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# A novel supermicrosurgery training model: The chicken thigh



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**Summary** *Background:* Supermicrosurgery is an increasingly important technique in reconstructive surgery. It requires a more technically refined skill set compared with standard microsurgery. All currently available biologic training models involve the use of live rats. A nonliving model would be more accessible and cost-effective for practice. We have developed such a model using chicken thighs purchased from a local grocery store.

*Methods:* The ischiatic neurovascular bundle was identified in 20 chicken thighs and dissected distally to the end of the specimen. The vessel diameters were measured at several points along the artery, vein, and their respective branches. Vessels with diameters in the 0.3–0.8-mm range were then divided and supermicrosurgical anastomoses were attempted.

*Results:* The branching pattern of the ischiatic artery and vein were anatomically consistent with intermediate and terminal secondary and tertiary branches consistently in the range of 0.3–0.8 mm. In all specimens, at least one 0.3-mm vessel could be identified, though additional intramuscular dissection was sometimes required. It was demonstrated that supermicrosurgical anastomoses could be successfully performed using these branches.

*Conclusions:* This study introduces a novel, convenient, and economical model for supermicrosurgery utilizing easily obtained chicken thighs. The chicken thighs have an anatomically consistent vascular branching pattern, and vessels of appropriate sizes for training can be

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easily identified and isolated. Surgeons looking to develop or refine supermicrosurgical skills may find this nonliving, biologic model very useful.

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## Introduction

Supermicrosurgery, the technique of anastomosing vessels  $<0.8$  mm,<sup>1</sup> has been increasingly utilized in reconstructive surgery in procedures such as fingertip replantation,<sup>2</sup> perforator-to-perforator free tissue transfer,<sup>3,4</sup> and lymphaticovenular anastomosis (LVA). For LVA in particular, venules and lymphatics of 0.5 mm in diameter or smaller are routinely selected for anastomosis.<sup>5</sup> Even more than in standard microsurgery, supermicrosurgery demands rigorous eye–microscope–hand coordination, dexterous handling of delicate tissues, and fluid, fine motor skills. These technical skills need to be developed and practiced for these technically demanding procedures to be successfully performed.

Currently available biologic supermicrosurgical training models all involve the use of live rats.<sup>6–8</sup> While these provide vessels of adequate caliber for supermicrosurgical training, animal models are expensive and require dedicated research programs, animal use certification and care protocols, and specialized facilities. These factors can make training with the animals impractical, if not impossible, for many surgeons seeking to develop these specialized skills.

The purpose of this study was to develop a cost-effective and biologically realistic training model for supermicrosurgery that is more easily accessible than the previous models that have been described.

## Materials and methods

### Specimens

Twenty-two chicken thighs were obtained from a grocery store without consideration given to the age of chicken and the size and weight of the individual thighs. Specimens were examined to assure that excessive injury to the vasculature had not been incurred during processing of the poultry. Two specimens were found to have exposed ischiatic vessels and muscle tear and were eliminated; hence, 20 specimens were included in the study. Dissection and supermicrosurgical anastomoses were performed by two microsurgeons and one microsurgery fellow.

### Dissection technique

With the femur oriented vertically toward the surgeon's left-hand side and the skin side of the chicken thigh facing down (toward the bench), the ischiatic neurovascular bundle was exposed by dissecting along the areolar plane between the iliotibialis and iliofibularis muscles (Figure 1). The iliotibialis and iliofibularis were reflected to the left and right, respectively, as the dissection proceeded. Optimal exposure of the vasculature was achieved by partial excision of both

