.[13]

Despite the fact that 3D printing tools and technology have been easily accessible for over a decade, it is the advancement and availability of scanner technology, compliant-powered software, and computational technology that have made a significant impact. This has led to increased awareness and improved access to resources, fueled by both commercial and public interest.

With the advent of milling technology, a plethora of novel material choices became accessible for the fabrication of dental restorations. In a similar vein, ongoing advancements are being made in the field of 3D printing for dental implants, resulting in the emergence of successive generations. Given the extensive application of 3D printing in dentistry, combined with the extensive history of scanning and grinding technology, it can be argued that dentists possess a greater understanding of these additive manufacturing techniques than any other professional group.

CAD software continues to be predominantly utilized by individuals who are well-trained and experienced in operating computers. However, this reliance on skilled operators may not resonate with younger generations. Additionally, the software itself is constantly evolving to become more intelligent and user-friendly. Exciting future advancements in technology that go beyond the obvious benefits of cost reduction, performance improvement, and faster treatments, which are not frequently encountered in our patients, include the capability of 3D printing on digitally colored pottery and incorporating staining techniques. Furthermore, there are developments aimed at reducing the post-processing requirements for metal parts and integrating machining/milling techniques with the workflow of 3D printing metal parts.

All of these factors indicate that the increasing use of digital technology in dentistry has gained significant traction. In the authors' opinion, we have surpassed the stage of early adoption and now have the potential to widely apply 3D dental printing technology in dental laboratories and patient care. The rate of development in this field is notably high, with a focus on not only individual resources but also the integration of equipment and software planning. This comprehensive approach is crucial in creating a seamless, efficient, and well-organized workflow, which will ultimately determine the

successful adoption and integration of this disruptive technology.

With the advent of this new technology, a fresh opportunity presents itself. However, our challenge lies in refraining from viewing 3D printing as a mere replacement for traditional methods, but rather as a means to foster creativity, innovation, and the development of new, cost-effective procedures for our patients. It is crucial for us to resist the temptation of assuming that digital technology is inherently superior, and instead conduct thorough research to establish standards and ensure that the tools entering our laboratories and surgeries can at least replicate the most commonly utilized "analog" procedures.

CONCLUSION

3D imaging, modeling, and CAD technology have had a significant impact on all aspects of dentistry. The advancements in 3D printing allow for the creation of unique and intricate geometric forms using digital data and a variety of materials, regardless of location or industrial setting. Currently, a wide range of dental procedures can be performed using a 3D printer, although there is still a need for further technological development to meet all patient requirements. Orthodontics, for example, already fully utilizes high-resolution printing on resin, and the same technology is employed in printing dental restoration models and patterns for the lost wax process, which are vital in internal scanning procedures. In the field of high-performance and implantation, the use of anatomical models made through various 3D printing methods has become commonplace and essential for the design of complex dental procedures. The importance of a reliable supply chain is widely acknowledged.

Despite the affordability of 3D printers, it is crucial to carefully consider the expenses associated with their operation, equipment, maintenance, and the necessity of skilled operators. Additionally, the need for background processing and compliance with rigorous health and safety protocols must be taken into account. However, beyond these considerations, it is evident that 3D printing will have a significant impact on the realm of pediatric dentistry.

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