

## 3D Printing in Cartilage to Avoid Knee Replacement

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May 3, 2018

### Abstract

3D printing is widely using latest technologies in all fields. Nowadays in medical field 3D printing is used for all kinds of organ replacements. In this article instead of using bio ink, biodegradable hydrogel is used for replacing the knee cartilage. Damage of knee cartilage is the major problem in humans. Hydrogel based cartilage is make the task easier than the normal knee replacements. It creates the artificial hydrogel cartilage by custom designed. It uses the process of virtual models of a patient particular organ using Computer Tomography (CT) and Magnetic Resonance Imaging (MRI), with the help of physician or a surgeon can make the close matches of the damaged cartilage to the original. The knee injury is a painful, difficult to operate and also expensive to repair. By using this 3D cartilage, the complicated operations can be made simpler and the implants that fit exactly.

**Key Words:**Hydrogel; bioink; cartilage; artificial knee replacement; Biodegradable;

## 1 INTRODUCTION

Cartilage is found in joint places in many part of the body which are a connective tissue. Cartilage is rubbery, tough and Flexible in nature which is placed between the bones of joints as a supportive tissue. Cartilage damage causes the patient swelling and joint pain in the affected area [1]. Damaged cartilage takes much longer to heal, because it does not have supply of blood like other tissues that are supplied by blood [2]. Damage of cartilage and other knee diseases causes knee replacement which is a complex surgical procedure lead to more pain and takes several days to recovery. The Knee replacement surgery can be performed as a partial or a total knee replacement [3]. The common knee replacement surgery consists of the removal of damaged part or joint surface and replaces with the metal or plastic type components is fixed for the motion of the knee. The common knee replacement operation causes the pain after surgery. Patients are allowed to leave the hospital within 5 days, but it may take 6 weeks or longer for the recovery and also by using the mobility aids like crutches and walking frames [4]. The most of the patient recovery were 3 months, though it takes 6 months for the complete recovery [5]. Drawbacks of knee replacements can be overcome by 3d printing cartilage in knee using biodegradable hydrogel. Nowadays hydrogels have become very popular due to their properties like biocompatibility, high water content, softness and flexibility. Natural and synthetic hydrophilic polymers can be cross-linked physically or chemically to produce hydrogels. According to the nature of the groups present in the structure these gels can be charged or non-charged [6]. The existing 3D printing system uses bio ink where it uses the concept of three-dimensional (3D) printing in order to replace or regenerate the damaged knee tissues [7]. An inkjet bio printer executes small droplets of bio ink for the 3D printing. Where the custom designed imaging of the knee cartilage from the CT or MRI is made to build using the 3D printing with bio-ink. The limitations of bio-ink are based on the material viscosity used in the bio-ink [8].

## 2 EXISTING SYSTEM

3D printing of organs in existing system uses inkjet printing. Inkjet printing uses small drops of ink with high resolution which can be printed exactly. This ink used for printing the knee cartilage can be able to inject living cells as same as the biological tissues. These inkjet 3D printing uses electrostatically inkjet printer head to avoid heat which damages the living cells. The cell suspension in the inkjet process includes bovine vascular endothelial cells used as ink for printing. Then it is moved for the culture disks that can be incubated for several hours. These seeding techniques were a latest process of tissue engineering. Printing is based on the dot patterns. Figure 3 shows the hydrogel pattern. The printer has 12 nozzles with the distance of 508m. After the printing it is exposed to the atmosphere of 5 percentage CO<sub>2</sub> at 37C for 60minutes. The figure 2 is shown below.

## 3 NEW SYSTEM

Knee Cartilage using biodegradable hydrogel makes the implants to work easier than other treatments. Hydrogel based replacements make the complicated operations very easier. It may also use for Heart Implants. This results in decrease the emergencies to searching and waiting for donors for perfect match. This biodegradable hydrogel technique not only supports our environment but also saves n less of people. It includes various steps to implement this process. The block diagram is shown in figure 1.

