Video Article

Step By Step: Microsurgical training method combining two nonliving animal models

José Couceiro[1], Raquel Castro[2], Huey Tien[2], Tuna Ozyurekoglu[2]

[1]Orthopaedic Surgery Department, Hand Surgery Unit, POVISA Hospital

[2]Christine M Kleintert Institute for Hand and Microsurgery

Correspondence to: José Couceiro at couceirox@gmail.com

URL: https://www.jove.com/video/52625
DOI: doi:10.3791/52625

Keywords: Mico-surgical, Training, nonliving, chicken, costs, accessible, experimental

Date Published: 5/9/2015

Citation: Couceiro, J., Castro, R., Tien, H., Ozyurekoglu, T. Step By Step: Microsurgical training method combining two nonliving animal models. *J. Vis. Exp.* (99), e52625, doi:10.3791/52625 (2015).

Abstract

The learning of microsurgical techniques and the maintenance of microsurgical skills have been traditionally based on the use of living animals, mainly laboratory rats. This method although extremely valuable can be economically demanding both for the surgeon and the sponsoring institution; it also requires special training facilities that may not always be available or accessible. Furthermore ethical concerns can limit the use of living animals for training purposes. Alternative training methods, such as inert tubes and gloves have not gained popularity among surgeons since they do not offer an experience similar to that of a clinical situation. Non-living animal models include the use of chicken thighs and wings; they offer a practice experience that resembles a clinical situation to a considerable extent. This type of training is relatively cheap and easily available. The microscope and instruments required can be acquired over the internet, and the chicken pieces can be bought at the local supermarket.

This approach allows a motivated trainee to rehearse different types of surgical techniques several times at a reasonable expense, helping to develop or maintain his surgical expertise if more complex facilities are not available. On the current manuscript we describe how to setup a small practice station, how to dissect the specimens, and how to practice both with the chicken thighs and with the chicken wings in a progressive fashion. This approach takes advantage on the versatility of the chicken thigh model and the small size of the chicken wing Brachial artery.

Video Link

The video component of this article can be found at https://www.jove.com/video/52625/

Introduction

An ample array of training models have been described for the learning and maintenance of both basic and advanced microsurgical skills. These include living animals[1,2], human cadaveric specimens[3], inert models[4,5] and non-living animal models[6-9].The Living animal models, specifically those using rats have been extensively used in the teaching of microsurgery [1,2]; and they are considered the current gold standard of training. In spite of their remarkable instructive value, when an intensive or prolonged training is required; economical and ethical concerns can hinder their practical usage.

Cadaveric models[3] offer the opportunity to practice in an environment similar to that of the actual clinical situation; they are unfortunately restricted to anatomy labs and similar facilities, a microscope must be available at the lab as well; these models are therefore not widely available. Inert models such as rubber tubes, or gloves[4,5] are cheap, and easily accessible, the required equipment for their application is minimal. The resemblance to a clinical situation is tenuous however; and their application is generally limited to the introductory stages of training, before the trainee starts practicing on rats. To the best of our knowledge Hino[6] was the first to propose the use of non-living chicken for the development and maintenance of clinical microsurgical skills. His model is based on the extraction and subsequent usage of the chicken brachial artery from commercial chicken wings. This approach does not need institution review board approval, rodent anaesthesia, laboratory technicians or postoperative care.

Following Hino´s description of the chicken wing artery model numerous other nonliving animal models were published. The use of commercial chicken thighs was first suggested by Marsh et al.[7] who reported the use of the femoral artery, vein and nerve for didactic purposes. This particular model expands the possibilities of training including structures different from the arteries; it permits the trainee to perform a variety of complex procedures such as vein grafts, nerve grafts or fascicular repairs. Jeong et al.[8] Further studied Marsh' chicken thigh model and its applications to the teaching of resident doctors. The authors analysed chicken tissue samples histologically and found that it presented similarities to human tissues. The time to perform an anastomosis by the trainee was significantly reduced by practice in their study. They concluded that "the femoral neurovascular bundles of chicken are an appropriate and effective model for teaching and practicing microsurgery". In 2013 my colleagues and I[9] published a microsurgical training regimen that combined both the chicken thigh and the chicken wing models; this approach benefits from the versatility of the chicken thighs and from the limited size of the chicken wing artery which can represent more of a challenge than the femoral vessels for the more advanced trainees.

On the current manuscript we describe step by step the process of setting up a microsurgical practice station; the materials required, how to dissect the neurovascular structures of each model and how to effectively apply the training regimen.

