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Enhancing Orthopaedic Residents' Microsurgery Suturing Skills Using a Low-Fidelity Setup*

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ABSTRACT

Objective. To describe the suturing consistency of orthopaedic residents in microsurgery using a low-fidelity set-up.

Background. Residents lack the time and resources to practice microsurgical suturing under a microscope before being exposed to live surgeries. Speedy and consistent suturing are critical skills during live surgery (e.g., vessel anastomosis in free flap surgery, or critical revascularization). This study presents a budget-friendly home or office setup for microsurgery practice to improve the consistency of suture distance and interval.

Methodology. This is a cross-sectional study that measured the consistency of suture distances and intervals and time to completion of seven Orthopaedic residents using a locally available digital USB-powered microscope, a monitor, and latex sheets. Consistency was analyzed using intraclass correlation.

Results. All residents had a faster time to completion with each attempt (mean 1st attempt = 27.7 min, 2nd attempt = 20.4 min, 3rd attempt = 17 min). The third attempt showed significantly improved suture consistency in all participants (ICC = 0.50, p<0.001).

Conclusion. This budget-friendly home or office set-up for microsurgery practice improves time to completion and consistency in suture intervals when suturing under magnification.

Keywords. microsurgery, simulation model, microvascular surgery, surgical education, simulation

INTRODUCTION

Microsurgery is defined as any type of surgery performed with the assistance of a microscope.[1] It is a skill honed by a small subset of Orthopaedic surgeons who perform free tissue transfers, neurovascular repairs, and replantation of amputated digits.

High-fidelity training comes only with specialized workshops or access to a microscope. There are few microsurgical workshops conducted locally. Anecdotally, a resident's first encounter with a microscope is likely inside the operating room during live surgery.

Familiarity, consistency, and speed are critical to the success of any microsurgery. Variable clinical exposure, premiums on operating room efficiency, and a steep learning curve make microsurgical suturing a difficult skill to master.[2]

Significance of the study

We presented a low-fidelity set-up with a digital microscope for microsurgical suturing exercise on non-living models that can be done almost anytime and anywhere, to help residents

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**This study was presented in the following:*
1. *POA 31st Annual Mid-Year Convention, Bacolod, Negros Occidental, Philippines – April 2023, Won 2nd Place, Innovations Category Research Contest*
2. *Asia Pacific Orthopaedic Association, Hand and Upper Limb Society Meeting, Seoul, South Korea – June 2023*
3. *SICOT Young Surgeons Meeting 2023 – Chennai, India – August 2023*

develop and improve their suturing consistency under magnification.

OBJECTIVES

General objective

- Describe the suturing consistency of orthopaedic residents in microsurgery using a low-fidelity set-up

Specific objectives

- Determine how long (in minutes) each resident takes to complete the suturing exercise
- Determine if the residents improve their consistency in the suture distances and intervals
- Determine if there is a significant difference in the consistency of suture distances and intervals with each attempt

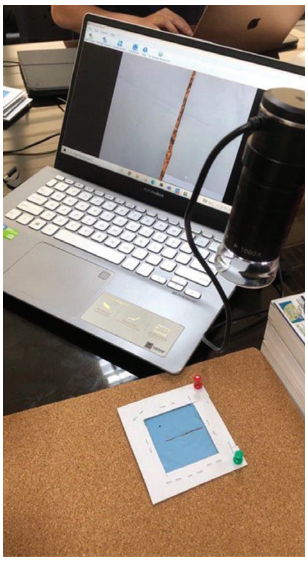

Figure 1. USB-powered digital microscope connected to a laptop.

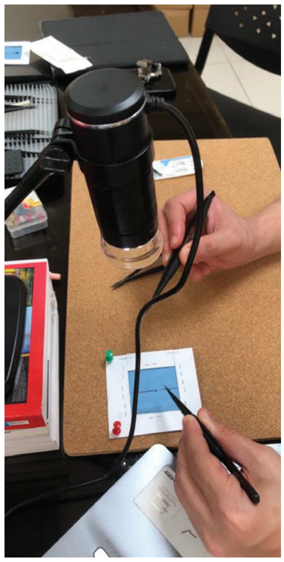

Figure 2. Participant performing microsurgical exercise.

METHODOLOGY

This was a cross-sectional study done at the De La Salle University Medical Center, Dasmariñas (DLSUMC). We included all Orthopaedic surgery residents (7 residents) at DLSUMC. This study was approved by the institutional review board and was exempted from review by the ethics committee because of the non-involvement of patients and patient data.

