A Cross-Sectional Survey Study among Hand Surgeons in the United States on Standardizing Microsurgery Training

Raman Mehrzad¹ Adnan Prsic¹ Marten Basta¹ Reena Bhatt¹

¹Department of Plastic and Reconstructive Surgery, Rhode Island Hospital, Alpert Medical School of Brown University, Providence, Rhode Island, United States

Address for correspondence Raman Mehrzad, MD, MHL, Rhode Island Hospital, 235 Plain St. Suite 102, Providence, RI 02905-3241, United States (e-mail: raman_m1@hotmail.com).

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Abstract

Keywords

- microsurgery
- hand and upper extremity surgery
- training
- curriculum
- education

Although microsurgery plays a more expansive role in hand surgery, microsurgery training systems may not have followed the same evolution, as have other operative techniques. A cross-sectional survey study with 13 multiple choice questions was administered to the members of the American Society for Surgery of the Hand; 503 out of 3,395 responded to the survey (14.8% response rate), and 58% did not have a microsurgical laboratory in their institution, whereas 42% did. Of the institutions that had a microsurgical laboratory, 32.4% also had a microsurgical rat laboratory. Of all respondents, 78% agreed or strongly agreed that their training program should have microsurgery training outside of the operating room, and 53% agreed or strongly agreed that their curriculum needed improvement; 65.6% agreed or strongly agreed that training should be standardized across the nation. Our results indicate that the training needs standardization and that institutional training curriculum needs to be improved. This is a Level III study.

Introduction

Today, microsurgery plays a more expansive role in hand and upper extremity surgery and has become a major component of other surgical specialties, such as plastic surgery, oral and maxillofacial surgery, otolaryngology, and ophthalmology. Cancer, trauma, congenital malformations, transplantation, and multiple fields of reconstructive surgery have all widened their surgical possibilities through the advances of microsurgery. Furthermore, as the field of hand vascularized composite allotransplantation evolves, consummate microsurgery skills will be needed in this area. A culmination of technical advances has made microsurgery an essential and fundamental surgical technique for a well-rounded hand surgeon ready to tackle vascular anastomoses, free tissue transfer, as well as neurorrhaphies and nerve transfers. With this in mind, microsurgery has been incorporated in many surgical specialties' residency training curricula as well as hand and upper extremity fellowships.

However, throughout the years, microsurgery teaching and training systems may not have followed the same evolution

as have other operative techniques. The ultimate purpose of any training program is to train competent surgeons comfortable performing procedures that produce value for patients according to the needs of the health care industry.^{1–3} With the current residency training work hour restrictions and varied requirements in individual surgical curriculums, achieving proficiency in microsurgical technique is challenging without a designated and standardized curriculum. Not only did this affect surgical residents, but hand and upper extremity fellowship trainees reported limited and variable exposure to clinical cases involving microsurgery.⁴ As time becomes more restrictive and the demand for microsurgical techniques become the standard, better and more standardized training will become a necessity to meet future clinical needs. Importantly, although a few studies have noticed the importance of microsurgical training,^{2,3} no studies to date have evaluated the microsurgery training program curriculums or the perspectives of trainees or attendings.

To understand attitudes, training, and practice of microsurgical techniques among hand and upper extremity surgeons in the United States, we conducted a basic survey

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among the members of the American Society for Surgery of the Hand (ASSH) from December 2016 to February 2017. These data will help us determine whether accredited training programs should have a minimum standard in microsurgery training as part of their residency or hand and upper extremity curriculum.