Protocol

1. Preparation:

1. Obtain a tabletop stereo microscope, with a variable 3,5 x to 45x zoom, 200 mm working distance, 55 to 75 mm variable inter-pupillary distance and an accessory led ring light. Any similar microscope is adequate, it can be set up on a small table and is not extremely expensive.
2. Gather and prepare a set of microsurgical instruments with two microsurgical pickups, one dissecting scissor, and one needle-driver; this is the minimum required, it must be taken into account that these are practice instruments, and high end quality instruments are not needed.
3. Use 9/0 monofilament micro-suture for all the practices. Buy commercially available chicken thighs or wings and food colorant at the local supermarket.
4. A 20 G angio-catheter is used for the patency tests on the chicken femoral arteries. For the Brachial arteries a thinner 27 G catheter is needed. These can be acquired over the internet at a local Pharmacy or with the instruments set. Buy a commercially available syringe to inject the food colorant.

2. Macroscopic dissection techniques:

1. The approach to the femoral vessels is straightforward. For chicken thighs, perform a blunt dissection technique just medial to the femoral shaft, separate the femoral muscle from the bone and expose the femoral artery, vein and nerve. The nerve can be further dissected into two separate fascicles for different types of nerve repair practices.
2. In order to access the chicken Brachial artery in the chicken wings, incise the skin longitudinally with a scissor, from the shoulder up to the tip of the wing. Observe the artery running between the biceps and triceps brachii.

3. Recommended training regimen:

1. Training with the femoral artery.
   NOTE: The first step in the training regimen is to practice with the chicken femoral artery.

   1. Place the piece under the microscope and start the microsurgical dissection. Free the femoral artery from the underlying tissues; and divide it horizontally. Perform an adventicectomy. Use the micro-pickups and micro-scissors to trim any adventicia overlying the arterial lumen. Rinse the inner lumen with regular tap water. Write down the starting time
   2. Perform an end to end anastomosis.
      1. Start on the back wall of the artery on the side opposite to the operator. Place the first stitch; start on the left side if working horizontally, on the lower side if working vertically. Pass the needle from the outside of the artery towards the lumen and then from the lumen to the outside of the artery.
      2. Tie the stitch, perform a double knot first, and then two single throws alternating directions. Complete the whole back wall with the above described technique.
      3. Starting on the right hand side if you are working horizontally or the upper side if you are working vertically, place a single stitch from the outside to the lumen and then from the lumen to the outside. Tie the knot as described above. Complete the front wall repeating the procedure described in 3.1.2.2.
      4. Write down the final time this will allow you to keep a time record, so you can control your progression.
         NOTE: The authors prefer a one way up technique; but any type of microsurgical suture can be rehearsed. It is recommendable that the trainee completes around 25 microsurgical anastomoses in this manner before he can try other clinical scenarios. These include vein grafting for arterial gaps, end to end nerve repairs, and the use of vein conduits for the treatment of nerve gaps. An important technique in microvascular surgery, that can be learned with this training method is the continuous or running suture, to perform this technique the trainee proceeds as 3.1.2.1 but the stich is not cut, continue to perform stitches as in 3.1.2.1 without cutting them until you complete the whole suture and tie it to the original stitch at the end.

2. Training with the Brachial artery
   1. Place the piece under the microscope. Complete the procedure as described above for the femoral artery.
      NOTE: The only difference is the size. The Brachial artery is much smaller than the femoral artery and the anastomosis is considerably more challenging.

3. Patency tests
   1. Cross a smooth 20 or 27 G angio-catheter through the anastomosis, to check for obstructions caused by stitches suturing both vessel walls together.
   2. Apply a syringe with commercial food colorant to the end of the angio-catheter, and perfuse dye into the artery to test for jet leakage

3. Open the artery longitudinally to visualize the stitches, their parallelism and the amount of wall taken.

Representative Results

The authors have chronometered their times with the present training method and have seen it to significantly reduce the anastomosis times for a femoral artery at the end of the third week. The trainee can control the improvements on his technique by checking his times, his patency percentages and the alignment of his stitches. The system described in this manuscript is depicted in Figure 1 it includes a tabletop microscope and a set of microsurgical instruments. The macroscopic dissections are shown in Figures 2 and 3. An example of a femoral artery microsurgical anastomosis is shown in Figure 4. Figure 5 shows a Brachial artery microsurgical anastomosis. Figure 6 shows a femoral artery repair with a vein graft. The patency tests are shown in Figure 7.