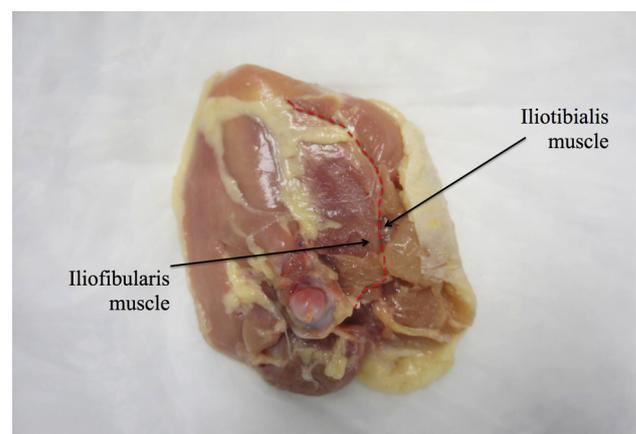
muscles. The primary branches of the ischiatic artery and vein were skeletonized and traced with antegrade dissection to sequentially identify the secondary and tertiary branches (Figure 2). The dissection was terminated when one of the following two end points was reached: 1) when any of the branches reached the size of 0.3 mm or 2) when the dissection reached the rightmost end of the specimen.

### Equipment and instruments

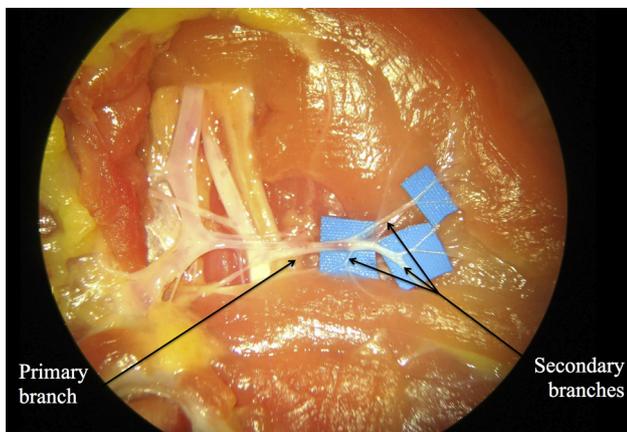
Zeiss Opmi Primo ceiling-mount microscope (Carl Zeiss Meditec, Jena, Germany) with maximum magnification of 21.3 $\times$  was used. Magnification of 8.5 $\times$  or less was used for the initial dissection of the ischiatic neurovascular bundle and its primary branches. When reaching vessels  $<0.8$  mm, 13.6 $\times$  and 21.3 $\times$  magnifications were required to adequately skeletonize and prepare the vessels for supermicrosurgical anastomosis. A magnification of 21.3 $\times$  was used exclusively for supermicrosurgical suturing. Synovis S & T standard and superfine microsurgical instruments (Synovis, Neuhausen, Switzerland) were used. Synovis S & T type V, 12/0 nylon suture (Synovis, Neuhausen, Switzerland) with a 50- $\mu$ m-diameter needle was used for supermicrosurgical suturing. Measurements of vascular branches were taken with Shinwa stainless steel gauge, model 58698, with a precision to the nearest 0.05 mm (Shinwa Measurement, Niigata, Japan) (Figure 3).

## Results

The ischiatic artery and vein consistently sent off primary branches at the mid-femoral point. The primary arterial



**Figure 1** The ischiatic neuromuscular bundle is exposed by dissecting the areolar plane between iliotibialis and iliofibularis muscles. The exposure of the vasculatures is enhanced by partial excision of both muscles.

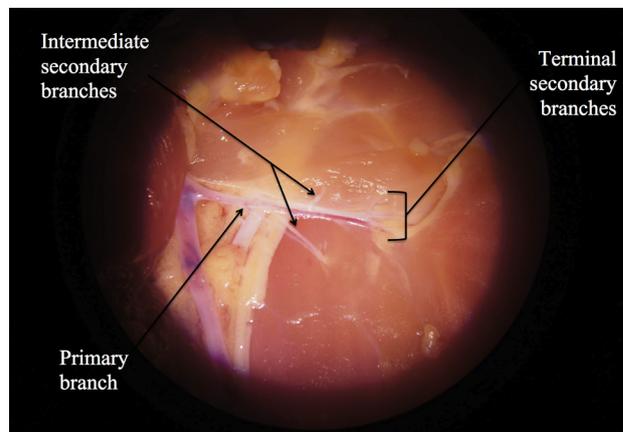


**Figure 2** Ischiatic vein, artery, and nerve are seen here from left to right. All give off primary branches (in transverse orientation in the picture), which sequentially sprout secondary and tertiary branches.

