International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Special Issue, MAY 2022

Reconstruction and Segmentation Of Cancer Affected Patient's Lower Jaw, Developing Cad Model Of Cancer Part And Rapid Prototyping

Mr. Sai Aditya Vardhan Sanku*, Mr. Naveen Gorsipudi*, Mr. Aravind Gollapalli*, Mr. Sashendra Srinivasa Baswanth Pappula*, Mr. Pavan Sai Mattapalli*, Mr. B Bharath Kumar, Dr G Avinash****

***UG students, Department of Mechanical Engineering, Pragati Engineering College (A)**

****Faculty, Department of Mechanical Engineering College, Pragati Engineering College (A)**

Abstract: Additive manufacturing is one of the latest manufacturing techniques which has the ability to generate complex parts. Our paper deals with application of this technique in the field of biomedical. This work concerns a type of bone cancer known as Osteosarcoma. A methodology has been proposed here in which Computer Tomography (CT) scan data is used to make a 3D model and the portion containing cancer is studied in Computer Aided Design (CAD) software. Different 3D printing parameters were changed to obtain a good quality part and respective time estimations were made. It was observed that bone implant in case of osteosarcoma can be easily fabricated using this method.

Key words: Cancer, Prototype, CT, CAD, 3D printing

I. INTRODUCTION

3D printing is to manufacture any 3D data designed with CAD programs using a printer, by adding layers of material to a 3D physical part. 3D printing can be defined as additive manufacturing (AM) or layered manufacturing. 3D printing which has some techniques like selective laser sintering (SLS) material jetting, stereolithography (SLA), material extrusion and binder jetting etc. can be used for different materials and areas. It is interesting for many areas due to its success in the production of complex parts and the saving of material and time thanks to high-speed production. The effects of the developing technology can be seen in every field, from medicine to manufacturing. 3D printers have become a part of this developing technology. Although it is thought to be a very new technology for us, what is actually changed is that they are now more accessible and affordable than before. It is thought that 3D printing will move forward day by day thanks to the different facilities that provides for many different sectors. This technology, which is preferred especially for many applications in the field of health, provides great benefits especially for medical imaging and dental imaging, since it can largely manage studies such as medical device design and production that define the patient-specific anatomical structure. Applications using biocompatible materials such as the creation of tissue without any damage with living cells, blood vessel production, dental implants and special medical prostheses are just some of the contributions of the 3D printer to the biomedical field. In addition, this technology is also being researched in order to fix or replace defective organs such as kidneys, heart. Moreover, with this technology, organs that will perform the same biological functions as the original organs can be created. Thanks to this technology with organ and tissue printing, the future will be provided for many patients, and there is now a growing research effort focusing on the use of its research in a variety of biomedical applications. 3D printer technology has become a preferred application in many sectors, especially in recent years its use in biomedical applications has attracted attention. In this study, 3D technology is introduced and various 3D method are referred. The superior properties of the method and its use in biomedical applications are mentioned. The use of the method in surgical applications, medical imaging, pharmaceutical industry, production of patient-specific medical prostheses and implants, vet medicine applications, skin engineering and stem cell studies and organ printing were explained. In addition, this study includes the benefits of this technology which is expected to become widespread in the biomedical applications, the current challenges that need to be developed, trends and future opportunities.

Recently the use of 3D printing in the biomedical applications has been interesting for lots of researches. Many companies around the world have contributed to the increase in the use of this manufacturing method in the medicine with their laboratories and scientific researches. This technology offers significant benefits for biomedical applications and devices owing to the ability to