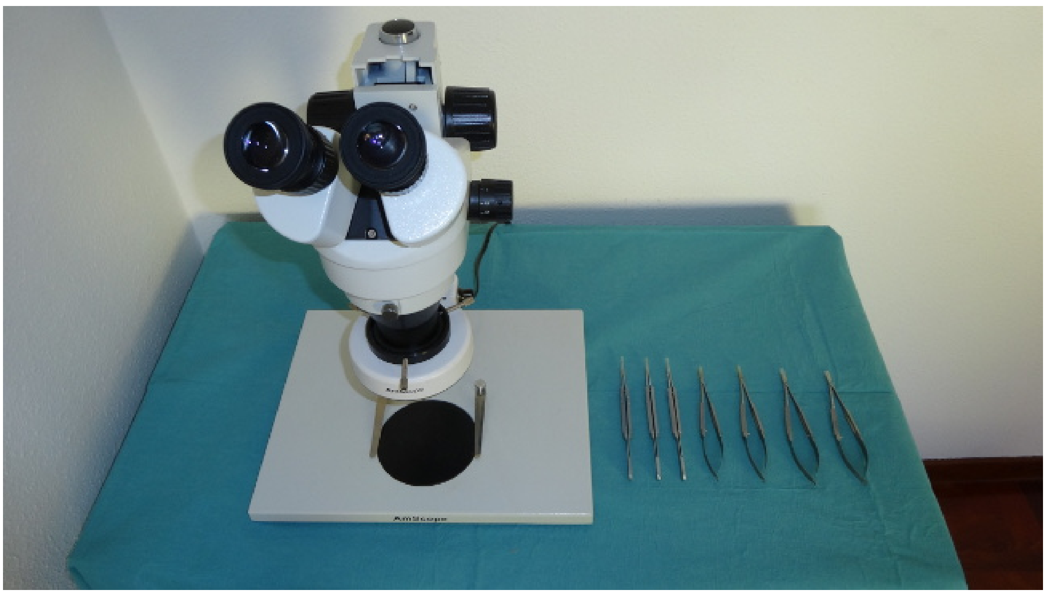

Figure 1: The corresponding author's own microsurgical practice station. It includes a tabletop microscope and a set of training microsurgical instruments. It can be set up on a very limited space at the office or at home.

