

A Case-control Analysis of the Knight's Move Technique in a Chicken Wing Microsurgery Model: Video Article

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INTRODUCTION

International consensus has defined supermicrosurgery as a microneurovascular technique for vessels and single nerve fascicles ranging from 0.3 to 0.8 mm in diameter,¹ but Yamamoto et al have further lowered this threshold to 0.5 mm and smaller.² Current supermicrosurgical anastomotic techniques rely on the precision and dexterity of human hands with the specific use of customized supermicrosurgery instruments³ or extremely small caliber sutures as threader loops or intravascular stents to facilitate the anastomoses,^{2,4-7} prompting the introduction of robotic devices to overcome this limitation.⁸

Adjunctive techniques described include temporary lymphatic expansion for lymphotomies in preparation for side-to-side (S-S) and end-to-side (E-S) anastomoses,⁹ the parachute technique,¹⁰ intraluminal fillers,¹¹ and a 30- μ m needle usage.¹² However, in all these instances, specialized supermicrosurgery instruments were used. In this study, we ask the question as to whether we need to. An animal model study showed that there was a 90% survival rate at 1 week in a rat superficial inferior epigastric flap model (vessel dimensions of up to 0.3–0.4 mm), using conventional microsurgery instruments albeit with 11/0 Ethilon sutures. Nevertheless, the authors reported a steep learning curve to reach this level of dexterity.¹³

The challenge lies in avoiding the risk of catching the vessel's backwall (a limiting factor particularly in very small caliber lumens) instead of relying on the conventional microsurgical arc of needle movement (Fig. 1). In this video article, we employ a method (inspired by the katana-wielding technique "Tsubama Gaeshi"¹⁴ and akin to the knight's movement in chess, hence the term) to

challenge the notion that supermicrosurgery is not possible with conventional microsurgery instruments.

METHODS

In a case-control study of a chicken wing ex vivo model¹⁵ based on the ulnar artery (UA) and its side-branch, the recurrent ulnar artery (RUA), we compared the outcomes across 60 anastomotic sites (Fig. 2). These were divided into 2 groups: the microsurgery control UA group involving E-E anastomoses of the chicken UA (n = 20) and the supermicrosurgery RUA group, which in turn was categorized into 2 sub-cohorts—20 anastomoses of the end-to-end ("E-E") RUA segments (n = 20) and end-to-side ("E-S") RUA-UA segments, respectively (n = 20). A conventional "one-way up" microsurgical technique was used in the UA control group, while the knight's move technique (Fig. 3) was used for the supermicrosurgery group.

All anastomoses were performed using standard microsurgery instruments (Steth2scalpel.com Limited, London, UK), comprising only a needle-holder, a curved micro-scissor, jeweler's forceps, and a vessel dilator, while the surgical sutures used were 10/0 (0.2 Metric, Art. No. 03174; Art. Code 7V43) S&T Nylon sutures with a 70- μ m diameter 3/8 needle (S&T, Switzerland), as shown in the Supplemental Video. (See Video [online], which displays the recurrent ulnar artery super microsurgery model.)

In this study, we used table-top microscopes (Brunel Microscopes Ltd, UK) with magnification setting of 45 \times for the "E-E" RUA anastomoses, 30 \times for the "E-S" RUA-UA anastomoses and 25 \times for the "E-E" UA. The external diameter of each vessel was assessed using a slide crack ruler (Shinwa Ltd, Nagoya, Aichi, Japan), and the number of sutures necessary per anastomosis was documented. Mechanical patency was assessed by inserting the tips of the vessel dilator into the vessel after anastomoses completion with the assumption that with 5–6 sutures, these tiny vessels would not leak. The only variable in this study was the size of the vessels from specimen to specimen, with all other confounding factors accounted for. The time taken to perform them was recorded in real time. The data were analyzed in terms of mean, SD, and student's *t*-tests using GraphPad PRISM.