Materials and Methods

A cross-sectional survey study, using a researcher-administered online questionnaire, was conducted among the members of the ASSH e-mail list from December 2016 to February 2017. Questions included inquiries regarding level of training, practice type (private/academic), microsurgical comfort, and microsurgical curriculum outside of the operating room in addition to other questions (see ►Appendix A). Data were collected through an online survey method sent to the recipients' e-mail addresses. Respondents were selected by random sampling from an e-mail address list that was received from the ASSH. Data were collected on standardized online forms with fixed internal evaluation and entered into a patient data management program. A p -value of < 0.05 was considered statistically significant to indicate the independent predictors of knowledge, attitude, and practice. We define "microsurgery" in a basic sense as the ability to perform nerve transfers or perform brachial plexus surgeries with magnification, utilize a microscope for surgical dissection, replant a finger, or raise and transfer free tissue. However, the authors recognize that this list is certainly not comprehensive.

For survey questions, see ►Appendix A.

Results

The survey was sent to a total of 3,678 recipients; 283 of these were opted out. Thus, the survey reached out to 3,395 recipients. Of these, 503 responded fully to the survey for a total response rate of 14.8%.

Overall, 418 (80.9%) were attending surgeons, 28 (5.6%) were residents, and 68 (13.5%) were others. Others included fellows and chief residents (44), retired surgeons (9), professors and emeritus professors (2), and private practice surgeons (16). Of all respondents, 329 (65.4%) were orthopaedic surgeons, 111 (22.1%) plastic surgeons, 12 (2.4%) general surgeons, and 51 (10.1%) others. Others included hand surgeons (48), pediatric pathologists (1), and microsurgeons (2). For attending surgeons, 186 (37.0%) had > 20 years for experience, 81 (16.1%) had 11 to 20 years of experience, 64 (12.7%) had 6 to 10 years of experience, and 99 (19.7%) had < 5 years of experience (►Table 1).

For residents, 2 were in postgraduate year (PGY) level > 7 ; 4 (0.8%) in PGY 7; 20 (4%) in PGY 6; 9 (1.8%) in PGY 5 and 4 respectively; and 1 (0.2%) in PGY 2 and 1 respectively (►Table 1).

Overall, 57.5% did not have a microsurgical laboratory in their institution, whereas 42.5% did. Of the institutions that had a microsurgical laboratory, 32.4% had a microsurgical rat laboratory (►Table 1).

The results of questions 7 to 13 are included in tables as follows (►Table 2 and ►Fig. 1).

Statistical Analysis

A statistical analysis was performed for questions 10, 12, and 13 (►Tables 3–5). The list of survey responders with their self-reported variables such as PGY year, years of experience, and effect on outcome of question was compared with or without the self-reported variable. For question 10, 69.9% of survey responders felt comfortable performing microsurgery when residents were excluded and all others included. Similar number, 69.9%, was obtained when fellows were excluded. When excluding surgeons in private practice from the attending responses, 68.6% of surgeons were comfortable performing microsurgery, versus 46.2% when including private practice ($p < 0.05$).

The prevalence of orthopaedic trained hand surgeon responders was 65.4% and when these were excluded. The percentage of those comfortable with microsurgery was 81.6% versus 59.9% when orthopaedic trained hand surgeons were included ($p < 0.05$). In comparison, the prevalence of plastic surgery trained survey responders was 22.1%, and when these were excluded, the percent of those comfortable with microsurgery was 63.3% versus 82.0% when plastic trained hand surgeons were included ($p < 0.05$). Experience level > 5 years did not affect comfort. The factor of experience level did not have statistical significance unless first year of practice was the factor. Excluding those in their first year of practice, 73.5% were comfortable with microsurgery versus 31.5% of those in their first year of practice ($p < 0.0001$).

A total of 31.6% of responders performed one or more microsurgical cases per week. Of these, 84.3% reported being comfortable with microsurgery, which was significantly higher than respondents performing less than one microsurgery case per week (59.6% were comfortable with microsurgery, $p < 0.0001$).

A total of 7.8% of subjects took advantage of a microsurgical rat laboratory more than once per month but less than once per week. Of these, 87.2% were comfortable with microsurgery, whereas only 65.7% of those using a microsurgical rat laboratory more than once per year but less than once per month were comfortable with microsurgery ($p < 0.006$). Interestingly, using a microsurgical rat laboratory for training more frequently (weekly) did not appear to make subjects more comfortable with microsurgery: 84.6% were comfortable with microsurgery, but this was not statistically ($p = 1.0$).