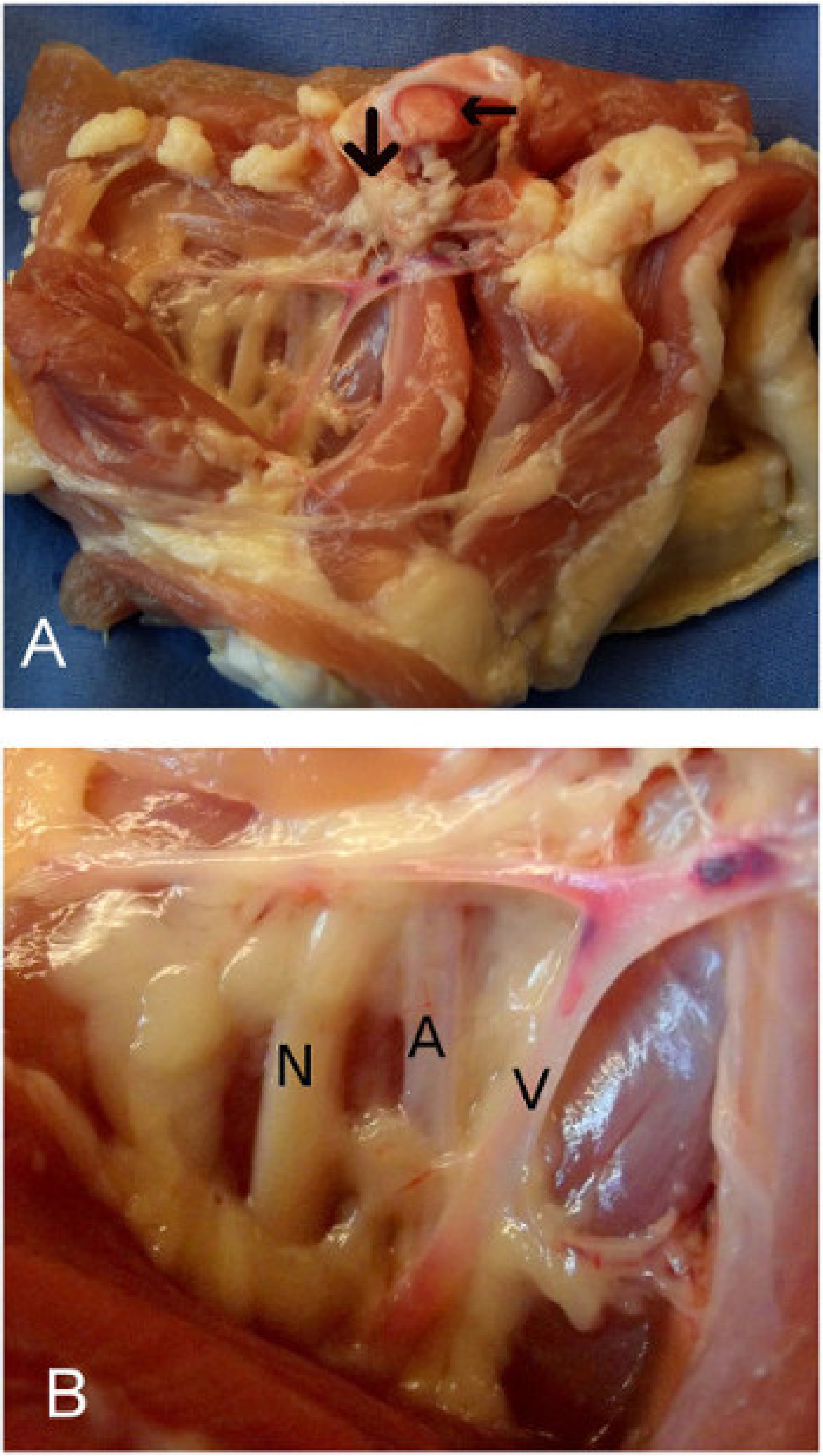

Figure 2 A: A macroscopic dissection of a chicken thigh, The femoral vessels and sciatic nerve can be easily exposed running a finger just medial to the femoral shaft. The horizontal arrow marks the femoral head. The dissection plane is marked by the vertical arrow just parallel to the femoral shaft **B:** The femoral artery (a) vein (v) and sciatic nerve (n) are shown here in detail.

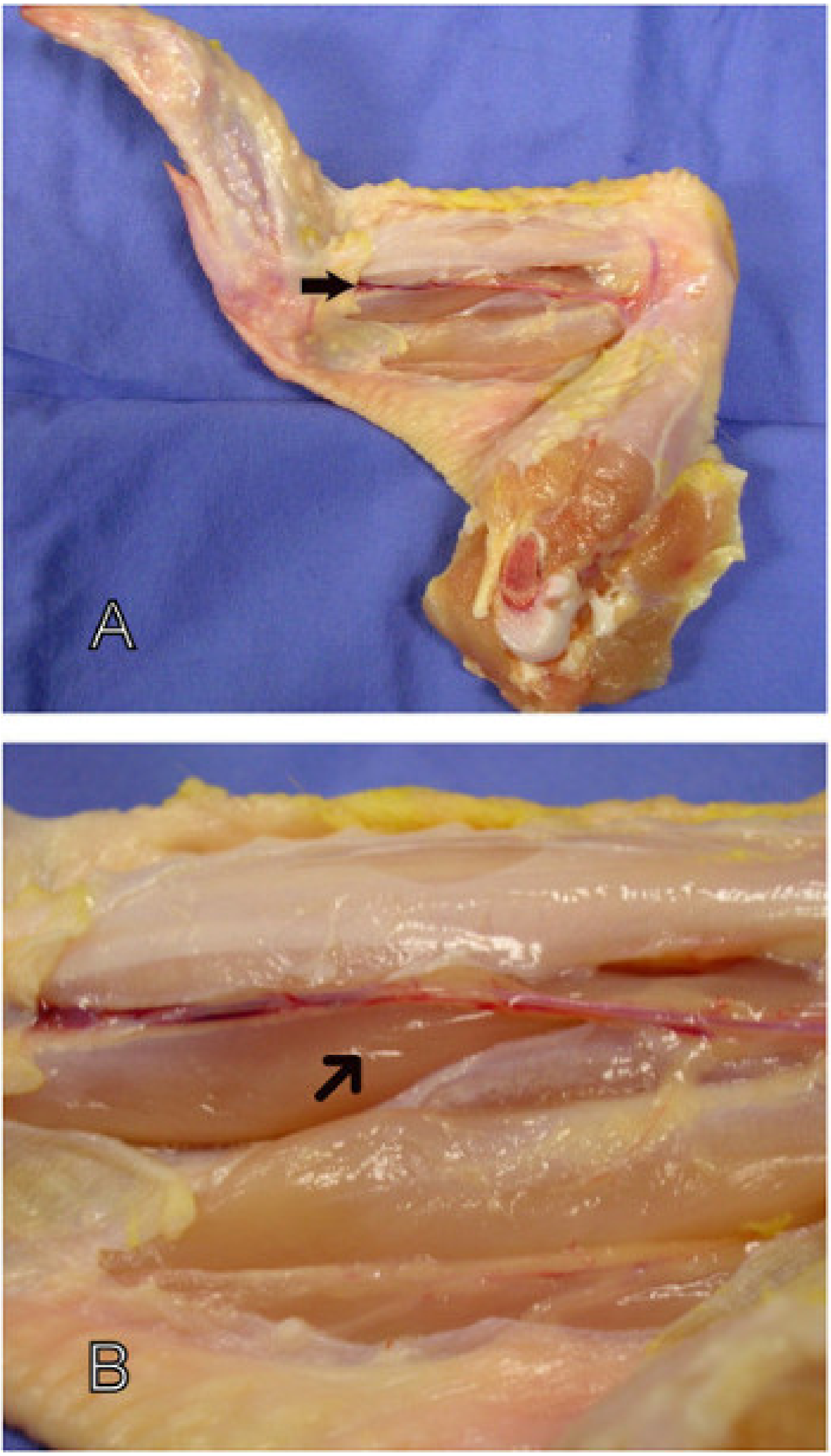

Figure 3 A and B: A macroscopic dissection of a chicken wing. The brachial artery runs between the Biceps and Triceps Brachii. The artery is marked with an arrow on both photographs it is quite superficial and the approach is simple; it can be achieved with commercial cooking scissors.