Prior to measurement, a hand and microsurgical consultant did a microsurgical suturing demonstration using the same setup. The ideal sutures should be tightly knotted and lie 1-2 mm from the wound edge (suture distance) and with 2–3 mm in between sutures (suture interval).

The microscope used was a generic Wireless HD camera with adjustable magnification up to 1000x magnification (Figure 1). Clinically, image clarity was found to be best at around 2x to 3x magnification using fine adjustment at 12 inches working length. The setup was as follows: the participant sat with forearms flat on the table, with the microscope at 12 inches above the microsurgical field, and the laptop/screen in front of the participant at his/her most convenient position (Figure 2).

Square latex sheets cut from surgical gloves were used to simulate transected vessels. The perimeters of these sheets were fixed by staples between an illustration board and a corkboard. A laceration was made in the middle of the latex. Nylon 7-0 sutures and microsurgical instruments were used to repair the laceration using a simple interrupted technique. A completed attempt required the completion of five sutures passed and tied tightly (Figure 3). All attempts were observed directly by the researchers. Participants were not allowed to look directly at the instrument or sutures and looked only at the laptop screen to simulate a microsurgery. All participants were given three attempts, with 10-minute intervals in between attempts. We allotted a total of two hours per participant including the rest periods to complete the activity. Up to four participants could perform the surgical exercise simultaneously.

A vernier plastic caliper (Eagle Professional tools 6" / 150 mm) was used to measure the suture distances and intervals after each attempt (Figures 4 and 5). Measurements were made by a researcher, and double-checked by the supervising hand surgeon consultant. The time to completion was recorded from the first suture bite until the completion of the final suture.

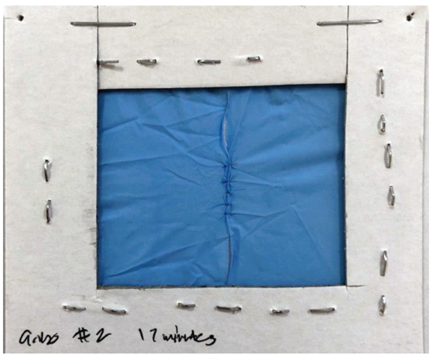

Figure 3. Example of a completed attempt.

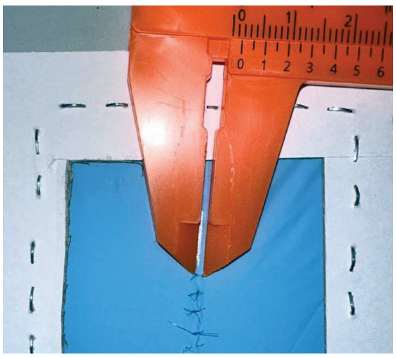

Figure 4. Measuring the suture distance.

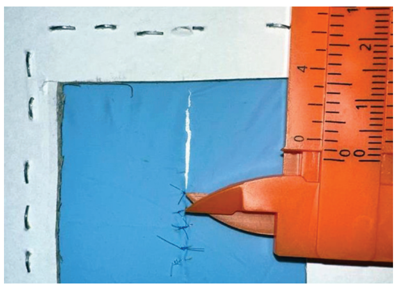

Figure 5. Measuring the suture intervals.