Question 12 (►Table 5) had notable results. When microsurgery rat laboratories were available, 91.4% of respondents felt that microsurgery curriculum needed improvement versus 84.7% of those without a microsurgery rat laboratory ($p < 0.05$).

When orthopaedic surgeons were included as respondents to the statement regarding whether their microsurgery curriculum needs improvement, 84% answered "yes" versus 92% when orthopaedic surgeons were excluded from this group ($p < 0.05$). However, when plastic surgeons were included in statement regarding whether their microsurgery curriculum needs improvement, 91.9% answered "yes"

Table 1 Survey respondent and program characteristics

Summary of survey respondent and program characteristics (N = 503)		
Characteristic	Subgroup	N (%)
Surgical specialty	Orthopaedic	329 (65.4)
	Plastic surgery	111 (22.1)
	General surgery	12 (2.4)
	Hand surgery (other)	51 (10.1)
Level of training	Attending	418 (83.1)
	Fellow	22 (4.4)
	Resident	28 (5.6)
	Retired	9 (1.8)
Private practice		26 (5.2)
Attending experience	< 5 years	99 (23.7)
	5–10 years	64 (15.3)
	10–20 years	81 (19.4)
	> 20 years	186 (44.5)
Resident level	Senior resident (PGY 5 or higher)	35 (7.0)
	Junior resident (PGY 4 or less)	11 (2.2)
Microsurgery training laboratory at institution		214 (42.5)
Microsurgery rat laboratory present		163 (76.2)
Frequency of resident rat laboratory training?	N/A	337 (67.0)
	Less than monthly	101 (20.1)
	Monthly	39 (7.8)
	Weekly	26 (5.2)
Frequency of microsurgical free flaps or replants?	N/A	117 (23.3)
	Less than once a week	227 (45.1)
	Once a week	50 (9.9)
	More than once a week	109 (21.7)

Abbreviations: NA, not applicable; PGY, postgraduate year.

versus 85.5% when plastic surgeons were excluded (no statistical significance) (► **Table 5**).

For question 13 asking whether microsurgery training or curriculum should be standardized across the nation, there were no significant differences in responses when stratified for absence or presence of factors listed in ► **Table 5**.

Discussion

We conducted a cross-sectional survey study to analyze the experience of microsurgery training at different institutions in the United States, to get a better understanding of how the training systems work and in what way they can be enhanced. The questionnaire contained 13 multiple choice questions e-mailed to members of the ASSH with the presumed idea that they were exposed to microsurgery during their training. We intentionally aimed to survey upper extremity surgeons as microsurgery is intimately related

to hand surgery. Our results identify interesting aspects of current experiences and perspectives of attending surgeons and surgeons in training.

Most respondents were orthopaedic and plastic surgeons. Of those, the majority had > 20 years of experience. The resident response accounted for 5.6% of the respondents and the majority were PGY 5 or above. Sixteen of the respondents were in private practice, and six were retired, accounting for only 4.8% of our total survey respondents. Thus, our study focuses primarily on the attitudes of attending hand surgeons including private practice surgeons. Although 37% have been in practice for > 20 years, an equally high number have been in practice for < 10 years (32.4%).

Our study demonstrates that 36.8% of the residents and fellows are not comfortable performing microsurgery (► **Table 2**), and only < 66.67% of all residents and fellows are comfortable performing microsurgery. Also, the majority would favor standardization of program curriculums.