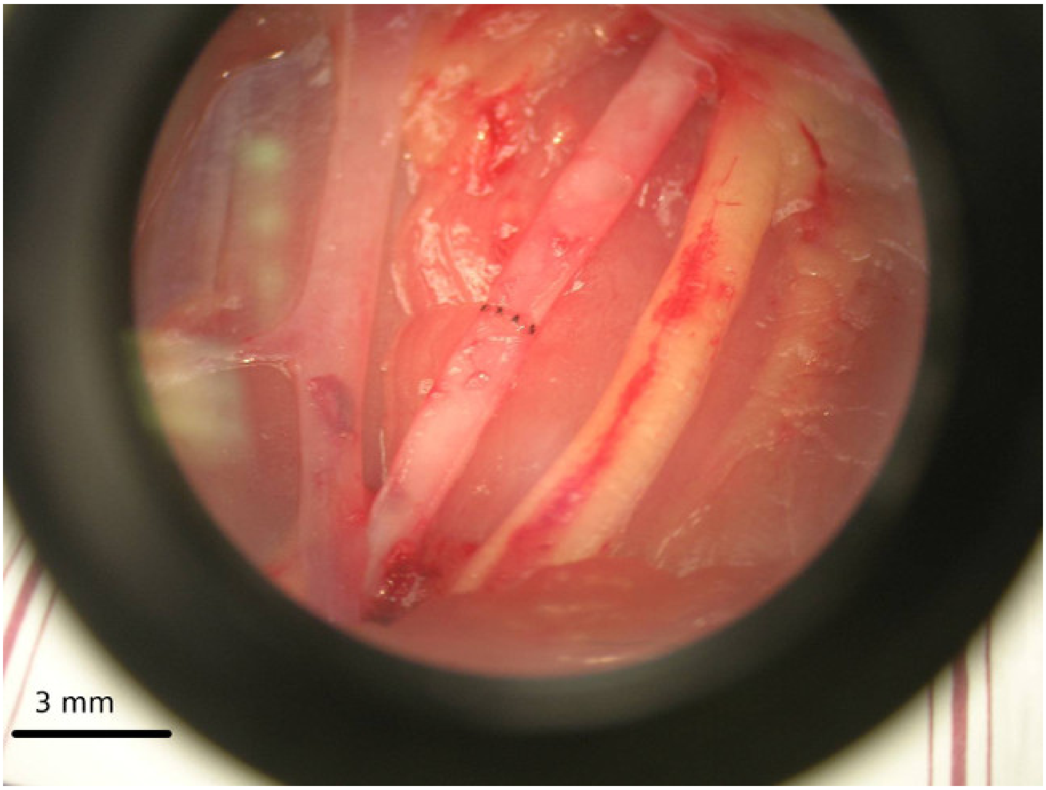

Figure 4: Microscopic image of a femoral artery end to end suture, here a one way up technique with single stitches was performed. Any other type of suture can be practiced at the trainee's discretion.

