

# Emergence of 3d printers in healthcare



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### **Emergence of 3D printers in healthcare**

On 8 August 1984 Charles W ' Chuck' Hull made a remarkable invention, he had created something that would later than revolutionize how things are made in industries, this invention was the first 3D printer. A breakthrough for the application of 3D printer in the medical field came in the year 2011 when the doctors were able to produce a bio resorbable device that helped a young boy to breathe who till then had problems in breathing and had lost all hopes to live. Since then there have been numerous inventions made such as prosthetic arm, ear cartilage, an artificial heart valve, all been made by 3D printers thus helping patients lead a normal life. Today a large number of hospitals are using 3D printers to transform the radiological scans into 3D objects, producing medical instruments from 3D printers and the use of this technology is likely to grow as more advancement are made with respect to the design software used. In this essay, I will discuss the applications that 3D printers have in the medical field, the limitations of the use of 3D printers, the cost implications and the market available for this technology in the medical field.

### **Application of 3D printers in healthcare**

There are numerous ways in which the 3D printers can be used in the medical field. According to Jason S. Naftulin, Eyal Y. Kimchi<sup>1</sup> and Sydney S. Cash, brain surfaces by 3D printers are created by first obtaining high resolution images from respective departments. There are many open source software's that can produce such high-quality images. K-Pacs

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(<http://www.k-pacs.net/>) is one such software available. These high-quality images are then converted into a brains model using another software, FreeSurfer (<http://surfer.nmr.mgh.harvard.edu/>) is an open source and free software that can be installed and used for this purpose. These models are then sent to 3D printers, similarly the skull is also created by first obtaining the scan, then modelling it and later sending to 3D printers. This makes analysing the brain and creating artificial skull to help the doctors better understand the condition of the patients. (Naftulin, Kimchi, & Cash, 2015).

Emily J. Hurst writes that in many hospitals the use for 3D printers is also for medical imaging, she also writes that the images are first taken from individual departments and are then sent to 3D printers, the only pre-requisite is that the quality of these images should be high as better scans create better models which can then be analysed by the doctors. She also explains that 3D models are used by doctors to better understand the complexity in certain surgical operations. By having a look at the 3D model a detailed plan can be made as to how to go through the operation. She also feels that the use of 3D printers for prosthetics like arms and legs is increasing its popularity especially for children. These artificial limbs are light weighted and can be easily customised for patients. For pharmaceutical industry, she believes that 3D printers provide low cost and innovative approach as the pills produced can sustain for a longer period of time. However, she feels that the use for 3D printers for tissue and organs needs a lot of research as they involve complex cells and vascular network. (Hurst, 2017).

Helena Dodziuk also agrees that the use of 3D printers in prosthetics is increasingly growing as it is low cost and effective. The only drawback for prosthetics for children is that as their body grows the need to have new prosthetics will be essential which will then increase the cost of the artificial limb if long span of time is considered, but according to her, research is being done and soon extendable 3D prosthetics will be available. Another application highlighted by her is the production of hearing aids using 3D printers. She also showcases that 3D printers are also used in dentistry to produce crowns, bridges, plaster and other orthodontic appliances. She also states that the 3D printers are also used for other implants such as jaw implants and sometimes can be used for the treatment of diabetes and arthritis. (Dodziuk, 2016).

David Keith Mills besides emphasising on the use of 3D printers for prosthetics, medical implants and customised drugs also provides an insight as to how this technology in future can be used for bone formation that may lead to possibilities of bone repair and bone regeneration. (Mills, 2015).

### **Cost implications**

Initial studies and researches have shown that there has been a remarkable improvement in diagnosis and treatment after using 3D printers. As the use of 3D printers in the sector of healthcare increases it is bound to improve the efficiency. A prosthetic which is hand-made takes a lot of time to be produced and in-case it is damaged the whole process has to be performed again manually, however the use of 3D printers will not only save the time but in-case of any damage the same can be re-printed again, thus saving time and money. Several learning institutions are employing the use of 3D

printers for students to practice on printed models instead of costly human parts such as bones. Cost savings are also observed for 3D printed objects produced, for example to understand and study patient specific anatomy before medical procedure so appropriate approach is taken before undertaking the surgery. Though at experimental and initial phase 3D printers have also been used in liver transplant planning for identification of the preferred approach of carving the donor liver with minimal tissue loss.

