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HIGH ACCURACY OF DESIGNS WHEN USING 3D PRINTING IN IMPLANTOLOGY

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Abstract:

3D printing was hailed as a technology that would change the development of dentistry. 3D printing is becoming a subject of great interest in maxillofacial surgery, prosthodontics, endodontics, orthodontics and periodontics. This technology plays an important role in the treatment of dental diseases, and with the development of 3D imaging and modeling technologies such as cone-beam computed tomography and intraoral scanning, as well as a relatively long history of using CAD/CAM technologies in dentistry, it will become increasingly important. The use of 3D printing includes the production of milled guides for dental implants, the production of physical models for orthopedic dentistry, orthodontics and surgery, the production of dental, craniomaxillofacial and orthopedic implants, as well as the fabrication of copings and frameworks for implant and dental restorations. Three-dimensional production has many advantages: improving the quality of treatment, developing personalized medicine and providing high-speed services, which make 3D printing an integral part of the future of dentistry. This article discusses the accuracy of the design when using 3D printing. We also discuss the dependence of the accuracy of models, made by using three-dimensional printing on a number of factors, such as the 3D printing method, the 3D printer settings and the printing program.

Keywords: *3D printing, dental model, 3D printer, precision, additive manufacturing.*

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INTRODUCTION:

Medical imaging technologies include research ranging from x-ray radiology to more advanced and advanced medical imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), and laser digitization. These new technologies can provide detailed three-dimensional images of the anatomy of the area of interest and, therefore, valuable data for diagnostic and therapeutic applications [1-3]. Three-dimensional (3D) printing is the latest technological development that can play a significant role in the diagnosis and treatment of dental diseases [3-7]. This method has a number of advantages over conventional milling. 3D printing allows you to form objects with any geometric complexity, from various types of compounds, composites, or materials. Additive manufacturing systems reduce the construction of complex objects to a manageable, simple, and relatively fast process. These properties led to their widespread use. In addition, 3D printing has a huge potential for improving oral hygiene, which is confirmed in various studies and clinical treatments [5]. Recently, three-dimensional printing technologies have been used for dental reconstructive treatment of patients with maxillofacial deformities [8-10]. The widespread use of 3D printers leads to a shift from a more traditional clinical process to an almost exclusively digital format [11-12]. Visualization of treatment results makes it a promising clinical tool [13]. Its increased use is largely due to the fact that it can provide an individual approach for a short period of time, which corresponds to the goal of individualized medicine, where each patient requires a specific, individual, therapeutic approach [14]. Since one of the goals of modern medicine is to introduce personalized care, 3D printing technology should be used to support such methods for it can provide a specific approach for each patient in a short period of time with minimal costs and maintaining a high quality of service [15]. As we can see, the driving force behind progress in 3D printing for medicine and dentistry is the ability to personalize products, save on small-scale manufacturing, simplify the exchange and processing of patient image data, and modernize education [5]. Training programs using 3D-printed models encourage students and residents to learn dental skills. As knowledge develops, post-graduate programs should consider introducing 3D printing into their curricula [16]. It is very important that clinicians and technicians are familiar with the advantages and disadvantages of automated manufacturing, as these procedures continue to evolve and become an integral part of dentistry [17].

Of particular interest is the accuracy of 3D printing, which is confirmed by the growing number of publications on this topic. The accuracy of 3D printing technology is of great importance for clinical applications [18-21]. Computers are now used to create precisely detailed models that can be evaluated from different perspectives in a process known as computer-aided design (CAD). An automated production process (CAM) was developed to materialize virtual objects using CAD. To convert a virtual file to a real object, CAM works using a machine connected to a computer, similar to a printer or peripheral device [22]. CAD/CAM production is more accurate than injection wax technology, as it is based on minimal human intervention and bypassing several manufacturing steps, such as waxing, casting, and polishing. Automated manufacturing procedures will undoubtedly change many aspects of dentistry in the future, especially in terms of ease of treatment and production time [23]. Also, abutments and CAD/CAM implant frames are better suited than conventional cast components. The designed implant surface has the advantage of smooth processing with certain characteristics, which makes it easier to record accurate geometry with minimal irregularities [24]. To date, the availability of three-dimensional (3D) desktop printers allows cost-effective production of drill guides in dental laboratories, which contributes to the widespread introduction of this technology in implantology [19, 25]. Modern research shows high accuracy of manufactured guides that eliminate external factors that exist in the workflow of controlled surgery [26]. In addition, 3D printing has become an integral part of orthopedic dentistry due

to its accuracy. The use of the milling method using the CAD/CAM system and the additive manufacturing method of 3D printing for the manufacture of dental prostheses is steadily developing, attracting great interest in the field of dentistry [18]. A dental impression is a negative impression of the structure of the oral cavity used for making a dental prosthesis or restoration. Accurate measurement is crucial for making dental restorations with an adequate fit. Mismatch of the implant to the prosthesis due to inaccurate calculation leads to mechanical and biological complications [27]. In the past, using the traditional method, the impression was obtained by pouring a semi-rigid material into a dental impression tray, which then solidified. This procedure was inconvenient for patients, and the accuracy of measurements depended significantly on the level of skill and technique of the practitioners. However, advances in digital technology and the introduction of computer-aided design / automated manufacturing (CAD/CAM) have made major changes to the traditional way of manufacturing, improving the accuracy and quality of services provided.