 DOI : 10.35291/2454-9150.2022.0222

manufacture the optional product according to specific patient needs. For example, many instruments used in surgery are currently produced by forging or casting methods and by using the mould required for the part, with special surface coating for desiderated surface properties and mechanical properties. These procedures need uneconomic machine and equipment, so distinct implants or patient specific are unaffordable and seldom produced. Machining of titanium alloys is more difficult as it has low elastic modulus, high mechanical strength and low thermal conductivity compared to 314L stainless steel. For this reason, patient specific implants are uneconomic to manufacture from these materials. These methods generate large material waste, and it is not possible to manufacture functional grade implants, so it is a miracle opportunity in order to the manufacturing of various functional biomedical equipment. Biomedical is a branch of technology that deals with the production of all material, apparatus and devices that can be used for diagnosis and treatment in medicine. Artificial kidneys, heart, dental implants, knee prostheses, lenses, pacemakers and hip etc. this includes biomedical applications. Printing for these medical applications allows the customized complicated geometry of implants and upon request production, which can result in a significant attenuation in expense and stock. Also, the unit cost remains constant for all products since special tooling for any product is not necessary in 3D printing. This expense assessment forms the basis and purpose of this method for biomedical orthopedic implants. Since this technology has many advantages, its use in biomedical applications is increasing day by day. It is used in biomedical applications such as implants and tissue engineering. It is predicted that its use in these application areas will increase in the near future, as shown in Fig. 2.1. Today, it is preferred for many different applications, especially in the medical sector, as shown in Fig. 2.2. Despite some remarkable achievements, the development of organs tissue with this method goes on pose important challenges. From cancer treatment to patient-specific prostheses; In many areas of medicine, inventions strengthened with 3D printing are sought to improve the quality of life or save patients life.

II. SLICER

Slicer interfaces between scanning data (CT, MRI, Technical scanner,) and Rapid Prototyping, STL file format, CAD and Finite Element analysis. The software is an image-processing package with 3D visualization functions that interfaces with all common scanner formats.

Additional modules provide the interface towards Rapid Prototyping using STL or direct layer formats with support. Alternatively, an interface to CAD (design of custom-made prosthesis and new product lines based on image data) or to Finite Element mesh is available.

Slicer is an interactive tool for the visualization and segmentation of CT images as well as MRI images and 3D rendering of objects. Therefore, in the medical field slicer can be used for diagnostic, operation planning or rehearsal purposes. A very flexible interface to rapid prototyping systems is included for building distinctive segmentation objects.

The software enables the user to control and correct the segmentation of CT-scans and MRI- scans. For instance, image artifacts coming from metal implants can easily be removed. The object(s) to be visualized and/or produced can be defined exactly by medical staff. No technical knowledge is needed for creating on screen 3D visualizations of medical objects (a cranium, pelvis, etc.)

Separate software is available to define and calculate the necessary data to build the medical object(s) created within slicer on all rapid prototyping systems. The interface created to process the images provides several segmentation and visualization tools.

III. ULTIMAKER CURA

Cura is an open-source slicing application for 3D printers. It was created by David Braam who was later employed by Ultimaker, a 3D printer manufacturing company, to maintain the software. Cura is available under LGPLv3 license. Cura was initially released under the open source Affero General Public License version 3, but on 28 September 2017 the license was changed to LGPLv3. This change allowed for more integration with third-party CAD applications. Development is hosted on GitHub. Ultimaker Cura is used by over one million users worldwide and handles 1.4 million print jobs per week. It is the preferred 3D printing software for Ultimaker 3D printers, but it can be used with other printers as well.

IV. RESULTS AND DISCUSSION

The results in this work are obtained by slicing the segmented part in Ultimaker CURA. The details available after slicing are time estimation and material requirement. There are a total of 4 trails and 2 iterations for each with 1st iteration being layer height 0.1 mm and 2nd iteration being layer height 0.2 mm which were carried out, out of which the first trail is done by keeping all the printing parameters as default. However, the best result in all trail is carried forward for next trail. In all the trails, the material used is Polylactic Acid (PLA). As mentioned before, in the first trail there were no changes made to any of the printing parameters including the orientation of the part on the build plate. The second and third trail concerns with changes in orientation of the part on build plate. In the fourth trail, considerable changes were made regarding wall thickness and wall count. At the end, all the trails with their respective iterations were compared to get an incisive idea as to how each parameter has made an impact on print time and material consumption.