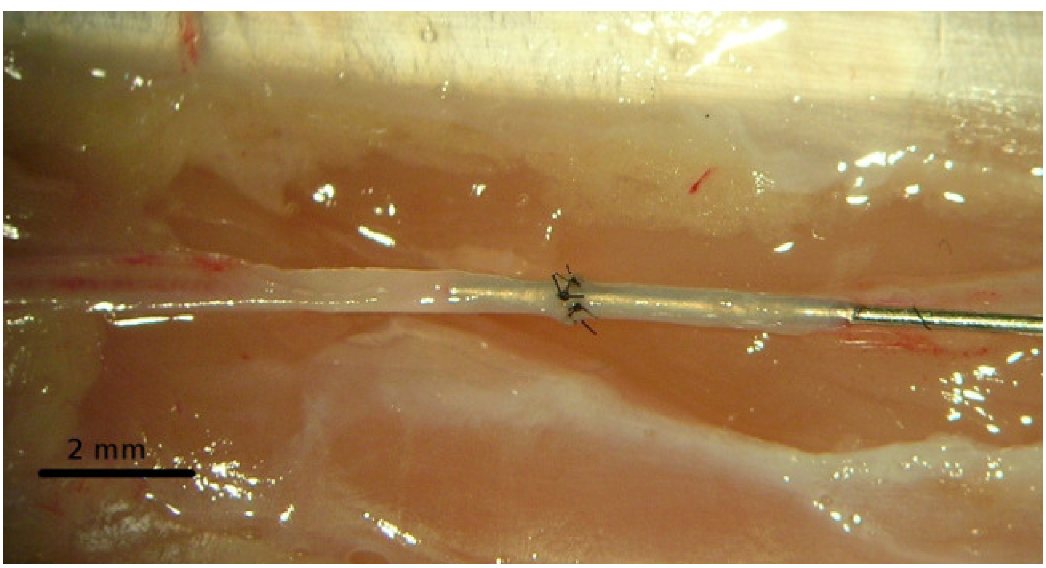

Figure 5: End to end suture of a chicken Brachial artery. This arteries are much smaller than the femoral ones and the procedure is much more technically demanding.

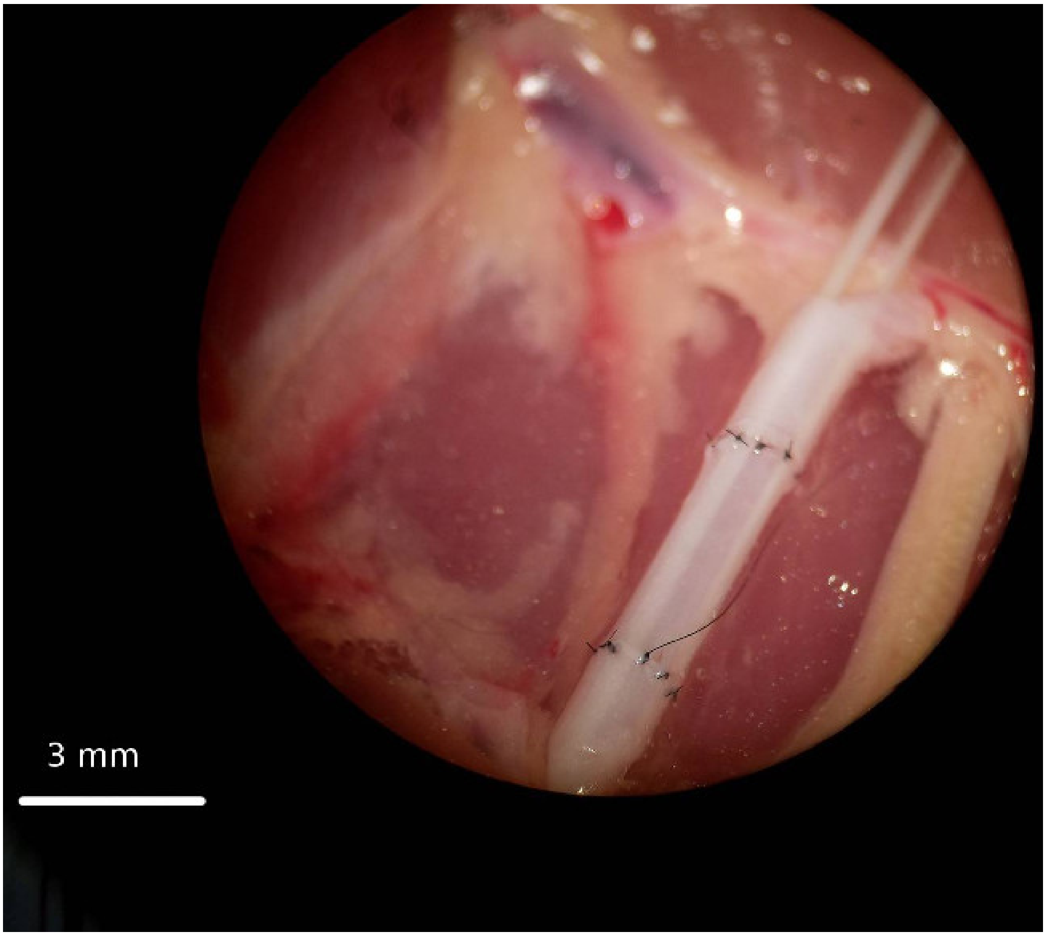

Figure 6: A femoral artery repair with a vein graft harvested from the femoral vein. The chicken thigh model is very versatile allowing for different types of practice exercises.

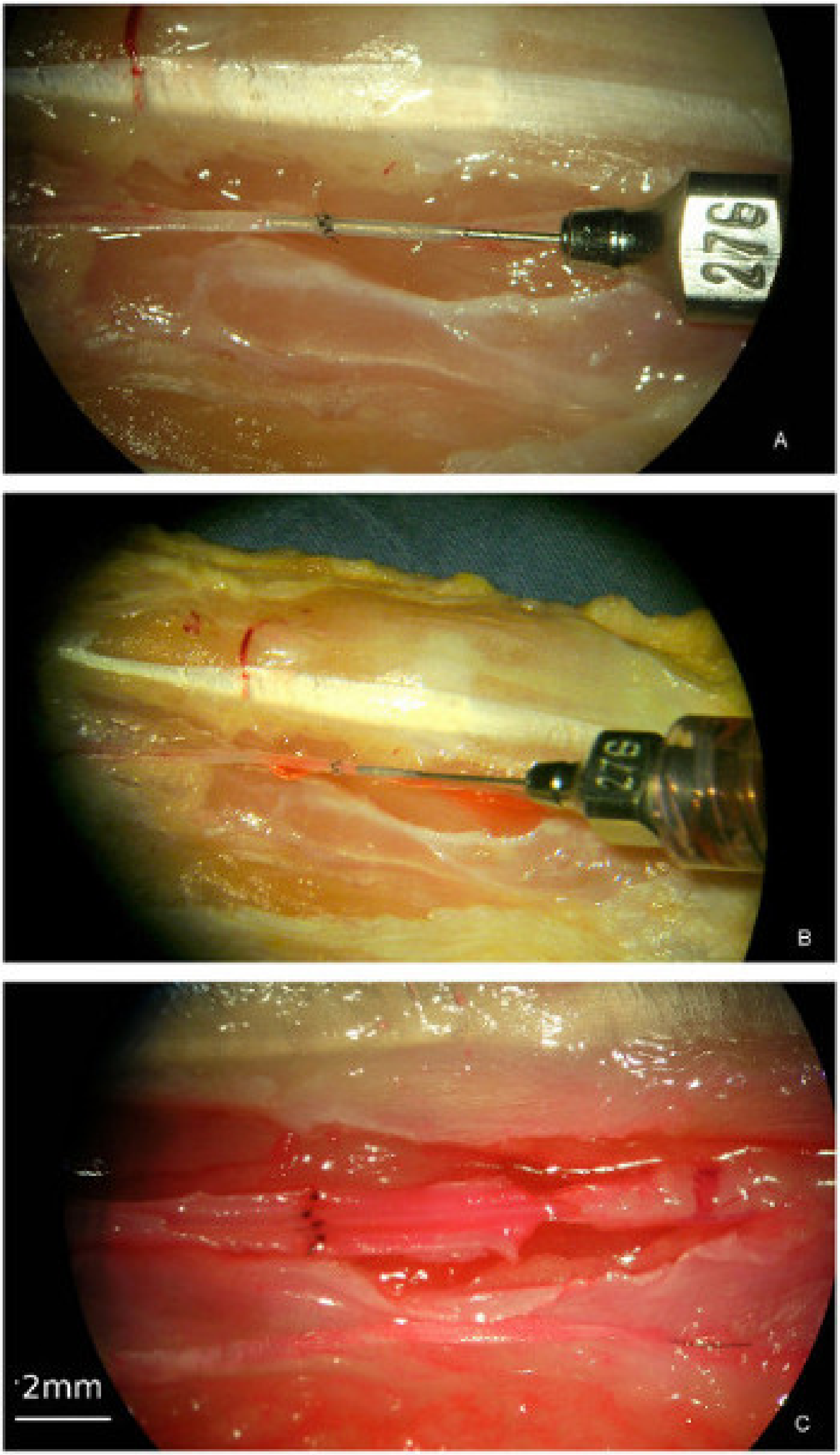

Figure 7: The patency tests. **A:** An angio-catheter of the appropriate diameter is crossed through the anastomosis to check for obstructions caused by stiches suturing both of the vessel's walls. **B:** Dye is perfused through the anastomosis to test for leakage. **C:** The anastomosis is opened longitudinally to visualize the suture alignment.

Discussion

The clinical practice of microsurgery requires a continuous practice and a high level of expertise; it's applications include free flaps, replantation and revascularization procedures, intracranial – extracranial anastomoses for neurosurgical procedures, peripheral nerve surgery and others. In spite of the wide variety of procedures that require microsurgical techniques, some of them are seldom performed in many centers. The surgeons therefore need sometimes to maintain their skill level rehearsing the surgeries on different practice models.

The most widely spread training model is currently the rat [1,2]; it is considered by many to be the "gold standard" in microsurgical instruction. Rats are indeed a very valuable tool in the teaching and learning of microsurgery. They provide a very similar environment to that of the clinical situation. This approach however exhibits some intrinsic limitations. The use of living animals presents an ethical dilemma; and is generally subjected to institutional review board approval. Furthermore they require anesthesia, and dedicated technicians and facilities. All These factors imply important economic costs; this restricts training on living animals to specific teaching units, experimental surgery departments and hospitals with similar resources.

