The Preferred Management of a Single-Digit Distal Phalanx Amputation

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Abstract

Background Replantation of a single digit at the distal phalanx level is not routinely performed since it is technically challenging with questionable cost-effectiveness. The purpose of this study was to analyze international microsurgeons' clinical decisions when faced with this common scenario.

Methods A survey of a right-middle finger distal phalanx transverse complete amputation case was conducted via online and paper questionnaires. Microsurgeons around the world were invited to provide their treatment recommendations. In total, 383 microsurgeons replied, and their responses were stratified and analyzed by geographical areas, specialties, microsurgery fellowship training, and clinical experiences.

Results Among 383 microsurgeons, 170 (44.3%) chose replantation as their preferred management option, 137 (35.8%) chose revision amputation, 62 (16.2%) chose local flap coverage, 8 (2.1%) chose composite graft, and 6 (1.6%) favored other choices as their reconstruction method for the case study. Microsurgeons from the Asia-Pacific, Middle East/South Asia, and Central/South America regions tend to perform replantation (70.7, 68.8, and 67.4%, respectively) whereas surgeons from North America and Europe showed a lower preference toward replantation (20.5 and 26.8%, respectively $p < 0.001$). Having completed a microsurgery fellowship increased the attempt rate of replantation by 15.3% ($p = 0.004$). Clinical experience and the surgeons' specialties did not show statistical significance in clinical decision making.

Conclusion From the present study, the geographic preferences and microsurgery fellowship experience influence the method of reconstruction for distal phalanx amputation. Multiple factors are taken into consideration in selecting the most suitable reconstructive method for each case scenario. In addition to the technical challenges of the proposed surgery, the cost of the procedure and the type of facility needed are important variables in the decision making process.

Keywords
- distal phalanx reconstruction
- replantation
- questionnaire

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From current literature, the accepted indications for digit replantation are thumb amputation, multiple digit amputation, pediatric amputation, and amputation at the level of distal phalanx.[1] Distal phalanx amputation is a common clinical scenario. Replantation is recommended since vital structures including the fingertip glabrous skin, bone, and nail can be preserved, achieving functional and cosmetic outcomes without donor site morbidity. The recent success rate of Tamai Zone I replantation is up to 70 to 90%.[2,3] However, performing replantation at this level is technically demanding and requires long–operation time and hospitalization. Potential complications arising from surgery and the time required for a patient to return to work are additional concerns; and cost-effectiveness also plays a significant role in the decision-making process.[4] Often, microsurgeons are reluctant to perform replantation because this long procedure also disrupts their surgical schedule and there is no financial incentive. Therefore, we hypothesized that the overall attempt rate of performing distal phalanx replantation is low and that such cases are usually managed with alternative methods.[5–8]

In distal phalanx amputation, when the amputated part is unavailable, various choices of reconstruction exist. Secondary healing, direct closure, skin graft, local flap, distant flap, and free flap coverage can all be used. These surgical approaches are usually easier than replantation, but the results are presumably inferior since these alternative methods cannot substitute for the complex structure of the distal phalanx. In addition, all these reconstructive methods have donor site morbidities. Thus, all factors considered, the decision for the most appropriate management should be based on the general medical condition, patient's expectation, surgeon's skill, facilities at the institute, and the insurance system altogether.[5–7,9]

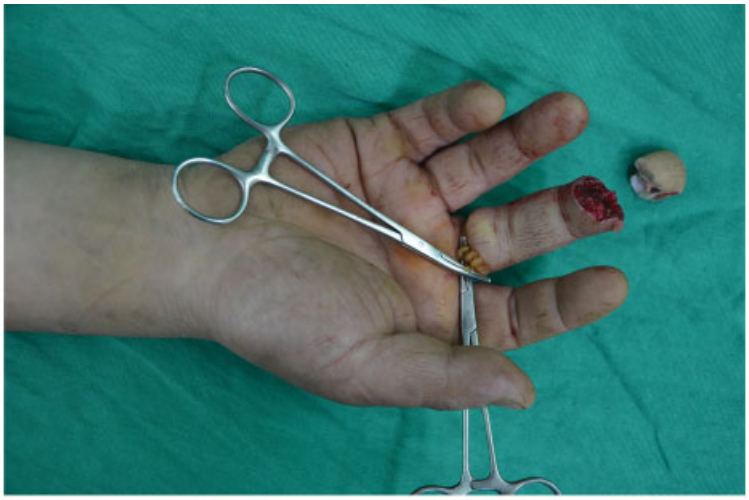
To understand the decision-making process of microsurgeons around the world, when faced with this particular scenario, a case study was conducted and surgeons around the world were invited to present their clinical strategy through an online questionnaire.