branch had a mean caliber of  $1.13 \pm 0.23$  mm at its origin and  $1.07 \pm 0.26$  mm at the terminal branching point (Figure 8); the primary venous branch had a mean caliber of  $1.07 \pm 0.24$  mm at the origin and  $0.91 \pm 0.29$  mm at the terminal branching point, which was defined as the distal end of the primary branch. Two separate secondary branching systems were found – the *intermediate* and *terminal* secondary branching systems (Figure 4). Prior to reaching the terminal branching point, both primary arterial and venous branches gave off a variable number of intermediate secondary branches (Figure 4). Terminal branching points were usually found within 2 cm from the rightmost end of the specimen, and from this point, the terminal secondary branches originated. The intermediate and terminal secondary arterial branches had a mean caliber of  $0.55 \pm 0.18$  mm, and those of the secondary venous branches had a mean caliber of  $0.48 \pm 0.18$  mm at their respective origins (Figures 5 and 8). In all specimens, one or more secondary or tertiary branches tapered to



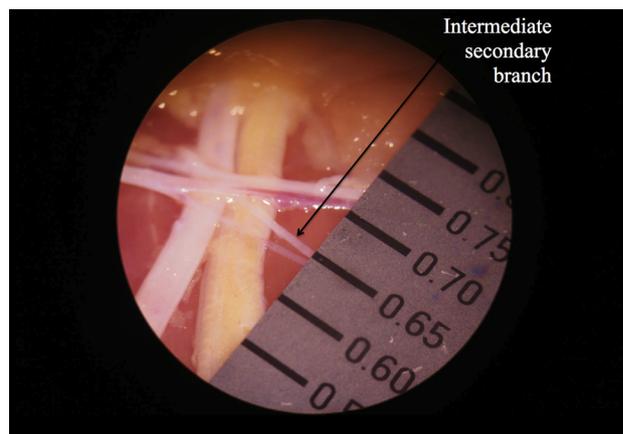
**Figure 3** Shinwa gauge (Shinwa Measurement, Niigata, Japan) used in the measurement of the blood vessels and instruments needed for specimen dissection. Supermicrosurgical instruments not shown.



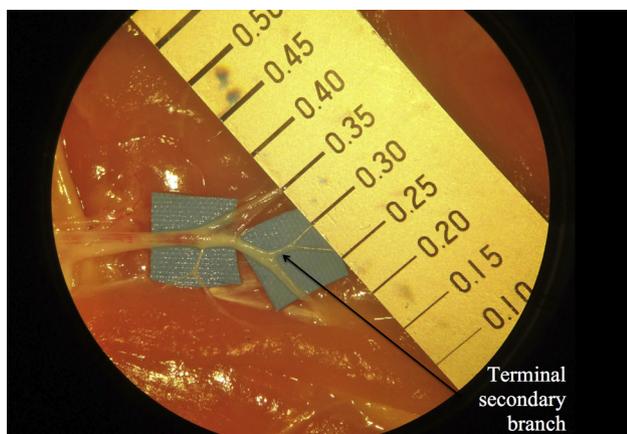
**Figure 4** The primary branches sprout a variable number of intermediate secondary branches on their way to becoming terminal secondary branches. The intermediate secondary branches insert into muscles at a variable distance from their origins.

0.3 mm (Figure 6). The intermediate secondary branches were inserted into muscles at a variable distance from their origins (Figure 4). Intramuscular dissection was usually necessary to expose vessels of 0.3 mm. By contrast, terminal secondary branches required relatively less dissection to reach vessels of this size.

