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Development of 3D Printed Brain Tumour for Surgical Biopsy

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Abstract The traditional treatment for brain cancer includes surgery, radiotherapy and chemotherapy. The neurosurgeon usually plans and performs the surgery with the help of two dimensional MRI images. If the size and the exact location of tumour is not clear it is difficult to perform a safe surgery and sometimes may cause permanent damage to the normal tissues. Such problems could be minimized by having first hand information regarding the tumour and hence an attempt is made in the present research to create 3D printed models of brain tumours using a medical image processing software based on MRI datasets. The MRI data saved as DICOM (Digital Imaging and Communications in Medicine) would be integrated with 3D slicer. 3D printer produces a physical 3D models using STL file generated from 3D slicer. Thus the 3D printed model of Brain Tumour could be served as a tool for preoperative surgical planning.

1. INTRODUCTION

A Brain Tumour forms when cells grow abnormally within the brain. In India, every year 40,000 to 50.000 people are diagnosed with brain tumour, out of which 20% are children. The symptoms include new or increasingly strong headache, blurred vision, and loss of balance, confusion and seizures. The treatment depends on the stage of tumor and it includes surgery, radiation therapy and chemotherapy. In some situations tumors can’t be removed, so doctors may refer it for biopsy. In biopsy a piece of tumor is collected and will be sent for pathology examination, where it is tested under a microscope and decides the type of cells it contains. Biopsy is performed with the help of a needle and the CT/MRI scans uses to pinpoint the exact location of the tumor. Doctors get only 2D cross sectional images for viewing the tumor in MRI scan. Hence it always takes a skilled neurologist to detect the tumor in brain anatomy.

3D Printing Technology has become a boom in recent years for the creation of customized prosthetics, implants, and surgical tools. 3D printed brain models were found convenient in understanding the anatomy of brain and tumour, surgical simulation [1]. The applicability of 3D printing technology is very limited in brain tumors analysis. Ivan Lau et al., presented the preliminary experience of creating patient specific 3D printed model of brain tumour in a pediatric patient and demonstrated the feasibility of using 3D printing [2]. Vakharia et al. conducted a systematic review of 3D printing on cranial neurosurgery simulation. This analysis focused on the benefits of 3D printed models in preoperative simulation and training [3]. A computer based image processing software for preoperative surgical planning was used by kikins et al in 1996. They used the MRI images on 14 cases to analyze the brain tumors [4]. The authors reviewed the important concepts and described the techniques of interactive 3D visualization from routine 3D T_1 – weighted, MR angiography and brain suite software [5]. Mirchael Kuhlmann et al., attempted to construct the model using conjoint CT and

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MRI images on a 4 month old male patient and succeeded in creating a realistic 3D model of a pineal gland tumours, which was used on a trial basis in neuroendoscopic training and simulation [6]. Sayalilopes et al. presented a method for automatic tumour detection with an added feature of reconstructing its 3D image. This involves the implementation in various steps of detecting and exacting the tumour with 2D slices of MRI brain images by region growing technique [7].

2. METHODOLOGY

Based on the tumor location and type of tissue involved, the brain tumours are categorized as primary and metastatic. Primary brain tumours begin to form within the brain. A metastatic tumour is formed when cancer cells located elsewhere in the body break away and travel to the brain.