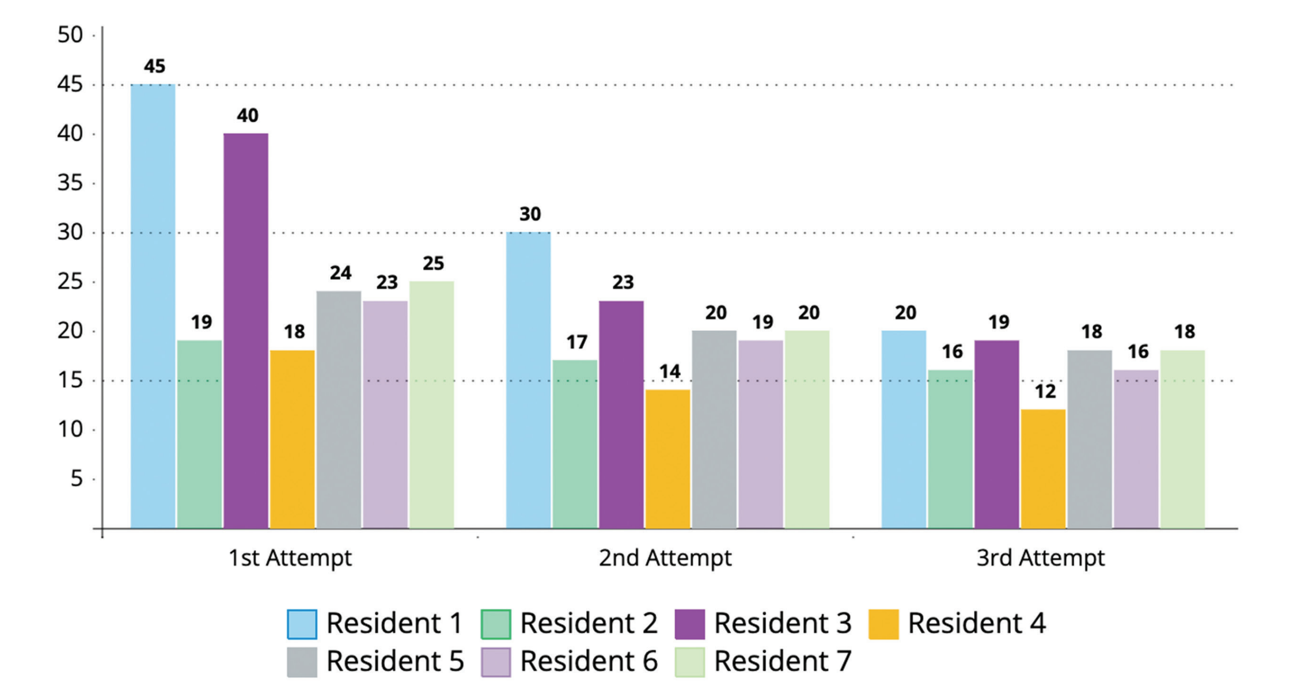

Figure 6. Time to Completion (in minutes). Each participant is represented by a vertical bar. The three groupings along the X-axis represent the three attempts. Y-axis is represented by time to completion in minutes.

Descriptive statistics (mean, standard deviation) were used to describe suture distances, suture intervals, and the time to completion was measured (Table 1). Consistency was measured using intraclass correlation. Values less than 0.5 indicated poor consistency, values of 0.5 to 0.75 indicated moderate consistency, values ranging from 0.75 to 0.9 indicated good consistency, and values greater than 0.9 indicated excellent consistency.

RESULTS

Participants were orthopaedic surgery residents (YL1-YL4), with a mean age of 32.1 (29-33 years). None of the residents did suturing under the microscope before this research was done. All of them can do simple interrupted suturing with non-microsurgical size sutures without magnification. None of them had resting tremors. No changes were made to the participants' caffeine or nicotine intake, if any.

Time to completion

All participants were faster with each attempt, with the mean time to completion of 27.7 minutes in the first attempt, 20.4 minutes on the second attempt, and 17 minutes in the final attempt. There was a 38.7% improvement in time from the first to the final attempt (Figure 6).

Table 1. Intraclass correlation of suture intervals

Suture intervals (in mm)	Ortho 1	Ortho 2	Ortho 3	Ortho 4	Ortho 5	Ortho 6	Ortho 7	ICC	*p*
Attempt 1	3.00	2.20	7.00	4.00	4.00	4.00	3.00	0.37	0.004
	2.50	2.20	3.50	6.00	3.00	5.00	2.50		
	2.00	2.00	3.00	5.00	2.00	5.00	2.50		
	3.00	2.00	3.20	5.00	3.00	4.00	2.50		
Attempt 2	3.50	3.50	3.00	5.00	3.00	4.50	4.00	0.18	0.064
	2.50	2.00	5.00	8.00	3.00	1.00	3.00		
	2.50	3.00	4.00	8.00	2.50	1.20	3.00		
	2.50	2.00	1.80	7.00	2.00	5.00	2.50		
Attempt 3	3.00	3.00	5.50	5.00	5.00	3.00	3.00	0.50	<0.001
	2.00	3.00	4.50	6.00	4.00	4.00	3.00		
	2.20	4.00	4.00	5.00	4.00	2.00	3.00		
	2.00	2.00	5.00	5.00	5.00	3.00	4.00		

ICC – Intraclass Correlation
*ICC Attempt 2 vs ICC Attempt 3 = (0.18 vs 0.50) = statistically significant improvement ($p<0.001$)