Future research areas should include evaluating clinical results of treatment using 3D printed objects [16]. This conclusion was reached in the study by Zhang HR, Yin LF, Liu YL, Yan LY, Wang N, Liu G, An XL, Liu B [28]. They built digital dental models using cone-beam computed tomography (CBCT), created a virtual model using 3D printing, and determined the accuracy of the 3D printing of the dental model by comparing the result with a traditional dental impression. The authors concluded that 3D printing models had higher accuracy compared to traditional cast models. Dental digital models built with CBCT provide digital storage of patients ' condition. A virtual dental model made using a 3D printer simplifies the process of clinical examination. FDM 3D printing models (fused deposition modeling) show a high degree of accuracy. Thus, these models are suitable for clinical practice. Today, CAD / CAM is the only means of producing durable, metal-free, color-imitating components in dental practice, including implantology, and also provides the possibility of making indirect restorations [25, 29]. The CAD / CAM method uses sophisticated technologies. The scanner digitizes the prepared tooth, and the frame or restoration is then made in accordance with the previously installed design. In addition, CAD/CAM systems were developed to eliminate or minimize potential sources of errors present in traditional manufacturing technologies [30].

However, the accuracy of 3D printing depends on a number of criteria. Thus, studies conducted by Tahayeri A, Morgan M, Fugolin AP, Bompolaki D, Athirasala A,Pfeifer CS, Ferracane JL, Bertassoni LE, [6] prove that both the orientation of the print and the setting of the resin color affect the accuracy of the print. The setting of the resin color and the thickness of the print layer also affected the intensity of the laser beam. The authors also found that the thickness of the 3D printing layer does not significantly affect the mechanical properties of 3D printing resins. To improve the accuracy of 3D printing of dental materials in the future, work should be carried out using 3D printing systems that allow you to optimize the printing parameters depending on the selected resin.

In addition, depending on the 3D printing method, the machine, and external factors, the accuracy varies, even if the same computer-aided design (CAD) model is printed [6, 31]. There are a number of available 3D printers with the ability to print various objects using a variety of printing technologies. The most commonly used 3D printers are solid-state fused deposition modeling devices (FDM), in which a thin plastic thread is used to lay layers to create a plastic object. Powder 3D printers, such as selective laser sintering, use nylon or a similar thermoplastic powder that is locally melted by a laser beam. Recently, various liquid-based 3D printing technologies have been introduced, such as stereolithography (SLA) and digital light processing (DLP), as well as PolyJet (photopolymer inkjet). Ultraviolet (UV) curable resin is polymerized to form the desired shape by light sources in these technologies [4].

Kim T, Lee S, Kim GB, Hong D, Kwon J, Park JW, Kim N [31]conducted a study that evaluated the differences between the CAD model and printed parts with a simplified guide developed on the basis of the implant guide, and compared the accuracy between 3 types of 3D printers. The guide of the upper and lower jaw implant, made of complex anatomical structures, is difficult to accurately measure. For accurate measurements, 16 simplified guides were developed based on the upper and lower jaw implant guides, which were manufactured using the following 3 different 3D printer technologies: photopolymer inkjet (PolyJet), stereolithographic apparatus (SLA), and inkjet printing (MJP). Each simplified guide was measured 4 times with digital calipers for 20 linear measurements. The measured simplified guides were compared with the CAD model, and the accuracy of 3D printers was also compared. The researchers came to the following conclusion: when comparing CAD models and 3D-printed parts of simplified guide implants, there were significant differences in accuracy. PolyJet and SLA 3D printers met the required accuracy for clinical applications in dentistry. However, the most

appropriate 3D printer should be selected taking into account all the circumstances of the specific clinical situation (patient's condition, clinic equipment, doctor's skills, etc.).

CONCLUSION:

3D printing has a number of advantages that allow it to compete with traditional methods of making models and even displace them. These advantages include high accuracy, which is a key factor in the effectiveness of the treatment and allows you to use these models everywhere in clinical practice, reducing the operation time, high aesthetic qualities, the prospect of developing personalized medicine, which is a key goal of modern medicine, ease of use and the ability to create objects of varying complexity. All this contributes to the use of this technology in the diagnosis and treatment of dental diseases of all directions. These advantages stimulate the creation of new and improvement of old models of 3D printers and printing programs, which makes it possible to improve the result of this technology, facilitate the work of the doctor and use this technology in new areas of dentistry. In addition, there is a trend to develop new, cost-effective, durable, accurate and biocompatible materials for 3D printing. Thus, the introduction of three-dimensional printing in dentistry can improve the quality of medical care provided to the patient.

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