University Hospitals
Ear, Nose & Throat Institute

# Comparative Analysis of 3D Printed Materials for Cortical Mastoidectomy Simulation

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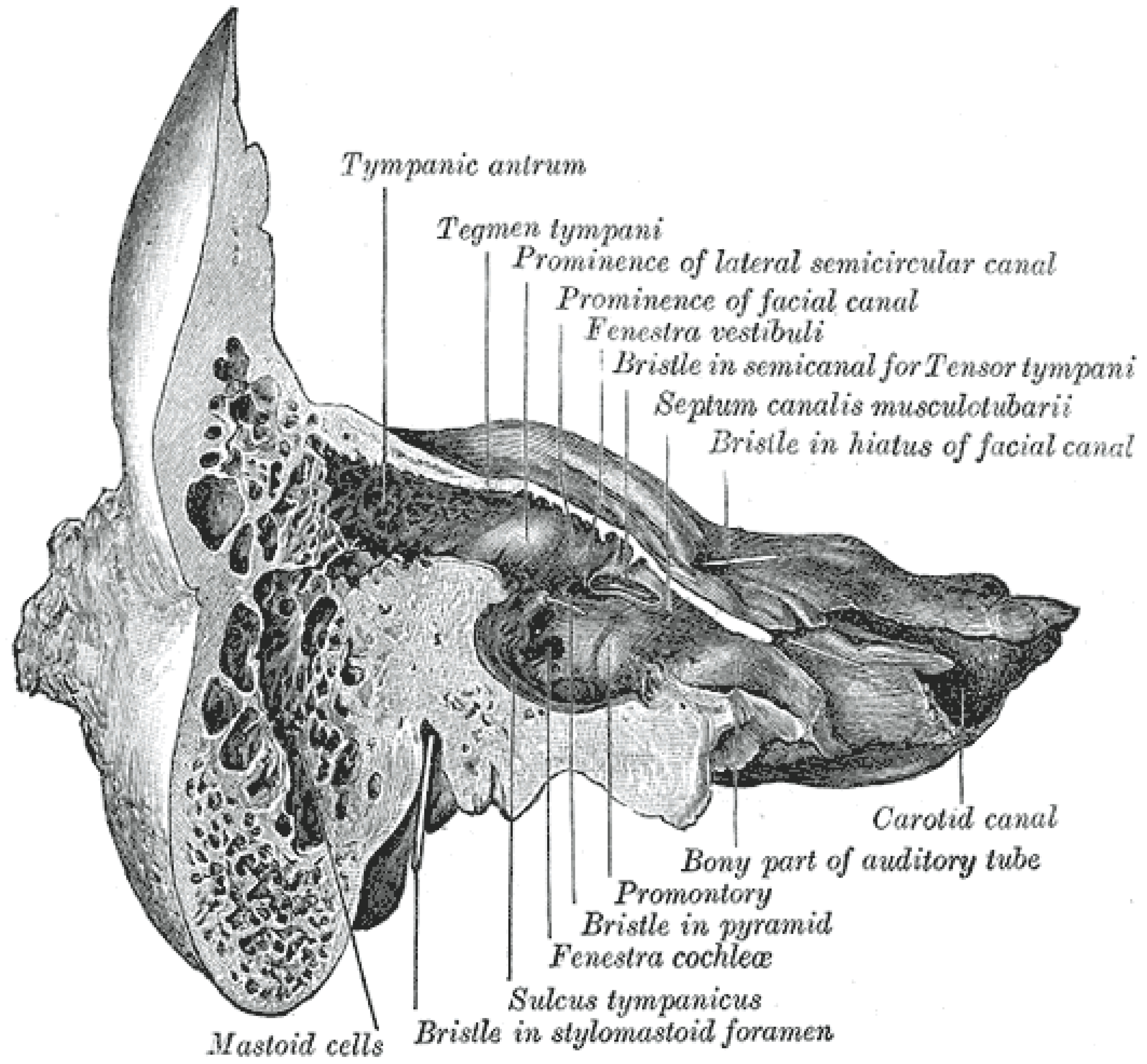
## INTRODUCTION

Cadaveric temporal bone dissection has been a standard educational tool for teaching Otologic surgery skills. However there is overall limited access to cadaveric temporal bones due to strict regulatory controls. Recently There has been validation of cadaveric temporal bone dissection to prepare residents for independent Otologic surgery (Mowry and Hansen, 2014). While there are non-cadaveric Temporal bone simulations such as Virtual reality systems or physical model systems these current models are limited by cost and inability to capture sound, color, and tactile feel of drilling in vivo temporal bone.

