Optimization of 3D Print Material for the Recreation of Patient-specific Temporal Bone Models

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Background

- 3D printing, more specifically fused deposition modeling (FDM), is arising as an inexpensive and accessible method of enhancing surgical training for residents as a supplement to live surgery and cadaveric specimens. 3D printed TB prototypes have been shown to improve drilling accuracy and spatial representation during mastoidectomy simulation in residents.[1] In addition, 3D printing has been applied to surgical planning for endoscopic sinus and skull base procedures, craniofacial trauma, and facial reconstructive surgery.[2-5] The applications for 3D printing in otolaryngologic surgical training and planning have significant potential to drastically improve the simulated learning environment and enhance patient care.

- **Study Aim:** To identify the 3D printed material that most accurately represents the temporal bone through evaluation of its visual qualities and haptic feedback.

Methods

- Fifteen study participants with an average of 3.6 years of post-graduate training and 56.5 temporal bone (TB) procedures participated. Each participant performed a mastoidectomy on human cadaveric TB and five 3D printed TBs of different materials. After drilling each unique material, participants completed surveys (Figure 1) to assess each model's appearance and physical likeness on a Likert scale from 0 to 10 (0 being least representative and 10 being the most representative). The 3D models were acquired by CT imaging and segmented using 3D Slicer software.

Model number:

Please assess the temporal bone's appearance, relative to one in vivo, on a scale from 0 to 10 with 0 being poorly representative, and 10 being perfectly representative:

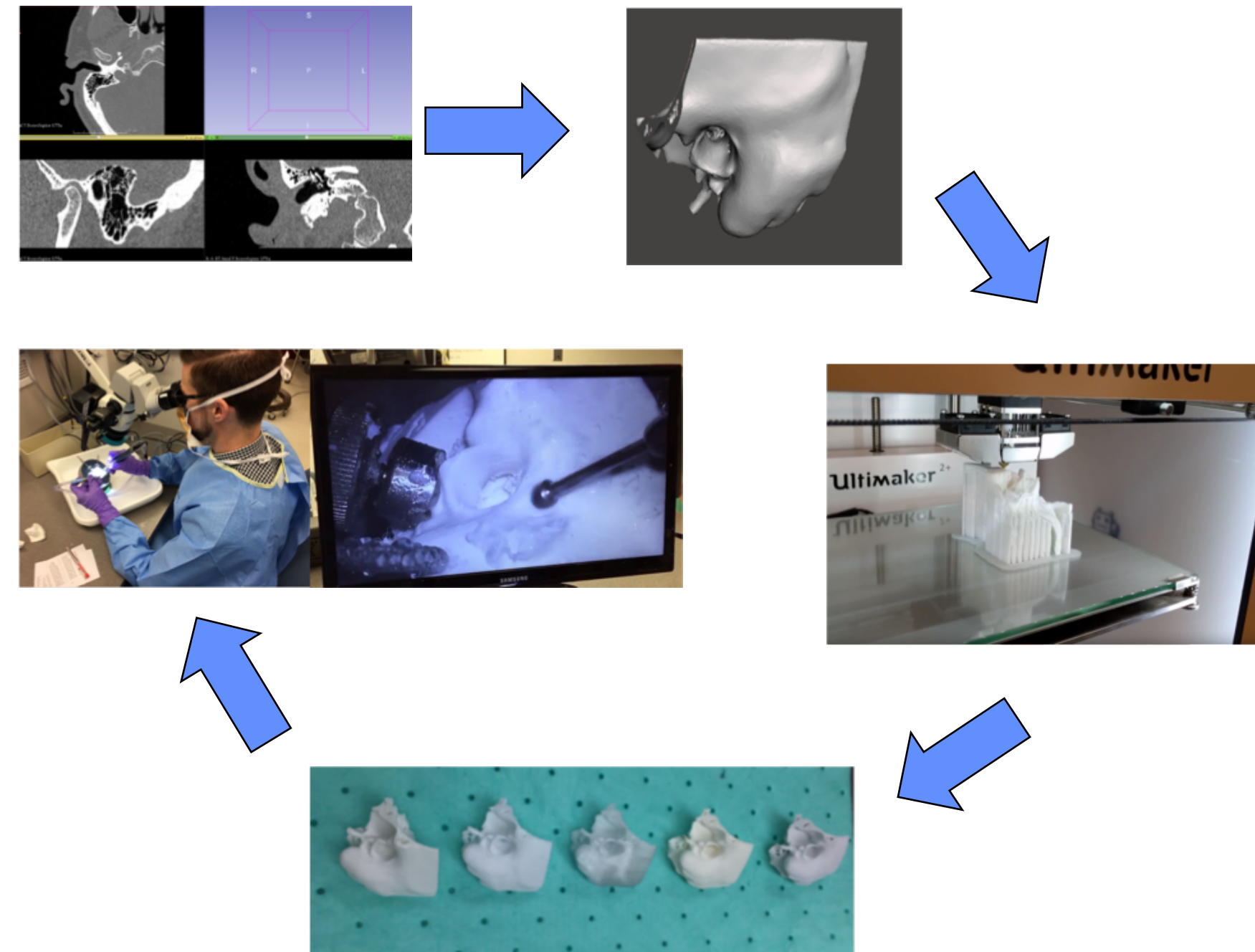0   1   2   3   4   5   6   7   8   9   10