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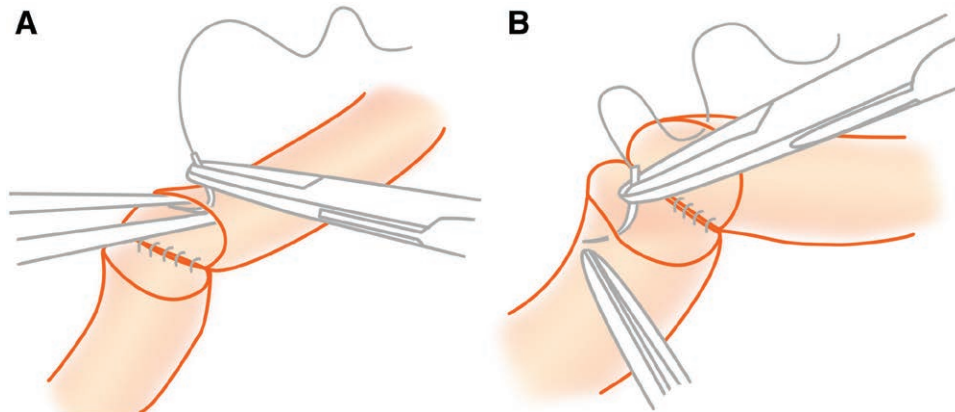


Fig. 1. Conventional microsurgical anastomotic technique.

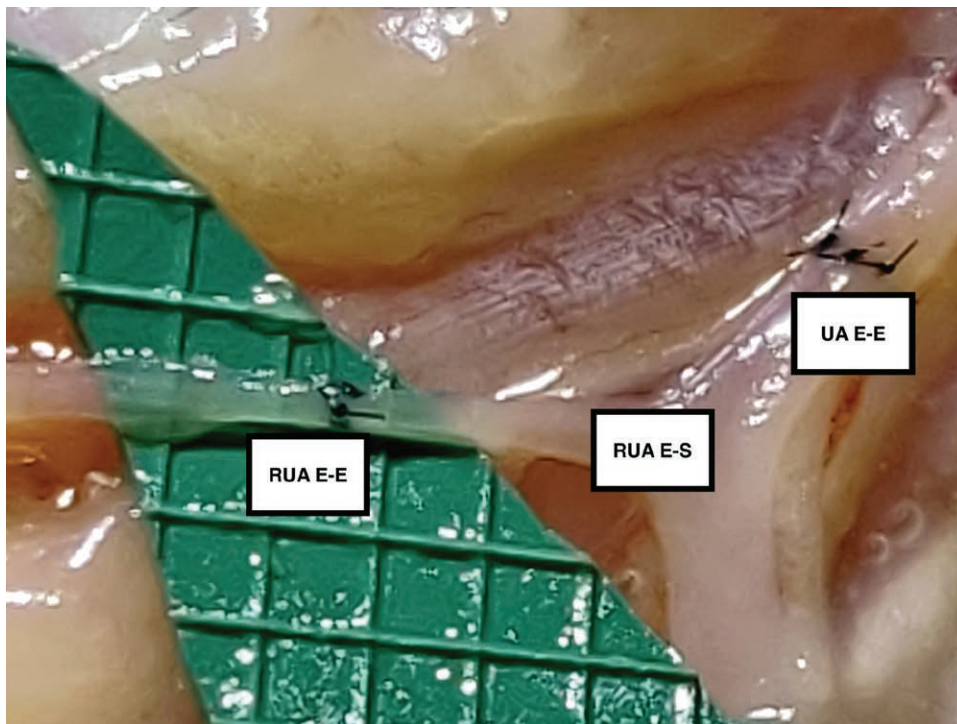


Fig. 2. Photograph showing the anastomosis sites of the UA E-E (the control group) and those of the RUA E-S and RUA E-E sub-cohorts.

RESULTS

Of the total of 60 anastomoses in this study, the overall patency was 98.4% with only one instance of non-patency in the RUA “E-S” sub-cohort. There was no statistical difference in terms of mechanical patency between the control microsurgery group (mean external diameter 0.95 ± 0.11 mm) and the supermicrosurgery sub-cohorts (EE mean external diameter 0.42 ± 0.08 mm; ES mean external diameter 0.56 ± 0.1 mm) with a *P* value of 0.484 (2-tailed Student’s *t*-test; *P* = ns).

Between the supermicrosurgery sub-cohorts, “EE” anastomoses were performed using an average of 5.5 sutures per anastomoses (range: 4–7), whereas in the case of “ES” anastomoses, a total of 5.2 sutures per anastomosis (range:

5–6) were performed. The operating times in terms of mean \pm SD for the “EE” and “ES” anastomoses were 363 ± 53 and 343 ± 27 seconds respectively, in this ex-vivo laboratory setting. As illustrated in the video, this was confirmed by passing 1 end of the vessel dilator¹³ (Steth2scalpel.com Limited, UK) across the anastomosed lumen, with the assumption being that 5–6 evenly placed sutures across a lymphatic channel of 0.35–0.5 mm diameter, for instance, would suffice. A summary analysis of this is shown in [Table 1](#).

