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Review Article

Application Status and Prospect of Three-Dimensional Printing Technology in the Field of Medical Devices

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Abstract: Three-dimensional (3D) printing technology belongs to a new manufacturing science and has been widely used in various fields of industry. This article will apply 3D printing technology as its main research topic, with emphasis on its application in the field of medical devices and prospects for contribution.

Keywords: *three-dimensional printing technology; medical equipment; application status; prospects*

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0 Introduction

Three-dimensional (3D) printing technology is additive manufacturing, also known as rapid prototyping technology. It uses 3D data to combine materials with each other through multiple layers to achieve the goal of its manufacturing component. In comparison to the limits of traditional processing technology and design constraints, it has become possible to achieve a mold without the aid of a cast. Using high-quality materials, the design to delivery cycle has been reduced while many processing materials are widely used in research, development, and production. Therefore, an in-depth study and analysis on the application of 3D printing technology in the field of medical devices reflect the need for consideration in its practical significance in the future prospects.

1 Application of 3D printing technology in the field of medical devices

Compared to the traditional process, the additive manufacturing technology is not ideal for controlling the precision of its by-products. With its high cost, the target for a simple structure of mass production cannot be achieved. Rapid changes in manufacturing methods resulted in greater freedom in design and an improved manufacturing procedure; therefore, the process of producing complex and individualized structure proved to have a greater advantage in both cost and delivery time[1].

First of all, the process of manufacturing and processing complex medical equipment could ensure the customization of the retentive structure and density reduction. At the same time, specific designs can be completed within a precise range.

Second, it allows the processing of personalized custom prostheses. This technology considers the individual characteristics of the patient. It complements the computed tomography (CT) and other diverse clinical diagnostic techniques where 3D computer data are produced, evident in the fields of orthopedics and plastic surgery.

Finally, it promotes sustainable development of artificial organs. The 3D printing technology can be used in tissue engineering on biodegradable stents, where 3D cells are assembled.

1.1 Polymer

The use of polymeric materials in the medical field is prevalent in clinical history. It is a technique used in pre-operative protocols along with surgical simulation and prosthesis. Based on the results of a CT scan, the patient's lesion area can be reconstructed with the help of 3D technology. This model can be used as an orthopedic template to achieve the form of an orthopedic implant before surgery. It also reduces the duration of the procedure when implanting a personalized wax film.

Polymeric materials are also widely used in the modeling of tissue engineering scaffolds, cell adhesions,

and tissue growth[2]. Compared to conventional techniques, the polymer produces a greater degree of freedom to the structure and contours of human organs. It increases the possibility for personalization and control more effectively, which promotes a positive development for tissue engineering.

1.2 Metal

The increasing demands in the field of aerospace in the recent years resulted in a heightened development of metallic materials by the material manufacturing technology. At the time, the technology was extensively used for processing materials such as stainless steel, aluminum, amorphous alloy, die steel, and so on. During the manufacturing process of metal materials, the most significant technical focus is placed on LENS, EBM, and so on. The help of electron beam and high-energy laser also ensure the metal component to be heated directly. From here, the complex structure will be formed after a layer has been developed. Over the recent years, the processing and manufacturing technologies have been thoroughly researched and widely used in the commercial field.

However, it is imperative to note that the process of the electron beam and high-energy laser still cause residual thermal stress. This result in deformation and micro-cracks occurs in the inner structure, which directly impacts the performance of the material. Internal defects such as the micro-cracks and closed voids can be solved through hot isostatic pressing. If the problem persists, one will need to effectively control the quality of the raw materials and production processes to achieve the corresponding goal.

In comparison to conventional techniques, roughness on the surface caused by laser cladding and the use of a large surface area could significantly improve the biocompatibility of materials. Furthermore, the porous alloy structure could provide an indispensable 3D environment for the growth of cells and accommodates more space for blood vessels and the nervous system. The strength of the structure and materials in this mixed interface is continuously enhanced with an improved 3D structure in the formation of bone tissues[3]. Using hydrochloric acid (HCl) and sodium hydroxide (NaOH) as the core entity of the molded structural components, the bioceramic coating is treated and coated, which enhances the biocompatibility of the material.

Therefore, the application of 3D printing technology provides the necessity for the customization of porous structures on metal materials which moves beyond the traditional process. With appropriate use of the porous structures, it guarantees increased biocompatibility of the implant and enhances the outcome of bone fusion. At the same time, it achieves the ideal mass reduction based on the mechanical behavior, reduces the rigidity of the metal structure, and effectively matches the natural bone structure. 3D printing technology stands out as it can be used in different application environments in various parts of the corresponding material and structure to ensure that the performance is consistent with the design requirements.

The application of 3D printing technology in the personalization of technical implants emphasizes in the following aspects:

1. The shape of an implant sustains its individual characteristics. Due to the distinct differences in individual bone structures, it can be difficult to work with the surrounding environment of implants if they are produced on a large scale. This is most evident in ultraprecise surgeries; with plastic surgery being is the most obvious example. For this reason, 3D printing technology offers the tool to personalize and customize implants that meet individual demands with high effectiveness and economic sustainability.
2. The fine structure of the implant is characterized by individuality. To obtain steady control over the fine structures, it is possible to succumb to the nature of biology and the different parts of mechanics using the same medical device by securing the surface structures and mechanical properties. This ensures the features of the bionic characteristics to be fully visible.
3. Based on the analysis and research of the preceding two factors, it demonstrates that 3D printing technology can be applied to the characteristics of metal in the field of medical devices. Since then, changes have been made to existing modes of diagnosis to produce and manufacture implantable medical devices. The model of 3D data can be obtained by the means of CT and other related clinical diagnosis and treatment. In addition, the 3D computer-aided design of the implant is based on the combination of reverse engineering. The 3D printing technology has become a manufacturing standard in the rationalization of STL data input. Therefore, the use of the relevant software will ensure a comprehensive 3D data, vertical

conversion, and the formation of two-dimensional segments.

2 Application prospects of 3D printing technology in the field of medical devices

In the recent years, China's research aptitudes in the field of additive manufacturing, especially in the field of aerospace, have achieved great heights. Moreover, major Chinese universities have launched research and development programs catering to the diverse technological needs with a remarkable outcome. However, the application and study of 3D printing technology in the field of medical devices are still scarce. At present, the Fourth Military Medical University has used RP technology to improve the development of half-face plastic surgery[4]. At the same time, local hospitals used the RP model to carry out complex hip reconstruction surgeries that lasted up to 9 years. The use of service modeling language (SML) technology processing methods in medical materials is applied through the interpenetration of porous titanium alloy structure, which became a benchmark for a successful reconstruction of porous femoral models.

Some experts have also used the SML technology to successfully construct a personalized bone plate in bone tumor surgeries. Clinical results demonstrate that the appropriate use of this technology highlights the importance of surgical removal on the area of the lesion, at the same time; it serves as a prototype for allogeneic bone transplant.

3 Conclusion

The future developmental prospects of 3D printing technology yield great potential through continuing growth, innovation, and progress. The medical enterprises of the fourth generation have also laid a solid foundation in the market prospects and commercial development. However, the cost of research and development for this technology is high with limited clinical data, as a result, the commercial development has been adversely affected. At present, financial support plays a key role in preserving the commercial operations of 3D printing technology.

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