Table 2. Intraclass correlation of suture distances

Suture distances (in mm)	Ortho 1	Ortho 2	Ortho 3	Ortho 4	Ortho 5	Ortho 6	Ortho 7	ICC	*p*
Attempt 1	1.50	0.90	0.75	2.25	3.00	2.25	2.00	-0.030	0.541
	2.00	0.95	0.45	3.00	2.25	2.00	2.75		
	2.00	1.00	0.50	2.50	2.25	1.50	2.50		
	1.50	0.95	0.75	2.75	1.75	2.00	2.20		
	1.50	1.00	0.50	2.50	1.00	2.50	2.00		
Attempt 2	1.00	1.50	0.50	0.75	2.50	1.50	2.75	0.102	0.163
	1.65	1.00	0.65	1.00	3.00	3.50	1.50		
	1.10	0.90	0.45	0.90	2.50	1.25	2.00		
	1.75	1.00	0.50	1.00	2.75	2.50	2.25		
	1.00	1.00	0.45	0.85	2.25	2.00	1.50		
Attempt 3	1.50	0.85	1.00	1.00	3.00	2.00	2.20	-0.022	0.509
	1.00	1.10	0.90	1.00	2.00	3.00	1.50		
	1.25	1.00	1.00	1.00	2.50	3.00	2.00		
	1.75	1.25	0.90	0.85	3.00	2.50	2.50		
	1.75	1.00	0.75	1.00	2.00	2.50	2.50		

ICC – Intraclass Correlation

Suture intervals

Consistency in suture intervals was improved on the final attempt. Participants had ICC values of 0.18 on the second attempt, which improved to a value of 0.50 on the final attempt (p <0.001) (Table 2).

Suture distances

Participants' consistency in suture distances remained the same among all attempts (Table 3).

Erroneous or unacceptable sutures

There was a total of nine erroneous sutures (9/105, 8.6%) in five participants. These sutures were either loose or too tight which caused the latex rubber to tear.

DISCUSSION

A resident's clinical experience is not enough to hone his/her microsurgical skills. Microsurgical training models can be broadly classified into three groups: synthetic, non-living, and virtual reality. Synthetic and non-living models allow trainees to be introduced to the manual microsurgical skill, by high repetition at minimal cost.[3] Ko et al., described a microvascular training curriculum beginning with the use of non-living models and progressing to the use of living animal models.[4] Most recommend that a course should last at least a week or 40 hours, while others recommend at least two to three months, including a personalized one-to-one format and step-by-step teaching. Still, others recommend that microsurgery training be integrated directly into the residency training program, with proven increases in residents' performance on Global Rating Scales.[4] Despite the proven benefits, implementation remains difficult. At present, no studies described the improvement in consistency of suture distances and intervals in a low-fidelity microsurgery setup.

We found that our participants improved the consistency of their suture intervals and shortened their time to completion when suturing under magnification under a low-fidelity setup. No improvement was found in the consistency of their suture distances. Most of the suture placements were acceptable. Participants were given only three attempts, with rest periods in between, to prevent exhaustion.

The size and scarcity of typical operating microscopes present considerable barriers to effective microsurgical training.[5] In contrast, our equipment can be deployed at the office or even at home, at any convenient time. Chai et al. also used a low-cost digital microscope with a 1-600x zoom amounting to ~2100 PhP.[6] While we did not consider the cost of the microsurgery instruments, affordable practice instruments are available online. Surgeons can develop required fine motor skills, hand and eye coordination, and depth perception through increased repetition. While other studies used subjective measurements of improvement, we objectively measured participants' improvements through suture distances and intervals.

CONCLUSION

A portable setup for microsurgery practice improves time to completion and consistency in suture intervals when suturing under magnification.

LIMITATIONS AND RECOMMENDATIONS

Our study utilizes a low-fidelity setup. This will be ideal for beginners to practice microsurgery, or experienced surgeons, who want to refine microsurgery techniques at their most convenient time and place. This should not replace a high-fidelity setup to properly simulate a proper microsurgical exercise.

This study has few participants due to time and financial constraints. We also wanted to pilot test the methodology in our local setting before expanding to other hospitals. A maximum of four participants were observed simultaneously because we only had four microsurgical instrument sets and four USB microscopes. The whole activity lasts five hours. Residents from different hospitals will have varying availability in a week and protected time. We recommend to expand the use of this setup for basic microsurgery training workshops with a larger sample size.

STATEMENT OF AUTHORSHIP

All authors certified fulfillment of ICMJE authorship criteria.

AUTHORS DISCLOSURE

The authors declared no conflict of interest.

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