The use of nonliving animal models described in this protocol, has the advantage of not raising any ethical concerns; it does not require institutional review board approval. Economically it compares favorably to living animal training. The required equipment is limited and can be acquired over the internet for a reasonable price; the author's tabletop stereomicroscope was bought for around 450 United States Dollars (USD) and the set of practice microsurgical instruments was purchased for around 150 USD. The author uses microsurgical sutures provided by his sponsoring institution; the price of sutures varies greatly and high quality sutures are not needed, a box of twelve sutures can be bought for around 70 USD on the internet. A microsurgical training station can be set up on a very limited area at home or at work; Jeong et al.[8] Placed their microscope at the residents' office; whilst we[9] used an available microscope close to the hand surgery fellows' quarters.

The most critical point in the application of this protocol is the need for the trainee to be constant and to stay motivated with his training, it is therefore very important that he starts training with the bigger vessels first and then proceed to the smaller chicken wing vessels to avoid frustration. The limitations of training with nonliving models involve primarily the lack of bleeding and the inexistence of hemodynamic phenomena like vasospasm and clotting. The advantages and disadvantages of this type of training are summarized on Table 1. The three tests detailed in section three are aimed to help the trainee check the vessel's patency in the absence of the earlier mentioned phenomena; they provide information on the quality of the trainee's suture, leaking, suture misalignment, and lumen obstruction caused by stitches suturing the front and back wall together.

The protocol can potentially be improved by the addition of a peristaltic pump[10] to simulate vessel flow or by flooding the field with liquid to simulate superficial tension. It is the authors opinion that this would result in the production of an even more realistic training environment and this should be the direction of future research.

Another possible field for development is the application of this training method to help the trainee learn more complex procedures, such as the cuff anastomosis technique[11] before it's actual application on animal research. The authors have however no experience with such techniques at present time.

In conclusion the protocol described in the present manuscript allows a determined trainee to setup a small practice station and use it to learn, perfect and maintain microsurgical skills progressively and sustainably; without the need for special facilities and minimizing animal deaths.

Disclosures

The authors have nothing to disclose.

Acknowledgements

The authors have no acknowledgements.

References

1. Lee, S. Historical events on development of experimental microsurgical organ transplantation. *Yonsei Med J.* **45** (6), 1115-20, doi:10.3349/ymj.2004.45.6.1115 (2004).
2. Shurey, S., Akelina, Y., Legagneux, J., Malzone, G., Jiga, L., & Ghanem, A. M.The rat model in microsurgery education: classical exercises and new horizons. *Arch Plast Surg.* **41** (3), 201-8, doi: 10.5999/aps.2014.41.3.201 (2014).
3. Olab,e J., Olabe, J., & Sancho. V. Human cadaveric infusión model for neurosurgical training. *Surg Neurol.* **72**, 700–702, doi: 10.1016/j.surneu.2009.02.028 (2009).
4. Peled, I. J., Kaplan, H. Y., & Wexler M. R. Microsilicone anastomoses. *Ann Plast Surg.* **10** (4), 331–332, (1983).
5. Gluer, N. M., & Rao, G. S. Canniesburn "ever-ready" model to practise microsurgery. *Br J Plast Surg.* **43** (3), 381–382, doi: 10.1016/0007-1226(90)90098-K (1990).
6. Hino, A. Training in microvascular surgery using a Chicken wing artery. *Neurosurgery.* **52** (6), 1495–1498, doi:10.1227/01.NEU.0000065174.83840.62 (2003).
7. Marsh, D. J., Norton, S. E., Mok, J., & Patel, H. D., Chen, H. C. Microsurgical training the Chicken thigh model. *Ann Plast Surg.* **59** (3),355–356, doi:10.1097/SAP.0b013e3180ca8739 (2007).
8. Jeong, H. S., Moon, M. S., Kim, H. S., Lee, H. K., Yi, S. Y. Microsurgical training with fresh chicken legs and their histological characteristics. *Ann Plast Surg.* **70** (1), 57-61, doi: 10.1097/SAP.0b013e31822f9931 (2013).

9. Couceiro, J.,Ozyurekoglu, T., Sanders, S., & Tien, H. Microsurgical training regimen with nonliving chicken models. *Microsurgery.* **33** (3), 251-2, doi: 10.1002/micr.22060 (2013).
10. Phoon, A. F., Gumley, G. J., & Rtshiladze, M. A. Microsurgical training using a pulsatile membrane pump and chicken thigh: A new, realistic, practical, nonliving educational model. *Surg.*(5) **,** 278e-279e, doi: 10.1097/PRS.0b013e3181ef82e2 (2010).
11. Zhou, Y., Gu, X., Xiang, J., Qian, S., & Chen, Z. A. comparative study on suture versus cuff anastomosis in mouse cervical cardiac transplant. *Exp Clin Transplant.* **8** (3), 245-9, (2010).