3D printing is a new method of creating 3-dimensional objects with various materials with different properties. The applications of this technology is highly versatile and has been used from commercial to medical fields.

Here we used computed tomography scans to create 3D printed models of temporal bones. These bones were then drilled by attending Neurotologists, who then filled out a Questionnaire regarding the realism of these 3D printed temporal bones.

With the results of this project thus far there are currently multiple avenues for further expansion of this technology. Current ventures include creating an anatomical library of 3D temporal bone files to better train residents in Otologic surgery. Another project is utilizing an industrial grade 3D printer to recreate a dual density model that has more realistic properties of drilling a temporal bone in Vivo

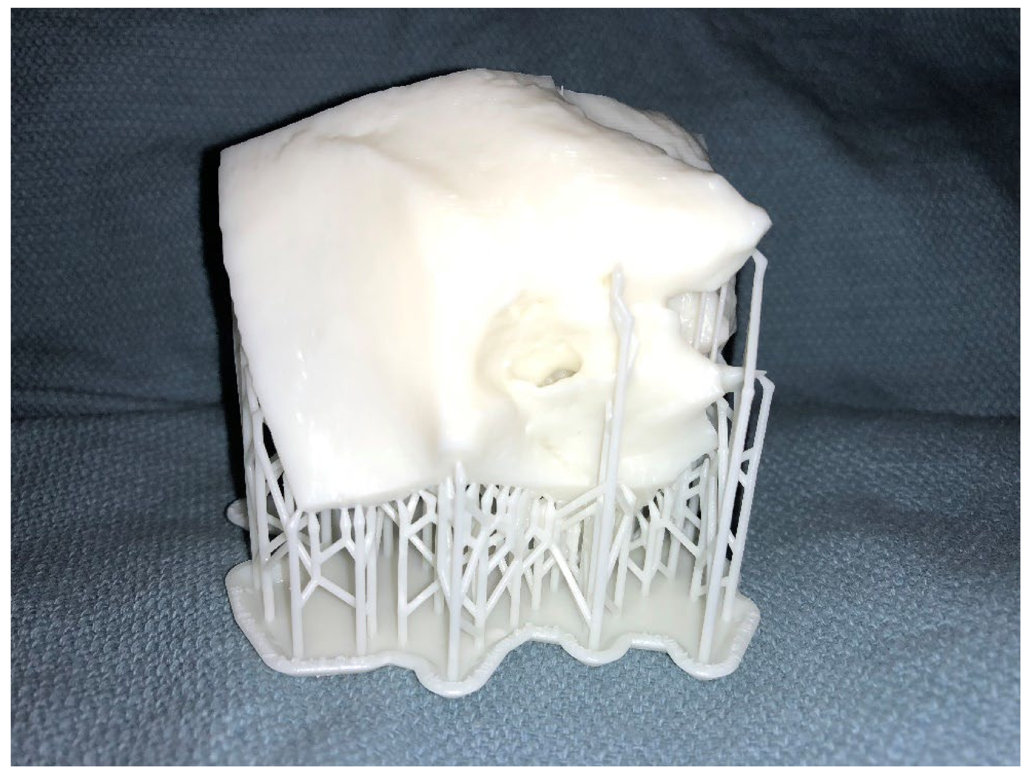



## METHODS

Model Segmentation:
- A normal CT scan of the adult temporal bone was acquired and segmented using Materialise mimcs to create a 3D model

Printing of 3D bones:
- 3D temporal bones from the segmented model were printed from the following printers and materials: Formlabs (Standard White and Tough), Maker Bot (Red ABS), Fortus (White Polycardonate), and Object (Yellow Photopolymer) using

