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Research Article

Surgery Dissector: Surgical Device Production With 3D Print Technology

3 Boyutlu Yazıcı Teknolojisi İle Cerrahi Alet Üretimi; Mikro Disektör

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Abstract: Three dimensional (3D) print technology usage is becoming more popular in medicine and surgical sciences. There is a couple of study about using 3D print technology for surgical device production and neurosurgery in the literature. In order to adjust dissector measurements to use during the surgical operation, from patient's CT and MRS outputs, spinal canal diameters, nerve root attached foramen diameters and disc gap wideness of the patient were measured. With these measurements, surgery dissector modelling was done by using Solidworks 3D CAD program in Dokuz Eylul University, Department of Biomechanics. Polylacticacid (PLA) filament was used in the devices during print process. In our study, surgical dissectors' sterilization was done with vapor in 1200C and used in an operation for lumbar narrow canal diagnosed patient whose measurements were checked before the surgery. There isn't any intraoperative complication observed during 3D printed surgery dissector usage. Although it seems that single using 3D printed surgery dissector is a disadvantage, it costs cheaper than existing surgery dissectors. In this article, we share our experiment about surgery's one of the most important device named "surgery dissector" production with 3D print technology and it's usage.

Keywords: Surgical Device Production, Polylacticacid, Three-Dimensional (3D) Print

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Özet: Üç boyutlu (3B) baskı teknolojisi kullanımı tıp ve cerrahi bilimlerinde daha popüler hale geliyor. Literatürde cerrahi cihaz üretimi ve nöroşirürji için 3D baskı teknolojisinin kullanımı hakkında birkaç çalışma vardır. Cerrahi operasyon sırasında kullanılacak disektör ölçümlerini ayarlamak için hastanın BT ve MRS çıkışlarından spinal kanal çapları, sinir köküne bağlı foramen çapları ve hastanın disk genişliği genişliği ölçüldü. Bu ölçümlerle Dokuz Eylül Üniversitesi Biyomekanik Anabilim Dalı Solidworks 3D CAD programı kullanılarak cerrahi disektör modellemesi yapıldı. Baskı işlemi sırasında cihazlarda polilaktik asit (PLA) filament kullanılmıştır. Çalışmamızda cerrahi disektörlerin sterilizasyonu 1200C'de buharla yapıldı ve ameliyattan önce ölçümleri kontrol edilen lomber dar kanal tanılı hasta operasyonunda kullanıldı. 3D baskılı cerrahi disektör kullanımı sırasında gözlenen herhangi bir intraoperatif komplikasyon yoktur. 3D baskılı cerrahi disektörü kullanma tekinin bir dezavantaj olduğu görülmesine rağmen, mevcut cerrahi disektörlerden daha ucuzdur. Bu makalede, ameliyatın "ameliyat disektörü" adı verilen en önemli cihazlardan biri olan deneyimle ilgili deneyimlerimizi 3D baskı teknolojisi ve kullanımı ile paylaşıyoruz.

Anahtar Kelimeler: Cerrahi Alet Üretimi, Polilaktikasit, Üç Boyutlu (3B) Yazıcı.

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1. Introduction

Three dimensional (3D) print technology usage is becoming more popular in medicine and surgical sciences (1,2). Surgeons are doing 3D print by using patients' computerized tomography (CT) and then making surgical approachment plans (3). There is a couple of study about using 3D print technology for surgical device production and neurosurgery in the literature (4,5).

The first 3D print was reported by Hideo Kodama in 1982. Today, 3D print production is very common in different areas with the usage of polylacticacid (PLA) as a raw material. Biological degradable implants and suture materials like PLA and polyglycolic acids (Vicryl, Ethicon, New Brunswick, NJ etc.) were examined intensely in surgical area (6).

Sterilization methods in low temperature like ethylene oxide "gas" sterilization doens't affect PLA force. However, ethylene oxide residuals at dangerous levels are a serious matter of concern. As an alternative, it's observed that glutaraldehide which is an effective sterilizer in room temperature maintains the highest PLA force in accordance with other chemical sterilizers (7).

The purpose of this article is sharing the experiment about surgery's one of the most important device named "surgery dissector" production with 3D print technology and it's usage.

2. Surgıcal Devıce Productıon And Implementatıon

2.1.The Modelling of Surgery Dissector

A surgical treatment was planned for a 59 years old female patient who had lumbar narrow canal diagnosis. The patient had narrow canal in lumbar area at 3 levels before the surgery. To make a 3D printed model of surgical dissector, computerized tomography (CT) and magnetic resonance screening (MRS) were applied to the patient before the operation. CT displays were acquired by Toshiba Aquilion LB v.6 (Toshiba Medical Systems, Tokyo, Japan) device. CT outputs were reconstructed with 120 kVp, 200 mAs, 120 mA,300 mm FOV, 512×512 grid thickness and 2 mm section thickness protocols. MRS displays were acquired by Siemens 1.5 T MRS device and two dimensional magnetic resonance echo screens were obtained under these parameters: The repetition time is (TR) 4040 ms, the first echo time is 50 ms and the last echo time is 800 ms. Every screen's section thickness is 3 mm. In order to adjust dissector measurements to use during the surgical operation, from patient's CT and MRS outputs, spinal canal diameters, nerve root attached foramen diameters and disc gap wideness of the patient were measured. With these measurements, surgery dissector modelling was done by using Solidworks 3D CAD program in Dokuz Eylul University, Department of Biomechanics.

2.2.The Production of Surgical Dissector in 3D Printer

Ultimaker 2 Extended and Ultimaker 3 Extended three-dimensional printers which are in Kutahya Health Sciences University Innovative Technology Laboratory were used for 3D printing of surgery dissector. Ultimaker 3 Extended working with FDM *(fused deposition modeling)* technology has double nozzles that have changeable diameters between 0.25-0.8 mm. The print area of the printer is 197 x 215 x 300 mm. It's filament diameter is 2.85 mm and layer solubility is changing between 20-600 microns. The extruders' movement direction on X and Y axis is 12.5 micronn and on Z axis is 2.5 micron. Between 30 – 300 mm/s velocities can be forced on to the lens plane which can be heated between 20-100 ºC. Ultimaker 3 Extended offers the user to print with different materials like Nylon, PLA, ABS, CPE, CPE+, PC, TPU 95A, PP and PVA. A .gcode file was created after separating layers of surgery dissector 3D model in Ultimaker Cura v. 3.6.0 software. Polylacticacid (PLA) filament was used in devices during the printing process. The printing parameters for PLA filament were shown in the Table 1.

Table 1.
Printing parameters for PLA filament

Nozzle Diameter	0.4 mm
Nozzle Temperature	200 ºC
Build Plate Temperature	60 ºC
Build Plate Height	Active Leveling
Fill Rate	%70

Every surgical dissector's printing time lasted between 35-45 minutes (Figure 1).

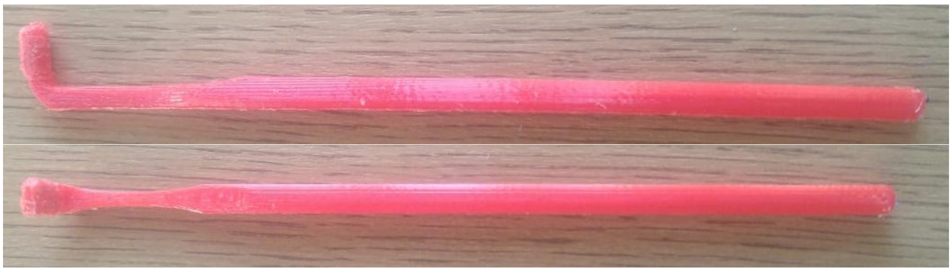

Figure 1.
Surgical dissector produced in a three-dimensional printer.

2.3.Sterilization of Surgical Dissector

The surgery dissectors producted by using PLA filament were sterilized before the operation. there was an attentive approach to choose a process for the sterilization operation in order to not compromise PLA's polymer structure. It is known that the sterilization made with autoclave ruins PLA's structural collectivity. Therefore, steam sterilization in 120 ^{0}C or dry heat sterilization in 170 ^{0}C are recommended. So, we did surgical surgery dissector sterilization in 120 ^{0}C with steam in our study.

3. Discussion

PLA is an FDA verified hypoallergenic and a safety raw material as a semipermanent dermal extender (8). PLA has a perfect security profile although it isn't completely motionless and it doesn't activate sensitivity reactions. According to these features, it is thought that PLA is a compatible substance with human body and there wasn't any allergic reaction after it's usage.

An intraoperative complication wasn't observed during 3D printed surgery dissector usage. The dissector was created suitable for the individual's anatomy so this made things easier for the surgical staff in the operation.

Although it seems that single using 3D printed surgery dissector is a disadvantage, it costs cheaper than existing surgery dissectors. We think that if there will be a routine implementation, it will be more economical in comparison with existing imported surgery dissectors in the long term. Besides, we believe that suitable creation surgical devices for an individual will decrease complication rates. Therefore, reoperation rates, medical treatment rates and hospitalization durations will decrease. Heavy costs depending on these situations will get low.

Clinical based multidisciplinary studies to be held with surgeons and engineers will provide facilities to develop new technology and devices. Personal 3D printed surgical devices will cause more successful surgical treatment and lower costs in the surgical clinics.

In the current releases, a range of applications were defined for 3D printing in different subspecialties of neurosurgery (9, 10, 11). These areas contain cerebrovascular, neurooncology, spinal, functional and endoscopical neurosurgery. 3D printing was applied in every area one by one in order to improve planning, training and treatment. With the advancing technology, 3D printing will cause more successful surgical treatments.

Although PLA filament is a biomaterial that can be used for FDM technology, mechanical properties are insufficient for the intended use of surgical equipment. According to the anatomical region to be used during the production of the surgical dissectors in a three-dimensional printer, the filament should be selected in the right direction. Usually equipment used in surgery is made of titanium. However, PEEK material will be advantageous compared to PLA and titanium as both biocompatibility and mechanical strength.

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