

A Study on Applying a 3D Printer to Healthcare; Dentistry Area

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Abstract

Background/Objectives: The purpose of this paper is presents various areas where 3D printer can be utilized. It is examine the range of utilizing 3D printer in various areas, and help understand 3D printer through presenting areas where 3D printer can be utilized in dentistry among healthcare areas in particular. **Methods/Statistical Analysis:** With regard to research method, data were searched for on-line and off-line. Image and papers relating to 3D were searched for and manufacturers were surveyed in Yahoo UK on-line. And cases of use were investigated through calling professionals who actually utilized 3D printer in dental clinic off-line. On the basis of details of on-line and off-line findings, the areas where 3D printers are currently utilized are summarized. **Findings:** The original purpose of 3D printer was to make a prototype before releasing a product. However, recently, areas where it has been utilized are extended to industry, healthcare and real life areas. In the industry area, a more precise and elaborate process is enabled by using the advantage of 3D printer that stacks one layer on top of another. These characteristics show excellent efficiency that reduces costs and efforts required in product development as the time taken to develop a product is decreased by 5~10 times in comparison with conventional method. In the health care area, 3D prosthesis can be made like that. So, it is possible to make a prosthesis that is more similar to human body part. Cases of applying a 3D printer to health care include prosthetic finger, dental surgery, bioartificial liver, skull, bronchial tube, paranasal sinus cancer surgery, conjoined twins surgery, and model for education. **Improvements:** In health care areas, an artificial bone, joint or tooth can be manufactured with a structure that best fits a patient's body if a printing technology is utilized by using a 3D printer. So, it is forecasted that dental treatment using this will develop and application scope will become wider in the future.

Keywords: Applying, Clear Aligner, 3D, Health Care, Printer

1. Introduction

It is intended to understand 3D printer, examine the range of utilizing 3D printer in various areas, and help understand 3D printer through presenting areas where 3D printer can be utilized in dentistry among health care areas in particular¹.

3D printer definition: It is a machine that makes a 3D solid object based on the input drawings, as a 2D printer prints a letter or picture.

It is the same principle as inkjet printer that prints 2D image (letter or picture) by spraying ink onto paper if a digitized file is sent. In a 2D printer, it moves forward and backward (x-axis) and left and right (y-axis). However, in a 3D printer, up and down (z-axis) movement is added here, and a solid object is made on the basis of the input 3D drawing.

It can be classified into major categories such as additive fabrication that stacks one layer on top of another (additive manufacturing or rapid prototyping) and subtractive

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fabrication that cuts from large solid block (computer numerical control carving). The additive fabrication is a method of making a 3D shape by stacking 0.01~0.08 mm of layers of powder (powder such as plaster or nylon etc.), liquid plastic or plastic yarn one after the other, which are thinner than paper. As layers become thinner, a more precise shape can be obtained. And the object can be colored at the same time. The subtractive fabrication is a method of cutting out a 3D shape from large solid block like carving. The subtractive fabrication has the advantage of more precise finished product in comparison with additive fabrication, but has the disadvantage of consuming a lot of materials, having difficulty in making a shape where the inside is scooped out like cup, and being obliged to do coloring work separately.

Manufacturing stages are composed of modeling, printing and finishing². Modeling is a stage where 3D drawings are made, and is making drawings by using 3D CAD (Computer Aided Design), 3D modeling program or 3D scanner, and so on. Printing is a stage where an object is made by using 3D drawings made in the modeling process, and is carrying out work by additive or subtractive fabrication. Here, the time required depends on the size and complexity of product. Finishing is a stage where supplementary work is carried out for the manufactured product and is carrying out work such as coloring, polishing the surface, or assembling the produced parts, and so on.

Originally, a 3D printer was developed for the purpose of making a prototype before a company made a thing a commercial product. It is known that 3D Systems, U.S., first developed the printer which made a 3D product by hardening liquid plastic in the early 1980s. It was developed from the early stages where materials were confined to plastic materials, and the ranges were extended to nylon and metal materials. And it reached the commercialization stages in various aspects as well as industrial prototype.

European Aeronautic Defence and Space Company (EADS) have printed a bicycle as a finished product by a 3D printer without assembling phase. And University of Southampton, U.K., has manufactured an unmanned aerial vehicle flying at 160 km/h. The medical world utilizes a 3D printer in areas requiring precision, such as patient-tailored artificial joint or artificial organs.

With the development of science and medical technology, the world has entered to the age of 100-year-olds. Recently spotlighted as the next generation technol-

ogy, 3D printer technology is helping to extend life as it expands its usage to the medical field. In particular, expectations are emerging saying that medical revolution will occur as 3D printers create human organs with cell tissues such as heart. Grafting in medicine is becoming active. Beyond dental implants, hearing aids, etc. they appear to be spreading as 3D printers are used in cancer, artificial organs, facial bone reconstruction, etc³.

Therefore, this study has the purpose to examine cases of using 3-dimensional printing that can be currently used in domestic clinical practices.

2. Materials and Methods

These data were searched for on-line and off-line. Image and papers relating to 3D were searched for and manufacturers were surveyed in Yahoo UK on-line. And cases of use were investigated through calling professionals who actually utilized 3D printer in dental clinic off-line. On the basis of details of on-line and off-line findings, the areas where 3D printers are currently utilized are summarized.

