# A Low-Cost 3D-Printed Tool with Multiaxial/Angular Vessel Orientation for Microvascular Anastomosis Training

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**Background:** Microsurgical anastomosis is a technically demanding skill. The most difficult part of the learning process was in achieving the necessary orientation and dexterity. In this project, we adopted computer-aided design and desktop 3D-printing in the development of an affordable training model with different levels of vessel orientation and angulation.

**Methods:** The training model was designed using CAD software (Rhino3D). The models were then 3D-printed with a thermoplastic polyurethane (TPU 95A) semi-flexible filament on a desktop fused deposition modeling, Ultimaker 2 + 3D printer.

**Results:** The printed training tool was assembled by fitting the ball-and-socket mechanism between two parts having an overall round table top with integrated vascular clamps. Trial with synthetic and nonliving animal blood vessels shows the utility of the clamps in holding the vessels within the working space. By rotating the top part, a multiaxial vessel orientation from 0 to 360 degrees was achieved. The top part was also capable of multiangular orientation of the vessels (±30 degrees) regardless of its axial orientation during vessel anastomosis. For the 3D-printing process, the average printing time was about 3.5 hours with a cost of 1.3$ per material.

**Conclusions:** The utility of desktop 3D printing represents an affordable modality in microsurgical training. The designed model is capable of providing a trainee with multiaxial and multiangular vessel orientation during the anastomosis process. To our knowledge, the adoption of this technology in the field of microsurgery training has never been investigated before. (*Plast Reconstr Surg Glob Open 2020;8:e2567; doi: 10.1097/GOX.0000000000002567; Published online 11 February 2020.*)

## INTRODUCTION

Microsurgery is one of the most complex surgical disciplines, requiring delicate and high level of hand dexterity for successful surgical outcome. Although practicing on living animal models is considered the gold standard before clinical practice, there is an expansive shift toward utilizing ethically sound, safe, feasible, and cost-effective initial training alternatives.[1] Studies have shown that simulated training on low-fidelity models was effective in establishing microsurgical skills that can be later transferred to animal or cadaveric models.[2] Moreover, improved technical performance translate to significant reduction in the number of needed animals and associated costs.[3] Many synthetic training tools have been described to acquire the basic microsurgical techniques and maintain one's hand dexterity during intervals of ineptitude.[1] Nonliving training models that mimic microvascular anastomosis and nerve repair have been also described, such as Gore-Tex tubes, polyurethane tubes found in intravenous cannula, rubber tubes, and premade practice cards consisting

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of silicone microtubes affixed to them.[1,3,4] All of these modalities, however, lack the three-dimensional nature that mimics the complex clinical scenarios. 3D-printing technology offers a new frontier in modern surgery and has myriad applications in medical education and surgical simulation.[5] Herein, we describe the use of computer-aided design and desktop 3D printing in the development of an affordable training model capable of providing trainees with different vessel orientation and angulation that can be used both with loupe magnification and under an operative microscope to mimic the complexity of different clinical scenarios.

The training model consists of two units, a circular table top having an attached clamp and a base. A ball-and-socket mechanism of attachment connects the two parts. The files were made printable as a Stereo-lithography file format (. STL). The models were then 3D-printed with a thermoplastic polyurethane (TPU 95A) semiflexible filament on a desktop fused deposition modeling, Ultimaker 2+3D printer.

The printed models were first cleaned from print support material and then assembled by fitting the ball-and-socket mechanism between the two units (**See Video**, [online], which displays the 3D-printed training model being assembled together with trial of vessel clamp and the different orientation/angulation scenarios that can be created to adjust the level of complexity of microvascular anastomosis training process). Trials with synthetic and nonliving animal blood vessels showed the utility of the clamps in holding the vessels within the working space. By rotating the top part, a multiaxial vessel orientation in 360 degrees can be achieved. The top part was also capable of multiangular orientation of the vessels (±30 degrees) regardless of the axial orientation during vessel anastomosis (**See Video**, [online], which displays the 3D-printed training model being assembled together

with trial of vessel clamp and the different orientation/angulation scenarios that can be created to adjust the level of complexity of microvascular anastomosis training process). For the 3D-printing process, the average printing time was about 3 and a half hours with an average cost of 1.3$ per material.

The utility of desktop 3D printing represents an affordable modality in microsurgical training. Scenarios with different levels of complexity can be created with the designed model, as it provides trainees with multiaxial and multiangular vessel orientation during the anastomosis process. To the best of our knowledge, the adoption of this technology in the field of microsurgical training simulation has never been investigated before.

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