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Short Communication

3D Printing of the Eye: A Revolution in Surgical Training

Prasanth Gireesh[1]* Abdulmajeed Alharbi[2] and Poulomi Das[3]

[1]*Medical Consultant, Cataract and IOL Clinic, M.N. Eye Hospital , Chennai , India*

[2]*Department of Ophthalmology, College of Medicine , Qassim University, Saudi Arabia*

[3]*Fellowship in Cataract and IOL, Aravind Eye Hospital , Pondicherry , India*

***Corresponding Author:** Prasanth Gireesh, Department Cataract and IOL Clinic, University/Organization M.N Eye Hospital, India.

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Three dimensional (3D) printing has come a long way since Charles Hall invented it in 1980 [1]. Over the past few years with cumulative improvements in the resolution, accuracy, cost-effectiveness, and speed of this highly customizable manufacturing process, it has become the future of medical education. Depending on the area of interest, these printed models demonstrate anatomical and structural fidelity consistent with the patient's actual disease process [2,3].

This fidelity has allowed learners to view and understand gross pathology and structural relationships prior to surgical intervention. An improved understanding and visualization has in turn allowed surgical teams to plan interventions more accurately and guide margins of resection, model appropriate implant dimensions and sometimes create the implant itself using 3D printing technology [3,4].

3D printing technology allows virtual 3D objects designed using computer aided design (CAD) software to be manufactured into the real world using a "printer" of sorts. The 3D file, once designed in any CAD software, has to be converted into a Stereolithography (STL) file. This STL file is again made ready for the 3D printer using a slicer software into G-Code (gcode file) and then transferred to the 3D printer using a USB pen drive, by LAN or even wirelessly. The most common type of 3D printer (Figure 1) contains a "printer head" which moves in 2 axes (plus 1 axis by movement of the printer base), melts a raw material from a spool and deposits it onto the base in a precisely controlled manner.

Figure 1: 3D Printer – The Maker Bot Replicator.

This is done layer by layer for every two dimensional slice of the object model until the entire 3D structure is completed. This process takes between 20 min and 20 hours or more depending on the size, complexity, and resolution of the object being "3D printed." This is called fused deposition modeling and the common raw materials used are polylactic acid (PLA), polyvinyl alcohol and acrylonitrile butadiene styrene (ABS), of which PLA is most biocompatible and ABS is most toxic. More advanced 3D printing technologies like photopolymerization use a liquid raw material and ultraviolet curing for faster printing [5].

A number of scientific instruments right now use 3D printing, like the smartphone-based fundus camera, smartphone-based slit lamp imaging, spectacles and lenses, eye drop helper for patients, surgical instruments, and orbit model. Not only that, 3D printer retina [6], corneal stroma equivalent [7], and bionic eye are under development right now using 3D printing technology.

We have developed a 3D model of the human eyeball using Ultimaker 3D printer using ABS filament. The cornea in the model eye is acrylic mold designed by CAD software.

Figure 2: Artificial made by 3D technology. The base is 3D printed, and the cornea is acrylic mold.

The eye has been in use in the wet lab for young surgeons to understand the anatomy and practice surgical skills. The cornea is detachable here.

Figure 3

The picture below shows phacoemulsification being practiced with clay and the human eye in wet lab. Both give surgeons almost an equal idea of the procedure and anatomy.

Figure 4

It has revolutionized the understanding and training of surgical skills especially in the field of microsurgery where great skill is most important for a surgeon.

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