Methods

Questionnaire Design

The questionnaire was designed with Google Forms.[10] Part one of the questionnaire was basic information of the survey participant, followed with 10 case scenarios and one-to-two questions related to treatment options. Participants completed questions pertaining to nationality, seniority (years as a microsurgery staff, more than 5 years of staff experience defines as a senior microsurgeon whereas less than 5 years defines as a junior microsurgeon), experience of microsurgery fellowship training, and specialty (hand surgeon/plastic surgeon/orthopaedics). At the beginning of the questionnaire, a case with a brief history and key photographs was shown. The replantation case had: a 44-year-old male who sustained a transverse amputation injury of the right middle finger at the level of the distal phalanx (Tamai zone I). The participants were asked to state their preferred choices for reconstruction in this case (►**Fig. 1**).

To the best of our knowledge, this is the first study that collects the opinions of global microsurgeons toward a common clinical scenario. Different modalities (paper and online surveys) were used to collect the responses; the only drawback is that the response rate could not be precisely calculated. Around 100 paper questionnaires were administrated at the 5th World Symposium for Lymphedema Surgery (Chang-Gung Memorial Hospital, Taoyuan, Taiwan, 2016),



- 44-year-old male
- Right middle finger amputation at distal phalanx level
- No distal interphalangeal joint injury
- Good quality of amputated part

Q: What is your choice of reconstruction?
Ans: _____

Fig. 1 The illustrated case and the question in this questionnaire.

the response rate was 30%. The electronic version of the questionnaire was first distributed via personal e-mails, ResearchGate,[11] and LinkedIn[12] accounts; up to 3,000 invitations sent and the response rate was around 3 to 5%. To receive the maximal responses, we then adapted the Facebook platform.[13] The senior author Dr. Tommy Nai-Jen Chang had established the platform "International Microsurgery Club (IMC)" with microsurgeons around the world as members.[14–18] The social medial platform is an effective method of deliver thoughts and information.[19,20] We invited all group members to respond to the questionnaire via Facebook Messenger and posted this information on the group page three times. The Facebook Messenger is more interactive than e-mail, so the response rate was higher (200/400, 50%). However, it was impossible to calculate the survey response rate via the Facebook platform because there was no way to know how many members actually read the open post. Only attending level microsurgeons were invited to participate in the study, residents and fellows were excluded. Data collection was done from May 2016 to November 2016. To be eligible for inclusion, microsurgeons need to meet at least one of the following criteria: microsurgery fellowship trained, have active microsurgery patients in clinical practice, belong to departments, and specialties that routinely perform microsurgery. In total, 383 microsurgeons participated in this study. Their responses were analyzed thoroughly, and stratified by geographical areas, whether fellowship trained or not, department where they worked (plastic, orthopaedic, or hand surgery) and their seniority (years as an attending physician).

Statistics

Statistical analysis was conducted using SPSS software version 22.0 (SPSS 22.0 software for Mac; SPSS Inc., Chicago, IL). Differences in the proportions of dichotomous variables were tested with Fisher's exact test, whereas differences in the location parameters of continuous variables were tested with the independent-sample Mann–Whitney *U*-test. For univariant and multivariant analysis, binary logistic regression was applied for predict model. All *p*-values were two-sided, and the significance level was set at $p < 0.05$.

Results

In total, 383 microsurgeons from all over the world were enrolled for the analysis (►**Table 1**). Among 383 microsurgeons, 170 (44.4%) chose replantation as their preferred management option, and 137 (35.8%) preferred revision amputation, 62 (16.2%) chose various local flap coverage, 8 (2.1%) favored composite graft, and 6 (1.6%) favored other choices as their method of reconstruction for the presented case (all classified into "others," $n = 213$ in total). (►**Fig. 2**).

Microsurgeons from the Asia Pacific, Middle East/South Asia, and Central/South America were more likely to perform replantation (70.7, 68.8, and 67.4%); whereas only 26.8 and 20.5% of microsurgeons from Europe and North America preferred replantation, respectively ($p < 0.001$; ►**Fig. 3**, ►**Table 2**).

Using the North America rate as the reference, the differences in replantation rate in Middle East/South Asia, Asia Pacific, Central/South America, and Africa were statically

Table 1 The international microsurgeons participated in the study

South Asia and Middle East	Asia Pacific	Oceania	Europe	North America	Central and South America	Africa
n = 32	*n* = 75	*n* = 3	*n* = 112	*n* = 78	*n* = 32	*n* = 40
India: 17	Taiwan: 30	Australia: 3	Germany: 33	United Sates: 70	Mexico: 17	Egypt: 22
Turkey: 3	Japan: 9		Netherland: 14	Canada: 8	Colombia: 6	South Africa: 6
Yemen: 2	Indonesia: 8		Austria: 8		Argentina: 4	Sudan: 5
Pakistan: 2	China: 7		United Kindem: 7		Brazil: 4	Nigeria: 4
Saudi: 2	South Korea: 5		Spain: 6		Venezuela: 4	Ghana: 1
Bangladesh: 1	Thailand: 5		Sweden: 4		Peru: 3	Algeria: 1
Iraq: 1	Hong Kong: 4		Finland: 3		Chile: 2	Kenya: 1
Israeli: 1	Philippines: 2		France: 3		Nicaragua: 1	
Jordan: 1	Singapore: 2		Russia: 3		El Salvador: 1	
Kuwait: 1	Malaysia: 1		Switzerland: 3			
Syria: 1	Myanmar: 1		Croatia: 2			
	Vietnam: 1		Portugal: 2			
			Poland: 2			
			Greece: 2			
			Denmark:1			
			Norway: 1			
			Belgium: 1			

Note: Nationality was classified into seven groups geographically.

