Tactile Comparison of Screw Insertion of 3D-Printed Versus Sawbones Tibia Models

Brittany Bautista Carrus, BS*; Michael Jax, BS; Leon Su, BS; Katherine Thompson, PhD; Arun Aneja, MD; Mary Lloyd Ireland, MD*
University of Kentucky, Lexington, KY, United States

Purpose: As orthopaedic residents are expected to master increasingly complex and numerous procedures, they must acquire many skills through surgical simulation laboratories. Access to these simulations is limited due to the high cost and limited availability of cadaver models. Sawbones models are an alternative that are more accessible and more cost-effective than cadaver bones without sacrificing anatomic accuracy. A chief complaint of orthopsedic surgeons is that Sawbones do not provide the same tactile sensation as real human bone. 3-dimensional (3D)-printed models provide a potential solution to this quality gap while also adding customizability and a lower cost. This study aimed to determine if a 3D-printed tibia model can better simulate the tactile sensation of real human bone than a Sawbones model and at what relative cost.

Methods: This study was a double-blind crossover-controlled trial involving 24 orthopaedic surgery residents and attending physicians. Participants were asked to drill and insert a screw into three proximal tibia models (one Sawbones and two 3D-printed) using a drill and plate system. The 3D models were printed using a consumer-grade FDM 3D printer. They varied in the number of solid shells (4 vs 6) that composed the outer layer, simulating the cortex of the bone. Both contained a 15% density infill, simulating the cancellous portion of the bone. After each screw insertion, the surgeons completed a survey indicating which model they felt was most similar to "healthy bone" and rated that similarity on a scale from 0 to 2 (0 = "not similar at all"; 2 = "very similar"). A two-sided binomial test was run to look for evidence that the chosen most similar model was not 33% (what would be expected by chance). A Bonferroni correction was used to adjust for the three tests run, setting $\alpha = 0.05/3$ to determine significance.

Results: 19 of 24 surgeons (79.2%) selected the 6-shell 3D model as most similar to "healthy bone" ($P<0.0001$), 16.7% (4 of 24) selected the 4-shell 3D model ($P = 0.1270$), and 4.2% (1 of 24) selected the Sawbones model ($P = 0.0016$). Additionally, when asked to rank each model's similarity to bone on a scale from 0 to 2, 58.3% of surgeons ranked the 6-shell 3D model as 2 ("very similar"), whereas no surgeons ranked it as 0 ("not similar at all"). Only 8.3% of surgeons ranked the Sawbones model as 2, whereas 20.8% ranked it as 0. A simple cost analysis showed that each 3D-printed proximal tibia model was approximately 35% of the cost of an anatomically identical Sawbones model, which costs $11.25.

Conclusion: This study suggests that 3D-printed bone models can better replicate the tactile sensation of real human bone than commercially available Sawbones models. This, in addition to being lower-cost and easily customizable, may allow surgeons in training more access to higher-quality simulations for surgical skills acquisition. Further work will confirm the tactile similarity and compare the mechanical properties of a 3D-printed bone model to real human bone.