Testing:
- The Senior Author with >10 years of surgical experience completed surgical simulation with all 6 3D printing materials and filled a Temporal bone questionnaire
- Each temporal bone was rated on: Realism, Odor generation, Powder formation, Recreation of the change in pitch noted during in vivo temporal bone surgery, Can this model be used as a simulation for surgery, Overall rank of temporal bone material models



## RESULTS

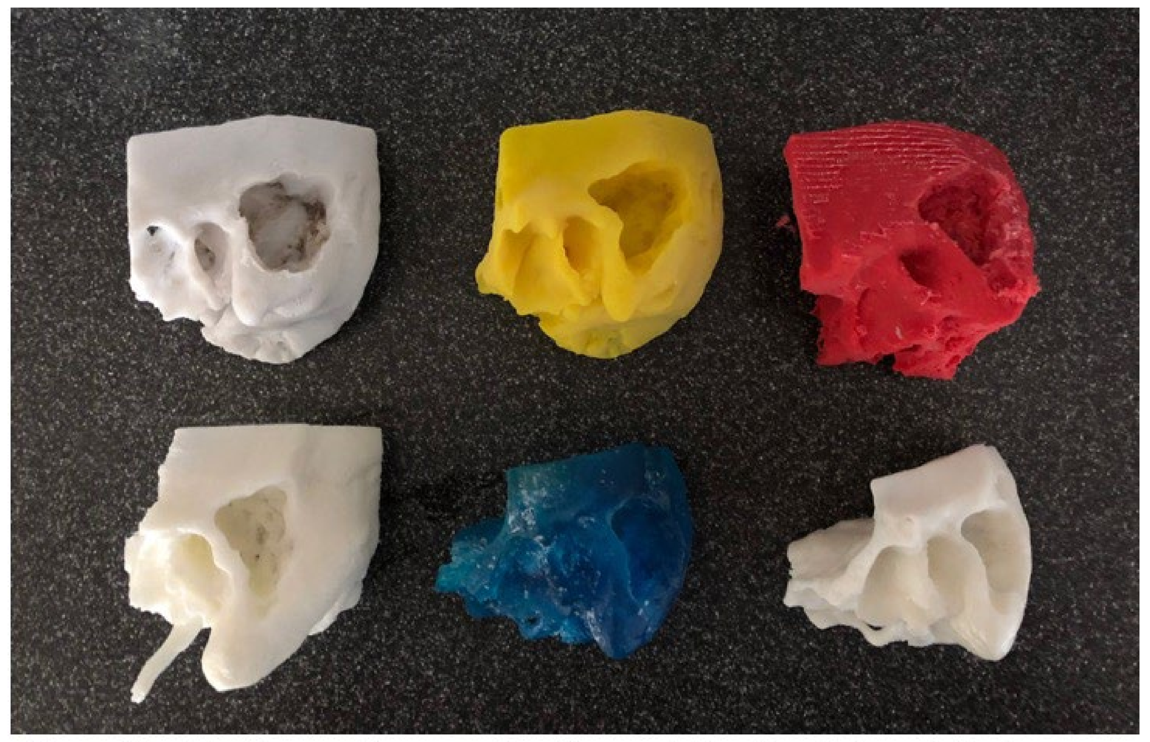
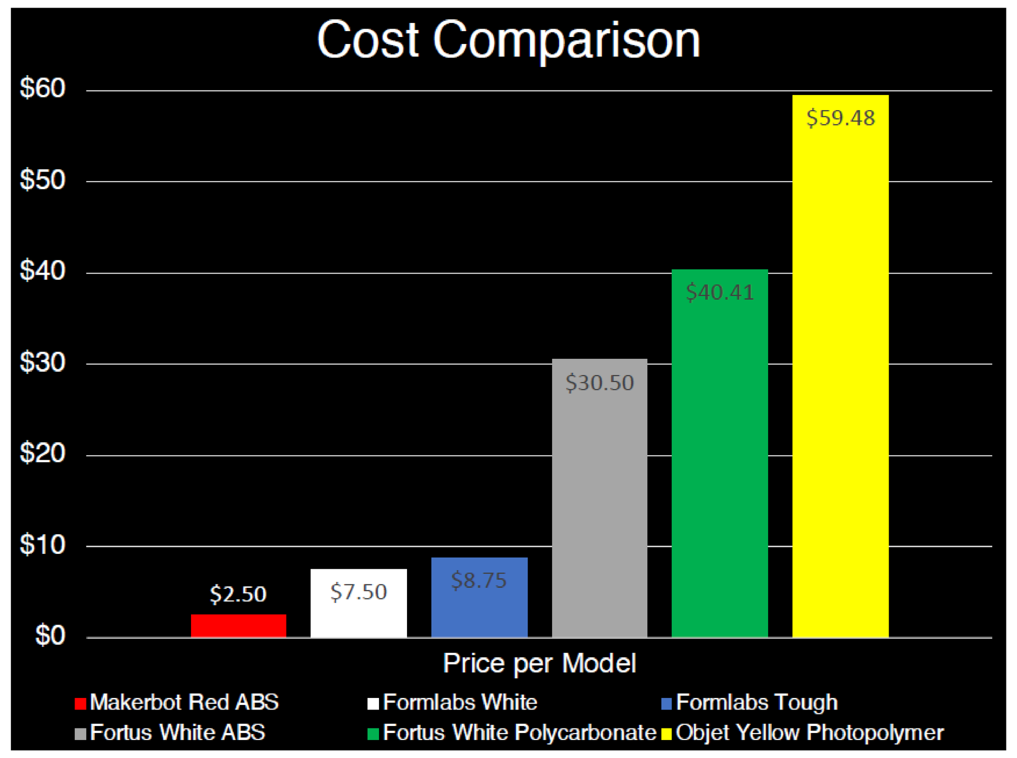