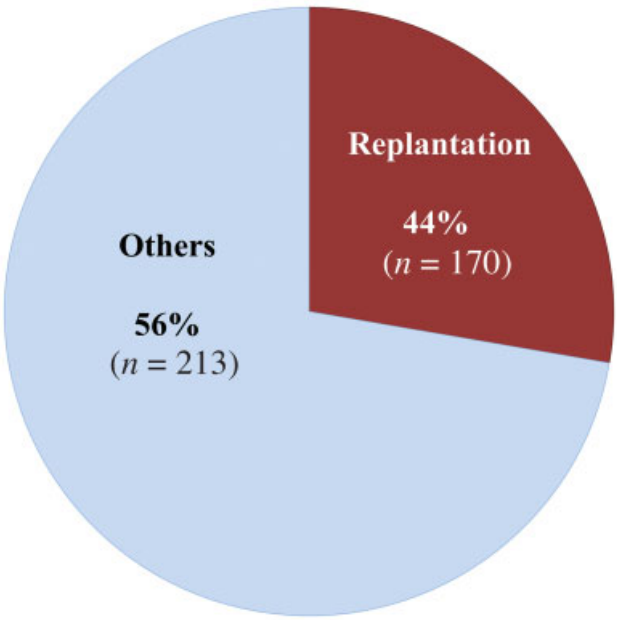


Fig. 2 The overall rate of participants who chose replantation as their reconstruction options. In total, 44% microsurgeons chose replantation whereas the other 56% chose other methods for reconstruction.

significance in the choice of replantation. ($p < 0.001$, multivariate study; ►**Fig. 3**, ►**Tables 3** and **4**). Having done a microsurgery fellowship, the rate of attempting replantation increased by 15.3%. (49.6 vs. 34.3%, $p = 0.04$ in the univariate analysis, $p = 0.022$ in the multivariate analysis; ►**Fig. 4**, ►**Table 4**) There were no statistically significant differences associated with seniority, which was divided into senior or junior surgeon status with the cut off of 5 clinical staff years, also no statistical significance whether surgeons were from the plastic surgery, orthopaedic, or hand surgery departments (►**Figs. 5** and **6**, ►**Table 4**).

Discussion

The goals of distal phalanx reconstruction include length preservation, pain free contact surface restoration, obtaining durable and sensate skin coverage, and nail plate preservation with acceptable cosmesis.[21] The success rate of the digit replantation mainly relies on the clinical condition, trauma mechanism, surgical skill, and microsurgeon's preferences. The success of replantation is multifactorial. Operative strategies, such as the two-stage operation for venous anastomosis[22] and using volar vein for anastomosis[23] can increase replantation success. Other factors, such as replantation done in daylight hours,[24] the use of medical leeches and the removal of nail plate from the replanted