 DOI : 10.35291/2454-9150.2022.0222

TRAIL – 1

All the printing parameters are left unchanged including the orientation of the print part with respect to build plate. This trail was considered as the raw trail and the final comparisons were made to this trail.

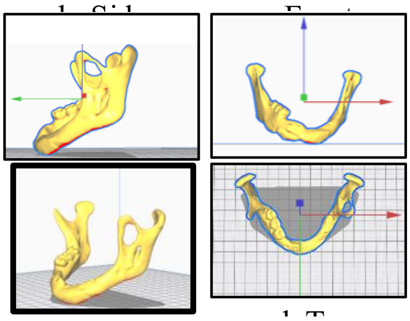

Fig 1 orientation of the part on build plate

Iteration-1 (LH 0.1 mm)

PARAMETER	-	VALUE / TYPE
Line width	-	0.4
Wall thickness	-	0.8
Wall Line count	-	2
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1
Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

Table 1 different printing parameters used for trail-1, iteration-1

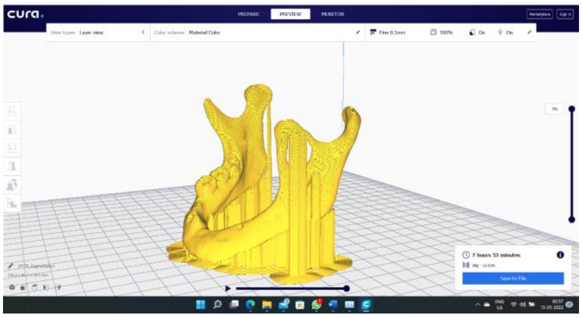

Fig 2 sliced part for trail-1, iteration-1

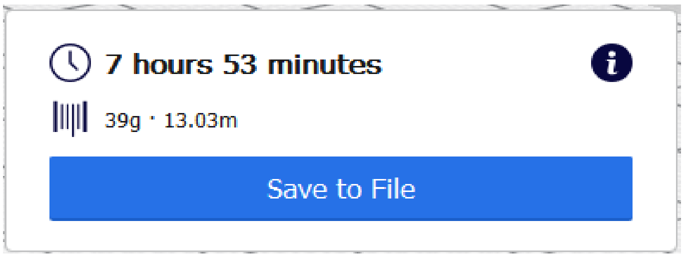

Fig 3 time estimate and material estimate for trail-1, iteration-1

Iteration-2 (LH 0.2 mm)

PARAMETER	-	VALUE / TYPE
Line width	-	0.4
Wall thickness	-	0.8
Wall Line count	-	2
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1
Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

Table 2 different printing parameters used for trail-1, iteration-2

 DOI : 10.35291/2454-9150.2022.0222

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-08, Special Issue, MAY 2022

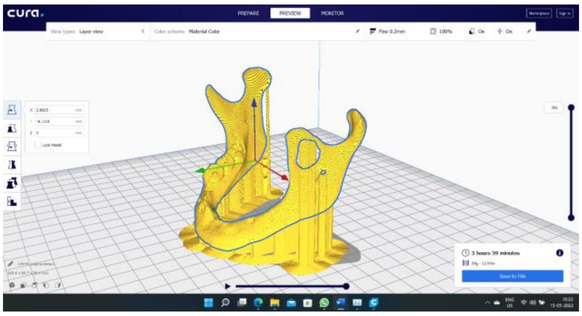

Fig 4 sliced part for trail-1, iteration-2

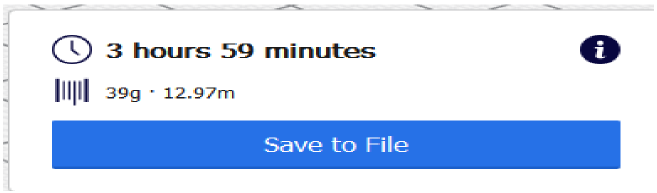

Fig 5 time estimate and material estimate for trail-1, iteration-2

TRAIL – 2

All the printing parameters are left unchanged except the orientation of the print part with respect to build plate. It was observed that the time taken and material requirements for the entire part to fully print has been slightly reduced in both the iterations.