Presently the treatment of any organ or tissue is dependent upon the availability of the specific tissue or organ from any living or diseased donor. However, the possibility of finding the specific donor is very rare and even if found the cost of surgery and the subsequent follow ups make this affair a very costly one. In comparison to this the 3D printers provide the possibility to construct a replacement using the patient's own tissues which will also reduce the possibility of organ rejection which is probable in case the organ or tissue is taken from donor. The printing of organ will also ascertain drug efficacy thus reducing the cost. The availability of customized medical instruments using 3D printers will mean that the tools for surgery are always readily available, increasing surgery success and reducing the time in hospitals for patients thus reducing the overall cost. If pharmaceutical drugs are produced with 3D printers then they will decrease the manufacturing cost as well as time to produce to tablets, thus companies producing low volume of drugs can use 3D printers for mass production. (Choonara, Toit, Kumar, & Kondiah, 2016).

**Limitations of 3D printers**

Though the 3D printers are proving to be a lot helpful and come up as an emerging technology, there still are some problems that this technology has to overcome. Firstly, these printers rely on the nozzle for the finalized product, but sometimes due to software issues the printers stop working and the sequence of layer formation gets disrupted. Powder based 3D printers also require special laboratories where the printing can be done. Another limitation is that the final product needs a lot of time for drying and the drying duration is very high. The products produced have also to go through FDA fulfilment as in past there have been numerous incidents which have caused serious harm. (Alhnan, Okwuosa, Sadia, Wan, & Ahmed, 2016).

The cost of the 3D printers according to Alexandru Pîrjan and Dana-Mihaela PetroÅŸanu is high and they state that the cost involved when using 3D printers is very high when it is used for large scale printing but it is suitable for small number or complex objects. They also state that printing large objects is also expensive. Since in healthcare there is a possibility that it may require large scale production this could prove expensive. Another limitation highlighted is that the quality of the products decreases with the continuous use of the same printer and the finished product can thus have flaws. The authors also mention that the sometimes the material used for printing the moulds does not last a longer and the materials are degradable and exposure to outside environment affects their state. (Alexandru Pîrjan, n. d.).

The cost of 3D printing can be a factor because it may take a few minutes or a number of hours to print some products, all depending upon the material used, size and complexity. There can also be a possibility that the 3D

printing companies may tie up with buyers through supply chain management thus there could be a chance of increasing cost of ownership. Another point to note is that the commonly materials used are plastic and resins and the use of other materials for production can increase the cost, but for healthcare the material required should be bio degradable so that it does not cost any infection or allergies in case the product from the 3D printers is used for implants within the body. If more than one object is used for printing, then it becomes very difficult and expensive to build and the size of the product also affects the cost. The 3D printers also face a fierce competition from emerging technologies such as ‘ laser origami’ which is supposed to be more fast and accurate. (Thangaraju & Chaudhary, 2014).

### **Market for 3D printers**

The future of the 3D market depends upon how this technology can penetrate into the market. The success of this technology depends upon how much it is being used in the areas that the traditional way of medical treatment has short coming and how much this technology can advance the current process. The biggest advantage that this technology brings is the ability to customize products that has never been seen before. Three areas in which the 3D technology is strong is the application in (1) digital three-dimensional design, (2) medical imaging, and (3) 3D printing. This thus is encouraging small vendors in the market to invest in 3D printers leading to a cost competitive market. If these new small vendors can be interconnected using the power of cloud computing a new flexible cost effective system can be established. The 3D printers can also decrease the supply chain investment as the inventory cost will be reduced if the printing is done only

on order. The number of links in supply chain will be reduced if 3D printers are used for production as it eliminated a lot of middle steps as compared to traditional way. The infrastructure required by 3D printers is also not huge as compared to traditional way and is not dependent upon the economic scale thus the cost of producing large number of units or less number of units will almost be the same thus changing the current manufacturing economics. The material wastage in 3D printers is very less and does not require expensive tools, requires less manufacturing steps leading to leaner supply chain.