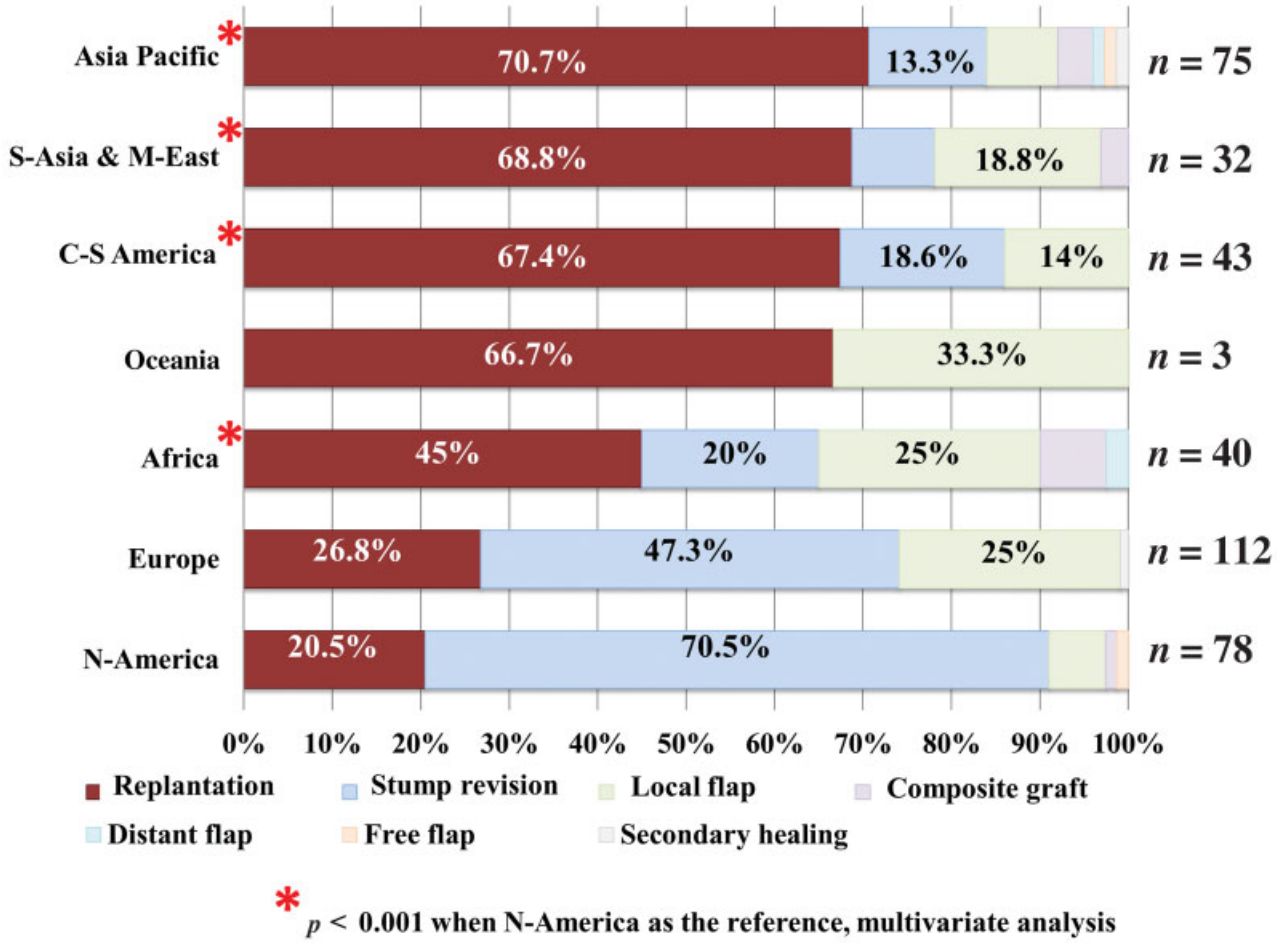


Fig. 3 Geographically, Asia Pacific, South Asia/Middle East, and Central/South America were more likely to perform replantation, whereas Europe and North America were less likely.

Table 2 General descriptive data between replantation compared with nonreplantation with Chi-square comparison

	Replantation	No Replantation (all the other options)	
	Number (%)	Number (%)	*p*-Value
Q1. Have you done any microsurgery fellowship training in your career?	168	213	0.004[a]
Yes	47 (28)	90 (42.3)	
No	121 (72)	123 (57)	
Q2. Geographic area	170	213	<0.001[a]
South Asia and Middle East	22 (12.9)	10 (4.7)	
Asia Pacific	53 (31.2)	22 (10.3)	
Central-South America	29 (17.1)	14 (6.6)	
Europe	30 (17.6)	82 (38.5)	
North America	16 (9.4)	62 (29.1)	
Africa	18 (10.6)	22 (10.3)	
Oceania	2 (1.2)	1 (0.5)	
Q3. Seniority	168	210	0.490
Junior (<5 staff year)	59 (35.1)	81 (38.6)	
Senior (>5 staff year)	109 (64.9)	129 (61.4)	
Q4. Specialty	166	207	0.866
Plastic surgery	132 (79.5)	168 (81.2)	
Orthopaedics	16 (9.6)	20 (9.7)	
Hand surgery	18 (10.8)	19 (9.2)	

[a]$p < 0.05$.

Table 3 Univariate Analysis for replantation compared with nonreplantation: geographic area comparison

	South Asia and Middle East	Asia Pacific	Central and South America	Europe	North America	Africa	Oceania
South Asia and middle east	Reference	0.913	1.062	6.013[a]	8.525[a]	2.689[a]	1.100
Asia Pacific	1.095	Reference	1.163	6.585[a]	9.335[a]	2.944[a]	1.205
Central and south America	0.942	0.860	Reference	5.662[a]	8.027[a]	2.532[a]	1.036
Europe	0.166[a]	0.152[a]	0.177[a]	Reference	1.418	0.447[a]	0.183
North America	0.117[a]	0.107[a]	0.125[a]	0.705	Reference	0.315[a]	0.129
Africa	0.372[a]	0.340[a]	0.395[a]	2.236[a]	3.170[a]	Reference	0.409
Oceania	0.909	0.830	0.966	5.467	7.750	2.444	Reference