Figure. 3D printed temporal bone models after completion of cortical mastoidectomy simulation.



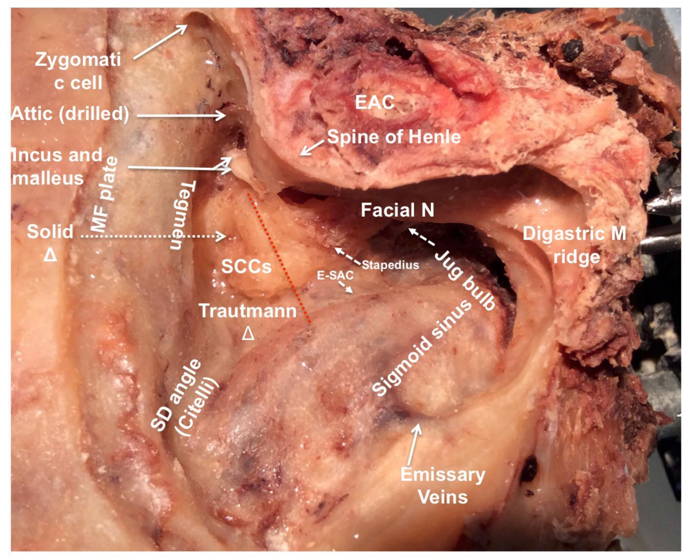

Best Ranked Temporal Bones:
1.) Fortus 400mc White Polycarbonate
2.) Formlabs Form 2 Standard White Resin
3.) Object350 Connex3 Yellow Photopolymer

- All models had top scores for realistic external bone contour
- All Models produced high to excessive powder
- Formlabs Form 2 Standard had the best correlation with in vivo cortical bone with drill use
- Maker Boke Red ABS was only model with change in pitch heard during in vivo temporal bone surgery

- Limitations: Difficulties with printing small internal hollow structures and anatomy, average printing times ranged from 5-12 hours per model

## CONCLUSIONS

3D printing temporal bone models is a valid method for recreating anatomical models that can be used for Otologic surgical training with reasonable cost and time. Though there are technical difficulties that may arise during the printing process and microstructures are limited by the capability of machinery at this time, 3D printing is a rapidly growing field and models with high definition printing capabilities are currently being made. Further directions are creating a temporal bone library, improving the surgical realism of 3D printed bones, comparing these 3D printed models directly tp cadaveric models, and increasing the number of participants to improve the generalizability of these results