3. Results

3.1 3D Printing Material Type Classification

The material types of 3D printing are classified into liquid-based type, powder-based type, and plastic-filament-extrusion-based type as shown in Table 1. Technology of liquid-based type includes SLA (Stereo Lithography Apparatus), Jetted Photopolymer and Ink Jet Printing. Technology of powder-based type includes SLS (Selective Laser Sintering), DMLS (Direct Metal Laser Sintering), and 3DP (Three Dimensional Printing). Technology of plastic-filament-extrusion-based type includes FDM (Fused Deposition Modeling), and LOM (Laminated Object Manufacturing).

3.2 3D Printer Utilization

With regard to areas where 3d printers are utilized, these are currently utilized in many places, like education, industry, architecture, health care and hobby, as shown in Table 2. Especially in health care and bio areas, each patient has distinct physical characteristics and different symptoms. So, it was thought that customized manufac-

Table 1. 3D printing material type classification

Material type	Technology name
Liquid based	SLA (Stereo Lithography Apparatus) Jetted Photopolymer Ink Jet Printing
Powder based	SLS (Selective Laser Sintering) DMLS (Direct Metal Laser Sintering) 3DP (Three Dimensional Printing)
Plastic filament extrusion based	FDM (Fused Deposition Modeling) LOM (Laminated Object Manufacturing)

ture was required. Therefore, a great interest is taken in the utilization of 3D printer.

Table 2. 3D printer utilization

Utilization	Content
Education	Can be utilized for education in various areas such as Science Technology, Art, Engineering and Math.
Industry	Through rapid prototyping, the time taken to develop a product can be reduced, and the design process can be drastically shortened.
Architecture	An architectural model can be simultaneously made together with design work. So, work can be carried out sufficiently.
Health care	A medical institution can print a needed model, and can print patient-customized shape.
Hobby	Decoration, living items, and the like can be printed and utilized by regular households as well.

3.3 Trends of 3D Printer in Korea

A demand for utilizing 3D printers gradually increases. However, products are very little developed. And the number of cases of utilizing a 3D printer increases for reducing the time taken to develop a product and strengthening the security in Korean manufacturers as well.

A 3D printer is utilized for the development of new product such as mobile phone and major auto parts in the IT, automobile, construction and toy areas and so on. And

a lot of 3D printers are utilized in health care areas (facial plastic surgery, orthodontic appliances, etc.) as well as university^{4,5}.

In biology areas, studies are carried out actively. So, it is forecasted that 3D printing technology can be variously utilized even in the parts relating to life.

Recently, 3D printers extended the range of application to health care areas. And a customized model, advantage of 3D printer, can be made. So, patient-tailored health care service is provided. And a great change will be made in surgery trends in the future. If a model of patient's body parts is made by using a 3D printer, medical personnel can make a surgical planning or carry out surgical simulation. So, the time required to perform surgery can be reduced. And risk can be decreased. Therefore, success rate can be increased.

3.4 Cases of Applying A 3D Printer to Health Care

Cases of applying a 3D printer to health care include prosthetic finger, dental surgery, bioartificial liver, skull, bronchial tube, paranasal sinus cancer surgery, conjoined twins surgery, and model for education as shown in Table 3.

Table 3. Cases of applying a 3D printer to health care

No	Content
1	Prosthetic finger
2	Dental surgery
3	Bioartificial liver
4	Skull
5	Bronchial tube
6	Paranasal sinus cancer surgery
7	Conjoined twins surgery
8	Model for education

3.5 Key Applications of 3D Printers in Dental Clinic

Cases of applying a 3D printer to dentistry are shown in Table 4. Currently in the dental clinic the key applications of 3D printers is apt to fabricating 3D printer models for crowns⁶, bridges, and prostheses⁷, dental orthodontic brace models⁸ and surgical guides. 3-Dimensional printers enhances lab economics by increasing productivity, reducing posting, and improving patient satisfaction as

they allow self-production. Clear aligner system were teeth are easily, conveniently and safely straightened with wireless orthodontics, precise 3D images of teeth are captured by dental 3D scanner, tooth movement is elaborately predicted and designed by computer clear aligner program and it is rapidly produced by directly sending the designed 3D image to its own 3D printer^{9,10}. Figure 1 shows clear aliner manufactured in person by using a 3D printer in a dental clinic nowadays.

Table 4. Key applications of 3D printers in dental clinic

No	Dental clinic of application
1	Crown and bridge models
2	RPD casting patterns
3	Diagnostic wax-up
4	Surgical guides
5	Veneer try-in
6	Clear aligners



Figure 1. Clear aligner⁹.

4. Conclusion

A 3D printer makes it possible to elaborately and rapidly make a product that a consumer wants according to consumer's needs. As seen from the areas where 3D printers are utilized, these are reflected in education, industry, architecture, health care and hobby areas, and so on. However, those will be more important and account for a larger proportion by developing their strong point that can make 3D printed copy of anything in the future. Good results are expected in all areas by steadily making studies and continuing to make a progress. Future assignments would be the technical development of 3-dimensional

printer which shall be continuously researched to combine accuracy and convenience as well as safety. It is natural that 3-dimensional printing technology and its development will increase. Thus, through continuous research, much effort shall be made for the invigoration of 3-dimensional printing technology and development.

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