Note: The number means odds ratio (OR) compared with vertical column.
[a]$p < 0.05$.

finger to promote bleeding,[2] artery-only anastomosis in fingertip replantation,[25] and combined with the subdermal pocket procedure,[26] all may increase success rate for better outcome. In our study, we presented the case of a laborer who suffered from a complete amputation of the right-middle finger just distal to the distal phalangeal joint level (Tamai zone I). Although an appropriate indication for replantation, only 44.4% of microsurgeons selected replantation as their preferred management option. Despite the stated benefits of replantation in the literature and recent advances in microsurgery, clinical attempt rate for replantation at the distal phalanx level remains low.[27,28]

Geographically we divided the microsurgeons into seven groups, including Asia Pacific, South Asia, and Middle East including Turkey, North America, Central to South America, Oceania, Africa, and Europe including Russia. The microsurgeons from Asia-Pacific, Middle East/South Asia, and Central/South America were more likely to perform replantation (70.7, 68.8, and 67.4%), whereas those from Europe and North America microsurgeons were less likely to attempt replantation at this level (26.8 and 20.5%, $p < 0.01$). We hypothesized that geographical areas with a higher preference for replantation were also more interested in super-microsurgery. Literature search for

Table 4 Univariate and multivariate analysis for replantation compared with nonreplantation: other associated factors analysis

		Univariate Analysis for replantation compared with nonreplantation			Multivariate Analysis for replantation compared with nonreplantation		
Factors		**Odds ratio**	**95% confidence interval**	***p*-Value**	**Odds ratio**	**95% confidence interval**	***p*-Value**
Fellowship	No	Reference			Reference		
	Yes	1.884	1.222–2.904	0.004[a]	1.832	1.089–3.081	0.022[a]
Seniority	Junior	Reference			Reference		
	Senior	1.16	0.761–1.768	0.490	1.551	0.933–2.579	0.091
Specialty							
	Plastic surgeon	Reference			Reference		
	Orthopaedics	1.018	0.508–2.042	0.960	0.99	0.447–2.190	0.980
	Hand surgeon	1.206	0.609–2.389	0.592	1.236	0.551–2.774	0.608
Nationality	North America	Reference			Reference		
	South Asia and Middle East	8.525	3.371–21.559	<0.001[a]	12.919	4.725–35.323	<0.001[a]
	Asia Pacific	9.335	4.449–19.586	<0.001[a]	12.631	5.649–28.241	<0.001[a]
	Central and south America	8.027	3.458–18.630	<0.001[a]	9.102	3.767–21.994	<0.001[a]
	Europe	1.418	0.711–2.828	0.322	2.052	0.973–4.326	0.059
	Africa	3.170	1.381–7.276	0.006[a]	5.513	2.167–14.024	<0.001[a]
	Oceania	7.750	0.66–90.945	0.103	7.377	0.615–88.487	0.115

[a] $p < 0.05$.

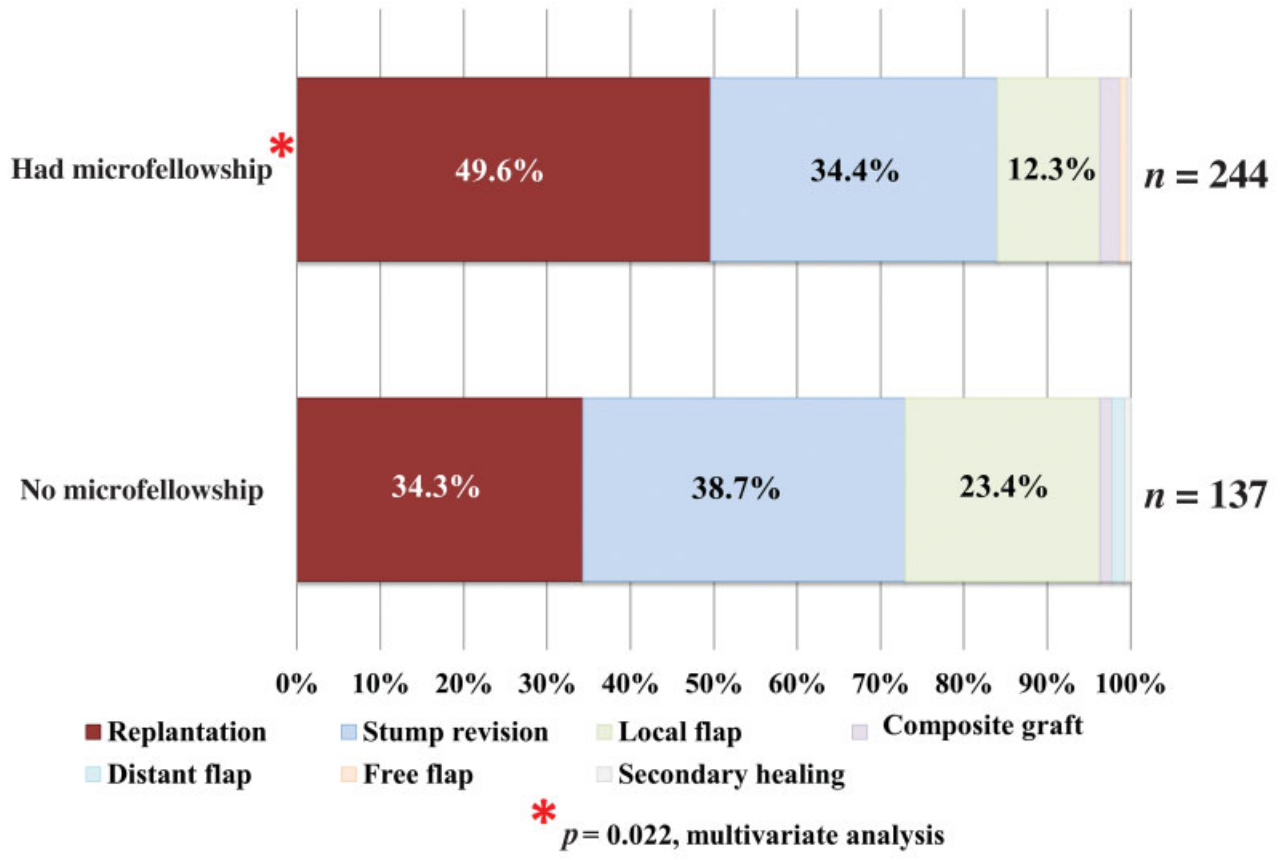


Fig. 4 The microsurgeons who had completed microsurgical fellowships showed higher interest in replantation reconstruction for the studied case.

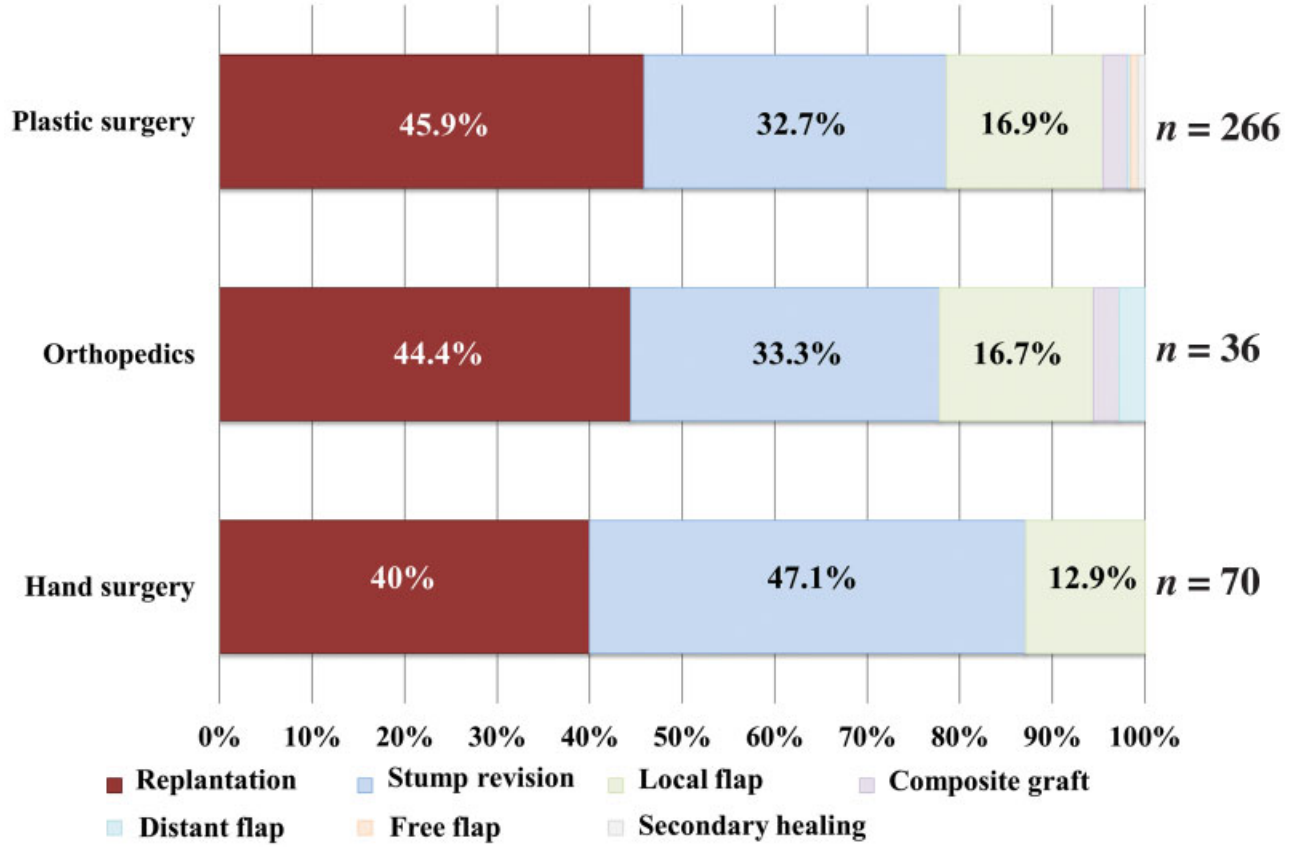


Fig. 5 The microsurgeons with different specialties did not have significant preference differences in choice of reconstructive option toward to the studied case.

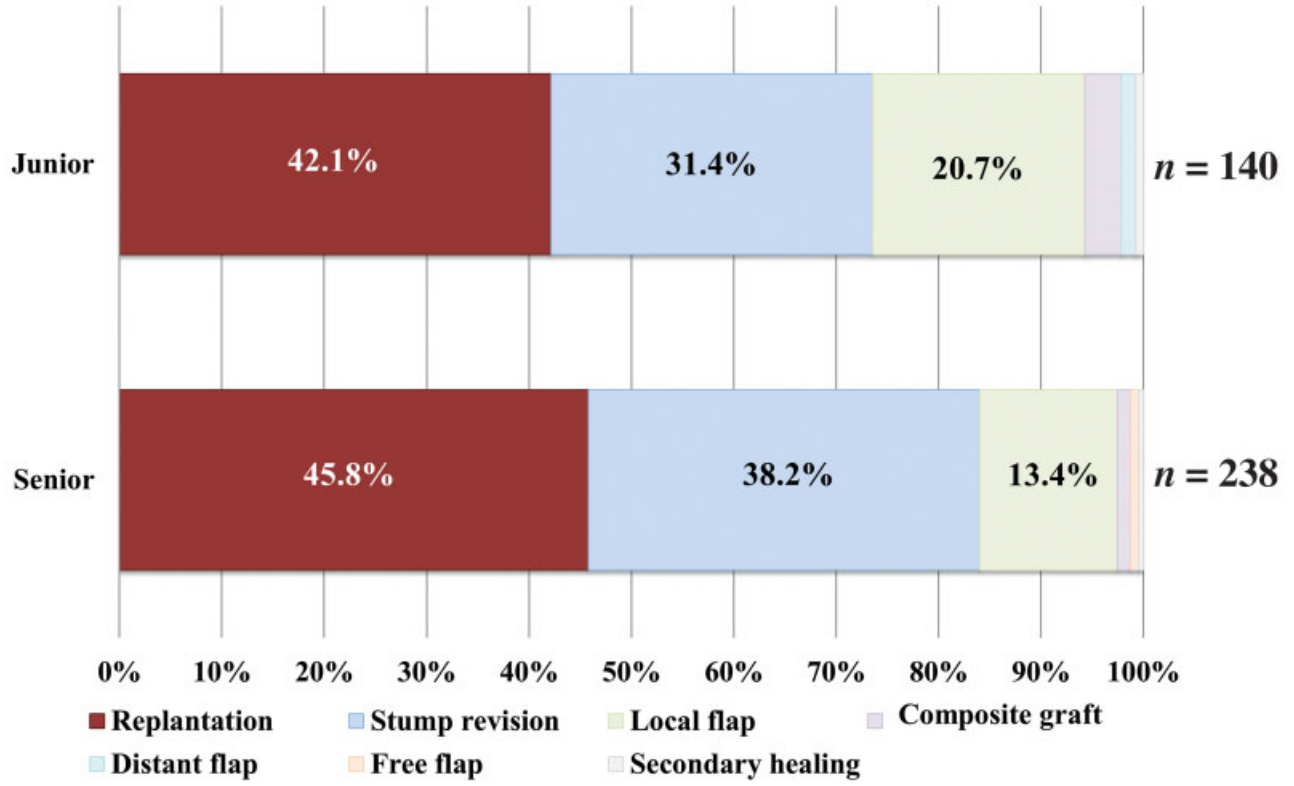


Fig. 6 The preferences between junior and senior microsurgeons were not significantly different.

recent super-microsurgery publications further supported that. A search on PubMed using the keywords "fingertip replantation," "distal phalanx replantation," and "free pulp replantation." Identified 30 publications within the past 5 years (2012–2016). Of these, 22 (73.3%) were from Asia-Pacific areas (Korea = 7, China = 6, Taiwan = 3, Japan = 3, and Singapore = 2) and the remainders were from Turkey ($n = 4$), Australia ($n = 1$), Germany ($n = 1$), the Czech Republic ($n = 1$), the United States ($n = 1$), and France ($n = 1$).