The mean dissection time to prepare at least one 0.3-mm vessel for anastomosis was  $20 \pm 6$  min (range 13–29 min). Supermicrosurgical anastomoses of 0.3–0.8-mm vessels were successfully performed in all specimens (Figure 7). We did not perform anastomosis of 0.3-mm vessels in all specimens, as not all of our trainees had reached this advanced level of supermicrosurgery training. Patency was assessed by 1) direct microscopic inspection of the lumen after dividing the vessel, 2) passing a 7/0 nylon into the lumen through the anastomosis, and 3) injecting methylene blue or another dye into the vessel using a 30-gauge needle. The injection method also allowed checking for leakage.



**Figure 5** Both intermediate and terminal secondary branches consistently demonstrated calibers suitable for supermicrosurgery (<0.8 mm) training at their origins from the primary branches.

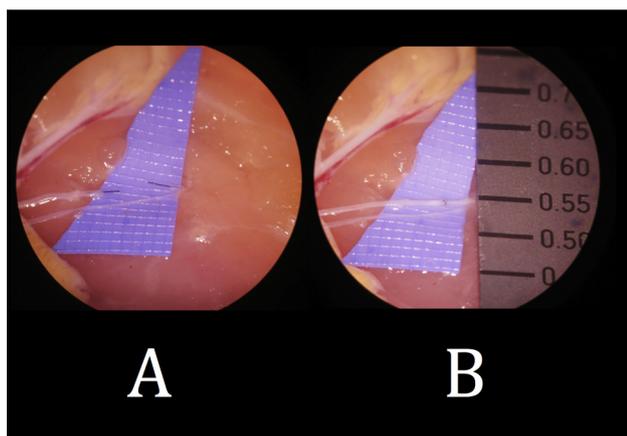


**Figure 6** 0.3-mm vessels were identified in all specimens. These vessels are appropriate for training for supermicrosurgical lymphaticovenular anastomosis.

## Discussion

The best way to develop a new surgical skill or to maintain a skill already acquired is through regular practice. Textbooks, videos, and mental simulation facilitate conceptual acquisition, but the motor skills involved can only be developed and maintained through repeated performance. Training with live animals, while providing realistic simulation, is logically difficult and expensive, given the need for dedicated programs, protocols, and facilities.

The chicken thigh has previously been described as a convenient, cost-effective microsurgery training model.<sup>9,10</sup> The chicken ischiatic artery and vein, with a mean diameter of 2.5–3 mm, offer excellent microsurgical simulation. We extended the utility of this nonliving, biologic model to supermicrosurgical training with the dissection of the secondary branches of the ischiatic vessels. The branching pattern of the ischiatic vessels is anatomically consistent. In all specimens, the primary branches originated at the mid-femoral point and sequentially branched into *intermediate* and *terminal* secondary branches. Both intermediate and terminal secondary branches had calibers



**Figure 7** Anastomosis of a 0.55-mm artery with 12/0 nylon using a 7/0 nylon as an intraluminal stent to facilitate precision suturing.

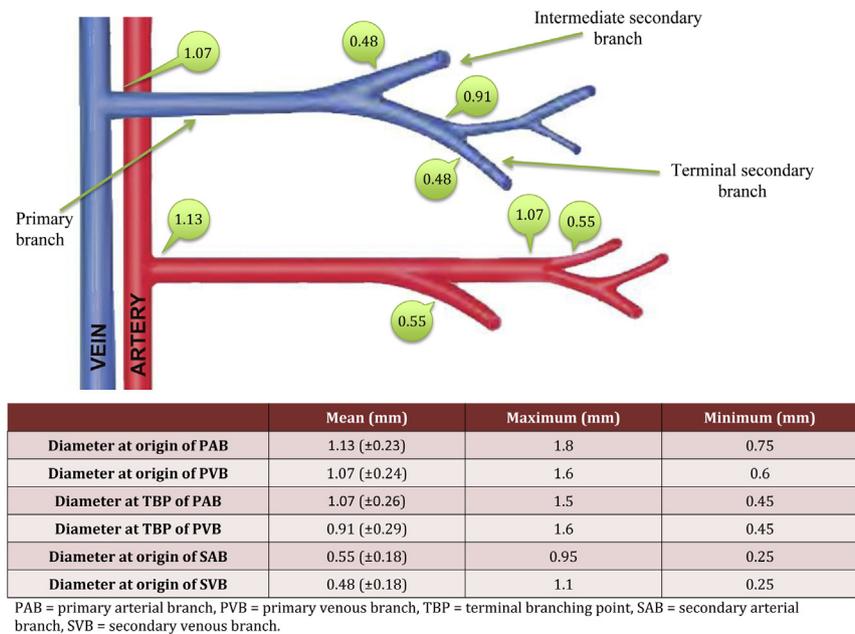
appropriate for supermicrosurgical training (<0.8 mm). Tracing them more distally consistently produced vessels of 0.3–0.5 mm.

