3D Printed Modeling: A Novel Hands-On Learning Tool for Craniosynostosis in Medical Education

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Introduction

- As the use of 3D imaging continues to surge in healthcare, it heralds a new era of medical advancement and education, promising transformative benefits.
- Craniosynostosis is defined as the premature closure of one or more cranial sutures, which alters the configuration of a child's head.
- Learning the surgical correction and pathology of this disease is often complicated, requiring various 3D abstractions of anatomical views around the skull.
- Especially with complex and delicate procedures such as craniosynostosis, 3D-printed models give physicians the opportunity to familiarize themselves with the approach and predict any possible complications beforehand.
- We aim that these models will benefit medical students' overall learning experience by enhancing their skills, productivity, and familiarity with pathological anatomy.
- Beginning this at an introductory level of medical education and building from there will foster a strong familiarity with anatomy and overall better physicians.

Methods

- The steps in creating a 3D structure include (1) acquisition of image data, (2) extraction of the chosen region of interest termed "segmentation," (3) transformation of the data from volumetric to a 3D triangular mesh, and (4) transfer of the data to a 3D printer for production.
- Computerized tomography data was collected and de-identified.
- The program utilized for isolating CT scan data is called "3D slicer." This platform is for analyzing and understanding medical image data. Slicer allows for powerful medical image processing, visualization, and data analysis tools.
- The models can also be printed in different views. This would be very helpful in teaching as students will be able to look at structures from different angles and capacities. As anatomy isn't one size fits all, this would allow for the first steps of learning.
- Various materials can be used to print 3D models, depending on the intended application. We used PLA standard plastic.