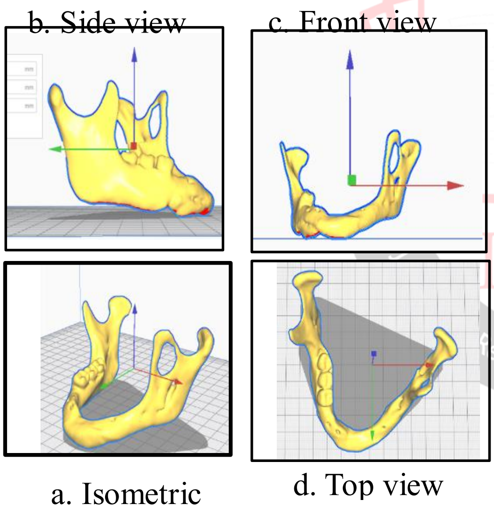

Fig 6 changed orientation of the part on build plate

Iteration-1 (LH 0.1 mm)

PARAMETER	-	VALUE / TYPE
Line width	-	0.4
Wall thickness	-	0.8
Wall Line count	-	2
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1
Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

Table 3 different printing parameters used for trail-2, iteration-1

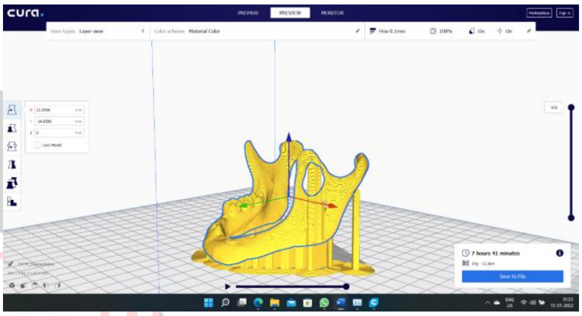

Fig 7 sliced part for trail-2, iteration-1

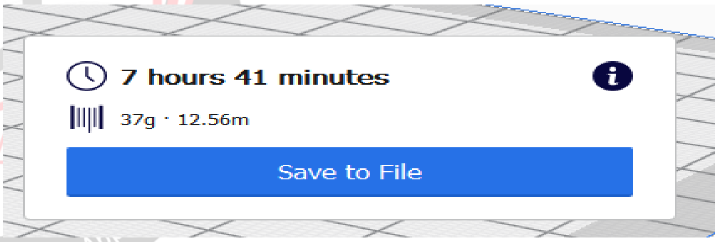

Fig 8 time estimate and material estimate for trail-2, iteration-1

Iteration – 2 (LH 0.2 mm)

PARAMETER	-	VALUE / TYPE
Line width	-	0.4
Wall thickness	-	0.8
Wall Line count	-	2
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1

