



Validation of a Novel Method in Paleoneurology: Endocast 3D Scanning and Printing



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INTRODUCTION

- Paleoneurology is the study of fossilized skulls and internal casts of braincases (endocasts) with the goal of understanding the evolution of hominid brain anatomy and function (Falk, 2014)
- Access to endocast databases are limited due to the need for protective storage facilities in museums and universities and the high costs associated with making casts
- Volume and surface area measurements using three-dimensional (3D) laser scanner models of human crania have been shown to be precise and repeatable (Sholts et al. 2010)
- High resolution 3D laser scanner models can be 3D printed cheaply and quickly
- However, so far limited resources have been devoted to making 3D fossil and endocast scans available freely online for 3D printing

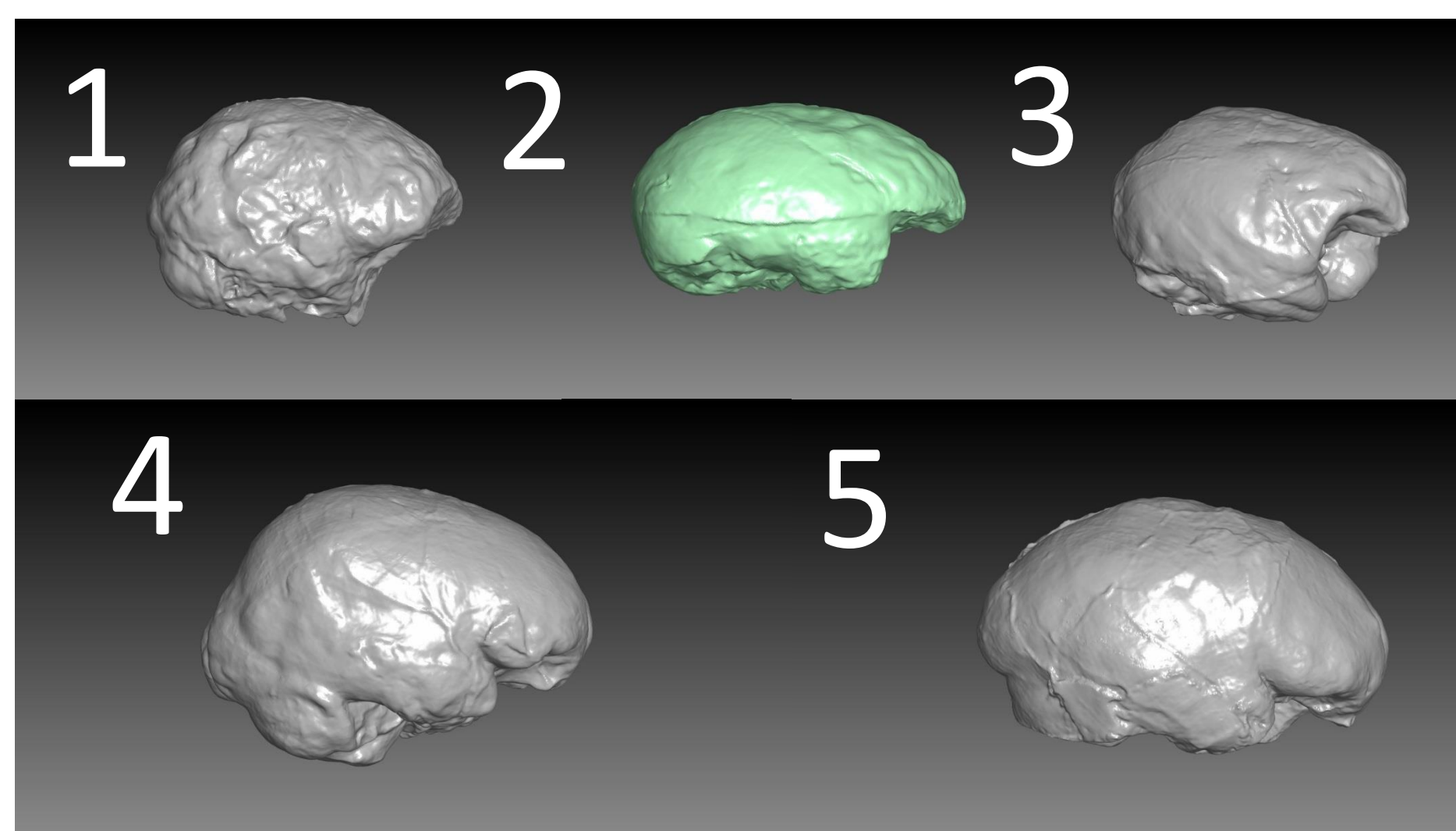
HYPOTHESIS

Morphometric measurements of endocasts are repeatable across 3D Laser Scanner Modeling software and 3D printed models of the endocasts.

ENDOCASTS

- Five endocasts were obtained from the Wolpoff Paleanthropology Laboratory at the University of Michigan:

 1. Taung Child (*Australopithecus africanus*)
 2. STS 60 (*Australopithecus africanus*)
 3. Unknown (*Pan troglodytes* or monkey)
 4. La Quina 5 (*Homo neanderthalensis*)
 5. Jebel Irhoud 2 (*Homo sapiens*)



METHODS

- **Endocasts:** Linear measurements of maximum height, width, and length were each taken with digital calipers three times per endocast and averaged. Photographs of measurement sites were recorded for reference. The volumes of the Taung Child, STS 60, and Chimp/Monkey endocasts were taken by measuring the displacement of brown rice in a graduated cylinder
- **3D Laser Scanner Models:** Each endocast was scanned using a HandyScan 3D REVscan® (Creaform, Inc.) at the University of Michigan 3D Laboratory. 3D files were stitched together and processed in collaboration with the UM3D Laboratory using 3-matik STL Additive Manufacturing Software® (Materialise, Inc.). Endocast measurements were replicated using the Measure Markup Tool in 3D-Tool V11® (3D-Tool GmbH & Co. KG)