Imaging

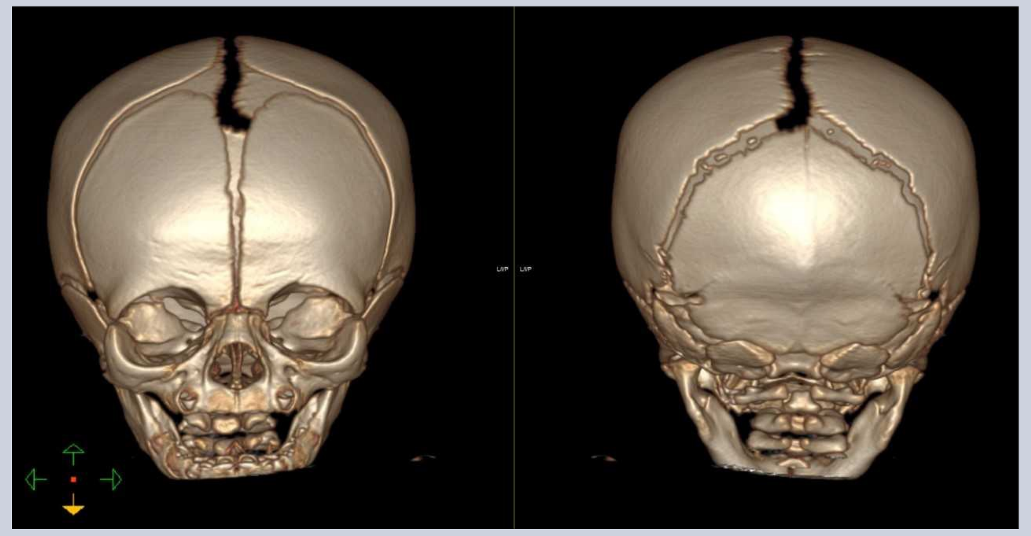

Figure 1: Normal skull sutures of a newborn baby

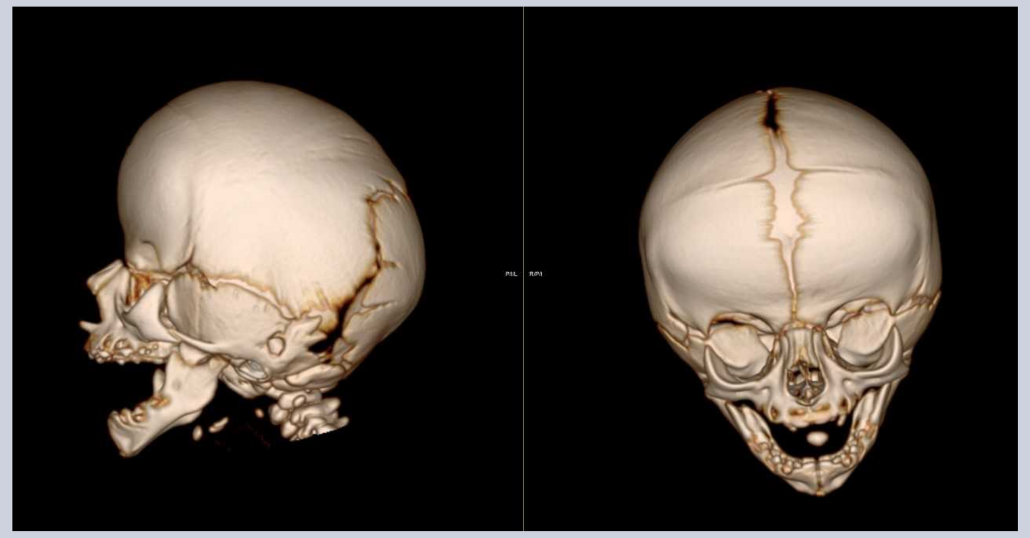

Figure 2: Bi-coronal craniosynostosis

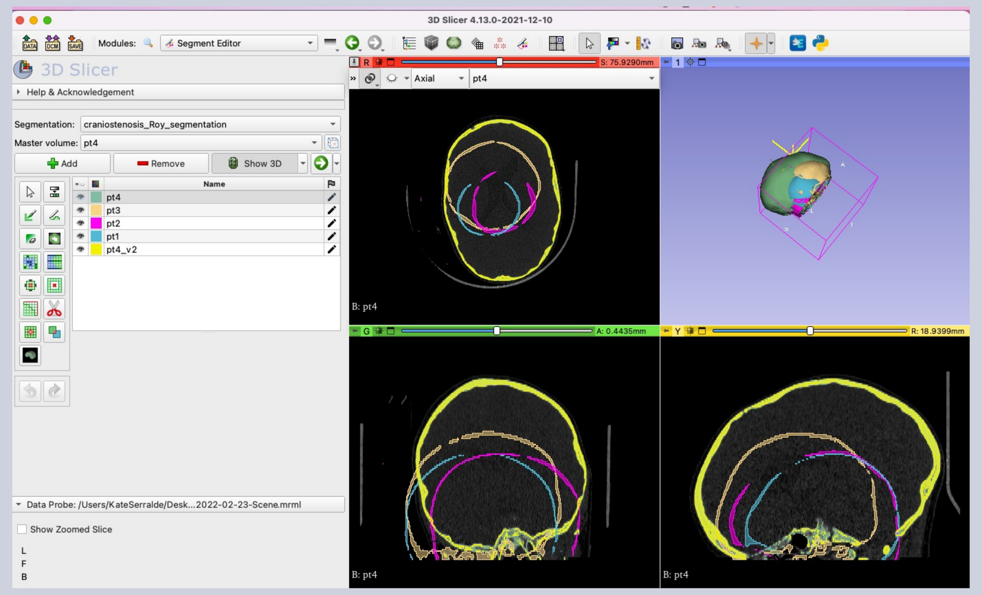

Figure 3: 3D slicer program- segmentation

Figure 4: 3D printer

Figure 5: Metopic craniosynostosis

Figure 6: Intra-parietal suture without craniosynostosis

Discussion

- Learning complex pathoanatomy is often limited to 2D radiological imaging, which forces many to have difficulty conceptualizing abnormal structures into a 3D perception.
- Integrating 3D models into medical education is not just a novelty but a necessity. These models offer a tangible and interactive approach to learning, particularly in the complex field of pathoanatomy, where traditional 2D radiological imaging often falls short.
- While 3D printing is a promising tool for visualizing pathologies like craniosynostosis, its limitations must be acknowledged.
- Newborn skulls tend to be thin structures, and sometimes will cause problems with printing the 3D models.
- The usage of patient data calls into question ethical considerations.
- Another limitation is time and effort. This has hindered the growth of 3D printing, as it can take a lot of time to isolate areas of interest during data processing.

Conclusion

- 3D models should be considered for use in fostering an enhanced education among medical students. Doing so would be essential to hands-on learning, especially with complicated first-year topics such as anatomy.

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