

# Fabrication of Lumbar Vertebrae by Polymer using Rapid Prototyping

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## Abstract:

In biomedical it is complex to regenerate or replace other lumbar vertebrae of the spinal cord because it is unique to every person. Lumbar vertebrae geometry also so complex to design in the Software but in most of the accidents fractures is occurring in vertebrae. This paper examines the fabrication process of Lumbar Vertebrae by using fused deposition modeling techniques with the application of reverse Engineering concepts. By a Reverse Engineering Technology the input data is collected from the CT scan because every patient has unique bone compare with other so the scan data is collected. Then Mimics software is used to create 3D surface models from stacks of 2D image data. These 3D model file is stored in stereolithography (STL) file format and used as an input file of rapid prototyping machine to fabricate the required part.

**Keywords:** Rapid Prototyping; Fused deposition modeling; Reverse engineering; 3D Printed Prototypes; Lumbar Vertebrae.

## Introduction:

### 1.1 Rapid Prototyping

Rapid Prototyping (RP) may be described as a group of strategies used to quick fabricate a scale model of a element or assembly the use of 3-dimensional computer aided layout (CAD) data. In manufacturing, rapid prototyping is used to create a three-dimensional model of a element or product. In addition to presenting 3-D visualization for digitally rendered gadgets, speedy prototyping may be used to test the performance of a element or product design before it's far synthetic in large quantities. Today, prototypes are frequently created with additive layer manufacturing generation, also known as 3-D Printing.

The technique starts off evolved with three-d modeling of the product and then STL document is exported via tessellating the geometric 3-D model. The amount and length of triangles in tessellating is decided through aspect deviation or chordal errors. These STL files are checked for defects like missing aspects, turn triangles, overlapping facets, dangling edges or faces and so on. Defect unfastened STL

files are used as an input to various slicing software's. At this degree choice of component deposition orientation is the maximum essential detail as element constructing time, floor exceptional, and quantity of aid systems, charge and plenty of others. Once component deposition orientation is decided and slice thickness is selected, tessellated model is sliced and the generated information in fashionable records formats SLC (stereo lithography contour) is saved. This fact is used to move to step 2 generation of physical version. The software that operates RP structures generates laser-scanning paths (in procedures like Stereo lithography, Selective Laser Sintering etc.) or cloth deposition paths (in approaches like Fused Deposition Modeling). This step is exclusive for distinct processes and relies upon on the primary deposition precept utilized in RP system. Information computed right here is used to deposit the component layer-via-layer on RP machine platform.