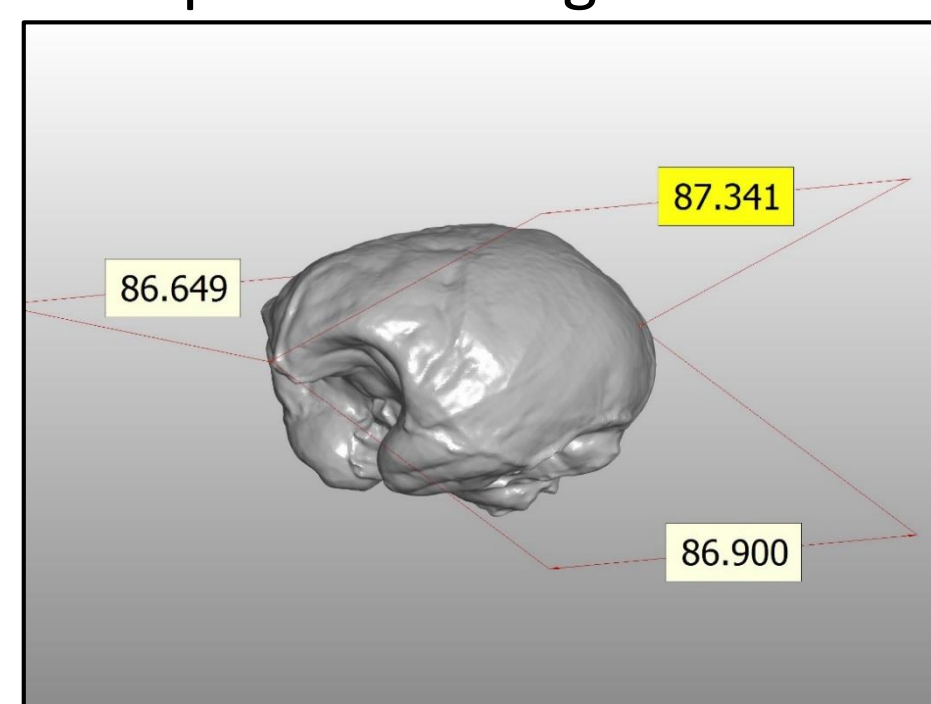


Figure 1: 3D-Tool V11 Length