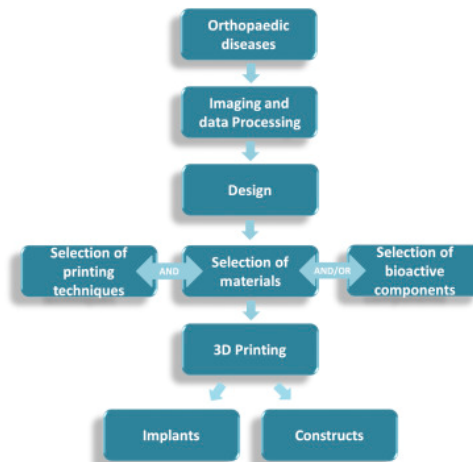


Fig.1 Block diagram

STEP 1: The first step in this process is to identify the problem and to verify the percentage of matching the biodegradable hydrogel technique. STEP 2: Using the CT and MRI scans, the image of the damaged parts is detected to scan the problematic areas. STEP 3: The human system is a very complex system in the world. Hence human knee will differ from person to person, Perfect knee should design according to the patient. STEP 4: Instead of using bio ink inkjet printers, using the 3D printing Techniques, with biodegradable hydrogel cartilage is very effective and safe to both environment and human system. STEP 5: In this process Polylactic Acid (PLA) is the biodegradable material can be either used as a filament or resins. STEP 6: After the verification of materials, components and the right design of the knee the 3D printing should be carry out. STEP 7: The printed cartilage is implanted in the patients knee exactly. Figure 4 shows the Ear shaped knee cartilage. STEP 8: The replaced knee should go for a review and maintain properly.

A. Figures and Tables

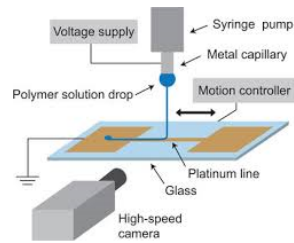


Fig 2- Inkjet Printing in 3D

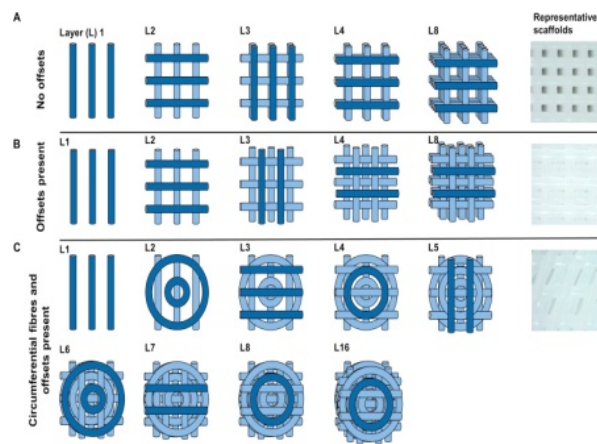


Fig 3-Hydrogel Pattern

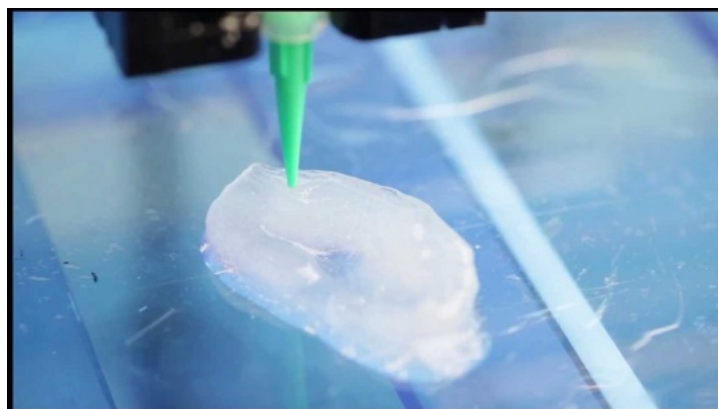


Fig 4-Ear shaped Knee Cartilage

## 4 CONCLUSION

The greatest advantage in 3D printers using biodegradable hydrogel provide in medical applications is the freedom to produce custom-made medical products and equipment. For example, the use of 3D printing to customize prosthetics and implants can provide great value for both patients and physicians. It is also easy for training and implementation. It can be easily adopted by all physicians. Hydrogel possess a degree of flexibility very similar to natural tissues due to their significant water content. 3D printers make the most complicated surgery easier. It can be performed for many different functions and are utilized for medical purposes like the 3D knee. The knee replacement surgery causes pain and takes time for recovery. With the new 3D printed replacement knees, pain is reduced and the perfect fitting knee can be created. The newly printed knees fit the patient naturally which makes it much more comfortable compared to ordinary replacement knees which come in different sizes that are pre-determined.

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