Evaluating the efficacy and value of drilling 3D-printed temporal bone models

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INTRODUCTION

- Surgical simulation can transfer necessary skills into the operating room, as well as prepare residents and physicians to be more efficient and precise in complex or rare anatomical cases.[1-2]
- Training with cadaveric specimens has been correlated to improved surgical performance by Otolaryngology residents; however, these specimens are often expensive (up to $500 for a pair) and in short supply.[3]
- Finding a 3D printing material that is affordable and can also mimic anatomical structures is crucial to developing 3D printed temporal bones that could supplement cadaver bones in surgical training.
- *Our Objective:* To evaluate the usefulness of 3D printed temporal bones in surgical training and determine which affordable 3D printing material comparable to cadaveric bone

MATERIALS & METHODS

- 3D printed temporal bone models were printed from computed tomography (CT) scans using affordable materials, including acrylonitrile butadiene styrene plastic filament (ABS), polylactic acid filament (PLA), high impact polystyrene (HIPS), and Formlabs white resin.
- 8 otolaryngology residents with previous drilling experience performed a simple mastoidectomy on the temporal bone models and were blinded to which 3D-print material was used.
- After drilling, residents completed an eight-item Likert scale questionnaire, which evaluated the value, ease of use, safety and likeness of the 3D-printed temporal bones compared to cadaveric temporal bones.

RESULTS

- The results of the survey are in Figure 1.
- When comparing materials, resin had significantly higher average ratings than HIPS (p=0.03) and PLA (p=0.003), but not compared to ABS (p=0.41). No other comparisons between materials were statistically significant.

Figure 1: 3D-printed temporal bone ratings compared to cadaver bone

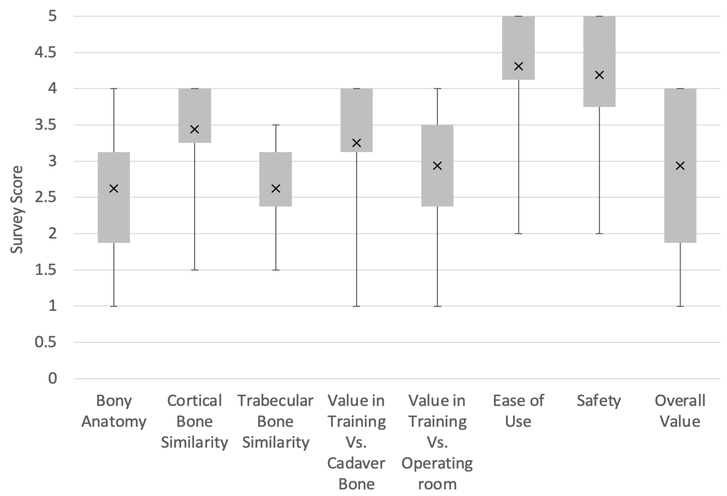

Figure 2A & B: 3D printed Adult temporal bone before (A) and after (B) drilling. This model is printed with Formlabs resin.

Figure 3: Microscopic image of the 3D printed temporal bone made with Formlabs resin. Image shows the dust created after drilling the model.

Figure 4: Microscopic image of the 3D printed temporal bone made with Formlabs resin. Image shows the middle ear bones after drilling the model.

DISCUSSION

- Despite previous studies showing that ABS and PLA were cheap materials and good bone substitutes, our residents rated these the lowest.
- Resin created the most similar dust to bone.
- Our residents suggest that the model is better for younger residents/medical students
- Limitations:
  - Small sample size (n=8)
  - Unable to correctly mimic haptic feedback of bone and soft tissue anatomy
  - Survey doesn't adequately parse out the level of irritation/suction clog from the model dust and the bony anatomy of structures like the ossicles/facial recess

CONCLUSION

The 3D printed temporal bones were safe and easy to use like cadaver bones; however, the models were rated poorly for their bony anatomy and overall value in surgical training. Future studies will aim to improve the anatomy of the models and the materials used to better represent the temporal bone drilling experience.

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REFERENCES

1. Sturm LP, Windsor JA, Cosman PH, Cregan P, Hewett PJ, Maddern GJ. A systematic review of skills transfer after surgical simulation training. *Ann Surg*. 2008;248(2):166-179.
2. Coote JD, Nguyen T, Tholen K, et al. Three-Dimensional Printed Patient Models for Complex Pediatric Spinal Surgery. Ochsner J. 2019;19(1):49-53.
3. Longfield EA, Brickman TM, Jeyakumar A. 3D Printed Pediatric Temporal Bone: A Novel Training Model. Otol Neurotol. 2015;36(5):793-795.