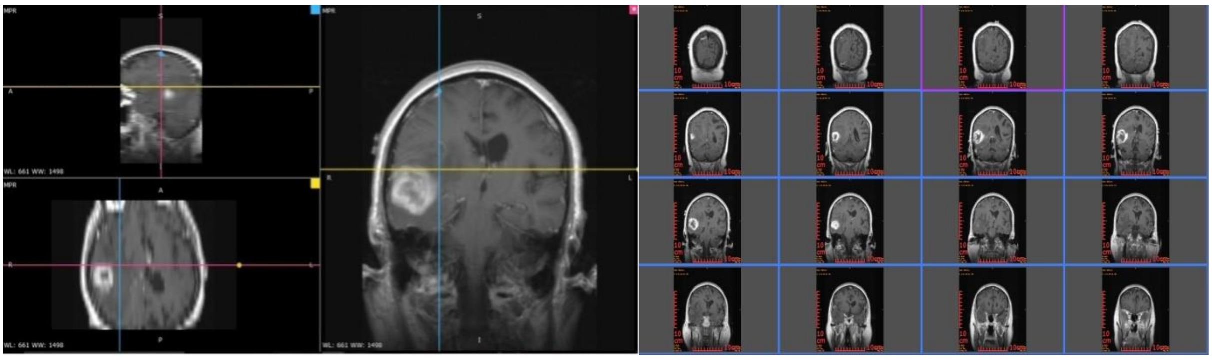

Figure 1 MRI data slices.

2.1 TREATMENT OPTIONS

A variety of therapies have been used to treat brain tumours. The type of treatment recommended depends on the size and type of the tumour, its growth rate, location of tumour, and the general health of the patient. Treatment options include surgery, radiation therapy, chemotherapy, targeted biological agents, or a combination of these. Surgery is generally the first step when the tumour is accessible and the vital structure does not get disturbed. Radiation is used to stop the tumour's growth and causes it to shrink. Chemotherapy destroys tumour cell that may remain after surgery, but it is not very effective for gliomas and at large level, because it is difficult for chemotherapeutic drugs to reach the brain.

3. CASE STUDY

Nine different cases have been considered for the study of size and position of the Brain tumour for pre surgical planning. Different stages that are included in the generation of 3D printed STL files are Image Acquisition, Segmentation, Creating ROI and Model Making. Medical Image Data could be obtained from CT or MRI data. CT scan images are to be used for orthopedic, dental applications and in the situation of high radiation exposure, where as the use of MRI images have the advantage of not exposing to radiation for image acquisition. It is used for medical imaging on soft tissues such as brain.

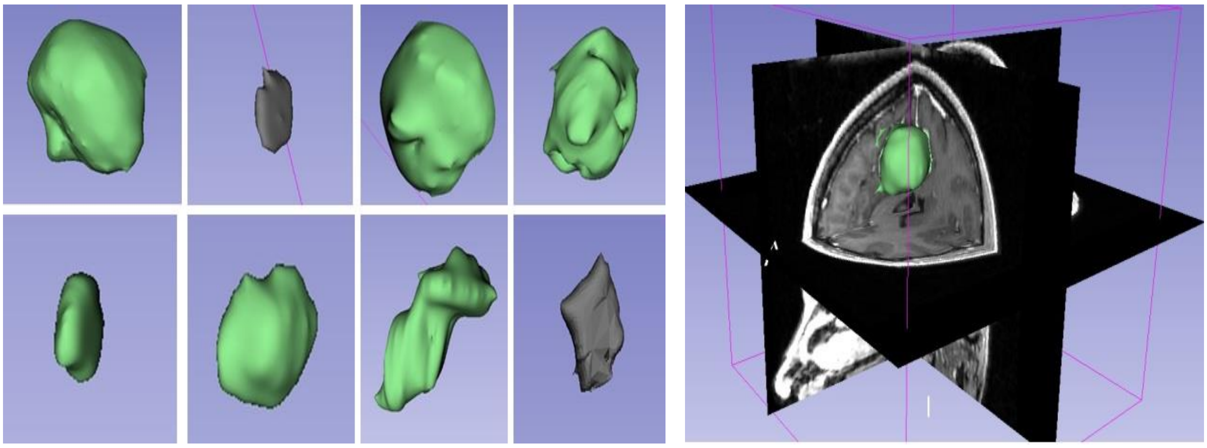

Figure 2(a) Tumours of different sizes (b) Position of tumour in the brain tissue.

