Research progress of 3D printing materials in stomatology

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Abstract. 3D printing technology is gradually used in the field of stomatology, such as repair, planting, orthodontics and other disciplines. 3D printing process mainly includes four aspects: oral scanning, Digital design, 3D printing materials and 3D printing technology and equipment. The properties of 3D printing materials are the key factors affecting the effect of 3D printing. This paper reviews the research and development of 3D printing materials in stomatology at home and abroad in recent years and prospects the future development of 3D printing materials in that field.

1. Introduction
3D printing technology is usually called additive manufacturing, based on the data of three-dimensional mathematical model, eventually forms a three-dimensional entity through layer by layer superposition[1]. The main advantages of 3D printing include improving manufacturing accuracy, simplifying tedious manufacturing process, saving processing materials and human resources, economic and environmental protection, shortening production time and improving production efficiency, realizing personalized production.

In the field of stomatology, 3D printing technology has been more and more widely used and studied, including oral repair, oral implantability, orthodontics, oral medicine. It also includes the manufacture of dental implantation guide plate, craniofacial and plastic surgery implantation, as well as the manufacture of inner crown and skeleton for implantation and tooth restoration, etc. With the continuous development of stomatology, the research of 3D printing materials has become the focus of many researchers. In recent years, great breakthroughs have been made, and new 3D printing materials have been used in the field of stomatology. In this paper, the 3D printing materials of gold, polymer, ceramics and bioactive materials in stomatology are reviewed.

2. Material type
2.1 Metal material
Dental metal products require metal materials to have good mechanical properties, chemical properties, biocompatibility and corrosion resistance. The requirements for raw materials are also very high, including high purity, low oxygen content, fine particle size, good plasticity, good liquidity and so on. At present, 3D printing metal powder materials mainly used in stomatology include titanium, titanium alloy, cobalt-chromium alloy, stainless steel and so on.

Among them, titanium and titanium alloy materials have the advantages of low density, high accuracy and high strength, and this kind of material has good biocompatibility, which is regarded as more ideal 3D printing metal material in the field of stomatology. Especially in oral and maxillofacial restoration, dental tissue repair and related implantation system [2] and other fields. Due to the defects of some properties of pure titanium, such as the strength of pure titanium is not as large as that of titanium
alloy, and the elastic modulus of pure titanium is higher than that of bone tissue, it is easy to cause the mechanical stress of titanium implant and bone fabric. For this reason, many researchers have tried to improve the properties of pure titanium in a variety of ways, such as adding coating or oxidizing pure titanium surface to its surface [3].

In the aspects of physical and mechanical properties, biological corrosion resistance and compatibility, it is necessary to deeply study whether the metal products printed in 3D are similar to those made by traditional processes and whether they are in accordance with the national standards. At present, new metal materials are still in the field of stomatology in vitro, especially as oral implantation materials, there is still a lot of research space. At present, 3D printing technology continues to develop, constantly optimize the performance of equipment and a variety of metal printing materials, metal 3D printing technology will also be more widely used in various fields of stomatology.

2.2 Polymer material
Polymer materials have become the basic mature printing in the field of 3D printing. As the representative of polymer materials, plastic has good thermoplasticity, mobility and rapid cooling adhesion, as well as its rapid curing properties [4]. In addition, because the polymer material has good adhesion, it can form new composites with ceramics, glass, fiber, inorganic powder, metal powder and so on. In stomatology, polylactic acid, Polycaprolactone, polyhydroxypropyl fumarate and so on are common 3D printing materials.

Polyether ether ketone (PEEK) is a thermoplastic polymer currently used to make 3D printing satellites, 3D printing automotive parts, and began to play a real shadow role in the 3D printing industry. The advantages of PEEK materials include: (1) The elastic modulus of PEEK material is similar to that of human bone, and the stress of skull is complete after repair; (2) X-ray transmission performance is good and does not produce metal artifacts, affect medical images, which is convenient to detect postoperative recovery; (3) the structure made of 3D printed PEKK material has better antibacterial performance than traditional PEEK, and can be sterilized and reused at high temperature; (4) PEEK itself has strong inertia, little stimulation to head skin, low rejection and high stability. It is currently used in the manufacture of denture parts.

