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3D Printing Technology Applications in Occupational Therapy

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Abstract

With the rapid development of three dimensional technologies in last three decades, it is widely spread worldwide and made dramatic impact into various fields such as medicine, dentistry, other health care and engineering area. The promising future of this 3D printing technology made new future in the medicine to design the various hard tissues, models of body parts, implants, orthosis and prosthesis with high accuracy. This paper focuses on the possibilities and benefits of 3D printing technology in the occupational therapy research or clinical practice and presents the different procedures for creating different types of three dimensional physical models.

Keywords: 3D printing; Occupational Therapy; Three dimensional Printing; Assistive devices

Introduction

Three dimensional (3D) printing is a novel emerging technology widely used for various fields such as medical, engineering, educations, and other industrial areas. It is the process of making three dimensional physical models by using 3D software, computer, and printer. The 3D printing technology is also called as by various names such as solid imaging, additive manufacturing, medical rapid prototyping, layer based manufacturing, laser prototyping, and solid free form fabrication [1]. This technology has been wildly used forproducing various types of customized low cost medical devices, but it is still in the infancy status in theresearch and clinical practice area of occupational therapy. In this review, we tried to explore the sources of three dimensional printing, 3D scanning method and the possibilities of future application of 3D printing technology into occupational therapy.

Using 3D Printing Technology in Health Care

With the rapid evolution of reverse engineering, 3D scanning or imaging technology and Computer Aided design, it helps to make three dimensional physical models of human body parts based on additive manufacturing method [2-4]. Outcome of 3D printing models has been used in medicine for various applications such as education and training tool, using in surgeries (Orthopaedic surgeries, spinal surgeries, customized orthosis and prosthesis), tissue and organ fabrication (heart, liver and pancreas), producing different types of medical implants, making of anatomical models of human body parts, stomatology, dental implants, hearing aids, and pharmaceutical research [5-9]. In term of cost, 3D printing method for making medical devices or implants are considered as cost effective and can produce in less time. Therefore, it helps to increase the productivity of effective customized medical devices with low rate [5,10-13]. There are number of methods used to create 3D printing physical model (RP model) such as selective laser sentring (SLS), stereo lithography (SLA), laminated object manufacturing (LOM), fused deposition modelling (FDM), Solid Ground Curing (SGC), 3D three-dimensional printing (3DP), Ink Jet printing techniques, vacuum casting and milling (VCM), two-photon polymerization (TPP), direct laser metal sintering (DLMS) [6, 14]. In medicine, there are different types of materials are used to create rapid prototype model of medical devices and implants such as stainless steel, Cobalt Chromium alloys (Co Cr), titanium (Ti) alloys, Polycaprolactone scaffolds, polymer-ceramic composite scaffold with made up of polypropylene-tricalcium phosphate, Ceramic materials-Porous ceramics, Alumnia, Zirconia, Calcium phosphate-based bioceramic , other bone cement materials and other biocompatible materials [14-15].

In the 3D scanning technological point of view, computerized tomography (CT), magnetic resonance imaging (MRI scan) has been used to take acquire the 3D images of the body parts. Initially, the acquired three dimensional images from the CT and MRI will be analysed with 3D software such as Mimics, 3D Doctor and then it will be converted and saved as STL file. Finally, the STL file (format) is transferred into the RP machine to create the physical model. The following Figure 1 shows that 3D printing machine.

3D Printing Technology Application in Occupational Therapy

Although 3D printing technology are rapidly increasing to use in

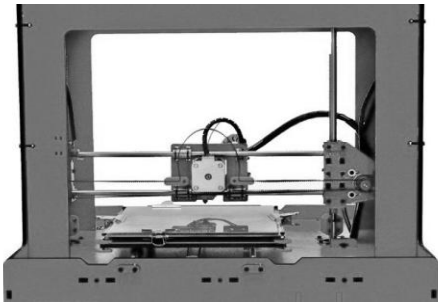

Figure 1: 3D printing machine (Source: www.3ders.org) (adapted and modified).