Training with vessels of 0.3–0.5-mm caliber is particularly crucial for LVA simulation. Subdermal venules >0.5 mm may have a higher intravascular pressure than that of the lymphatics, so LVA with inappropriately large venules often result in undesirable vein-to-lymphatic retrograde flow.<sup>5</sup> In addition to not decompressing the lymphatic system, it can cause alarmingly extensive ecchymosis. Conversely, we consider 0.3 mm as the lower size limit for LVA because anastomosis with lymphatics <0.3 mm frequently results in a significant size mismatch with the venules in end-to-end anastomotic configuration, requiring the more technically challenging end-to-side configuration.<sup>11</sup> In addition, the LVA created with these diminutive lymphatics may not provide effective bypass drainage.

Supermicrosurgery requires a more refined skill set than standard microsurgery. Some of the technical maneuvers utilized in supermicrosurgery are different from those used in standard microsurgery. Occluding clamps are not used in supermicrosurgery in order to limit damage to the delicate submillimeter vessels. It has been found that it is easier to remove adventitia from these small vessels prior to vessel division. The traction provided by the intact vessel facilitates the dissection process. We have found it helpful to stent the vessels intravascularly using 6/0 or 7/0 nylon while performing anastomoses in LVA simulations<sup>12–14</sup> (Figure 7). This technique allows the surgeon to clearly visualize the vessel lumen and greatly increases the surgeon's confidence in suture placement. The nylon suture effectively stents the lumen open and, in doing so, minimizes the risk of back walling. The use of a superfine needle holder with a locking mechanism was also found to be helpful. This transferred the mechanical burden of gripping the needle from the surgeon's intrinsic muscles to the lock mechanism, allowing the surgeon to better focus on needle placement and the anastomotic technique.

In contrast to the living, biologic models, our model does not require animal maintenance or anesthesia and eliminates all concerns regarding the ethical treatment of animals. The inconvenience of needing to re-dose an animal emerging from anesthesia during a practice session is eliminated. Nonliving vessels do not develop spasm, so smooth muscle relaxants are not needed and the trainee does not need to waste time waiting for a spasmodic vessel to relax. The dissection of vessels is quick and easy, as is evident by the short dissection time demonstrated in this study. The tapering of the secondary branches allows graduated training. Less experienced surgeons may start by training with 0.6–0.8-mm vessels, and then gradually transition to smaller vessels by dissecting more distally.

The described supermicrosurgical model offers combined advantages over both the currently available living biologic models<sup>6–8</sup> and the non-biologic model<sup>15</sup> without the disadvantages associated with either. The minimal cost of chicken thighs (\$0.99 USD per thigh) is in sharp contrast to the resources required to support an animal program. The model is available to trainees at any time of the day and does not require access to a specialized animal care facility. No preoperative, intraoperative, and postoperative



**Figure 8** Vascular anatomy of the chicken thigh. Different segments of the vasculature can be used in a graduated fashion as the trainee becomes progressively more proficient in microsurgical/supermicrosurgical skill.

care is required. In contrast to the non-biologic model utilizing synthetic vessels, this model offers near-identical tactile feedback of human supermicrosurgery, allowing a high-fidelity simulation. These advantages should translate into more frequent utilization of this model than others by trainees, and ultimately, more refined technical skills.

