Surgical planning using the additive manufacture.

Ing. Giuliana Calise*

Department of Science Materials, University Simon Bolivar, Venezuela

Abstract

Understanding and studying human anatomy is not something that is constant and easy to understand, therefore, classical anatomy has been studied under dissection rooms of medical schools. In recent years, certain universities worldwide do not have as many bodies to carry out such field work, in addition to the processing, maintenance and facilities to preserve a body have a high cost, also exposure to chemicals such as formaldehyde by time prolonged can cause health problems. It is for this reason that many universities have seen the need to use plastic models or plasticized corpses. However, the former are unrealistic and the latter involve a very expensive process and are not accessible to all medical institutions.

Keywords: Additive manufacturing, Surgical planning, Classical anatomy.

Accepted on March 05, 2021

Introduction

Given the complexity that characterizes the human anatomy, many specialists rely on medical strategies and techniques such as surgical planning. This technique allows the medical team to perform a review to confirm and evaluate the medical diagnosis, in order to generate confidence in the action. select the correct medical tools and thus foresee possible complications and risks inherent in an intervention in order to pursue objectives derived from a good surgical act [1-5].

Evidence has been found in a study where it is revealed that a significant percentage of patients who undergo complex surgical interventions, such as oncological and cardiac interventions, require multiple interventions because the medical team cannot effectively visualize the Pathology presented by the patient, in addition, with the use of surgical planning, steps can be created to give way to the intervention, but they are frequently used due to visualization problems of the clinical case to identify the problem to be solved in the patient [6].

From the need to study human anatomy and its complexity, anatomical models manufactured with the Additive Manufacturing (MA) technique have been developed. The creation of these anatomical models allows to achieve a better approximation of the patient's diagnosis and anatomy, due to the fact that they are manufactured with the use of DICOM medical images that reproduce the pathology of each patient. By using this medical imaging system, a correct segmentation of the case is guaranteed and therefore an anatomical mimicry to be reproduced through a three-dimensional model through the use of MA.

The use of adding anatomical models to surgical planning allows the development of medicine with a direct impact on surgical intervention. That is why there are currently technological institutes, private companies and university centers ready to promote MA in the surgical field by manufacturing anatomical models.

Use of MA to manufacture anatomical models for surgical planning

Over the past three decades, the manufacture of additively manufactured models has allowed the development and recreation of anatomical objects such as physical 3D printing models, thus providing surgeons with a much more tangible and realistic view of complex structures that may arise. during the intervention. With MA, a reduction in surgical time is sustained since, there is an improvement in surgical speed in terms of decision-making based on planning, in addition, the dimensional stability provided by the printed model guarantees closeness to the human anatomy through certain geometric scales extracted from DICOM image files.

The importance of additive manufacturing in the medical field is manifested in principle by its versatility. This aspect provides a range of techniques that are part of the surgical planning development tools. Advances in image processing allow complex data that at first glance is not easy to identify. This aspect is of utmost importance because the medical image gives a reading of the existence or absence of pathologies in the human body. The complexity that human anatomy presents on many occasions makes surgical intervention difficult, given its complexity and the areas that are not visible from the outside, in addition to the individuality of each pathology present in each patient, which is why it is beneficial to obtain a model that allows each surgeon to cut, manipulate, touch and use as a template in the operating room.

Materials

The materials used in the manufacture of the anatomical models had to be sterilizable to be able to serve as a support material and a visual guide in the surgical act. It is known that for FDM-type 3D printing there is an important range of materials, however, the selection of materials was made based on the hardness of the human organs under study to mimic and parameterize each case as much as possible. The hardness that mimicked the human body was achieved through the use of multimaterials, such as PVA and silicone, since these materials have their own characteristics an elastomer, like flexibility. Also, the use of silicone with platinum curing agent allowed the models to be sterilizable and antibacterial. An important property to highlight in the case of visualization through anatomical models is the transparency that was achieved with the use of silicone despite the thicknesses handled.

Case Presentation

Case study: Liver metastasis

An elderly female adult patient with a medical description referring to a liver metastasis was taken as a case study. The patient was referred through the Hospital Clinic Barcelona unit through Dr. Lukas Krauel. The materials, equipment and procedure used for 3D printing of the anatomical model are shown below. In addition to the results obtained.

Experimental procedure

Materials: Combinations of materials such as PLA were used for FDM and silicone printing (Ecoflex (00-10) and Essil 291). The properties of the materials used in this process can be reviewed in the materials section of Chapter II.

Equipment: The Sigma Release (FDM) printer was used. The specifications of the used machines can be seen in the previous section.

Procedure

Segmentation: The segmentation process described in the previous section was followed. For the 3D printing process in FDM, a meshof 30,000 was selected, as shown in Figures 1 and 2.