Please assess the temporal bone's feel while drilling, relative to one in vivo, on a scale from 0 to 10 with 0 being poorly representative, and 10 being perfectly representative:

0   1   2   3   4   5   6   7   8   9   10

Record any comments about the model below:

Figure 1: Temporal bone model assessment survey

Methods

Results

- Polyethylene terephthalate (PETG) had the highest average survey response for haptic feedback (HF) and appearance, scoring 8.3 (SD=1.7) and 7.6 (SD=1.5), respectively. The remaining plastics scored as follows for HF and appearance: polylactic acid (PLA) averaged 7.4 and 7.6, acrylonitrile butadiene styrene (ABS) 7.1 and 7.2, polycarbonate (PC) 7.4 and 3.9, and nylon 5.6 and 6.7.
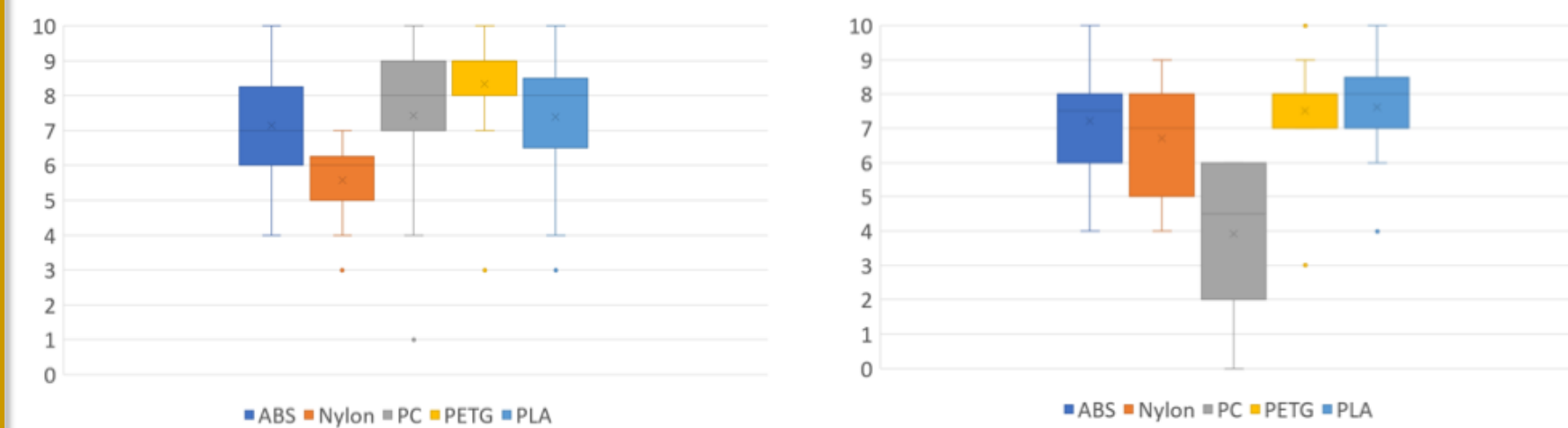

Figure 2: Haptic Feedback Average   **Figure. 3:** Appearance Average Score

Discussion/Conclusion

- This study identifies PETG as the optimal 3D printing material for temporal bone simulation. Study participants reported PETG to have the best overall appearance and haptic feedback, followed closely by PLA and ABS.
- The results presented can be applied to current 3D printed TB training modules to make them more realistic and useful for surgeons in training.
- 3D printed temporal bone models can be made with patient-specific pathology and are easily reproducible. These models offer supplemental hands-on training for a variety of pathology which may or may not be commonly encountered in live surgery or as cadaveric specimens.
- The FDM printer used in this study cost $4,300. After this initial investment, raw materials costs were about $0.90 per model.

- **Conclusion:** PETG 3D printed temporal bone models offer the most realistic appearance and haptic feedback as compared with PLA, ABS, PC and nylon. PLA and ABS were reliable alternatives that also performed well with both measures.

References

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