## Conclusion

To the best of our knowledge, this is the first description of a nonliving, biologic supermicrosurgery simulation model. It offers the key advantages of being easily obtainable, economical, and free of the inconvenience associated with animal use. The model can be easily implemented by any surgeon interested in developing or refining their supermicrosurgical skills. The convenience of the model is conducive to frequent training, which will translate into improved technical performance. As the old adage goes, "practice makes perfect".

## Financial disclosure and products page

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

## Conflict of interest

None.

## Statement of authorship

Each person listed as an author has participated in the study to a significant extent.

## Statement of originality

This manuscript represents an original contribution and has not been previously published.

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## References

1. Koshima I, Nanba Y, Tsutsui T, Takahashi Y. Medial plantar perforator flaps with supermicrosurgery. *Clinics in Plastic Surgery* 2003;30(3):447–55.
2. Fujitsu M. Pulp flap replantation of the amputated fingertip. *Plastic and Reconstructive Surgery* 2011;127(3):77e–8e.
3. Hong JP. The use of supermicrosurgery in lower extremity reconstruction: the next step in evolution. *Plastic and Reconstructive Surgery* 2009;123(1):230–5.
4. Kim CY, Kim YH. Supermicrosurgical reconstruction of large defects on ischemic extremities using supercharging techniques on latissimus dorsi perforator flaps. *Plastic and Reconstructive Surgery* 2012;1.
5. Nagase T, Gonda K, Inoue K, et al. Treatment of lymphedema with lymphaticovenular anastomoses. *International Journal of Clinical Oncology* 2005;10(5):304–10.
6. Yamashita S, Sugiyama N, Hasegawa K, Namba Y, Kimata Y. A novel model for supermicrosurgery training: the superficial inferior epigastric artery flap in rats. *Journal of Reconstructive and Microsurgery* 2008;24(08):537–43.
7. Ozkan M, Koshima I, Gonda K. A supermicrosurgical flap model in the rat: a free true abdominal perforator flap with a short pedicle. *Plastic and Reconstructive Surgery* 2006;117(2):479–85.

8. Liu H-L. Microvascular anastomosis of submillimeter vessels—a training model in rats. *Journal of Hand and Microsurgery* 2013; 5(1):14–7.
9. Galeano M, Zarabini AG. The usefulness of a fresh chicken leg as an experimental model during the intermediate stages of microsurgical training. *Annals of Plastic Surgery* 2001;47(1): 96–7.
10. Nimmons GL, Chang KE, Funk GF, Shonka DC, Pagedar NA. Validation of a task-specific scoring system for a microvascular surgery simulation model. *The Laryngoscope* 2012;122(10): 2164–8.
11. Yamamoto T, Yoshimatsu H, Narushima M, et al. Sequential anastomosis for lymphatic supermicrosurgery. *Annals of Plastic Surgery* 2012;1.
12. Narushima M, Koshima I, Mihara M, Uchida G, Gonda K. Intra-vascular stenting (IVaS) for safe and precise super-microsurgery. *Annals of Plastic Surgery* 2008;60(1):41–4.
13. Yoshimatsu H, Yamamoto T, Narushima M, Iida T, Koshima I. The guide wire method. *Annals of Plastic Surgery* 2013;1.
14. Yamamoto T, Narushima M, Kikuchi K, et al. Lambda-shaped anastomosis with intravascular stenting method for safe and effective lymphaticovenular anastomosis. *Plastic and Reconstructive Surgery* 2011;127(5):1987–92.
15. Matsumura N, Horie Y, Shibata T, Kubo M, Hayashi N, Endo S. Basic training model for supermicrosurgery: a novel practice card model. *Journal of Reconstructive and Microsurgery* 2011; 27(06):377–82.