Table 2 Survey results of microsurgery training

Summary of results regarding microsurgical training (N = 503)					
Question	Strongly disagree, N (%)	Disagree, N (%)	Neutral, N (%)	Agree, N (%)	Strongly agree, N (%)
For residents: are you comfortable with the idea of performing microsurgery?	5 (1.0)	9 (1.8)	21 (4.2)	24 (4.8)	36 (7.2)
For attendings: are you comfortable with the idea of performing microsurgery?	30 (6.0)	44 (8.7)	90 (17.9)	176 (35.0)	163 (32.4)
You feel your plastic surgery program should have microsurgery training outside of the operating room	12 (2.4)	4 (0.8)	96 (19.1)	156 (31.0)	235 (46.7)
You feel your program needs to improve its microsurgery training curriculum	25 (5.0)	43 (8.5)	167 (33.2)	182 (36.2)	86 (17.1)
You feel microsurgery training and curricula should be nationally standardized	20 (4.0)	53 (10.5)	128 (25.4)	202 (40.2)	100 (19.9)

Fig. 1 Bar chart showing responses regarding microsurgery training, simplified by combining “strongly agree with agree” and “strongly disagree with disagree.”

Whether broad microsurgical skills are needed for all hand surgeons is debatable; however, with the future surgical demands becoming more advanced, comfort in basic microsurgical skills is beneficial and potentially necessary.

It has been proven that microsurgery rat laboratories offer many advantages.⁵ They improve residents' surgical skills and provide a good simulator for clinical microsurgery. The rat laboratory enables supervised advanced courses that provide a simulation model for complicated microsurgical reconstruction procedures. Consequently, the rat model remains the current standard in training preparation for achieving competency in microsurgery for residents and fellows outside of the operating room. It may also enhance the

skills of recent graduate attendings with additional training opportunities.⁵ Interestingly, our survey showed that 57.5% did not have a microsurgical laboratory. Of the 42.5% that did, only 32.4% had a microsurgical rat laboratory with majority of residents and fellows using them less than one time per month. When stratified by presence or absence of microsurgical rat laboratory, those with microsurgical rat laboratories responded that they were comfortable with microsurgery 77.1% versus 60.2% when that factor was absent ($p < 0.001$). This statement, however, does not give credence to other simulation models that could be used to enhance microsurgical training curriculum outside the operating room.

Table 3 Statistical analysis for question 10

Factor	Prevalence (%)	I am comfortable performing microsurgery, factor absent (%)	I am comfortable performing microsurgery, factor present (%)	Chi-square test	Fisher's exact test
Resident	5.6	69.9	25.0	0.000	0.000
Attending	83.1	31.8	74.6	0.000	0.000
Retired	1.8	67.6	55.6	0.445	0.482
Fellow	4.4	69.9	13.6	0.000	0.000
Private practice	5.2	68.6	46.2	0.018	0.029
PGY 1	0.2	67.3	100.0	0.486	1.000
PGY 2	0.2	67.3	100.0	0.486	1.000
PGY 4	1.8	68.4	11.1	0.000	0.001
PGY 5	1.8	68.6	0.0	0.000	0.000
PGY 6	4.0	69.2	25.0	0.000	0.000
PGY 7	0.8	67.5	50.0	0.456	0.600
> PGY 7	0.4	67.3	100.0	0.324	1.000
Junior resident	2.2	68.3	27.3	0.004	0.007
Senior resident	7.0	70.5	25.7	0.000	0.000
Micro laboratory available	42.5	60.2	77.1	0.000	0.000
Micro laboratory, rat available	32.4	62.4	77.9	0.000	0.001
General surgeon	2.4	66.8	91.7	0.069	0.115
Orthopaedic surgeon	65.4	81.6	59.9	0.000	0.000
Specialty hand or other	10.1	66.2	78.4	0.076	0.084
Plastic surgeon	22.1	63.3	82.0	0.000	0.000
Experience 11–20 years	16.1	66.8	70.4	0.533	0.605
Experience 6–10 years	12.7	66.3	75.0	0.165	0.199
Experience < 5 years	19.7	64.1	80.8	0.001	0.001
Experience > 20 years	37.0	65.6	70.4	0.266	0.280
Experience, first year in practice	14.5	73.5	31.5	0.000	0.000
Micro laboratory use, weekly	5.2	66.5	84.6	0.054	0.056
Micro laboratory use, not available	67.0	80.7	60.8	0.000	0.000
Micro laboratory use, yearly	20.1	64.9	77.2	0.018	0.018
Micro laboratory use, monthly	7.8	65.7	87.2	0.006	0.007
Micro laboratory use, > yearly	12.9	64.6	86.2	0.000	0.000
Micro laboratory use, multiple time/week	31.6	59.6	84.3	0.000	0.000
> 2 micro cases/wk	21.7	63.5	81.7	0.000	0.000
< 1 micro cases/wk	45.1	70.3	63.9	0.127	0.152
micro cases/wk not available	23.3	72.3	51.3	0.000	0.000
1 micro case/wk	9.9	64.9	90.0	0.000	0.000