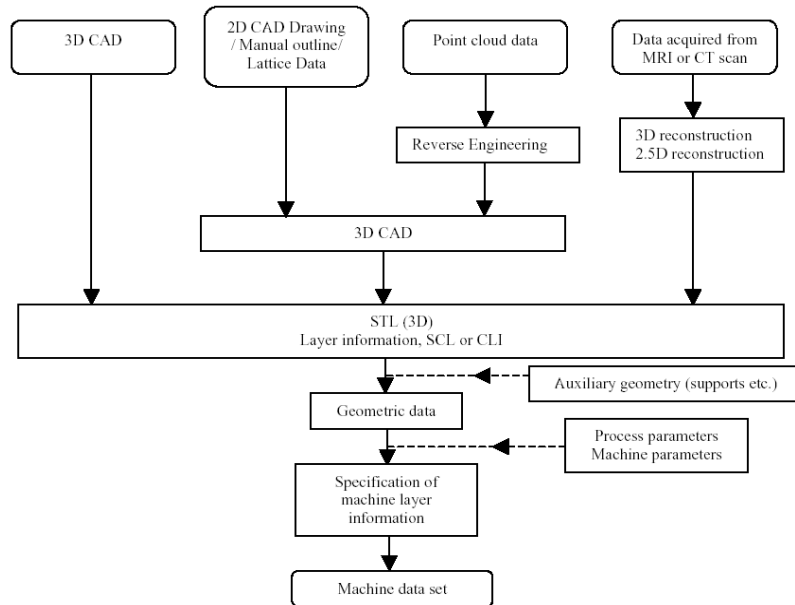


Fig 1.1: Generalized Illustration Of Data Flow In RP

## 1.2. APPLICATIONS

### Aerospace & Marine:



Fig 1.2.1 Model Of Aerospace

### Automotive Application

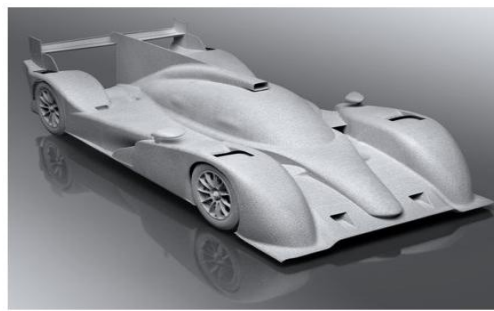


Fig 1.2.2 Model Of Car

### Biomedical Applications



Fig. 1.2.3 MODEL OF JAW

### Architecture



Fig 1.2.4 MODEL OF BUILDING

### Fashion and Jewellery

### Sculptures



Fig 1.2.5 MODEL OF SHOE



Fig 1.2.6 MODEL OF SCULPTURE

## METHODOLOGY

### 2.1. Reverse engineering in medical:

In biomedical, for reverse engineering the data is collect from the patient only. The way of getting data from the patient is by CT scan and MRI scan. From the scan we get the data in the DICOM file format.

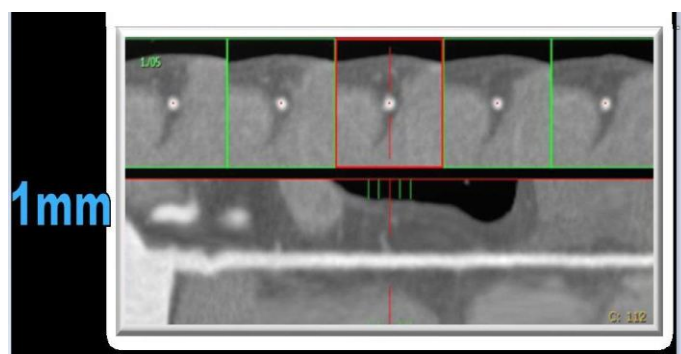


Fig 2.2 Slicing Thickness

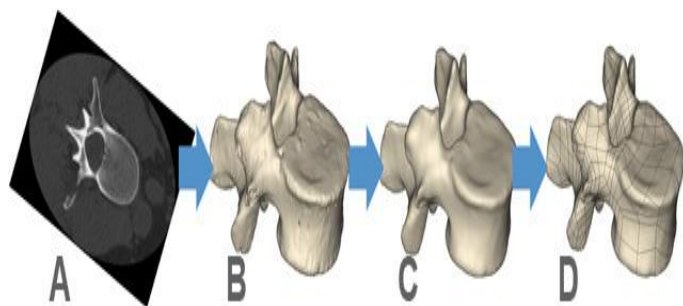


Fig 2.1 Reverse Engineering In Medical

### 2.2 Collecting of DICOM file:

Digital Imaging and Communications in Medicine (DICOM) is a widespread for coping with, storing, printing, and transmitting facts in scientific imaging. It includes a report format definition and a network communications protocol. DICOM documents may be exchanged among two entities which are capable of receiving photo and affected person records in DICOM layout.



In biomedical rapid prototyping the first step is to accumulate the DICOM document that is generated from the Computed Tomography (CT), Confocal Microscopy, Micro CT, Magnetic Resonance Imaging (MRI), , X-ray and Ultrasound, through image segmentation. The DICOM file image the slicing thickness most be considered as important factor because from that only the 3D image is created without any defect in it. In which it contains about 592 Dicom files. It consist of the layer of the spinal cord in the image. It consist of the 1mm in the all view like Axial, Coronal and Sagital.

