The Utilization of 3D Printed Anatomical Models in Craniosynostosis Secondary to Apert Syndrome: a Case Report

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Introduction

- Craniosynostosis is a condition that results from the premature fusion of one or more sutures in an infant's skull by ossification
- Premature closures result in increased intracranial pressure which can affect the respiratory system, neurologic system, and development of the child
- Syndromic forms require urgent surgical intervention with the main goal of creating enough space for the brain to grow and develop properly
- An example of complex multisuture craniosynostosis is Apert syndrome
- 3D printing (also referred to as additive manufacturing) is a novel toolset that may be used for presurgical planning and education
- This application has the potential to decrease surgical risk, improve operative efficiency, and enhance preoperative counseling

Results

- According to the survey, the 3D printed model was most applicable to pre-surgical planning and patient/family education
- Specifically, the benefit of viewing the large bridging veins in relationship to the skull helped decrease the risk of intraoperative bleeding by allowing the surgeon to plan the osteotomies to avoid the torcula and see where his incisions would cross over the dural venous sinuses
- In terms of patient education, the large blood vessels were demonstrated on the model and allowed for visual aid during the discussion of bleeding risk during informed consent

Discussion

- 3D analysis and planning allows for virtual planning using patient-specific anatomy while evaluating for difficulties that may arise during
- Our model reproduced specific anatomic variations and critical landmarks; of particular importance, our model provided awareness of the presence of large bridging veins and the course of the dural venous sinuses
- According to our survey, the model also enhanced the ability to communicate the risks of surgery with the family during the informed consent process
- Moving forward, larger studies may be able to determine whether preoperative examination of 3D printed models result in any true reduction in operative time

Figures

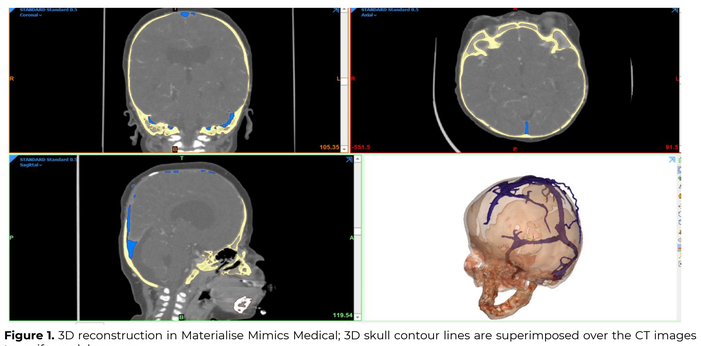

Figure 1. 3D reconstruction in Materialise Mimics Medical; 3D skull contour lines are superimposed over the CT images to verify model accuracy

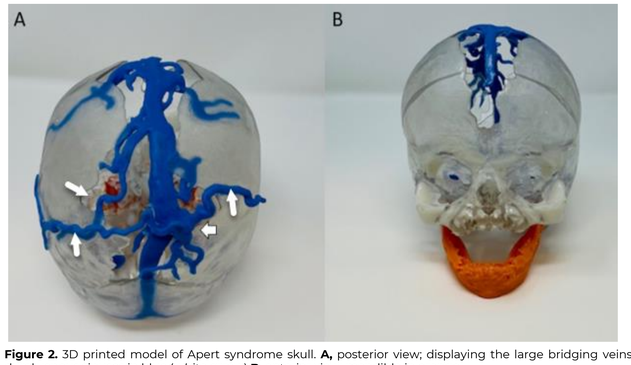

Figure 2. 3D printed model of Apert syndrome skull. **A,** posterior view; displaying the large bridging veins near dural venous sinuses in blue (*white arrow*) **B,** anterior view; mandible in orange

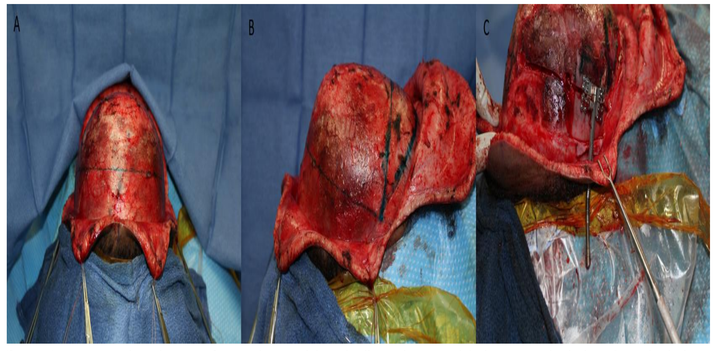

Figure 3. Intraoperative pictures of posterior cranial vault distraction **A,** axial view **B,** sagittal view **C,** sagittal view with distractors

Case Report

- 5-months-old male with a complex medical history that included bicoronal craniosynostosis due to Apert syndrome is evaluated for posterior cranial vault distraction osteogenesis (PCVDO) surgery
- CT images were acquired from the PAC system for segmentation and desired regions of interest were refined to the STL file for 3D printing
- Mimics Medical (Materialise NV, Leuven, Belgium) was utilized to create the reconstructed 3D model of the patient's skull (Figure 1)
- Model was then exported to 3-Matic (Materialise NV, Leuven, Belgium) for further post-processing
- 3D models were then printed via Stratasys J55 3D printer including the large bridging veins and dural venous sinuses to assist in preoperative planning (figure 2)
- PCVDO was performed at 7 months of age and distracted posteriorly at a rate of 1 mm per day, for a total movement of 3 cm over the following month with removal of hardware four months later (figure 3)
- The surgeon then completed a feedback survey postoperatively

Conclusions

- In conclusion, 3D printing technology has added to today's practice of personalized medicine through the replication of patient-specific anatomy
- Our case provides an example of how 3D printed models can utilized in the preparation of surgical planning for Apert syndrome including a 3D visualization of critical anatomic abnormalities and landmarks
- 3D models have proven useful in certain cases and possible future applications include, but are not limited to, healthcare, patient education, medical education, and surgical simulations