 DOI : 10.35291/2454-9150.2022.0222

ISSN : 2454-9150 Vol-08, Special Issue, MAY 2022

Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

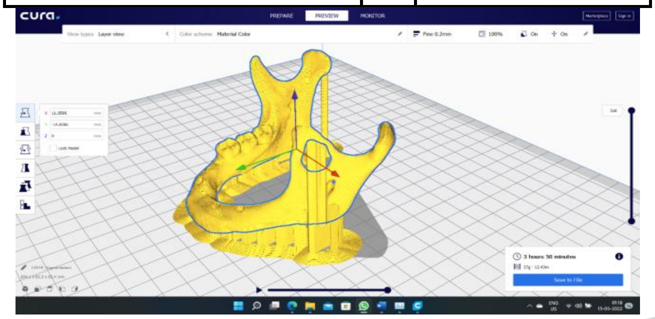

Table 4 different printing parameters used for trail-2, iteration-1

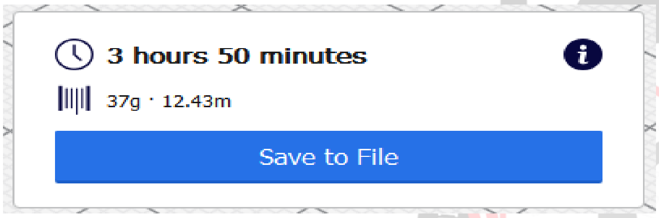

Fig 9 sliced part for trail-2, iteration-2

TRAIL – 3

All the printing parameters are left unchanged except the orientation of the print part with respect to build plate which has been further changed than the previous trail. It was observed that the time taken and material requirements for the entire part to fully print has been reduced in both the iterations.

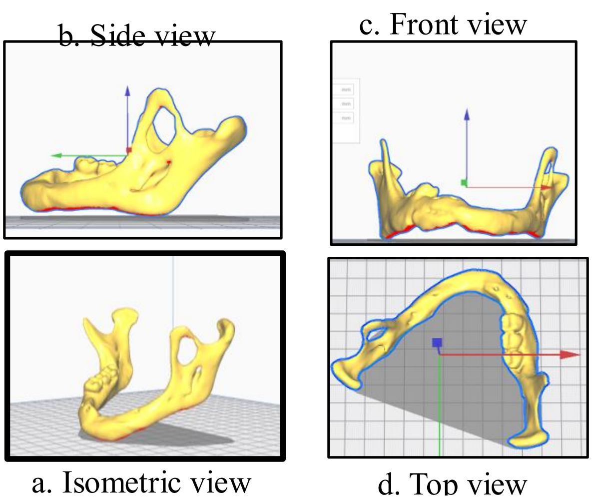

Fig 7.11 changed orientation of the part on build plate

Iteration – 1 (LH 0.1 mm)

PARAMETER	-	VALUE / TYPE
Line width	-	0.4
Wall thickness	-	0.8
Wall Line count	-	2
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1
Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

Table 5 different printing parameters used for trail-3, iteration-1

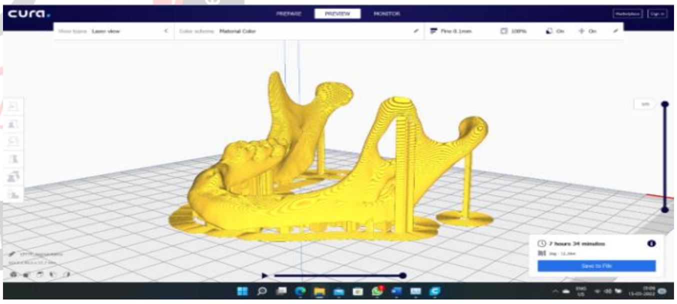

Fig 12 sliced part for trail-3, iteration-1

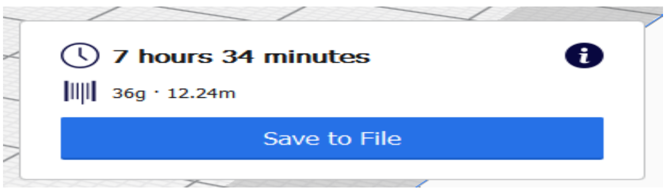

Fig 13 time estimate and material estimate for trail-3, iteration-1

Iteration – 2 (LH 0.2 mm)

PARAMETER		VALUE / TYPE
Line width	-	0.4

DOI : 10.35291/2454-9150.2022.0222

Wall thickness	-	0.8
Wall Line count	-	2
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1
Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