measurements

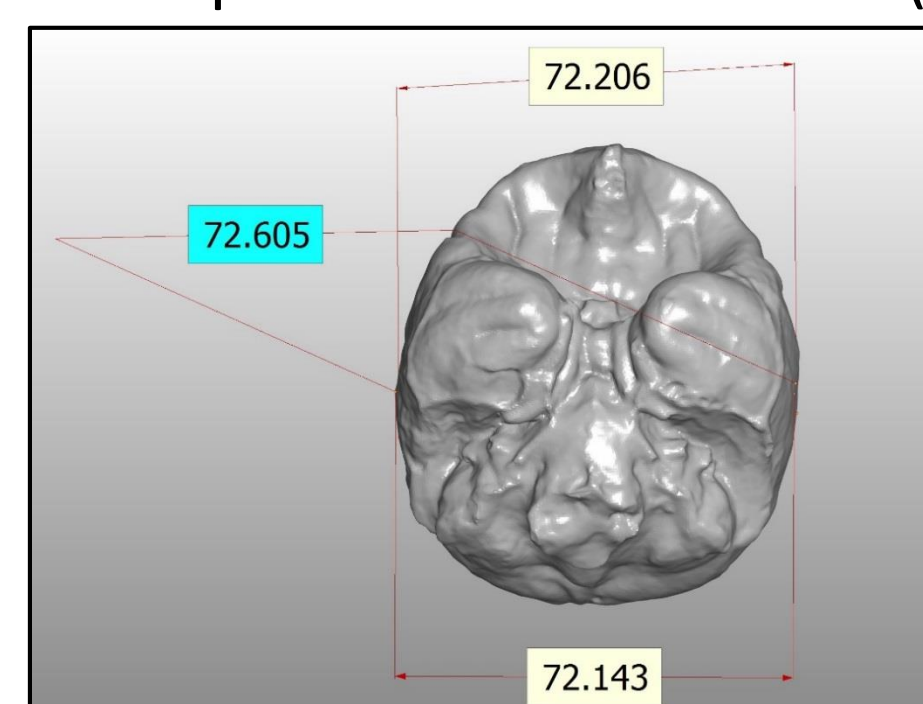


Figure 2: Width