Abbreviation: PGY, postgraduate year.

Table 4 Statistical analysis for question 12

Factor	Prevalence (%)	Microsurgery curriculum needs improvement, factor absent (%)	Microsurgery curriculum needs improvement, factor present (%)	Chi-square test	Fisher's exact test
Resident	5.6	86.5	92.9	0.335	0.562
Attending	83.1	88.2	86.6	0.684	0.860
Retired	1.8	87.2	66.7	0.070	0.101
Fellow	4.4	86.9	86.4	0.942	1.000
Private practice	5.2	86.6	92.3	0.400	0.557
PGY 1	0.2	86.9	100.0	0.697	1.000
PGY 2	0.2	86.9	100.0	0.697	1.000
PGY 4	1.8	87.0	77.8	0.415	0.335
PGY 5	1.8	86.6	100.0	0.239	0.614
PGY 6	4.0	86.7	90.0	0.673	1.000
PGY 7	0.8	87.0	75.0	0.480	0.431
> PGY 7	0.4	86.8	100.0	0.582	1.000
Junior resident	2.2	87.0	81.8	0.615	0.644
Senior resident	7.0	86.5	91.4	0.409	0.603
Micro laboratory available	42.5	84.4	90.2	0.059	0.062
Micro laboratory, rat available	32.4	84.7	91.4	0.037	0.047
General surgeon	2.4	86.8	91.7	0.619	1.000
Orthopaedic surgeon	65.4	92.0	84.2	0.014	0.018
Specialty hand or other	10.1	86.3	92.2	0.239	0.282
Plastic surgeon	22.1	85.5	91.9	0.076	0.081
Experience, first year in practice	14.5	86.7	87.7	0.828	1.000
Experience < 5 years	19.7	86.4	88.9	0.509	0.619
Experience 6–10 years	12.7	86.3	90.6	0.342	0.430
Experience 11–20 years	16.1	88.2	80.2	0.054	0.071
Experience > 20 years	37.0	86.8	87.1	0.912	1.000
Micro laboratory use, weekly	5.2	86.8	88.5	0.806	1.000
Micro laboratory use, not available	67.0	92.8	84.0	0.006	0.007
Micro laboratory use, yearly	20.1	85.1	94.1	0.017	0.020
Micro laboratory use, monthly	7.8	86.4	92.3	0.296	0.457
> 2 micro cases/wk	21.7	85.5	91.7	0.089	0.108
< 1 micro cases/wk	45.1	87.3	86.3	0.747	0.791
Micro cases/wk not available	23.3	88.9	80.3	0.017	0.028
1 micro case/wk	9.9	86.1	94.0	0.116	0.182

Abbreviation: PGY, postgraduate year.