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Key Guard for tremor problems

Smart phone rotation mount for limited hand function

Mouth Stick Holder

Figure 2: Different kind of assistive devices created by Occupational Therapy by 3D Printing technology [16] (adapted and modified).

Figure 3: 3D-Printed Grip with Stylus [17] (adapted and modified).

the medicine, its application in the occupational therapy research and clinical practice area is on early stage. Based on the literature search, there are only very few information collected through the online search and form the different databases such as PubMed, Scopus, CINHAL. One of the authors (Occupational Therapist) explored and described about the possibilities of 3D printing technology in creating of assistive technology for disabled persons such as ipad key guard for hand tremor, mouth stick holder [16] (Figure 2). 3D printing technology can also be applied in the classroom setting those students are having problems of hand function such as 3D printed hand grips. The following different types of assistive devices were developed with occupational therapist suggestion and design for classroom setting: Highlter grip holder, Container grip, bottle grip holder, and rocker grip holding device, large crayon, and painting brush grip holder (Figure 3 and Figure 4) [17]. However, Understanding of 3D technology and application of 3D software, and 3 dimensional prototyping is essential to implementing the design of desired assistive and adaptive devices. Assistive technology has very crucial role in daily life of disabled people to make easier to perform their daily living activities without any barriers.

E-resources of 3D Printing in Occupational Therapy and Clinical Applications

Based on the on hand-Google search, there are number of customized three dimensional products has been made by occupational therapist or biomedical engineer such as finger guide for

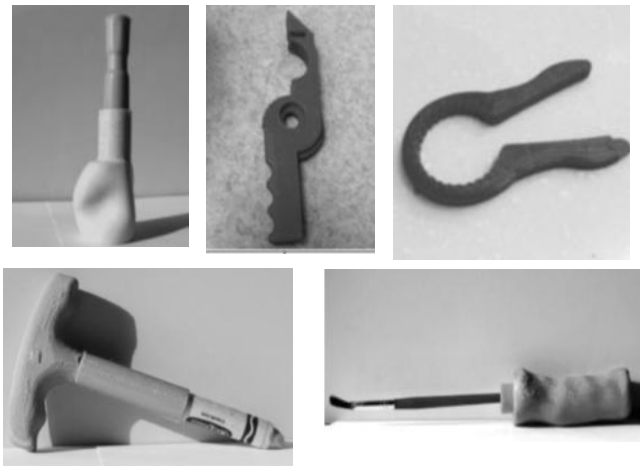

Figure 4: Different types of 3D printed grip design [17] (adapted and modified).

Finger grip holder for pen

BIOT hand prosthesis

Glass holder

Hand grip holder for eating utensils

Figure 5: 3D printing devices by occupational therapist and bioengineers, (adapted and modified) [18-19, 25].

pen, BIOT hand prosthesis [18], glass holder for poor hand function, and hand grip holder for eating utensils [19] (Figure 5). These online resources might give the idea for occupational therapists to create new assistive devices at any kind of design according to the requirements of the physically impaired patients.

Process of 3D Printing

The three dimensional printing technology involves with several steps such as obtaining, 3D scanning, processing the acquired images by 3D software, 3D printing and clinical application in different conditions and as per needs of the patients such as assistive devices of stroke and other neurological patients, splints for hand problems, learning aids for special needs children. Also, designed prototyped-anatomical body parts, 3D model can be used as teaching aid for the occupational therapy students. The process of 3D printing method is described below in Figure 6. Commercially available 3D scanners are expensive. Therefore, in occupational therapy practice, we can use lot of commercially inexpensive 3D scanner to obtain the 3D images of the products such as Kinect Xbox, Structure 3D scanner, iSense. Intially, Kinect Xbox was used as video game. However, recently it has been used as a one of the inexpensive 3D scanner and even used

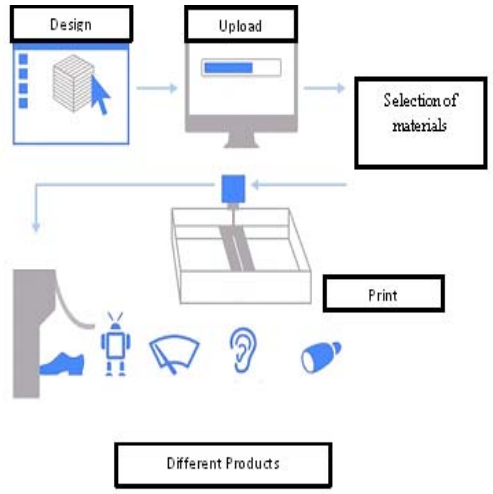

Figure 6: Process of 3D printing technology (adapted and modified) [Source: http://www.techandtrick.com/].