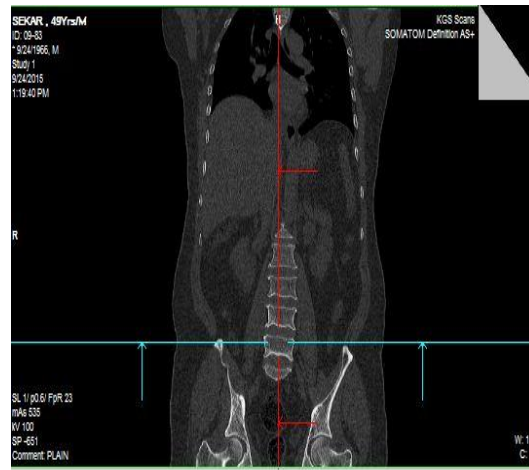


Fig 2.3 Coronal And Sagittal View

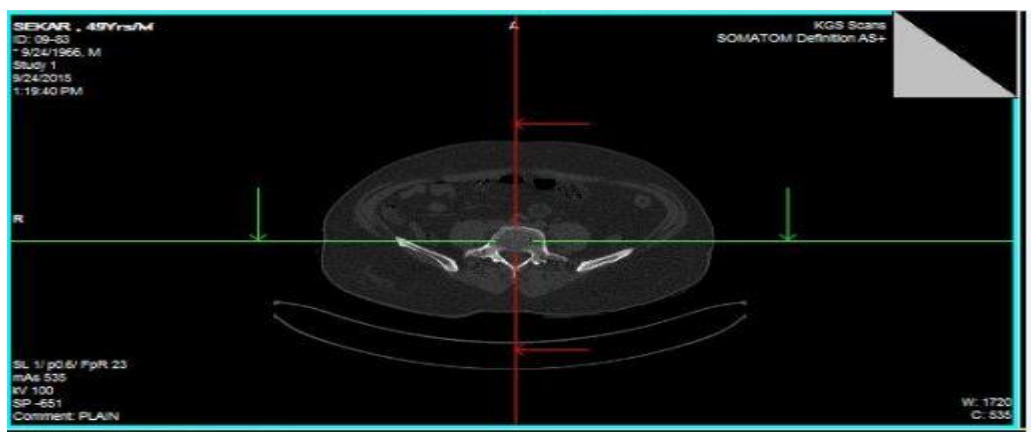


Fig 2.4 Axial View

## 2.3 MIMICS Software

Mimics is an acronym for Materialise Interactive Medical Image Control System. Mimics is an image processing software for 3D design and modeling, evolved by Materialise NV, a Belgian company specialized in additive manufacturing software program and technology for scientific, dental and additive production industries. Mimics is used to create 3D surface models from stacks of 2D picture records. These 3-d models can then be used for a spread of engineering applications.

### 2.3.1 Creating 3D Surface:

First load the DICOM file in to the MIMICS Software then there the view of the dicom file in axial, coronal and Sagittal slice view are generated. From there we select the region where it clearly viewed. The default threshold is between the -1024 to 3039 . By using manual threshold option select the compact bone option then range in the threshold vary from the 662 to 1988. Creating the mask mean that the soft tissue over the bone is to be created it will generated and also can be hidden.