Table 5 Statistical analysis for question 13

Factor	Prevalence (%)	Microsurgery curriculum needs to be standardized, factor absent (%)	Microsurgery curriculum needs to be standardized, factor present (%)	Chi-square test	Fisher's exact test
Resident	5.6	60.0	60.7	0.940	1.000
Attending	83.1	58.8	60.3	0.802	0.809
Retired	1.8	59.9	66.7	0.682	1.000
Fellow	4.4	60.9	40.9	0.061	0.075
Private practice	5.2	59.5	69.2	0.326	0.412
PGY 1	0.2	60.2	0.0	0.220	0.400
PGY 2	0.2	60.0	100.0	0.414	1.000
PGY 4	1.8	60.3	44.4	0.335	0.494
PGY 5	1.8	59.9	66.7	0.682	1.000
PGY 6	4.0	60.5	50.0	0.350	0.361
PGY 7	0.8	60.1	50.0	0.681	1.000
> PGY 7	0.4	59.9	100.0	0.248	0.519
Junior resident	2.2	60.4	45.5	0.318	0.360
Senior resident	7.0	60.3	57.1	0.717	0.724
Micro laboratory available	42.5	59.9	60.3	0.924	1.000
Micro laboratory, rat available	32.4	57.4	65.6	0.076	0.081
General surgeon	2.4	59.5	83.3	0.095	0.136
Orthopaedic surgeon	65.4	60.3	59.9	0.919	1.000
Specialty hand or other	10.1	59.1	68.6	0.187	0.228
Plastic surgeon	22.1	61.7	54.1	0.145	0.155
Experience, first year in practice	14.5	60.0	60.3	0.965	1.000
Experience < 5 years	19.7	62.1	51.5	0.053	0.067
Experience 6–10 years	12.7	60.1	59.4	0.907	1.000
Experience 11–20 years	16.1	59.7	61.7	0.735	0.805
Experience > 20 years	37.0	57.7	64.0	0.167	0.187
Micro laboratory use, weekly	5.2	59.7	65.4	0.568	0.683
Micro laboratory use, not available	67.0	63.9	58.2	0.220	0.246
Micro laboratory use, yearly	20.1	59.5	62.4	0.592	0.650
Micro laboratory use, monthly	7.8	59.5	66.7	0.379	0.401
> 2 micro cases/wk	21.7	60.7	57.8	0.589	0.659
< 1 micro cases/wk	45.1	61.2	58.6	0.547	0.583
Micro cases/wk not available	23.3	58.5	65.0	0.215	0.237
1 micro case/wk	9.9	60.0	60.0	0.995	1.000

Abbreviation: PGY, postgraduate year.

Microsurgery is an acquired surgical skill that requires extensive training and the supervision of expert instructors. The microsurgical rat laboratory is one proven model that enhances training skill. This study may highlight that microsurgical training outside the operating room should be entertained and could potentially lead to different models other than rat laboratory training if rat laboratory training is not easily achieved at all institutions. The vast majority of our respondents did not have a rat laboratory, and the ones that did used the laboratory infrequently. This carries multiple issues with the most important being that trainees may not get the proper training opportunity needed to become competent enough in this surgical field. In fact, 77.7% of our respondents agreed or strongly agreed that their training program should have microsurgery training outside of the operating room, and 53.3% agreed or strongly agreed that their microsurgery curriculum needs improvement. Of note, the prevalence of responders that used microsurgical rat laboratory multiple times per week was 31.6%. Of those responders to this question that did not use the microsurgical rat laboratory multiple times per week, 59.6% were comfortable performing microsurgery compared with 84.3% of those that used it multiple times per week ($p < 0.0001$). This did not delineate between residents, fellows, or practicing surgeons. This again leads to the notion that implementation of a regularly scheduled curriculum outside of the operating room, potentially including a rat laboratory, adds to the confidence and comfort behind the microscope. Also of interest is that our subset analysis of comfort in performing microsurgery showed when fellows or private practice surgeons were excluded from the analysis, the comfort with microsurgery was significantly improved, $p < 0.001$ and $p < 0.018$, respectively. The results would imply academic surgeons in nonprivate practice settings as well as residents in training programs may be more comfortable performing microsurgery than private surgeons and fellows, likely due to the supervision and experienced microsurgery attendings in these institutions.