DISCUSSION

The knight’s move combines the benefit of the open guide suture technique¹⁶ with a simple modification as

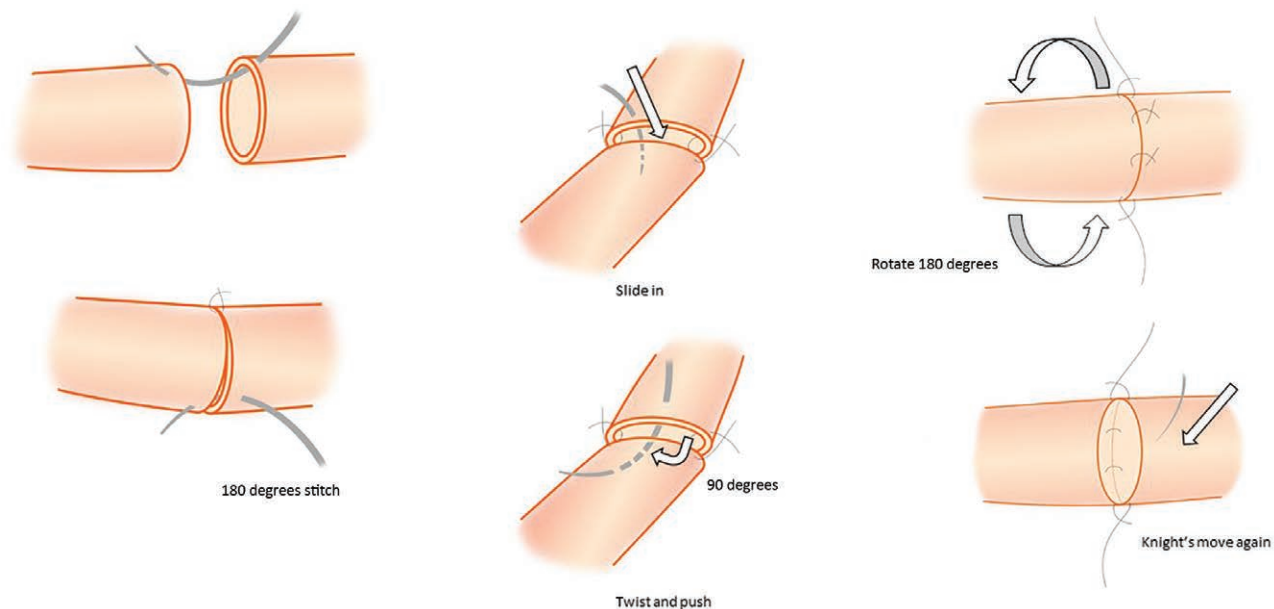


Fig. 3. Place 2 opposing sutures at 180 degrees to iron out any anastomotic mismatches (Steps 1 and 2). Next, push the needle point almost parallel through the proximal vessel wall before sliding it along its length between the opposing walls of the opposite lumen, rotating its tip by 90 degrees and exiting perpendicular to the opposite vessel wall. This is repeated in a double loop suture method (Steps 3 and 4) before twisting the vessel around and repeating the process (Steps 5 and 6).

Table 1. Analysis of the Supermicrosurgical Anastomoses in This Ex Vivo Model Based on the External Vessel Diameter, Number of Sutures Used, and Time Taken per Anastomoses

Statistic	ES Anastomoses			EE Anastomoses		
	Diameter	Sutures	Time (min)	Diameter	Sutures	Time (min)
Mean	0.555	5.2	5.72	0.4225	5.5	6.05
SD	0.1	0.41	0.45	0.08	0.83	0.89
CI	±0.044	±0.18	±0.2	±0.035	±0.364	±0.39

described. While this has been observed to be intuitively performed by the experienced supermicrosurgeon (in this case, 5 years for the primary author), describing it objectively allows mass usage of this technique, to the extent that even vessels/channels of up to 0.3 mm in external diameter (and by extension even lower dimensions in terms of internal diameter) can be safely anastomosed even with standard microsurgical instruments albeit at higher magnifications.