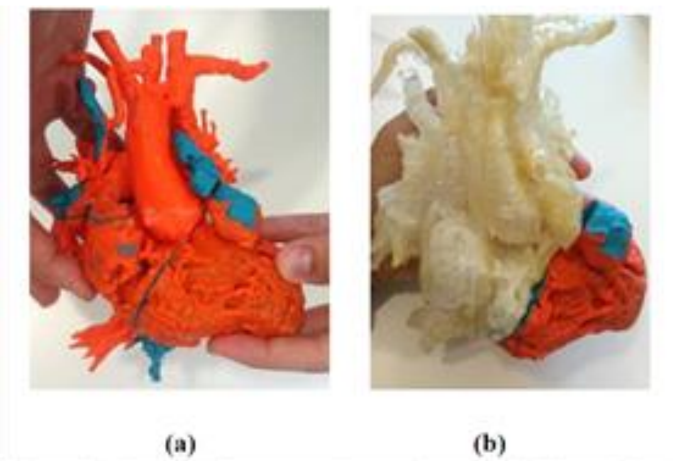

Figure 1. *Anatomical models made with FDM: (a) PLA, (b) Combination of materials (PVA+silicone).*

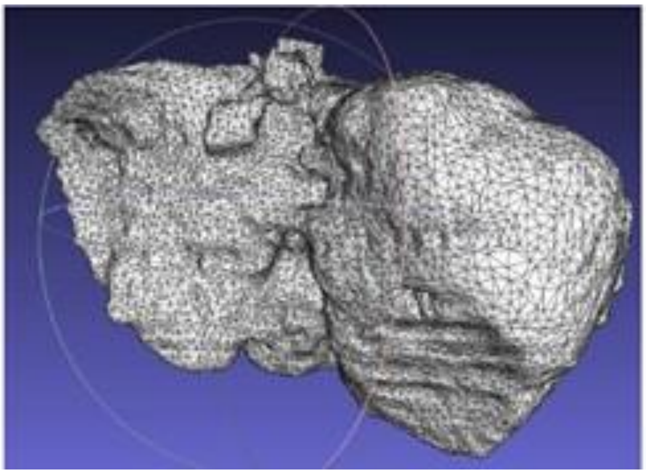

Figure 2. *Meshing of a liver model.*

Surgical planning: Surgical planning was carried out without problem, however, it was not possible to participate in the discussion meeting. However, According to Dr. Lucas Krauel of the Hospital San Joan de Déu: "The project and the proposed technologies for development have a direct and beneficial transfer for patients. If the results are satisfactory, achieving quality models and useful software tools, these could be generalized, become cheaper and become part of routine clinical practice that benefits future patients of our and other hospitals around the world. "

Discussion

To carry out this case, only the FDM technology with a combination of materials was used, that is, a rigid PLA casing was made and the part support was constructed with soluble PVA support. Two anatomical models causing the carcass fracture were obtained to evaluate the use of silicone and its translucency. The silicone that presented the best translucency was Essil 291 with respect to Ecoflex, this transparency factor may be due to the curing capacity and speed depending on the agent used. Silicones are known to be platinum cured so that they can be accepted in the surgical setting as they are sterilizable and antibacterial. However, commercial houses of this type of silicone do not accurately reveal the agent used for curing. On the other hand, the model manufactured under this combination of materials becomes competitive in the additive manufacturing market, since it does not exceed € 250.00 [7-14].

Conclusion

The importance of manufacturing anatomical models with MA lies in the impact they directly cause to surgical planning strategies in cases as complex as oncology and cardiology.According to the study carried out by Dr. Oscar Vidal of the Hospital Clinic Barcelona, the medical images showed a different strategy than the one that could be reached from the visualization of the veins that interconnected with the tumor of the oncological case of the anatomical model printed on 3D. From the anatomical visualization with the model, a strategy could be designed that guaranteed the success and safety of the intervention, and important operating room variables were roared, such as the time of the intervention. Likewise, in both the hepatic and cardiological cases, a multimaterial anatomical model printed in 2 materials of different hardnesses was designed, which allowed the human organ to be mimicked and the model was tested to evaluate possible risks inherent to an intervention and also to reduce the surgical time for the pre-surgical security offered by the practice of the operation in the model.

References

1. Stewart GR, Burgess AW, Hill DA. Back to the future: Teaching anatomy by whole-body dissection. Med J Aust. 2010; 193: 668-671.
2. Johnson EO, Charchanti AV, Troupis TG. Modernization of an anatomy class: From conceptualization to implementation. A case for integrated multimodal–multidisciplinary teaching. Anat Sci Educ. 2012; 5: 356-360.
3. McMenamin PG, Quayle MR, McHenry CR, et al. The production of anatomical teaching resources using three-dimensional (3D) printing technology. Anat Sci Educ. 2014; 7: 476-484.
4. Li C, Cheung TF, Fan VC, et al. Applications of three-dimensional printing in surgery. Surg Innov. 2017; 24: 82-88.
5. Malik HH, Darwood ARJ, Shaunak S, et al. Three-dimensional printing in surgery: A review of current surgical applications. J Surg Res. 2015; 199: 512-522.
6. Kong X, Nie L, Zhang H, et al. Do 3D printing models improve anatomical teaching about hepatic segments to medical students? A randomized controlled study. World J Surg. 2016; 40: 1969-1976.
7. Wong KV, Hernandez A. A review of additive manufacturing. Miami. Int Sch Res Notices. 2012; 10: 20-25.
8. Wiley. Polymer Handbook (4th Edn). 2003.
9. Makemike. Making the world again in three dimensions. 2016.
10. Recreus. How to print with FilaFlex. 2020.
11. Eprints. Design and Printing of 3D objects. 2017.
12. Neillsmaterials. Exson Essil 291 Silicone. 2017.
13. Upc. Stereolithography SLA 7000 System. 2020.

*Correspondence to:

Ing. Giuliana Calise
Department of Science Materials, University Simon Bolivar, Venezuela
Tel: +34675191931
E-mail: gm.calise@gmail.com