Remarkably, only 60% of residents and fellows agreed or strongly agreed that they are comfortable with the idea of performing microsurgery. Ideally, the ultimate goal of a training program should be to train 100% of their residents and fellows to be comfortable with microsurgical techniques. Because the vast majority of the respondents in training were PGY 5 or above, this further indicates that the microsurgical training curriculum needs to be improved to provide more adequate education and guidance in this field.

Further, > 45% of institutions performed microvascular free flaps or digital replantation less than once per week. Again, in our subset analysis, when those with greater than two microsurgical cases per week were included in analysis, 81.7% were comfortable performing microsurgery compared with 63.5% when those with greater than two cases per week were excluded ($p < 0.0001$). Considering that microsurgery, free tissue transfer, and digital replantation are some of the distinguishing traits of upper extremity surgeons, this opens up questions whether training programs without a high microsurgical volume are sufficiently developed and

equipped to offer the essential training for those requiring microsurgery as part of their armamentarium.

For attending surgeons, 67.4% responded that they agreed or strongly agreed that they were comfortable performing microsurgery. Bearing in mind that 53% had 11 to 20 years of experience, 37% had > 20 years for experience, and 12.7% had between 6 and 10 years for experience. When approximately 33.33% of the respondents do not feel comfortable in performing microsurgery, this seems to be a fairly high number, further indicating that training programs in the United States may need improvement.

Overall, 65.6% agreed or strongly agreed that microsurgery training or curriculum should be standardized across the nation, and our analysis by different factors supported this as there were no statistically significant differences when different factors were included or excluded from the analysis. This statement reflects the answers from residents, fellows, and attendings. Standardization of training programs and curriculums offers many advantages, and this has been studied in different fields both nationally and internationally.⁶⁻¹¹ It is also interesting to note that when microsurgery rat laboratories were available, 91.4% of respondents felt that microsurgery curriculum needed improvement versus 84.7% of those without a microsurgery rat laboratory ($p < 0.05$). This finding may imply that surgeons at centers with rat laboratory and perhaps high volume of microsurgical cases may need more specific high-level instruction and a more focused curriculum. Another explanation may also mean that these resources are underutilized and that a structured curriculum may assist with using the resources to their fullest capacity. Alternatively, the reason for this could also be that programs that have a rat laboratory do not have as strong clinical microsurgery program as the ones without a rat laboratory. Consequently, programs that do not have a rat laboratory do not feel they need it because they are strong with their clinical microsurgery training already. Nevertheless, the percentage of respondents arguing for a standardized curriculum is very high both groups regardless.

Many studies have shown that standardizing programs are not just more effective but improve the overall mission and goals of the program or organization. Benefits such as improved trainee involvement and empowerment, consistency (reduction of variation) among trainees performing the work, improved productivity without added stress, improved, consistent quality, work process stability, improved cost management as wastes are removed, and reduction or elimination of errors and mistakes (causes of defects) are just some benefits of standardization.^{1,12,13}

The question that needs to be evaluated is to why some programs and surgeons are more comfortable performing microsurgery whereas others are not. It is a known fact that some institutions are stronger in certain surgical fields and techniques than others. The reasons for this are probably culture, history, current supervisor skills of the program, and variability of trauma and reconstructive exposure. Another factor is that there is a significant difference in the perception of attending physicians and residents about the quality of

teaching and feedback that is currently occurring in the operating room.¹⁴ It is likely that if a program has many skilled microsurgeons in place, that program will likely also offer enhanced training in such. However, if microsurgical training curriculums would be standardized, we could improve these deficiencies in microsurgical training by providing program guidelines in required skill sets that are needed and encourage programs to recruit the necessary work skills for these objectives. Moreover, because our study shows that a fair proportion of institutions, residents, fellows, and attendings indeed *are* comfortable performing microsurgery, they could easily provide their protocols and syllabi for other programs to emulate.