measurements

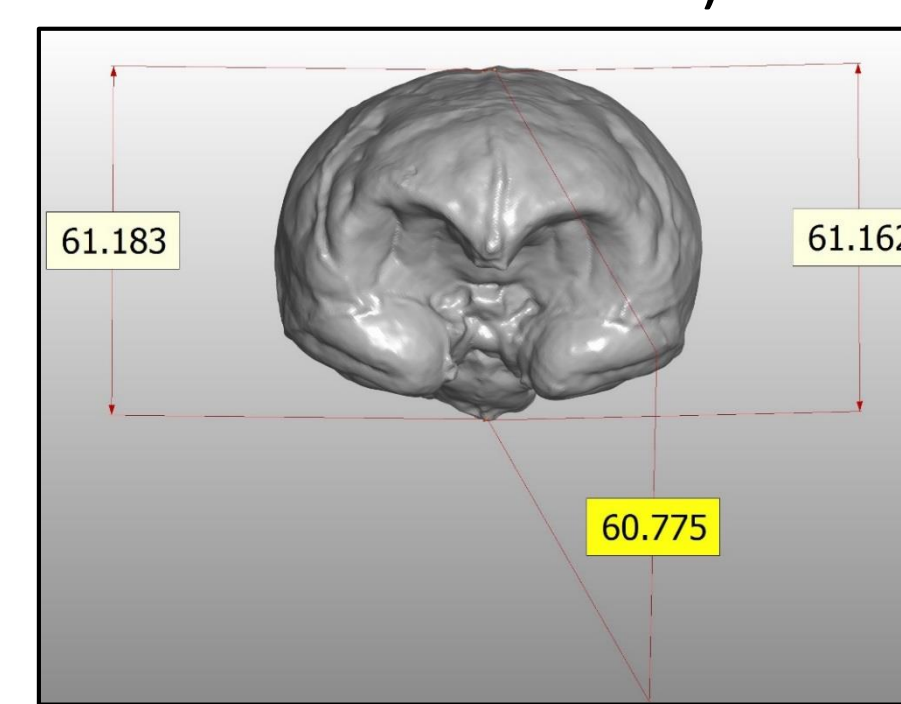