Zygomati
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Attic (drilled)
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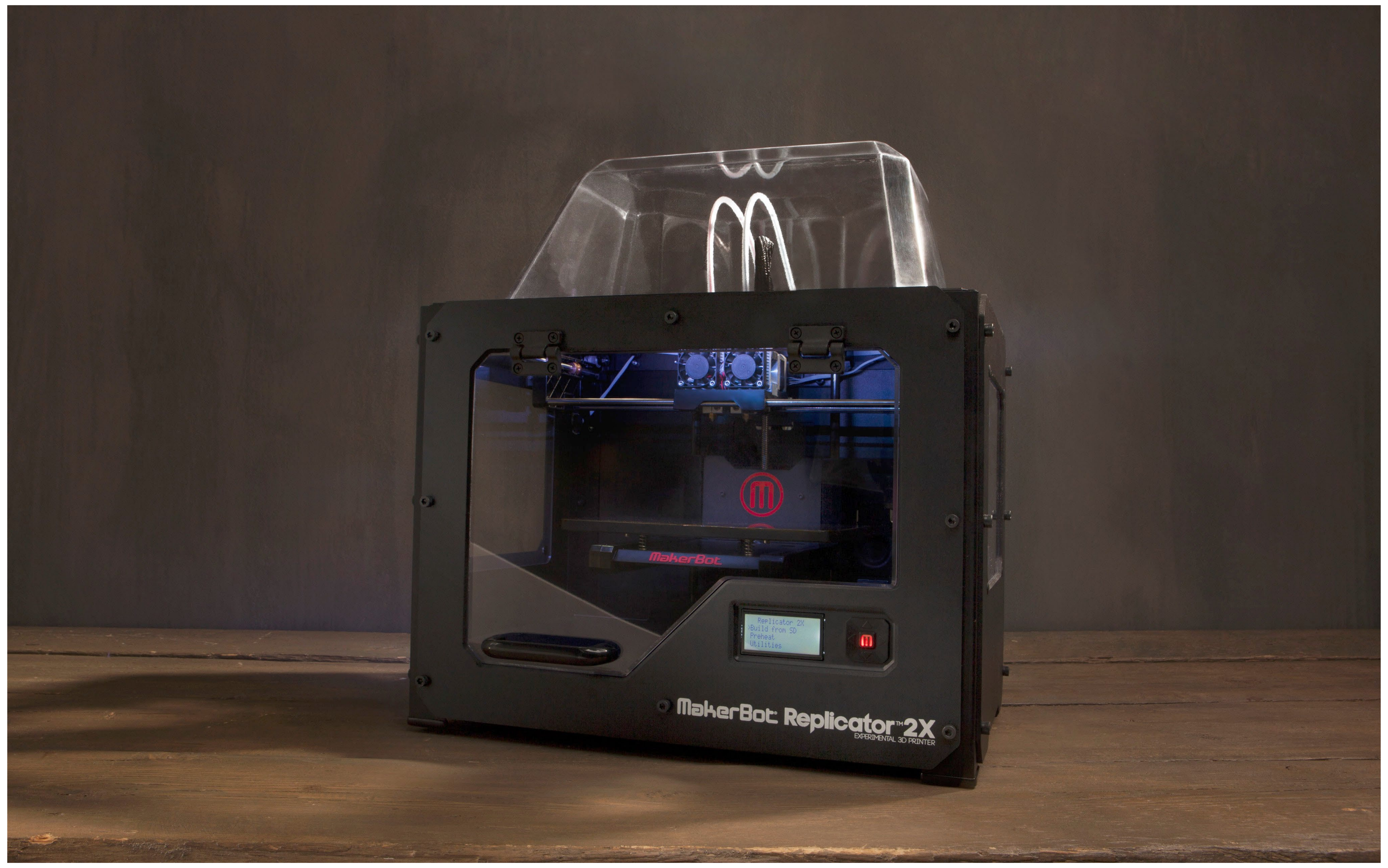
MakerBot Replicator 2X