Even though many important developments of microsurgery started in Europe and North America, these regions are currently less interested in a procedure like distal phalanx replantation.[29] The possible reasons might be as follows:

- Replantation at this level is technically difficult from the dissection and anastomosis of the small caliber vessels and the management of postoperative venous congestion.[22,25,30–33] Some techniques and adjuvant treatments proposed to improve the replant success rate include: dissection of the reverse digital artery, polypropylene suture guided interposition vein graft, delayed venous anastomosis, fish-mouth incision, fingernail removal, medical leech application, heparinized saline gauze soaking, negative pressure wound therapy, and subdermal pocket. These advances in microsurgery lead to a success rate of up to 78 to 96%; however, most microsurgeons still think distal phalanx replantation is a difficult task.[26,34–37]
- (2) The cost-effectiveness of replantation is still questionable. Although a successful replantation is optimal compared with a revision amputation or other methods of reconstruction, the drawbacks of prolong operative time and hospitalization, delayed complications, and delayed return to work still remain as problems.[8,9]
- (3) From the functional hand's point of view, the loss of part of the distal phalanx does not impose much of a functional deficit, the main complaint is cosmesis.[5] However, in our study, we have identified some area, such as Asian Pacific area prone to replant the amputated digits if possible. There are two possible explanations as follows: (1) in oriental countries, people regard body integrity and physical appearance as more important than function; therefore, many patients in those areas strongly request replantation even after being informed that it is not essential for hand function; and (2) The microsurgeons in this area may more familiar with the supermicrosurgery, therefore this injury is less–technical challenging and the decision of replantation is more possible.[38]
- (4) The replantation surgery disrupts the regular operating room schedule. In many hospitals, only few microsurgeons, operative theaters, and microsurgery set up are available. Therefore, sometimes it is reasonable that they would rather choose an easier method to finish the reconstruction. Even in expert's hands, a distal phalanx replantation still requires 3 to 4 hours. A replantation surgery usually disrupts the scheduled cases and often presents late in the night. Both reasons decrease the attempt rate of replantation.
- (5) In most hospitals, the microsurgeons do not receive additional financial incentives even for complicated operation. Therefore, distal phalanx amputations have usually been managed with other alternative methods.[5–7]

The results of this study revealed that Middle East/South Asia and Central/South America showed higher interest in replantation. The reason for this may be that microsurgeons in these areas are interested in gaining microsurgical experience through replantation because these regions are thought to be the developing areas of microsurgery.

A microsurgical fellowship is an important factor in favoring replantation in our case. Among surgeons with a microsurgical fellowship, the replantation rate increased by 15.3% compared with those without a microsurgical fellowship. A microsurgery fellowship may represent more than just additional training; it is a process of professional and personal development that indicates the willingness to take on challenging cases and overcome the obstacles in plastic surgery.[37]

Limitations

Despite novel investigative methods and approaches with significant findings, this study has some limitations. First, our participants were microsurgeons but the case was more familiar to hand surgeon. In many places, hand surgeons were not microsurgeons because some of them were orthopaedic hand surgeons. It may make our study had bias with higher rate of replantation. Second, the exact geographical classification of microsurgeon is almost impossible since the culture may be hugely varied within the same continent, and sometimes similar cultures cross two continents. Therefore, we split Asia into Asia Pacific and South Asia/Middle East, also merged Central and South America, since they both belong to Latin America. However, few countries like Russia and Turkey which span both Europe and Asia continents are difficult to classify geographically. Third, the experiences of a given microsurgeon cannot be clearly quantified, including their training background, number of cases performed, and the surgical technique, and success rate. For example, a young microsurgeon specializing in head and neck reconstruction may have more experience than a senior microsurgeon. Forth, the responses to the questionnaire may differ from what is actually performed when faced with such a case. For example, a few microsurgeons commented that although they preferred replantation in this study case, they were not familiar with the setup of the replantation and preferred to revise the stump, owing to their greater experience with this technique. Fifth, although our sample size is 383, it could not represent the opinion of the entire global microsurgeons; in addition, the small sample size in each geographic group may not represent the general consensus of the whole region. Sixth, extrinsic factors not reflected by the questionnaire might also affect the decision to replant, such as surgeon's working place (private clinic, state hospital, university hospital, etc.), the resources in operative theater (microscope availability), manpower, and the postoperation care system. Lastly, because the questionnaire was spread online, some countries where platform like

Facebook were not available will be excluded automatically, and the response rate cannot be calculated.

In our study, the respondents were selected from professional societies or invited by experts, so that nonprofessional opinions were excluded. The online questionnaire saved time and financial resources while making a global survey feasible.

Conclusion

Many factors are involved when microsurgeons make decisions toward a particular case. To the best of our knowledge, this study is the first one using popular social media to report the global microsurgeon's opinion on a common clinical scenario. The result identified geographical differences, which corresponds to the number of related studies published from respective countries in the recent literatures. In addition, the significance of a microsurgical fellowship on clinical decision making was highlighted.

Conflict of Interest
None declared.

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