3.1 IMAGE SEGMENTATION

Image segmentation is the crucial step used in many clinical applications in the image analysis. Brain data acquisition from MRI scan and the image segmentation are used for measuring and visualizing the brain's anatomical structure, tumour growth and size for surgical planning. Computerized methods for MR image segmentation and visualization have been extensively used to assist doctors to carryout qualitative diagnosis. The images saved in DICOM format would be imported into 3D slicer which is open access software for medical image processing for the purpose of image segmentation and 3D modelling.

3.2 CREATING ROI

The selected ROI (Region of Interest) could be painted using 3D slicer, preferred region could be segmented by opting the effect of grow cut. The cerebellum and brain tumour are considered separately while creating 3D printed model. The model maker function is used to create a computerized model of the ROI and the Laplacian filter is applied to optimize the model. The brain tumours in form of STL files have been exported for 3D printing using global 3D pramaan – 200 3D printer.

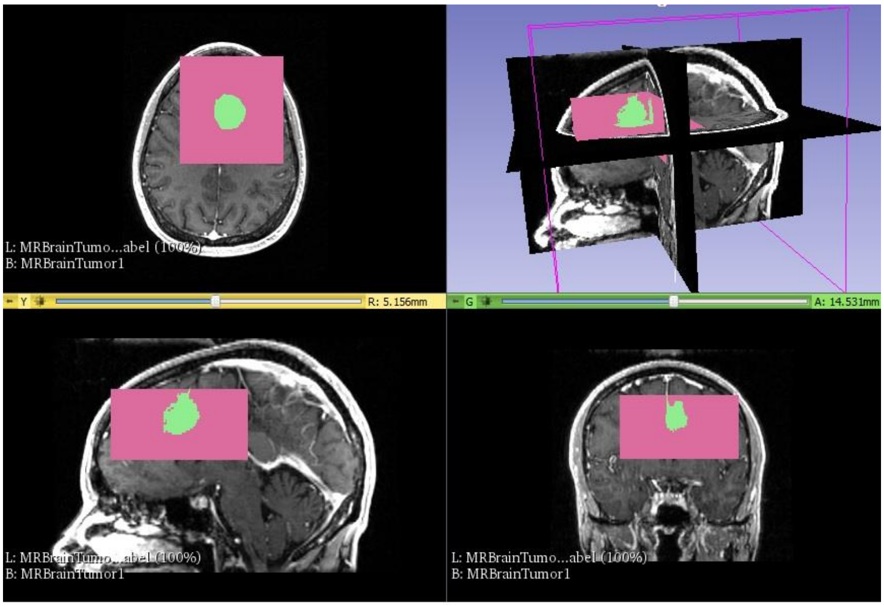

Figure 3 Grow cut effect and selection of ROI.

3.3 3D PRINTING

All 3D printers are encoded in STL files to build 3D models to deposition of materials layer by layer. Major considerations for the selection of 3D Printing Technology includes the parameters like time required to complete printing, cost of printer, and the choice of material and accuracy of model. The Radiologist can select a 3D printer which should be customized for surgical planning. Accurate printing of 3D model would be possible by minimizing the errors generated in each stage of the parameters like Image Acquisition, post processing and 3D printing.

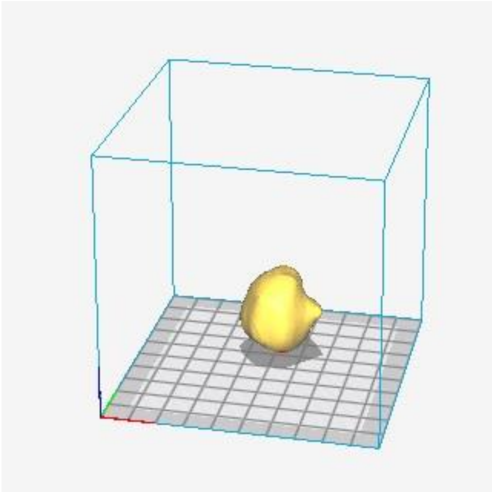

Figure 4 Brain tumour STL model.