Table 6 different printing parameters used for trail-2, iteration-

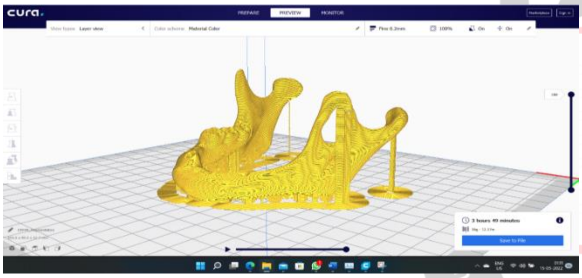

Fig 14 sliced part for trail-3, iteration-2

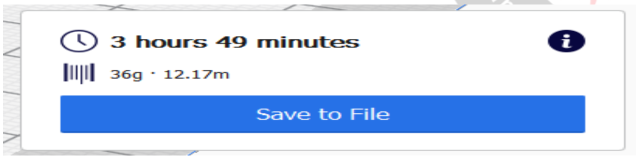

Fig 15 time estimate and material estimate for trail-3, iteration-2

TRAIL – 4

The wall thickness and the wall count were changed. However, the orientation of the print part with respect to build plate was kept same as the previous trail. It was observed that the time taken and material requirements for the entire part to fully print has been reduced significantly in both the iterations. This trail has given the most reliable result so far.

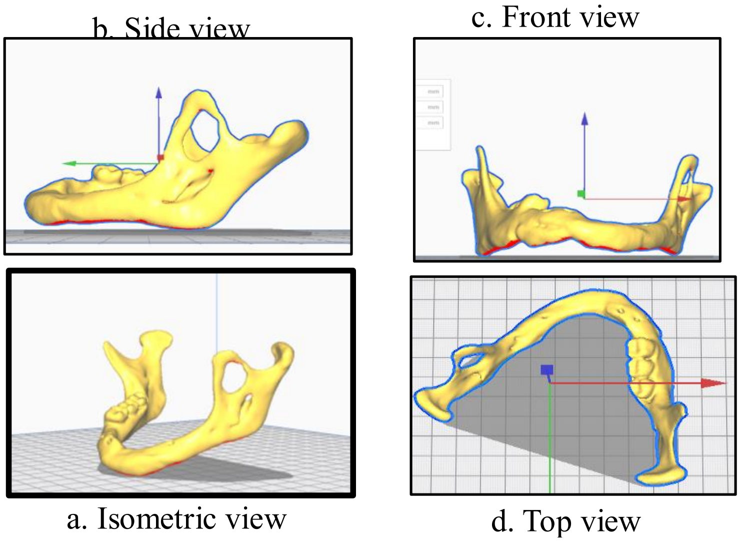

Fig 16 unchanged orientation of the part on build plate

Iteration – 1 (LH 0.1 mm)

PARAMETER	-	VALUE / TYPE
Line width	-	0.4
Wall thickness	-	1.6
Wall Line count	-	4
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1
Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

Table 7 different printing parameters used for trail-4, iteration-1

 DOI : 10.35291/2454-9150.2022.0222

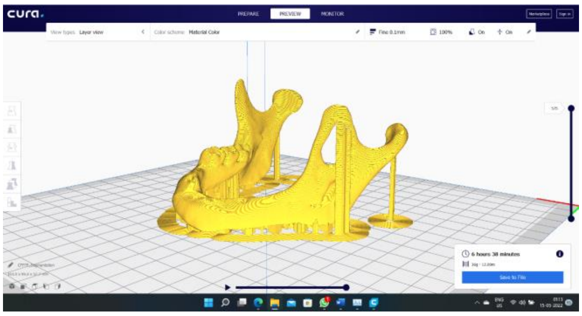

Fig 17 sliced part for trail-4, iteration-1

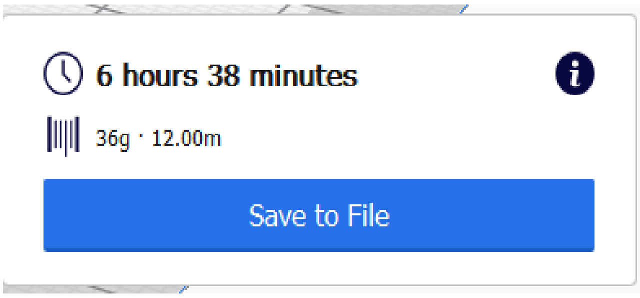

Fig 18 time estimate and material estimate for trail-4, iteration-1

Iteration – 2 (0.2 mm)