Even so, for the beginner supermicrosurgeon, the IVaS-based technique, as described by Narushima et al,⁶ remains a good starting point as 100% short-term patency is assured, even for vessels up to 0.15 mm in diameter.⁵ This involves placing a piece of suture (eg, 6/0 Nylon) across both lumens to facilitate the anastomoses before removing it. However, as alluded to by Miyamoto et al in a rat superficial epigastric artery model, IVaS takes a significantly longer time to perform compared with the open guide suture technique¹⁶ or similar techniques like the knight's move. As alluded to by Yamamoto et al², any supermicrosurgery technique ultimately depends on fine motor skills to precisely control the needle point. This comes with experience.

LIMITATIONS

This study is limited by the use of an ex vivo model with its inherent inability to assess real-time flow. It also remains a fact that higher magnifications of up to 45× is still required, even with the use of conventional microsurgical equipment.

SUMMARY

The knight's move technique allows for the use of conventional microsurgery instrumentation in a supermicrosurgery setting with results comparable to standard microsurgery in terms of mechanical patency. As to how it compares to the existing supermicrosurgery techniques, future clinical studies are necessary.

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REFERENCES

- Masia J, Olivares L, Koshima I, et al. Barcelona consensus on supermicrosurgery. *J Reconstr Microsurg.* 2014;30:53–58.
- Yamamoto T, Yamamoto N, Kageyama T, et al. Technical pearls in lymphatic supermicrosurgery. *Glob Health Med.* 2020;2:29–32.
- Mihara M, Hayashi Y, Iida T, et al. Instruments for supermicrosurgery in Japan. *Plast Reconstr Surg.* 2012;129:404e–406e.
- Todokoro T, Hara H, Yamamoto T, et al. A threader technique using an 11-0 loop needle for supermicrosurgery. *Microsurgery.* 2015;35:672–673.
- Yamamoto T, Narushima M, Kikuchi K, et al. Lambda-shaped anastomosis with intravascular stenting method for safe and effective lymphaticovenular anastomosis. *Plast Reconstr Surg.* 2011;127:1987–1992.
- Narushima M, Koshima I, Mihara M, et al. Intravascular stenting (IVaS) for safe and precise supermicrosurgery. *Ann Plast Surg.* 2008;60:41–44.
- Tashiro K, Yamashita S, Narushima M, et al. Hemi-intravascular stenting for supermicrosurgical anastomoses. *PRs Global Open.* 2017;5:e1533.
- van Mulken TJM, Schols RM, Scharnga AMJ, et al; MicroSurgical Robot Research Group. First-in-human robotic supermicrosurgery using a dedicated microsurgical robot for treating breast cancer-related lymphedema: a randomized pilot trial. *Nat Commun.* 2020;11:757.
- Yamamoto T, Yoshimatsu H, Yamamoto N, et al. Side-to-end Lymphaticovenular anastomosis through temporary lymphatic expansion. *PLoS One.* 2013;8:e59523.
- Yamamoto T, Chen WF, Yamamoto N, et al. Technical simplification of the supermicrosurgical side-to-end lymphaticovenular anastomosis using the parachute technique. *Microsurgery.* 2015;35:129–134.
- Qassemayr Q, Gianfermi M. Supermicrosurgery and hyaluronic acid: experimental feasibility study of a new method. *Ann Chir Plast Esthet.* 2015;60:e59–e65.
- Yamamoto T, Yamamoto N, Ishiura R. Thirty-micron needle for precise supermicrosurgery. *Microsurgery.* 2017;37:735–736.
- Mofikoya BO, Ugburo AO, Bankole OB. Microvascular anastomosis of vessels less than 0.5 mm in diameter: a supermicrosurgery training model in Lagos, Nigeria. *J Hand Microsurg.* 2011;3:15–17.
- Tsubame Gaeshi. Available at https://en.wikipedia.org/wiki/Tsubame_gaeshi
- Hayashi K, Hattori Y, Yii Chia DS, et al. A supermicrosurgery training model using the chicken mid and lower wing. *J Plast Reconstr Aesthet Surg.* 2018;71:943–945.
- Miyamoto S, Sakuraba M, Asano T, et al. Optimal technique for microvascular anastomosis of very small vessels: comparative study of three techniques in a rat superficial inferior epigastric arterial flap model. *J Plast Reconstr Aesthet Surg.* 2010;63:1196–1201.