In the present study, the tumour models are produced by controlling on the parameters like height of layer, amount of volume infill and time required to print the model. The STL file is imported into CURA open access software. Since the height of layer or thickness effects the accuracy of model, hence the radiologist should ensure for the desired accuracy for better treatment. The amount of volume infill can't effect on surgical planning, so that the radiologist can plan to generate 3D model with low volume infill.

Table 1 Effect of parameters on printing time of tumour model.

Layer Height (mm)	Volume Infill (%)	Time required for Printing	Layer Height (mm)	Volume Infill (%)	Time required for Printing	Layer Height (mm)	Volume Infill (%)	Time required for Printing
0.06	10	1 hr 13 min	0.1	10	40 min	0.15	10	22 min
	20	1 hr 27min		20	50 min		20	27 min
	30	1 hr 39 min		30	59 min		30	31 min
	40	1 hr 52 min		40	1 hr 09min		40	35 min
	50	2 hr 04 min		50	1 hr 18 min		50	39 min
	60	2 hr 16 min		60	1 hr 28 min		60	43 min
	70	2 hr 28 min		70	1 hr 37 min		70	47 min
	80	2 hr 40 min		80	1 hr 37 min		80	51 min
	90	2 hr 52 min		90	1 hr 56 min		90	55 min
	100	10 hr 47 min		100	3 hr 29 min		100	2 hr 16 min
0.2	10	20 min	0.4	10	10 min	0.6	10	08 min
	20	25 min		20	12 min		20	10 min
	30	30 min		30	15 min		30	11 min
	40	35 min		40	17 min		40	13 min
	50	39 min		50	20 min		50	14 min
	60	44 min		60	22 min		60	16 min
	70	49 min		70	24 min		70	17 min
	80	53 min		80	27 min		80	19 min
	90	58 min		90	29 min		90	20 min
	100	1 hr 44 min		100	52 min		100	35 min

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4. CONCLUSION

External Radiation Therapy commonly results hair loss, the loss of skin on the scalp and sometimes kills the healthy brain tissue. So in such situations it is very convenient to use image processing and 3D printing to fix the location and the size of tumour. It is concluded that the use of image Processing, Preoperative 3D printed tumour models have led to the reduction in surgical time, decreased time under anesthesia and dose of radiation. Based upon the results in table, it is concluded that with the increasing in layer height and the volume infill, the time required for printing increases.

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REFERENCES

[1] Mullar A, Krishna KG, Uhl E "The Applications of Rapid Prototyping techniques in cranial reconstruction and preoperative planning in neurosurgery", *J craniofacial surgery – **2003***, pg no 899 – 914.

[2] Iran Lau, Andrew squwlch, Yung wan, "Patient specific 3D printed model in delineating brain glioma and surrounding structure in a pediatric patient", published in *wolten kluwer – **2017***.

[3] Vakharia VN, Vakharia NN, Hill CS " Review of 3D printing on cranial neurosurgery simulation training", *World neuro surgery – **2016***, pg no 188 – 198.

[4] Kikins R, Gleoson PL, Moriatry TM, "Computer Assisted Interactive 3D planning for neurosurgical procedures", *neurosurgery – **1996.***

[5] Zafar Neyar, Rajendra V phadke, vivek singh, chaitanya godbole, " Three Dimensional Visualization of Intracranial Tumors with Cortical Surface and Vasculature from Routine MR Sequences", Published in *Neurology India – **2017***, **volume 65**, issue – 2, pg no 330 – 340.

[6] Michael kuhlmann, James Drake, "Development of 3D patient specific brain model with a pineal region tumor and hydrocephalus for neuroendoscopic simulation and training," published in *RCSI* - 2013, **volume – 6**, number – 1, pg no 68 – 71.

[7] Syali Loper, Deepak Jayaswal "A Methodical Approach for Detecting and 3D Reconstruction of Brain Tumor in MRI", Published in *International Journal of Computer Applications* – 2015, **volume – 118**, pg no 37 – 43.

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