PARAMETER	-	VALUE / TYPE
Line width	-	0.4
Wall thickness	-	1.6
Wall Line count	-	4
Infill	-	100%
Infill Pattern	-	Lines
Infill layer thickness	-	0.1
Print speed	-	60 mm/sec
Infill speed	-	60 mm/sec
Support structure	-	Touching Build plate
Support structure over hang angle	-	50°
Build Plate Adhesion type	-	Brim
Build Width	-	8

Table 8 different printing parameters used for trail-4, iteration-2

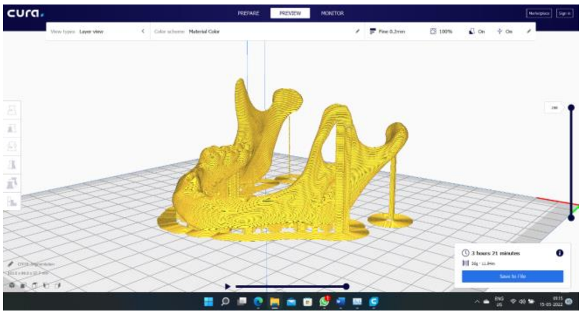

Fig 19 sliced part for trail-4, iteration-2

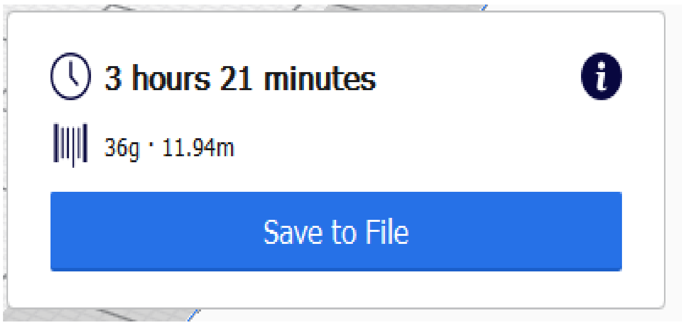

Fig 20 time estimate and material estimate for trail-4, iteration-2

V. CONCLUSIONS

Osteosarcoma is associated with specific genetic changes and diseases along with radiation exposure. It is an arbitrary disease and can occur to any random person. According to researchers the most likely people are the males under the age of 30 and require surgery in mild cases whereas excessive chemotherapy sessions are required in strong cases. If the disease is localized (has not spread to other areas of the body), the long-term survival rate is 70–75%. If osteosarcoma has already spread to the lungs or other bones at diagnosis, the long-term survival rate is about 30%. About 1 out of 5 osteosarcomas has spread at the time of diagnosis. Therefore, this type of implantation can be very helpful in the cases where it has not spread.

This work was carried out on a patient's skull who suffered with Osteosarcoma. The CT scan files were taken and a CAD model was developed after the segmentation of the cancer effected part using 3D Slicer software. This model is converted into STL format for facilitating 3D printing. The STL file is imported into Ultimaker CURA, a 3D printing software which is widely used for generating parts by many enthusiasts and professionals. Few printing parameters like orientation, wall thickness and wall count were changed for improving the printing time. Their respective time estimations and material requirements were noted at each trail. After 4 trails the time required to print the part has been reduced from 7 hours 53 minutes to 6 hours 38 minutes and 3 hours 59 minutes to 3 hours 21 minutes among two iterations with LH 0.1 mm and LH 0.2 mm respectively.