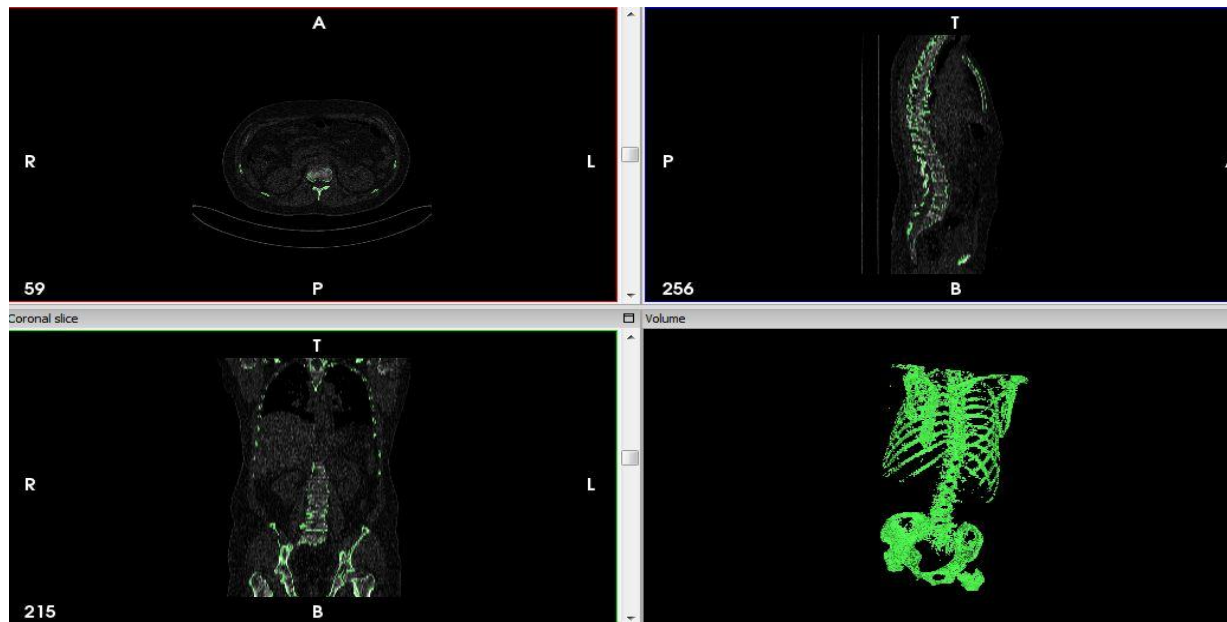


Fig 2.3.1 Creating 3D Model

## 2.4 Creating the specified part:

The complex part of lumbar vertebrae is generated by using MIMICS Software. In total 31 Vertebrae the Lumbar Vertebrae L2 be converted in 3D model and it can be separated from the Spinal Cord Vertebrae. It shown in fig 2.4.1

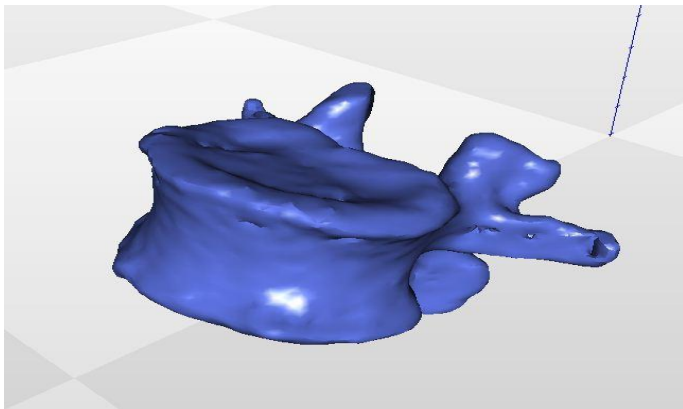


Fig 2.4.1 Model Created In Mimics Software

Using the software name reconverter 7 to convert the STL file in to the DWG file format. For the purpose of to get the dimension of the lumbar vertebrae.

By using the AutoCAD 2010 , open the File Open. Open dialog box is appeared. From selected the required file.From the Home, Click the Measure

icon and select the distance and click the required point to get the dimension of the lumbar vertebrae.

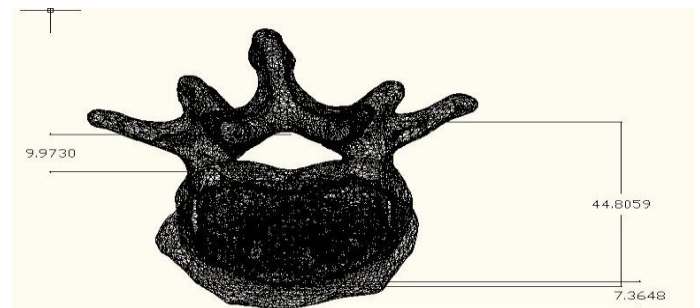


Fig 2.4.2 Dimension Of Lumbar Vertebrae

## 3.FUSED DEPOSITION MODELING

### 3.1 Fused deposition modeling:

During printing, those materials take the form of plastic filaments, which might be unwound from a rolled coil and fed through an extrusion nozzle. The nozzle melts the filaments and extrudes them onto a base, sometimes called a build platform or table. Both the nozzle and the base are managed through a computer that interprets the size of an object into three (X, Y and Z) coordinates for the nozzle and base to follow during printing.

In medical application, the required part is scan in the CT scan. The output of the CT scan in the DICOM (Digital Imaging and Communications in Medicine) format. Then the file is imported in the MIMICS Software (Materialise Interactive Medical Image Control System). Then the required part is created in MIMICS Software. The part is created in STL file format . Then it imported in FDM machine. The preferred software for your Ultimaker is Cura. It is bridge way between the system to the printer.

### 3.2 Build Volume:

The build platform of the printer is aluminum. The chassis are coated with the powder steel. The outermost body simply by the PVC panels. The movement of the bearing is wear-resistant.

The machine volume of realiz 3d printer is 24.6 L x 15.2 W x 15.5 H cm

The build volume of the component is 25.2 x 20 x 15 mm.



Fig 3.2.1 Fused deposition modeling machine

### 3.3 Material Extrusion:

Material Extrusion operates in a comparable fashion to a warm glue gun; plastic filament is heated to a malleable state and extruded through a nozzle.

The diameter of the extrusion nozzle of the machine is 0.4 mm.

The diameter of the filament i.e. Poly lactic acid is 1.75 mm.

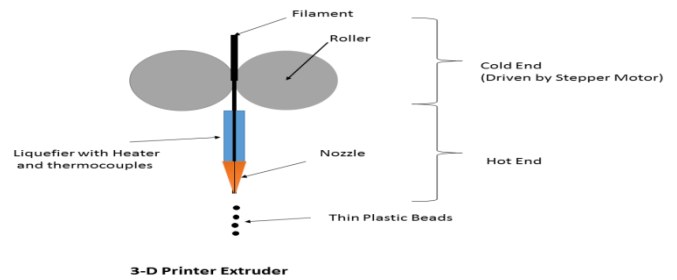


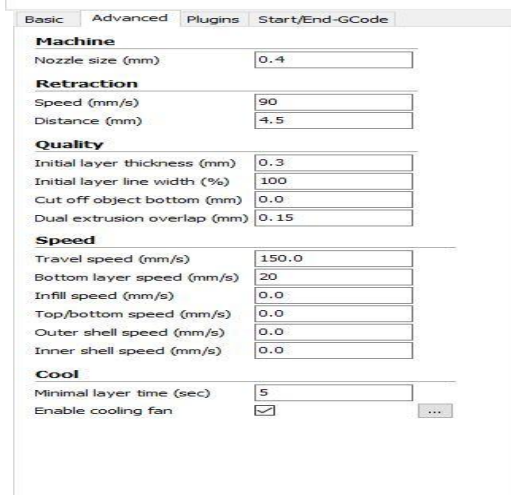
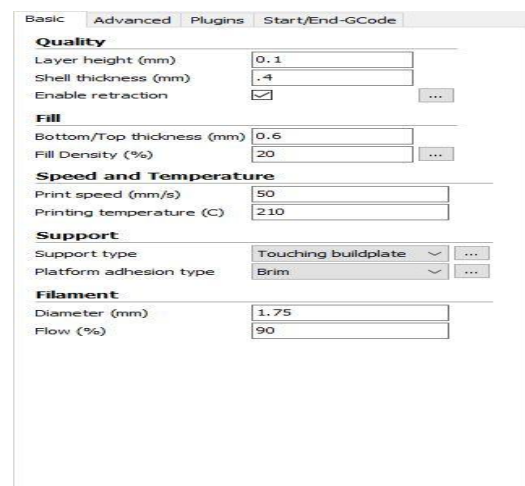
Fig.3.3.1 Material Extrusion

Extrusion velocity and extrusion temperature are two controllable parameters which, apart from layer thickness, have finest effect on the surface quality of FDM-constructed parts.

Travel speed of the nozzle = 150 mm/sec.

Travel speed of the nozzle during extrusion = 90 mm/sec.

Travel speed of the nozzle during retraction = 25 mm/sec.



The number of layer to form single vertebrae in the DICOM file is 50 layers. During printing the model the layer height is 0.2. So it need of 250 layer of plastic is overlay over to form the lumbar vertebrae.

### 3.4 Build & Support Material:

The build material of the component in the wire form. It will get heated in the nozzle up to glass

transition temperature. Then the material in the molten state it flows through the nozzle to form the part. The component to be build is in hexagonal shape inside the part. The density of material fill is 50 %.

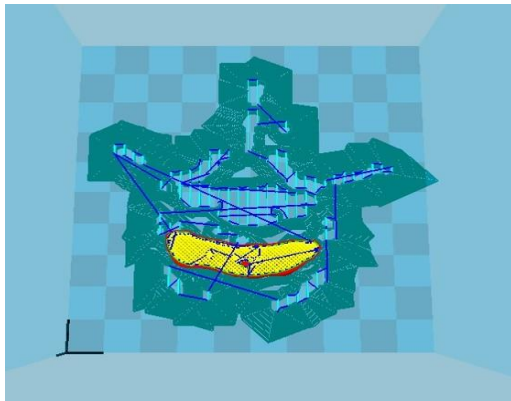


Fig 3.4.1 a) During Starting

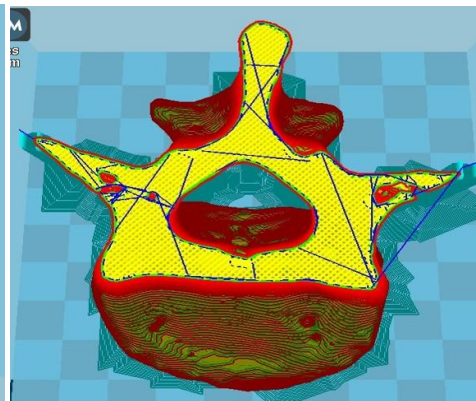


Fig 3.4.2 b) During Ending

The temperature is maintained in the nozzle and as in the bed of the printer. The temperature is specified below

- The extrude temperature of filament from the nozzle is 230°C.
- The Bed temperature of the machine is 120 °C.

Support material is almost as important as the base material in the realm of 3D printing. When working with a third dimension we have to deal with gravity.

Something desires to maintain layers in location and hold the base material out of the way. In FDM (Fused Deposition Modeling), a support material that dissolves while located in a bathtub of chemical compounds.

The difference between the build and support material is varied by the density of the material. If the density is low then it is support material, the density is high then it is part material.

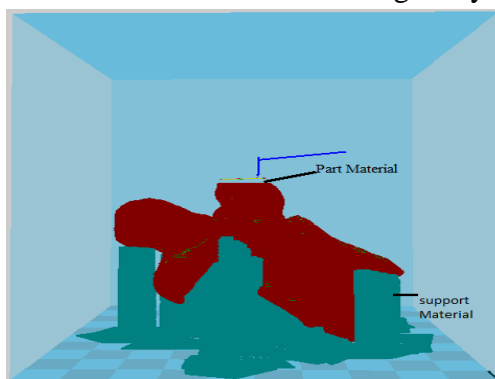


Fig 3.4.1 a) In Software

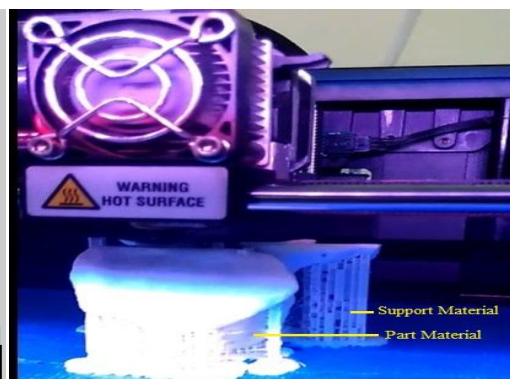


Fig 3.4.2 b) In Manufacturing



### 3.5 3D Printed Prototype of Lumbar Vertebrae:

After the completing the printing, the support materials are removed by the hand it self. The below

picture shows the different view of printed model of lumbar vertebrae.



Fig 3.5.1 Fabricated Lumbar Vertebrae

### CONCLUSION

Rapid Prototyping is capable of producing many complicated shapes of industrial products in a shorter period of time. Similarly it is capable of producing many complicated human bones, that can be used in replacement of human bone parts. Hence in this work Lumbar Vertebrae (L1 and L2 ) of human is considered for Manufacture.

By the concept of the Reverse Engineering the biomedical fabrication in Rapid Prototyping is made, so Initially the Dicom file of Spinal cord is collected in the CT scan centre which contains about 592 file. The spinal cord will be generated by 2D to 3D by using the MIMICS Software. The Lumbar Vertebrae part L1 and L2 is separated from the other vertebrae. The generated file is saved in the STL file format. Then it is convert in to DWG file format by using Reaconvertor7. It import in to the Auto CAD where the dimension for the lumbar Vertebrae is

taken. Vertebrae is around forty five cm (18 inch) in men and round forty three cm (17 inch) lengthy in women. The dimension that occurred from my DICOM file format consist of vertebrae is around 45 cm. Now the Lumbar Vertebrae of L1 and L2 is available in STL file format which is used to fabricate the model in Rapid Prototyping.

### APPENDIX

RP	Rapid Prototyping
MRI	Magnetic Resonance Imaging
STL	Stereo lithography
CAD	Computer Aided Design
DICOM	Digital Imaging and Communications in Medicine
CT	Computed Tomography
FDM	Fused Deposition Modeling



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