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Short Commentary

3D Printing for Customized Bone Implants

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Due to the rapid increase in aged population and/or traffic accident in many countries, the demand for replacing dysfunctional hard tissues with artificial components such as hip and knee implants is increasing. For patients with extensive bone loss or deformities, standard off-the-shelf orthopaedic implants often do not provide an acceptable clinical solution. To successfully treat such patients, customized devices with the external geometry derived from the patient's Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) data must be manufactured. Such patient-specific devices have the potential to reduce surgery, recovery and rehabilitation times, restore correct joint kinetics, improve implant fixation and reduce the likelihood of revision surgery. These combined factors reduce the patients' pain and suffering and should result in a considerable reduction in hospitalization time and medical costs. Therefore, it is important to fabricate patient-specific implants with high quality by reducing the risk of repeating surgeries and alleviating the pain of patients.

Titanium alloys are receiving a great deal of attention in both medical and dental applications. In addition to the well-known CP-Ti and Ti-6Al-4V alloy, many beta type titanium alloys comprising non-toxic and non-allergic elements have been developed for the next generation of bone implant material [1-9]. However, the hard machinery and high cost of materials removal arising from the conventional manufacturing processes are the two main obstacles of various potential applications of titanium alloys. Emerging advanced manufacturing technologies, Additive Manufacturing (AM) techniques, also known as 3D printing, are providing the ideal platform for the creation of these customized devices, where three dimensional complex parts could be realized by sequential production of two dimensional layers [10]. Thus, it facilitates the manufacture of parts with almost no geometric constraints and is economically feasible down to a batch size of one. So far, many titanium alloys components for implant have been successfully manufactured [9-23], where the 3D printed titanium alloys exhibit enhanced mechanical properties [9-12] and wear resistance property [14], reasonably excellent corrosion resistance properties [21-23]. The corresponding porous components, designed for further decreasing the stiffness of the implant materials to that of the bone, have shown very good fatigue properties [17-19]. The in vivo tests indicate that the porous titanium alloy scaffold components manufactured by 3D printing techniques could gain fast bone tissue in growth and show outstanding osteointegration and better mechanical properties compared to the traditional Polyether Ether Ketone (PEEK) counterparts, thereby illustrating excellent potential for clinical implants [24,25]. On the other hand, 3D printing techniques are capable of manufacturing many real components such as acetabula cup [9], screw placements and the customized implants [9,26].

Usually, increasing the time in surgery means the increase in the risk of operation. Fortunately, 3D printing, as an emerging technique, makes it possible to reduce the surgery operation time. 3D printing could be an accurate method to manufacture the implants to replace fracture bone for specific patient. Many literatures have demonstrated that, derived from the patient's 3D data by CT or MRI examinations, patient-specific 3D printed implants match the defect area well with the satisfactory of the patient's size and shape thereby enhancing the success of orthopedic surgery [27,28] through optimizing the surgery strategy to reduce the intraoperative fracture prior to surgery and shortening the surgical time. These patient-specific implant surgeries are easily for operating, which reduce the surgery time and improve good healing for maxillary defect. It has been pointed out that the patient-specific titanium calcaneal prosthesis, which is ready for use only within several days from order to be produced [29].

Because the 3D printing technologies have exhibited many advantages in comparison to other traditional technologies, such as ability to manufacture patient-specific complex component, high material utilization, support of tissue growth and the unique customized service for individual patient, 3D printing is considered to have a large potential market in medical fields.

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