Using a patient specific CAD model of the required part is

 DOI : 10.35291/2454-9150.2022.0222

always beneficial to the surgeon as well as to the patient due to the fact that the surgeons can familiarize with the patient's part and perform the surgery without any unforeseen issues and potentially with less complications while and post-surgery. Decreasing the printing time of the part reduces the wait time for proceeding on with the surgery.

REFERENCES

[1] U. Modi, S. Prakash, AIP Conf. Proc. 2148 (2019) 1.

[2] N. Kumar et al., IOP Conf. Ser.: Mater. Sci. Eng. 149 (2016) 012056.

[3] R.A. Wolfe, E.C. Roys, R.M. Merion, Trends in organ donation and transplantation in the United States, 1999–2008, Am. J. Transplant. 10 (4 Pt 2) (2010) 961–962.

[4] Qian Yan, H. Dong, J. Su, J. Han, B. Song, Q. Wei, Y. Shi, Engineering, 4 (2018), 729–742.

[5] Y. Zhang, Z. Yang, X. Li, Y. Chen, S. Zhang, M. Du, et al., Custom prosthetic reconstruction for proximal tibial osteosarcoma with proximal tibiofibular joint involved, Surg. Oncol. 17 (2) (2008) 87–95.

[6] J. Winder, R.S. Cooke, J. Gray, T. Fannin, T. Fegan, Medical rapid prototyping and 3D CT in the manufacture of custom made cranial titanium plates, J. Med. Eng. Technol. 23 (1) (1999) 26–28.

[7] Ho-Le, K., 1988. Finite element mesh generation methods: a review and classification. Computer-Aided Design 20 (1), 27e38.

[8] Hyperworks Online Student Guide, December 22, 2016. Available at: http://www. altairuniversity.com/wp-content/uploads/2014/02/elemquality.pdf.

[9] Jansen, T., Hanssen, N., Ritter, L., von Rymon-Lipinski, B., Keeve, E., 2005. Julius-a software framework for rapid application development in computer-aided-surgery. In: Proc. Annual Conference of the German Society for Biomedical Engineering (BMT'05), Nuremberg.

[10] Kalra, 2017. Development of an Elderly Female Torso Finite Element Model for Restraint System Research and Development Applications (Ph.D. dissertation). Wayne State University.

[11] Kang, Y., Engelke, K., Kalender, W.A., 2003. A new accurate and precise 3D segmentation method for skeletal structures in volumetric CT data. IEEE Transactions on Medical Imaging 22 (5), 586e598.

[12] Kwon, P.-J., Kim, H., Kim, U., 2009. A study on the web-based intelligent self-diagnosis medical system. Advances in Engineering Software 40 (6), 402e406.

[13] Lo, D.S., 2014. Finite Element Mesh Generation. CRC Press. LS-DYNA Keyword User Manual.

[14] Maintz, J.A., Viergever, M.A., 1998. A survey of medical image registration. Medical Image Analysis 2 (1), 1e36.

[15] Mao, H., Gao, H., Cao, L., Genthikatti, V.V., Yang, K.H., 2013. Development of high-quality hexahedral human brain meshes using feature-based multi-block approach. Computer Methods in Biomechanics and Biomedical Engineering 16 (3), 271e279.

[16] O¨ zsaglam, M.Y., C¸ unka¸s, M., 2015. Genetic algorithms for mesh surface smoothing. In: Proc. Seventh International Conference on Machine Vision (ICMV 2014). International Society for Optics and Photonics, pp. 944522e944522-5.

[17] Pham, D.L., Xu, C., Prince, J.L., 2000. Current methods in medical image segmentation. Annual Review of Biomedical Engineering 2 (1), 315e337.

[18] 3d Reconstruction - an overview | ScienceDirect Topics.

 DOI : 10.35291/2454-9150.2022.0222