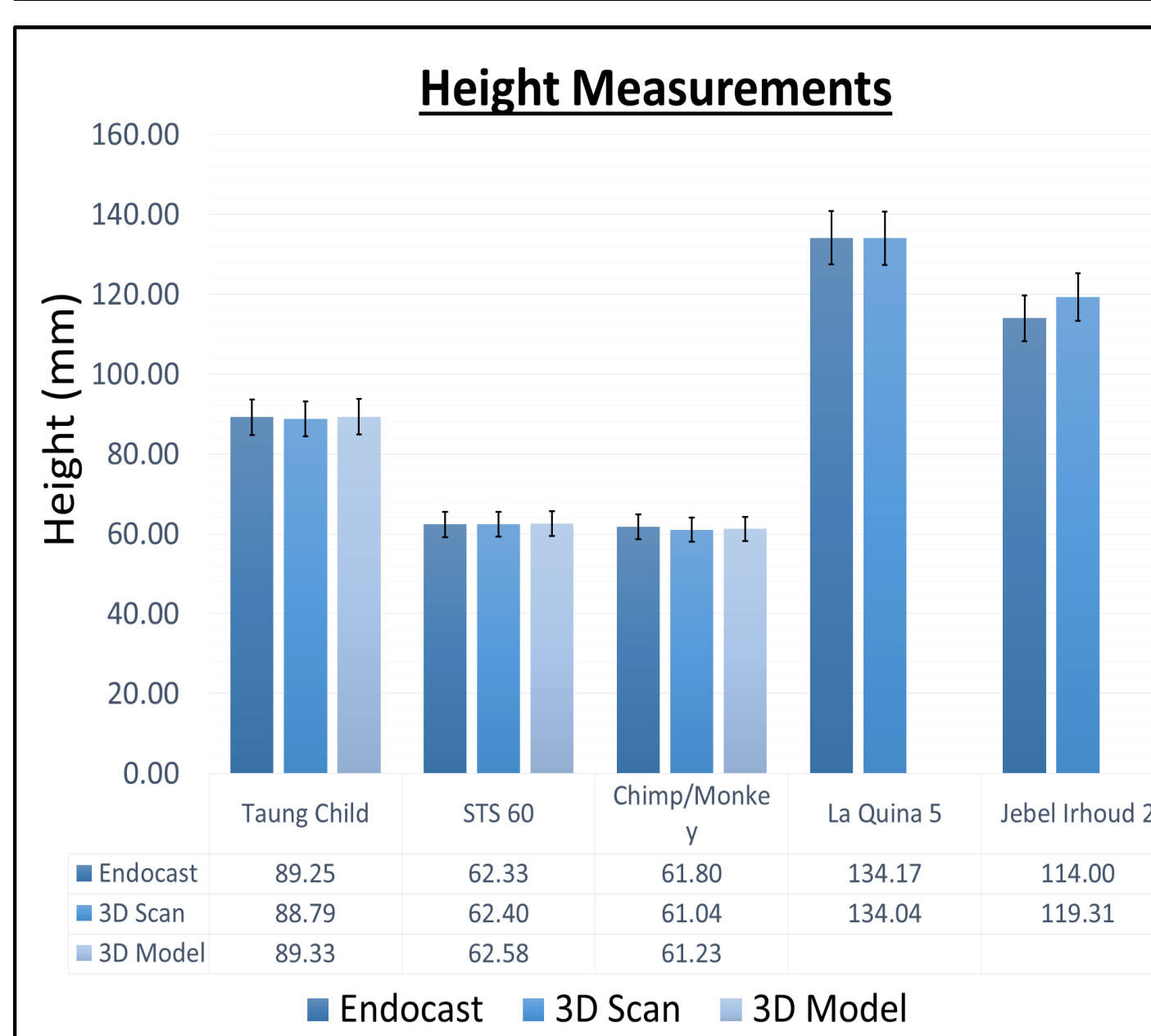
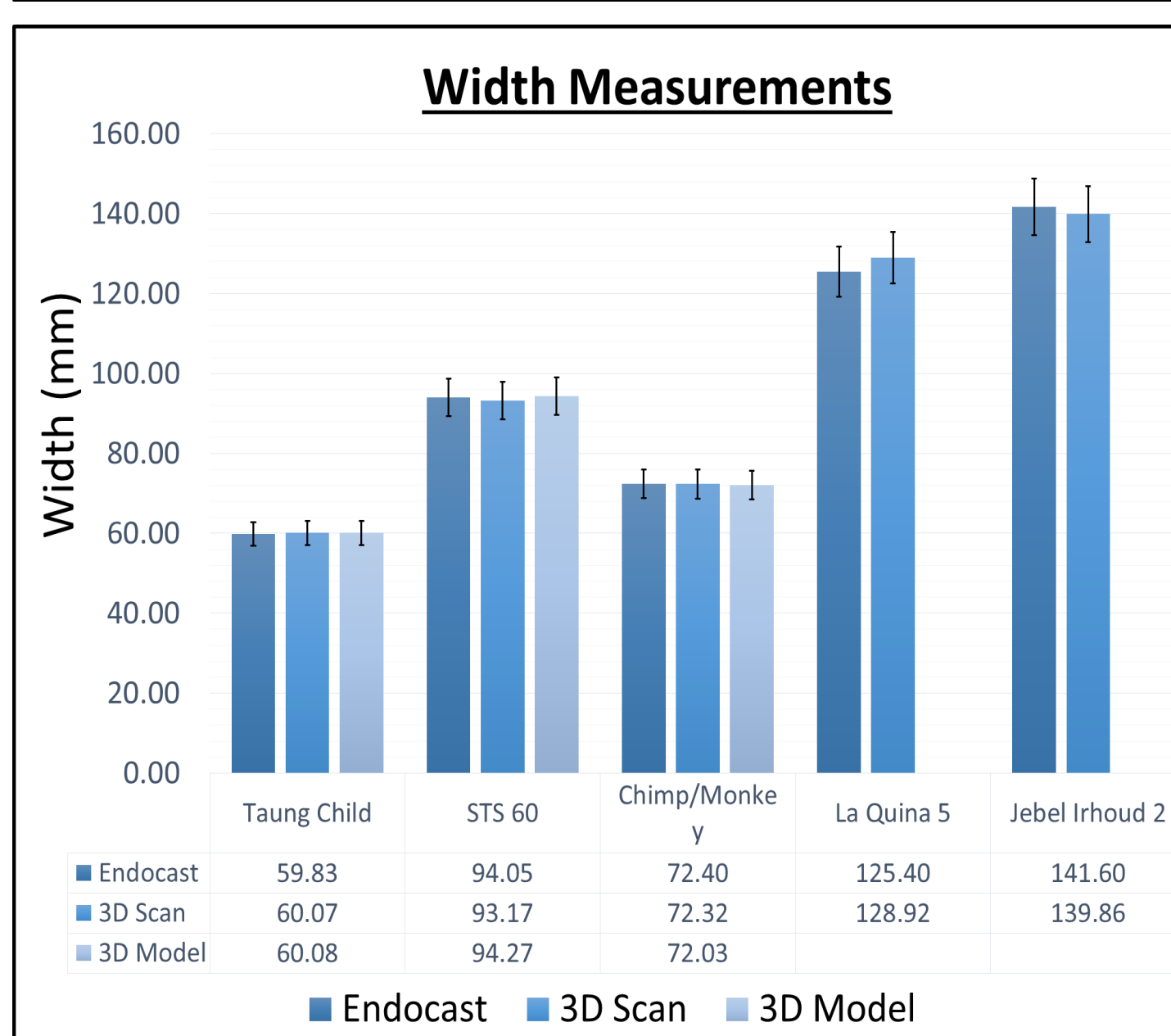
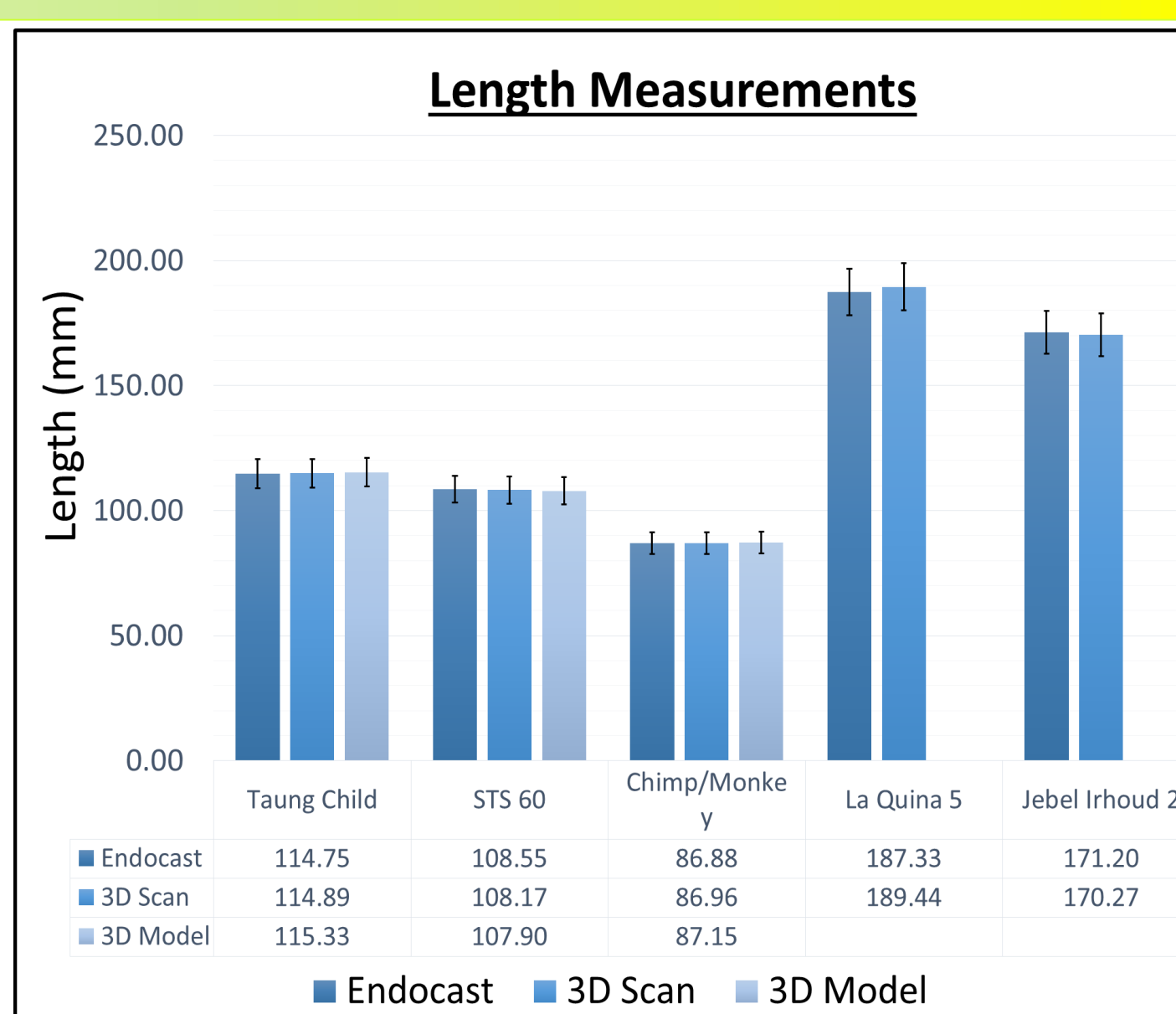
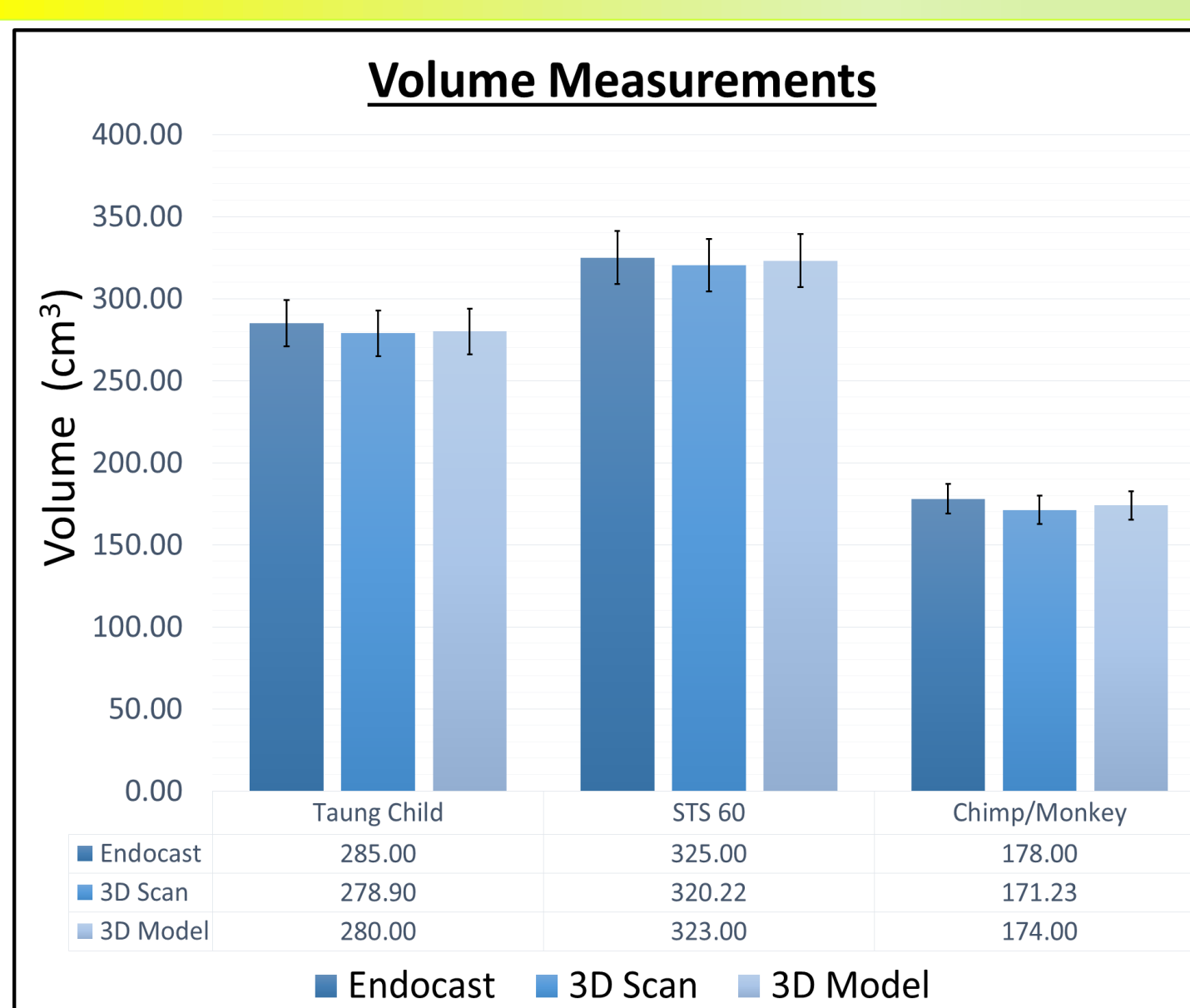


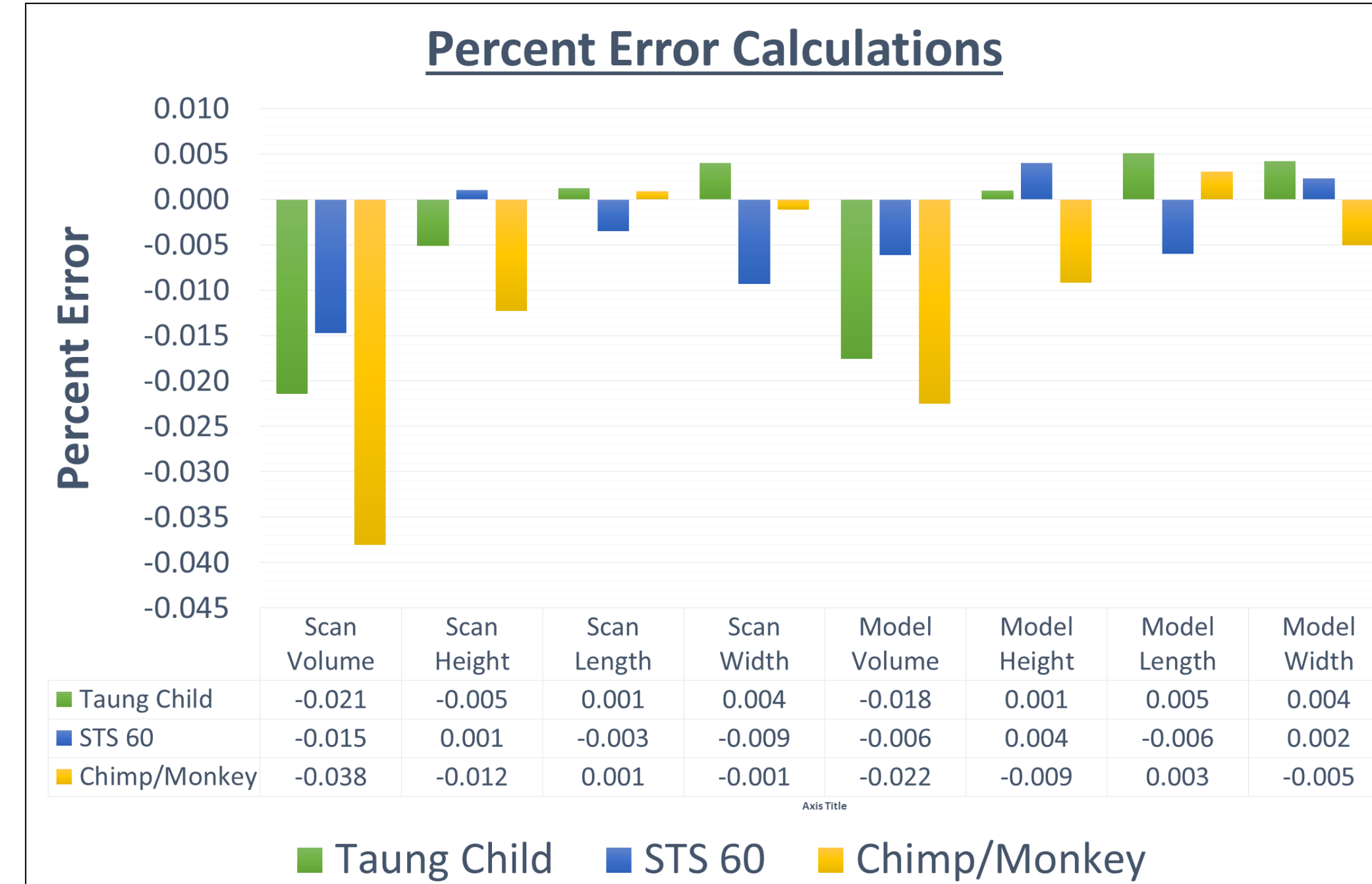
Figure 3: Height measurements

- **3D Printed Models:** The Taung Child, STS 60, and Chimp/Monkey endocasts were printed on a Dimension Elite 3D Printer at a layer thickness of 0.254 mm. Volume was calculated by measuring water displacement in a graduated cylinder. Length, width, and height measures were taken using digital calipers

RESULTS



SUMMARY



- Percent error was calculated for the linear and volumetric measurements using the following formula:
$$\% \text{ Error} = \frac{(\text{observed value} - \text{endocast value})}{\text{endocast value}} \times 100\%$$
- All of the measurements performed yielded percent error values of less than 1%.
- Volume measurements yielded the greatest percent error values, likely due to the use of differing materials (water and brown rice) for the volume displacement measures

CONCLUSIONS

- Highly accurate morphometric measurements across endocasts, 3D laser scanned models, and 3D printed models are possible using technology available to University of Michigan students
- Futures studies could investigate if the scanning and printing resolution is sufficiently high to compare specific brain features

REFERENCES

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