Two novel concepts are transforming microsurgical training: (1) objective assessments of surgical skills and (2) the nurturing of surgical skills in a simulation laboratory setting. The latter can help move the microsurgical learning curve from the patient to the laboratory, and this will in turn improve patient safety and outcomes. However, to optimize microsurgical training through a competency-based training program, it is vital for educators in microsurgery to recognize microsurgical skill acquisition. This essentially involves accurate objective assessment tools that can define and quantify microsurgical competency.

There are several strengths of this study. First, we had a fairly high response rate of 503 respondents (almost 15% response rate of total recipients of our survey). Second, we had many different specialties, such as plastic surgery, orthopaedic surgery, hand surgery, and general surgery. Third, we included perspectives of attendings, residents, and fellows. Moreover, we had respondents from different institutions from all over the country. Also, our questions were phrased to avoid question-order biases, leading question and wording biases. Last, only 4.8% of the respondents were in private practice, which suggests that the large majority of our respondents were directly involved in microsurgery training, and thus applicable to the survey.

There are a few limitations to this study. As true with any survey study, respondents may not have been encouraged to provide accurate answers or may not have felt comfortable providing answers that present themselves in an unfavorable manner. For instance, this is seen in the results section when we asked for the amount of attendings. On question 1, we got 407 respondents labeling themselves as attendings. However, on question 3, when asked about how many years of experience the respondents had, 73 out of 503 stated that they are not attendings, which equals a total of 430 attendings. The reason for this is likely that some retired surgeons and/or private practice surgeons are still labeling themselves as attendings while others are not in different sections. Second, some data errors due to question nonresponses may exist, as the number of respondents who chose to respond to the survey question may be different from those who chose not to respond. Furthermore, our study was also biased toward upper extremity surgeons within different specialties, as microsurgical skills are an essential component of major upper extremity surgery and may not reflect all specialties adequately. However, due to our high response rate and broad

demographics, we believe that these results are fairly representative of the current trends and viewpoints of the microsurgery field.

In conclusion, our study demonstrates that the microsurgery curriculum across American residency training programs may be inadequate. Because the ultimate goal of a training program should be to train all their trainees to be competent physicians and surgeons whom are comfortable performing procedures, these results may indicate that the microsurgical training curriculum needs to be improved and potentially even standardized across the nation to provide more adequate education and guidance in this field. However, further studies are needed, and we advocate the necessity of further investigations germane to this topic.

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Conflict of Interest

None.

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Appendix A

The following questions and multiple-choice answers were included in our survey:

1. You are:
 - a. A resident
 - b. An attending
 - c. Other
2. Which field are you in?
 - a. Plastic surgery
 - b. Oral maxillofacial surgery
 - c. Orthopaedic surgery
 - d. General surgery
 - e. Ophthalmology
 - f. Other surgical specialty:
Please specify which_____.
3. If you are an attending, how many years of experience do you have?
 - a. < 5
 - b. 6–10
 - c. 11–20
 - d. > 20
4. If you are a resident, what postgraduate year (PGY) level of residency training are you in?
 - a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5
 - f. 6
 - g. 7
 - h. >7
5. Do you have a microsurgical training laboratory?
 - a. Yes
 - b. No
6. If you have a microsurgical training laboratory, is it a microsurgery rat laboratory?
 - a. Yes
 - b. No
 - c. N/A
7. How often does your program let your residents have rat laboratory training?
 - a. > 1 time per week
 - b. $\geq$ 1 time per month but less than 1 time per week
 - c. $\geq$ 1 time per year but less than 1 time per month
 - d. N/A
8. How often does your institution perform microvascular free flaps?
 - a. > 1 time per week
 - b. 1 time per week
 - c. < 1 time per week
 - d. N/A
9. For a resident graduating from a training program: you feel comfortable with the idea of performing microsurgery.
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree
10. Attendings: you feel comfortable performing microsurgery.
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree
11. You feel that your training program should have micro-surgery training outside of the operating room.
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree
12. You feel that your program needs to improve its micro-surgery curriculum.
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree
13. You feel that microsurgery training/curriculum should be standardized across the nation?
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree