Case Study on Rapid Prototyping

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Abstract— Rapid prototyping is very important technology in medical science. Additive manufacturing (AM) of which rapid prototyping (RP) is a subset augments traditional material forming, removal and assembly methods of manufacturing. This overcomes traditional restrictions in manufacturing technology, with significant commercial and technological implications. This area has been further developed to design and build custom fit implants for both in vivo and in vitro applications. The intention here is to increase the quality of patient's lives who are burdened with a defect caused by trauma, genetic defect or disease. This paper represents a case study on rapid prototyping of the carnical plate of human skull.

Key words: Rapid Prototyping, Implant, Medical Science, Additive Manufacturing

I. INTRODUCTION

This case study required a cranial plate to be designed and manufactured due to sustained blunt force trauma to a patient's right hand side of the craniofacial region. A model of the patient's skull was converted from CT scanned data and manipulated using Mimics and 3-matics software to produce a 3D image file in STL format. Using 3-matic software two cranial plates were designed and manufactured on a 3D Systems SLA machine. The first cranial plate was designed using the "Create Cranioplasty" prosthesis tool. This method generates the plate automatically using the existing geometry of the patient's skull and the algorithms within the software. This method is generally used when the surface area concerned is reasonably uniform.

The second plate was designed using the "Create Spine" command. This allows a cross section of the patient's skull to be viewed and a spine created through the skull intersecting the affected area. Inserting control points along the spine, the position of the spine can be manipulated by moving each point individually to match the profile of the opposite side of the skull. Therefore this is a subjective method of achieving the profile of the cranial plate.

II. PROCESS STEPS

A. Mimics Process Steps

The data in this case study had already been converted from DICOM 2D data to 3D data and saved in STL format.

Mimics steps include:
– DICOM data images imported into Mimics software
– Project loaded and orientation selected
– Selecting a particular area on the skull and selecting region grow will produce new mask in yellow and eliminate background interference
– By selecting "Calculate 3D" a 3D model will appear. When the mask has been edited the file must be saved as a binary STL file, for file transfer
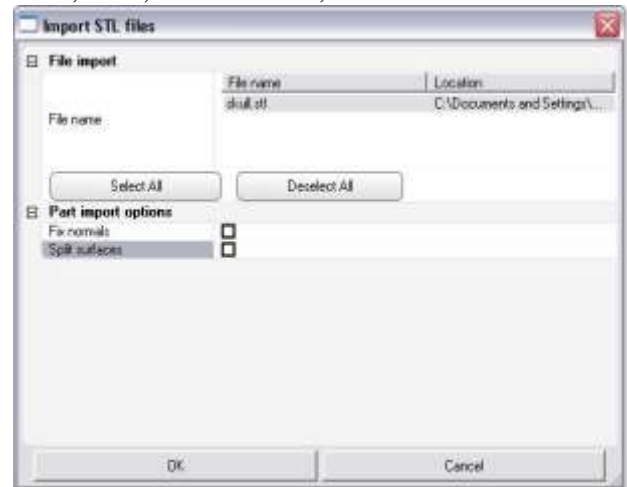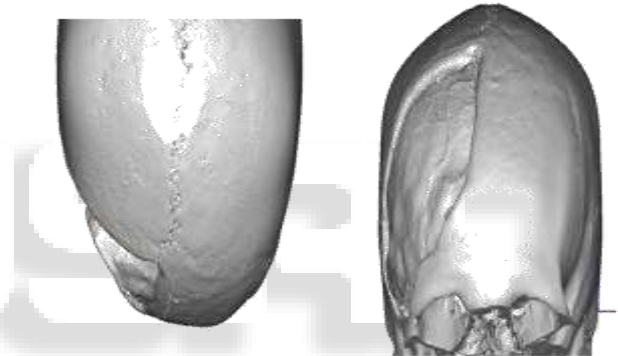

Fig. 1: Part imported as STL file.

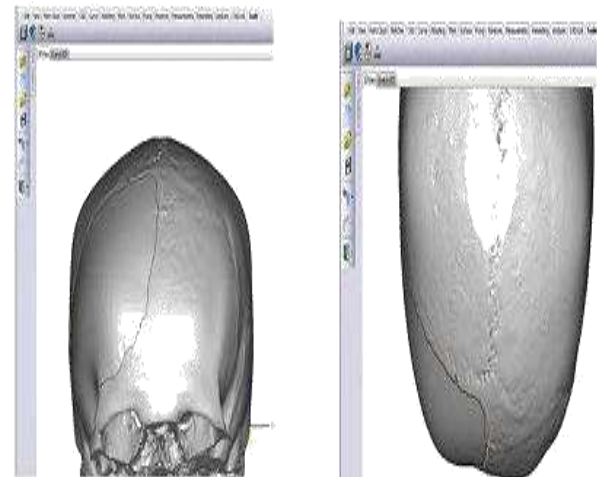Fig. 2: (a), (b) Curve tool selected and polyline plotted around the cranial defect.

Fig. 3: (a), (b) Front and plan view of cranial plate generated by selecting "Create Cranioplasty" tool.

A more pronounced profile is generated by this method. The create cranioplasty tool automatically creates tangency to the existing shape of the skull edge and uses algorithms in the software to generate profile.
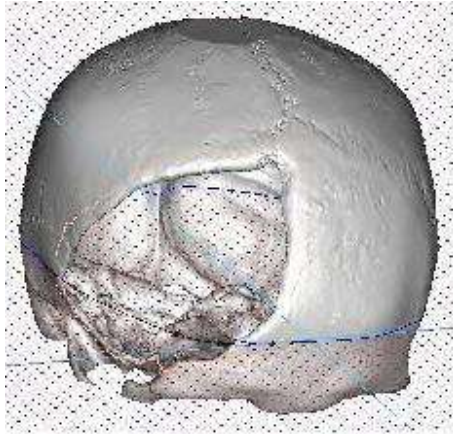
B. Matic Manual Method

Fig. 4: 3D skull cross section.

A spline is fitted through a cross section of the skull and control points fitted so the profile of skull can be adjusted to generate a corresponding match. (Select sketcher, new sketch, import an intersection of skull into sketch)
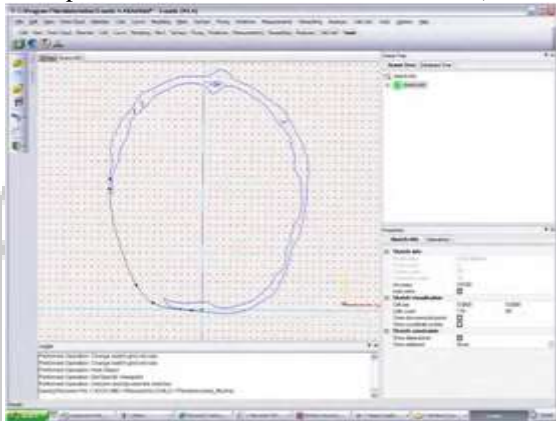

Fig. 5: A 2D skull cross section.

A cross section of the skull is inserted into a new sketch and a spline created and manipulated by control points to generate symmetry. (Select sketcher, create spline and drag control points)
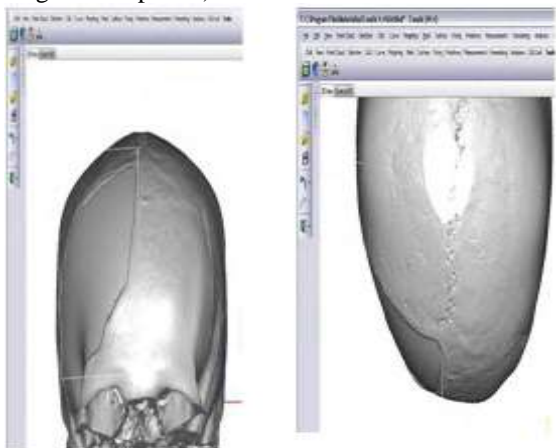

Fig. 6: (a), (b), skull front and top view.

Under the tools tab select "Create Cranioplasty" icon and select the guide curve defined in sketch. A cranial plate is generated using software algorithms for the surrounding edge and the inserted spine. It can be seen that the profile of the cranial plate is relatively symmetrical with the opposite side due to the inserted spine controlling the profile. The file is then saved as an STL file.
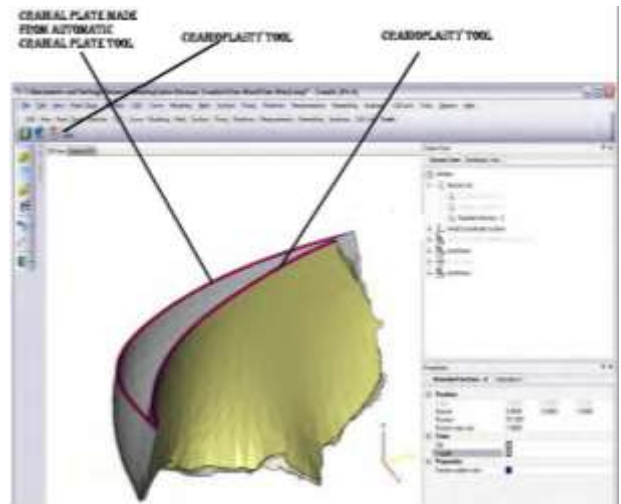

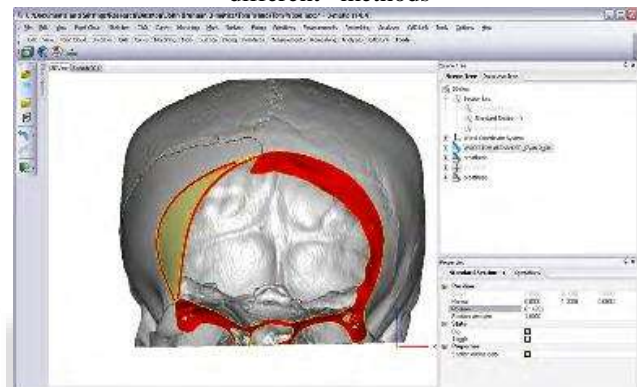Fig. 7: Differences between cranial plates generated by two different methods

Fig. 8: Front view of both cranial plates showing their different profiles.

Fig. 9: A sliced 3D Z-Corp case study skull model.

Fig. 10: Cranial plates rapid prototyped on 3D Systems 250 SLA machine

Fig. 11: Section of skull with cranial plate made from inserting spline, manual method.

III. SUMMARY

Both plates, although designed from the same data, have different profiles but give a satisfactory fit. However the shape of the plate designed from the manual method is more symmetrical and therefore would look more aesthetically pleasing if designed and manufactured out of a biocompatible material such as titanium and fitted as a custom designed implant. However using the "Create Cranioplasty tool" is more time efficient.

IV. CONCLUSIONS

− Generating the cranial plate using the two methods produced 2 plates of similar fit.
− The profiles of the two plates were considerably different.
− Using the "Create Cranioplasty" tool was significantly easier and faster than the manual method.
− The two cranial plates should have been made 0.5mm thicker to provide better location on the skull.
− The manual method is subjective by nature and allows the designer to intuitively control the final design

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