Kinect | Structure 3D scanner | iSense

Figure 7: In expensive 3D scanning tool [23-24, 27].

as clinical diagnostic tool in the medical field [20]. One of the study used Kinect as 3D scanner to obtain the 3D images of the clubfoot to design the braces [21] (Figure 7). The obtained images from the kinect or other 3D scanner will be saved as obj file. Then, Artec 9 studio 3D software would be helpful to design the 3D model by global processing and texture mapping methods and it can be converted and save as STL file. As a final stage, STL will be transferred into the 3D printing machine with the help of computer aided design (CAD) software to get the 3D medical, assistive devices in any design.

Advantages of 3D Printed Devices in Occupational Therapy Practice

Application of bracing or splinting (wrist splints, finger splints, cast replacements, and other types of orthotic and prosthetic devices) is one of the common intervention practices in occupational therapy to treat the patients with acute and chronic conditions. Using 3D printed medical deviceshas lot of advantages when compared with making of assistive devices or medical devices by conventional methods such as comfort, fit, aesthetic features, and it makes faster recovery from physical impairment due to the design. For example, compliance of the splints or braces has very crucial role to improve the function and recovery of the patients. However, previous study reported that around two third of the clients had noncompliance of splints or braces [22-28]. There are number of factors determines to achieve the successful wearing of splints treatment regime to improve faster recovery from the physical impairment of the patients.

3D splints [Source: Paterson et al.2012] | 3D-printed cast for fracture healing [Source: **Evill,2013]** | Conventional fabricated splints [Source: Paterson et al.2012]

Figure 8: Difference between 3D printed devices and conventional splints.

Poor adherence of treatment regimen might be occur due to the following reasons such as medical devices with unaesthetic features, uncomfortable fit leads to pressure or ulcers on the bony prominent area of the body parts, difficult to put and remove the splints [28-31]. At the same time, using 3D printed splints or other assistive devices has lot of advantages such as comfort and fit, proper ventilation, light weight, aesthetic features and can design at any geometry at the same cost, saved 3D data can be used at any time to design the devices in less time. As an example, the following figure 8 shows the 3D printed devices and a traditional or conventional wrist immobilization splints. The 3D printed devices will have smooth, soft in nature at the edges, easy to use with proper ventilation for skin, proper comfort and fit and aesthetic features. It will induce positive emotional responses to the patients'and will improve the adherence of treatment regime. In addition, in terms of costing, for making 3D printed medical devices will have less expenses than conventional methods. A 3D printed robotic arm developed by Washington University at St. Louis for a teenage girl in two hundred dollars and duration of minutes, while conventional methods will take expenses around US$50,000 - $70,000 [32-33]. Low cost 3D printers can be purchased in around $2800- 2900 [34], to create functional, aesthetic, comfortable assistive devices.

Discussion

In the future, application of three dimensional printing technologies in occupational therapy practice will definitely induce significant impact in term of creating customized 3D splints and other assistive devices. In our review, we have discussed about types of 3D printing technology and its application in medicine and occupational therapy. Customizations of 3 dimensional printing devices are time consuming and having crucial role to faster recovery from the illness or make them independent in the daily activities by providing comfort and right fitting of devices to the physically or mentally impaired patients. 3D printing devices has also some other benefits such as cheap materials, adjustable, durable , faster productivity, less time, desired design, and easily remodify existing devices and aesthetic nature. It is one of the reliable and fast growing technologies in health care, will provide invaluable supports to the doctors, occupational therapist and other health care professionals, and patients.

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