From the development of 3D printing technology, light-cured stereoscopic forming belongs to the earliest and most mature technology, and has been widely used. 3D printing Guang Min resin, that is, light-cured resin, UV resin, It is a widely used polymer material in the field of stomatology. For the field of stomatology, liquid resin materials need excellent stability, low viscosity, rapid curing and high degree [5]. Some studies have shown that liquid Guang Min resin can be printed into biodegradable tissue engineering scaffolds, and the scaffolds made by light-curing rapid prototyping technology have the same mechanical properties as human cancellous bone. And it can promote the adhesion and differentiation of fibroblasts. The rapid development of light-cured resin materials continues to promote the progress of stomatology, which is conducive to the more personalized and accurate oral cavity medicine.

2.3 Ceramic material
Ceramic materials in the field of stomatology require good aesthetic and biological compatibility, low density, high strength, high hardness, high temperature resistance, corrosion resistance, good chemical stability and other excellent physical and chemical properties. It is widely used in machinery manufacturing, aerospace, biomedical and other industries. Because of its excellent mechanical properties and aesthetic properties, it is also used as dental repair materials. When zirconia ceramics are machined by cutting technology, a lot of materials will be removed, resulting in waste, resulting in the high price of all-ceramic crowns. It may also have internal crack caused by cutting force in denture. 3D printing zirconia ceramic denture has a utilization ratio of more than 90%, which is relatively low cost. 3D printing zirconia can reduce material waste and environmental pollution. The imitating properties of hardness and other mechanical properties can be realized by printing special internal structure. In the early 3D printing and manufacturing of zirconia, laser sintering was the main method, but there were
some problems, such as low density and forming efficiency, rough surface and crack [6]. Light-cured ceramics have good surface quality and structural accuracy controllability, and have become a hot research topic. At present, there are still some problems in 3D printing of zirconia materials, such as large internal stress, easy crack after sintering and large volume shrinkage, which may affect its mechanical properties and clinical suitability. Ceramic materials and their processing technology still need to be further studied.

2.4 Biological tissue material

The use of 3D printing materials and technology to produce human cells, tissues and organs with good biological function has been the pursuit of many scholars. Scholars continue to explore 3D printing technology, and closely combine biological tissue engineering technology to make biofunctional artificial cells, tissues and organs to replace the missing tissues that need to be repaired. Hydrogel is a kind of water-soluble polymer, which is produced by chemical or physical cross-linking. It is a kind of 3D network structure [7]. Hydrogel has excellent biocompatibility, can construct tissue engineering scaffold, and can be processed to form controllable drug release carrier. However, at present, the hydrogel written by 3D drawing organisms has low hardness, which may lead to structural collapse or limit the complexity of shape. Therefore, the latest progress of 3D printing biomaterials will promote the progress and development of 3D printing biomaterials domain. In the field of stomatology, whether personalized biological tissue materials or existing finished products, 3D printing products play an important role in dental and oral surgery [8]. At present, 3D printing technology basically realizes the biological printing of human dental pulp cell (human dental pulp cells, hDPCs, which lays the foundation for 3D biological printing technology to be more widely used in tooth tissue. Furthermore, the fusion of hydroxyapatite and Guang Min polymer can be used to fabricate bioactive bone tissue engineering scaffolds.

3. Prospects for development

In recent years, 3D printing digital oral technology has brought high precision and low cost oral data and products to stomatology. The application and development of 3D printing in the field of stomatology will also be enhanced day by day. Therefore, the research and innovation of oral 3D printing materials is even more urgent. Although at present, there are still some problems in the field of stomatology, such as: most of the printing materials rely on imports, resulting in high prices, 3D printing technology and equipment need to be improved and improved; The quality and use of 3D printing materials need to be further investigated and studied, and relevant specifications and standards need to be established to standardize the physical and chemical properties, mechanical properties, biosafety and so on of 3D printing materials in the field of stomatology. In order to promote the wider application of 3D printing technology in the field of stomatology, the research and development of biological safety, mechanical properties and printing technology need to be further deepened. 4D printing and other high-tech technology is the key direction of 3D printing in the field of stomatology in the future. At the same time, in the course of the research, we should fully grasp the relevant policy guarantees of the country, and of course, we also need to consider the binding force of the CFDA (State Administration of Food and Drug Administration). It is believed that in the near future, with the development and innovation of 3D printing materials and supporting material processing methods, 3D printing materials and technologies in the field of stomatology will bring revolutionary development to the clinical application of oral cavity.

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